World Bank Loan Project



# HUAAN SECTION (TANKOUCHENGGUAN) ZHANGZHOU-HUAAN HIGHWAY

**The Other Highway Project**
**Fujian Provincial Highway Project II**
**Tongjiang-Sanya**
**National Highway Trunk Line**
**People's Republic of China**

# Statement of Environmental Impact Assessment



**Research Institute of Highway**
**Ministry of Communications**

**April, 1999**

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# Foreword

Zhangzhou-Zhaoan expressway is an important section within Fujian province of the national trunk road from Tongjiang, Heilongjiang province, to Sanya, Hainan province. Zhangzhou-Zhaoan expressway connects other three expressways of Xiamen-Zhanngzhou, Quanzhou-Xiamen and Fuzhou-Quanzhou in the north, and the expressway of Shantou-Chaozhou, Shantou-Shenzhen in the south, forming an expressway corridor from the capital city of Fujian to Guangdong province, Hong Kong and Macao, linking the south-east area of Fujian province with the Zhujiang river delta area, to bring into full play of the important function of "window" opening to the outside world of the special economic zone in the area, which is of great significance to both Fujian and Guangdong provinces, as well as the coastal area's economic development.

Zhangzhou-Zhaoan expressway is the Fujian Provincial Highway Project II with the World Bank loan. The Zhangzhou-Huaan Section (Tankou-Chengguan) is one of the Other Highway Project of the Project II. The road project will further improve the road network condition with higher capacity to accommodate the increasing traffic to help speed up northern area's economic development of Zhangzhou.

Entrusted by the project owner, the Research Institute of Highway (RIOH) of the Ministry of Communications (MOC) undertakes the environmental impact assessment for the attached project. In December, 1998, with the assistance from the project owner, the Fujian Communications Planning and Design Institute (FCPDI), and relevant departments of the local government, the EIA working group from the RIOH conducted an on-site investigation of the area along the road, visited such sensitive spots as villages, schools, hospitals and etc., canvassed opinions and suggestions of the public on the proposed road project, land acquisition and resettlement policy and the environmental protection measures, and collected materials relevant to the EIA work, on the base of which the Statement of the Environmental Impact Assessment for the Huaan Section of Zhangzhou-Huaan highway was accomplished in February, 1999. In March, 1999 the EIA working group had discussions with the environmental expert from the World Bank, with amendments made to the Statement of EIA done in February, 1999, based on the advice from the expert. We would like express our appreciation to all those who gave us support to make the EIA work success.

# Content

## 1. General Introduction

### 1.1 Purpose of the EIA

Highway construction is a kind of development involved with natural environment and resources with great social and economic implications. The construction of the highway and the highway traffic will cause a number of impacts on the natural and the social environment. The purposes of the EIA for this Project are as follows.

(1) By description, forecast and assessment of the social, economic, natural and ecological environmental impacts, both in terms of their scope and extent, arising from the proposed highway project in different stages of highway design, construction and operation, to provide the basis for optimized selection of the road alignment;

(2) To set forth feasible preventive and protective measures so as to minimize the negative impacts caused by the highway project, in the stages of construction and operation of the highway, in terms of the pollution and local vegetation damages, and to provide recommendations for the environmental engineering design;

(3) To provide supplement information and scientific basis for the environmental management and the development planning for the areas along the highway to promote sustainable development of social economic transport in harmony with the environment.

### 1.2 Laws, regulations and documents as the basis of the EIA report

(1) "Law of Environmental Protection of the People's Republic of China";

(2) "Law of Water and Soil Retention of the People's Republic of China";

(3) "Land Administration Law of the People's Republic of China";

(4) "Law of the People's Republic of China for the Prevention and Treatment of Noise Pollution";

(5) "Regulations Concerning with the Environmental Protection and Management of Capital Construction Project", State Council Ordinance No.253;

(6) "Notice to Strengthen the Environmental Impact Assessment and Management of Construction Project Financed by Loan from International Financial Organizations" jointly issued by NEPA, State Planning Commission, the Ministry of Finance and People's Bank of China in 1993;

(7) "Technical Guidelines for IEA", HJ/T2.1 ~ 2.3-93, HJ/T2.4-1995 and HJ/T-19-1997, SEPA;

(8) "Measures Concerning the Environmental Protection and Management for Communications Construction Project" issued by the Ministry of Communications

(9) "Specifications for Environmental Impact Assessment of Highway Construction Project" JTJ005-96;

(10) "Engineering Feasibility Study Report for Huaan Section (from Tankou to Chengguan) of Zhangzhou-Huaan Highway", made by Fujian Provincial Highway Planning and Design Institute, December, 1998.

(11) "Confirmation of the Standards to be used for Environmental Impact Assessment for Zhangzhou-Zhaoan Expressway" [1998] No. 032, issued by the Fujian Provincial Environmental Protection Bureau;

(12) Operational Directive (OD) 4.01 (1991) on Environmental Assessment, (World Bank);

(13) Opertional Policies (OP) 4.01 (1999), Bank Procedures (BP) 4.01 (1999), Good Practices (GP) 4.01 (1999) on Environmental Assessment (World Babnk);

### 1.3 Assessment scope, emphasis, standards and time horizon

#### 1.3.1 Assessment scope

The assessment scope of the project for ecological, noise and air environment is within the area of 200 meters from both sides along the central line of the proposed road, based on the features of the environmental impact at the stages of construction and operation of the road and the features of the natural environment. The assessment scope of the social economic environment is only in the areas with direct impacts.

#### 1.3.2 Emphasis of the assessment

Based on the EIA analysis, the environmental impacts on the ecological environment, water and soil retention and the noise impact on the schools and resident areas are taken as the emphasis of the assessment.

#### 1.3.3 Assessment standards

According to the document of "Confirmation of the Standards to be used for Environmental Impact Assessment for Zhangzhou-Zhaoan Expressway" [1998] No. 032, issued by the Fujian Provincial Environmental Protection Bureau, the standards used in the assessment are as follows:

(1) The Class II standard prescribed in the "Soil Quality Standard" GB15618-1995 is used for the assessment of lead content in the soil, as shown in Table 1-1.

**Table 1-1 Class II standard of lead content in the soil**

| PH value of the soil | < 6.5 | 6.5 ~ 7.5 | > 7.5 |
|---|---|---|---|
| Lead content | 250 | 300 | 350 |

(2) The Class III standard in the "Surface Water Quality Standard" (GB3838-88) is used, as shown in Table 1-2.

**Table 1-2 Water quality standard (Unit: mg/L, except for PH)**

| Item | PH | Permanganate index | SS * | Dissolved $O_2$ | Total Lead | Oil | BOD |
|---|---|---|---|---|---|---|---|
| Standard value | 6.5 ~ 8.5 | ≤ 6 | ≤ 150 | ≥ 5 | ≤ 0.05 | 0.05 | ≤ 4 |

* water quality standard for agricultural irrigation water

(3) Standard for noise assessment

The "Standard Noise Limit for Construction Site" (GB12523-90) shall be used

for assessment for the construction period, as shown in Table 1-3; and the "Ambient Noise Standard for Urban Area" (GB3096-93) shall be used for the noise assessment for the operation period of the highway as follows: class IV standard for areas within a distance of 100 meters from the central line of the road, class II standard for the areas within a distance of 100 ~ 200 meters from the central line of the road, and Class I standard for schools and hospitals, as shown in Table 1-4.

**Table 1-3 Standard noise limit for construction site (GB12523-90)**

| Construction stage | Main sources of noise | Noise limit | |
|---|---|---|---|
| | | Daytime | Nighttime |
| Earth & stone work | Bulldozer, excavator, loader, etc. | 75 | 55 |
| Piling | Various piling machine | 85 | banned |
| Structure work | Concrete mixer, vibrator etc. | 70 | 55 |

**Table 1-4 Ambient noise standard (GB3096-93)** $L_{Aeq}$: dB

| Classification | Daytime | Nighttime |
|---|---|---|
| Class I | 55 | 45 |
| Class II | 60 | 50 |
| Class IV | 70 | 55 |

(4) Ambient air quality assessment standard

For the construction period, TSP shall meet the requirement specified in the Class II standard of the "Ambient Air Quality Standard".

For operation period, the Class II standard the "Ambient Air Quality" (GB3095-96) shall be used, as shown in Table 1-5.

**Table 1-5 Ambient air quality standard** $mg/m^3$

| Pollutant | TSP | NOx | CO |
|---|---|---|---|
| Concentration (daily average) | 0.30 | 0.10 | 4.00 |
| Limit (one hour average) | 1.00 | 0.15 | 10.00 |

### 1.3.4 Time horizon

According to the time schedule of the engineering work and the traffic forecast, the time horizon for the assessment shall be construction period and operation period with correspondent year of 2000, 2005, 2010 and 2015.

## 1.4 Environment protection target

(1) The target of environment protection for the proposed road project includes the agricultural ecological system and to maintain a proper environment for people's daily life and for school teaching and studying activities along both sides of the road.

(2) The environmental protection targets in terms of noise and air environment are shown in Table 1-6.

**Table 1-6 Environmental protection targets**

| Environment | Protection target | Location | Brief description of environment | Impact factor |
|---|---|---|---|---|
| Ecological & water environment | Cover plant & small animals | whole road | Cover plants on both sides of existing road & planted woods | land occupation by road and engineering construction work |
| | Farm land | whole road | Land acqusition of farm land 33.1 mu, including paddy, dry land and pool, | land occupation by road and engineering construction work |
| | Soil retention | whole road | More barrens, less cover plants, palnty of rain | earth cutting, filling, borrowing |
| | Jiulongjiang river | whole road | Along the river, not water source pretection area | engineering construction, soil erosion, pavement run-off |
| Ambient noise, Ambient air, Social environment | Taikou | k28 | 10m from road, existing road through the village | construction noise, TSP, traffic noise in operation period, traffic emissions, |
| | Huangzao (HZ) | k54 | 10m from road, resident houses beside the road, over 100 residents | |
| | HZ primary school | k53+600 | 50m from road, 3 story school building on the right side of road, 300 students, 15 teachers | |
| | Xinyushen | k55+800 | 10m from road, existing road through the town | |
| | Xinyu primary school | k55+800 | 20m from road, 3 story school building 400 students and 4 rows of dormitories for 120 resident students with enclosing wall, with the ground level 5 m higher than the road pavement surface | |
| | Xinyu hospital | k56 | 50m from road, 10 medical workers and 4 hospital beds | |

## 1.5 Classification of the EIA

In accordance with the classification of the EIA work as required by the World Bank for road improvement project, this project involves with reconstruction of the existing road passing through such sensitive spots as resident area; therefore it is necessary to compile the EIA report and the environmental action plan (EAP).

In accordance with the classification of the EIA for special subject as specified in the "Technical Guidelines for IEA", the EIA for the ecological environment (including water environment) should be Class III; the EIA for acoustic environment should be Class II; and the EIA for ambient air quality should be Class III.

## 1.6 Assessment method

In the environmental impact assessment, the principle of "combining points with lines, representing road section with typical points" shall be adopted. Assessment of current status is based on survey and statistic analysis; with modeling and analogue methods for forecast and assessment of noise and ambient air impact; analogue method for water environment; survey and statistic analysis for social economic environment. Some indicators or values exceeding the standard limits may also be used in the assessment.

## 1.7 Assessment procedures

The assessment procedures for the Project are shown in Fig.1-1.

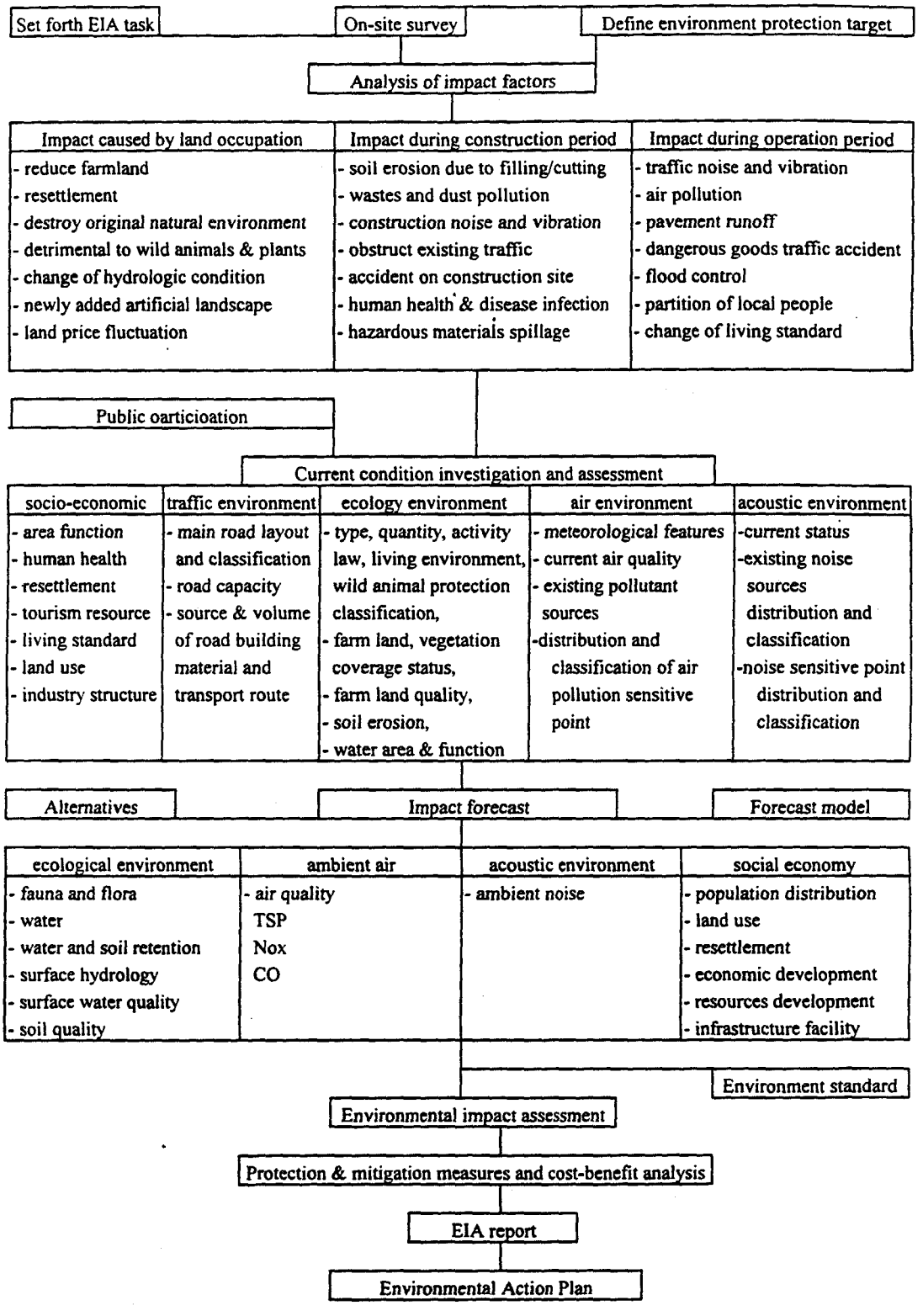



**Figure 1-1 EIA technical procedure**

## 2. Engineering Brief

### 2.1 Alignment and main control points

The Zhangzhou-Huaan section starts from the border area of Zhangzhou and Huaan at the opposite bank of Tankou (the original Zhang-Hua route k23+200), towards the upstream direction along the Jiulongjiang river, via Qianzhe (k25+750), to Taikou k28+140. The original alignment will generally be followed with necessary modification of straightening, widening and newly added pavement. A new bridge of the same type will be built at the upper stream of the existing bridge; and the two bridges will share the up-stream and down-stream traffic respectively. After the bridge, the route shall be once again along the original route, via Jianmei k29+400, Dakeng k32+400, to Xiazhangkou k36+400. The route continues along the river, via Shakeng k40+000, Xinlai k43+ 400, Waishe k50+800, where a new tunnel of 170m long and a new Huangzao bridge (5 span - 245.5m) are to be built, after which, the road will have a separate interchange with the railway, to Xinyu k55+700. Starting from k56, the road will be rising with high embankment via Shapuwei at k57+250; the rising gradient continues until the Hongqishan Huaan power plant area. The road will go into a 2,180m tunnel at k57+900, on the left side of the mountain. After the tunnel, the original temporary road used for the railway construction will be used and reconstructed connecting with the existing road. A small bridge is to be built to cross over the Wuya Dongkou of the power plant, linking with and along the inner side of the existing road, with pavement widened; in paralell with the gutter drainage of the power plant the road will end at k64+930 in front of the Huaan railway station.

The main control points are the starting point Tankou, Qianze, Taikou, Lishui woodland, Huangzao, Xinyu, Shapuwei, Hongqishan tunnel, Lizaiping, and the end point of Chenguan, with a total length of 41.73km, which is 12.07km shorter than the existing road.

### 2.2 Traffic forecast

The traffic forecast can be summarized in Table 2-1, based on the economic development and the passenger and freight transport volume.

**Table 2-1 Summary of the traffic forecast**

| Year | 2000 | 2005 | 2010 | 2015 |
|---|---|---|---|---|
| Tankou ~ Chengguan | 2,236 | 3,637 | 5,191 | 7,340 |

### 2.3 Construction scale and technical standards

Table 2-2 shows the construction scale and the technical standard adopted for the Project.

**Table 2-2 Construction scale and the technical standard**

| Indicator | Tankou – Chengguan Class II road |
|---|---|
| Design speed (km/h) | 40 |
| Subgrade width (m) | 12 |
| Carriageway width (m) | 9 |
| General minimum radius of horizontal curve (m) | 100 |
| Ultimate minimum radius of horizontal curve (m) | 60 |
| Stopping sight distance (m) | 40 |
| Maximum longitudinal gradient (%) | 7 |
| Design flood frequency for subgrade | 1/50 |
| Design loading capacity for bridge | Vehicle - 20, trailer - 100 |

## 2.4 Major construction work amount

### 2.4.1 Subgrade

Since some of the road section is along the river side, the subgrade design is mainly controlled by flood, bridge and the earth / stone filling. The road has little longitudinal fluctuations, with the maximum longitudinal gradient being 3.5%. The subgrade width is 12m, and the gradient of cut side slope is dependent on the geological conditions, as well as the height and the materials of the filling. For earth side slope, it is 1:0.5, 1:0.75 or 1:1.15; for stone side slope, it is 1:0.25, 1:0.33 or 1:0.5. Total earth and stone work amount for the subgrade is 1,784,200m$^3$.

### 2.4.2 Drainage protection

Design of longitudinal and horizontal drainage for the subgrade is done taking into consideration of the layout of bridge and culvert. Drainage ditches are to be set on both sides of fill embankment (no drainage ditch on the river side). Drainage ditches are to be set on both sides of the subgrade of cut section, with interception ditch on the top of the slope. Chute and water drop well are to be built with stone pitching, to make sure the water flow swiftly, as well as proper strength and stability of the subgrade. Total earth and stone work for the drainage protection is 55,088m$^3$.

### 2.4.3. Pavement

The carriageway width of the road is 9m with cement concrete pavement.

### 2.4.4 Bridge

There are a total of 28 bridges to be built for the road with a total length of 1,082.6m, of which 2 are large bridges, i.e. Huangzao bridge, 245.5m long; Taikou bridge, 131.8m long; 12 are medium bridge, with total length of 429.02m; 14 are small bridge with total length of 277.0m.

### 2.4.5 Tunnel

Two tunnels will be built with total length of 2,350m. One is 2,180m long, with geological features of surrounding rock of V, IV kind; another is 170m, with

geological features of surrounding rock of II, IV kind.

### 2.4.6 Main engineering work amount

Table 2-3 shows the summary of the main engineering work amount.

**Table 2-3 Summary of main engineering work amount**

| No. | Indicator | Unit | Engineering work amount |
|---|---|---|---|
| 1 | Length | km | 41.73 |
| 2 | Subgrade earth & stone work | $m^3$ | 1,784,200 |
| (1) | Earth work | $m^3$ | 739,200 |
| (2) | Stone work | $m^3$ | 1,045,000 |
| 3 | Drainage protection | $m^3$ | 55,080 |
| 4 | Pavement | $m^2$ | 347,170 |
| 5 | Bridge | m / number | 1,082.6 / 28 |
| (1) | Large bridge | m / number | 376.58 / 2 |
| (2) | Medium bridge | m / number | 429.02 / 12 |
| (3) | Small bridge | m / number | 277 / 14 |
| 6 | Culvert | number | 102 |
| 7 | Tunnel | m / number | 2,350 / 2 |
| 8 | Safety facility | km | 41.73 |
| 9 | Land acquisition | *mu* | 167.5 |
| 10 | Relocated building | $m^2$ | 10,192 |

## 2.5 Estimation of investment and time schedule of construction work

Total cost for the Project is estimated at CNY 243.518 million, of which construction cost is CNY 186.931 million, with the cost per kilometer of CNY 5.836 million.

The time schedule of the Project is shown in Table 2-4.

**Table 2-4 Time schedule of the Project**

| | Date |
|---|---|
| Design of construction plan | January, 1998 ~ April, 1999 |
| Construction | May, 1999 ~ May, 2001 |

The sources of the financing for the Project are shown in Table 2-5.

**Table 2-5 Sources of the road financing**

| Source | CNY (million) | Share (%) | Remarks |
|---|---|---|---|
| Grants from province, municipality & local county | 85.52 | 35 | Local county10% |
| Domestic bank loan | 85.00 | 35 | |
| World Bank loan | 73.00 | 30 | |

## 2.6 Identification and classification of environmental impact

According to the on-site investigation and analysis, the environmental impact factors for the Project can be summarized as follows.

At the design stage, the impacts to be considered and identified are those arising from such factors as the alignment of the road involving permanent and temporary occupation of land and woodland, resettlement of residents, which will have impact on the land use, farming, community life and the natural landscape.

At the construction stage, the impacts to be considered and identified are those arising from the engineering construction work, such as damage to the surface vegetation and the wild life habitat and soil erosion caused by cutting and filling work, which may also change the water flow and quality; the dusts and noises caused by the construction machines, which will have impact on the nearby school students and residents; the construction machine will have impact on the existing road traffic, which will increase the accident risk; and the engineering construction work will also cause inconvenience for the local residents. The construction work for some sections along the Jiulongjiang river will have negative impact on the soil erosion of the area and on the river water quality.

At the operation period, the impacts to be considered and identified are those arising from the traffic, such as the impacts of noise and air pollutants from the vehicles and vehicle emissions, CO, NOx, and etc.; and due to the fact that it needs time to recover the vegetation, soil erosion may still exist. The pavement run-off will have negative impact on the Jiulongjiang river water quality.

According to the engineering and environmental features the main environmental impacts can be identified as shown in Table 2-7.

**Table 2-7 Identification of the environmental impact caused by the Project**

| Impact factor | Impacts | Construction stage | Operation stage |
|---|---|---|---|
| Societal environment | Integration of transport network, economic & resource development | o | ♦ |
| | Living standard, economic income | ◊ | ◊ |
| | Resettlement, partition of community, residents daily life | ♦ | o |
| Natural | Landform and landscape | ◊ | o |
| Ecological | Vegetation damage, soil erosion | ♦ | o |
| | Water pollution | ◊ | o |
| | Soil and farmland crops, land loss | o | o |
| | Fauna and flora | o | o |
| Noise | Resident area, school | ◊ | ♦ |
| Ambient air | Dusts, TSP | ♦ | o |
| | Vehicle emissions (CO, NOx) | o | ◊ |

Note: ♦ significant impact; ◊ medium impact; o slight impact

## 3. Environmental Conditions and the Current Status Assessment

### 3.1 Natural and geographical conditions

#### 3.1.1 Meteorological condition

Huaan county is located in the north periphery of the southern sub-tropic area, a transition area from the southern sub-tropic area to the mid Asia tropic area. The landform in the north-west being higher than that in the south-east forms a screen to protect the south area from being affected by the north cold air, greatly weakened the cold air influence. The Jiulongjiang river passes through the mid area in south north direction. The meteorological condition is characteristic of hot humidity maritime monsoon with a lot of rain in summer, evergreen plants all the year round, progressively increasing thermal distribution and decreasing rainfall distribution from the north-west to the south-east, and frequent disaster climate.

The meteorological conditions based on the statistics of the Huaan county Meteorological Bureau are as follows.

(1) Temperature

Annual average temperature is 20.8℃;
Extreme highest temperature 40.6℃ (July 18, 1988);
Extreme lowest temperature - 3.8℃ (January 2, 1963);
The hottest month is July, with monthly average temperature of 28.2℃;
There are 23 days per year with temperature high above 35℃.

(2) Rainfall

Annual average rainfall is 1,631.5mm;
The maximum rainfall per year is 2,124.3mm(1961);
The maximum rainfall per month is 620mm (September, 1961);
The maximum rainfall per day is 1,992mm(June 25, 1985);
There are average 18.4 days per year with rainfall greater than 25mm;
The rainy season is from May to June, and the typhoon season (after flood season) is from July to September.

(3) Wind

Annual average wind speed is 1.5m/s; the prevailing wind is in north-east direction with frequency of 9%, maximum speed of 10m/s.

(4) Fog

The average foggy day per year is 15.6 days.

(5) Relative humidity

The annual average relative humidity is 79%.

#### 3.1.2 Hydrological condition

The proposed road is mainly along the North Stream of Jiulongjiang river.

The North Stream of Jiulongjiang river is 274km long, of which 107km are within Huaan county area, with drainage area of 9,640km$^2$. Its annual average run-off volume is 209m$^3$/s; with historic lowest run-off volume of 171m$^3$/s; historic highest water level of 99.4m and the maximum run-off volume of 11,500m$^3$/s.

### 3.1.3 Landform and geological condition

(1) Natural geography

Huaan county, located in the south-west of Fujian province at the middle reaches of the North Stream of Jiulongjiang river, is one of the satellite counties of Zhangzhou municipality. It borders on Changtai county in the south-east, with Anqi county to its north-east, Zhangping municipality to its north-west. The Yingtan-Xiamen railway and the North Stream of Jiulongjiang river pass through the county area in south-north direction. It is 77km from Zhangzhou and 127km from Xiamen special economic zone.

(2) Landform

The road area is hilly with hills and low mountains with elevation over 20 ~ 150m and that of mountain peak over 300 ~ 600m. The gradient of the hills is over 15 ~ 30°, and there are steep cliff and precipice to form steep V-shaped valley. The North Stream of Jiulongjiang river is all the way through along with the road. The river bed in the low land area of the mountains is broad and wide with a lot of alluvial gravel and sands.

(3) Geological structure

The area is located at Zhouning Huaan block heave belt, with Variscan ~ Indo-Chinese epoch development, Yanshan epoch east direction fault, with 8 bands of fault passing through the road alignment. The F8 fault of Indo-Chinese epoch is nearly orthogonal with the alignment of the Hongqishan tunnel. The width of fault crush zone is over 130 ~ 150m.

(4) Hydrological and geological condition

The underground water in this area can be classified into pore phreatic flow from Quaternary system sliderock crushstone, rubblestone, and alluvial sand gravel; pore water from basement rock weathered zone; crevice water from fault crush zone and joint fissure. Spring usually occurs around ravine and low land areas, which is kind of pore space water from alluvial layer with small run-off volume fluctuating from season to season, depending on the main source of rainfall.

(5) Poor geological phenomenon

(i) There are a total of 14 sections with high side slope for the road, some of which are of soil side slope at the upper part with rock foundation and the depth of the top layer soil is over 6 ~ 8m. Therefore, consequent landslide may occur at the soil rock interface.

(ii) The bury depth of Hongqishan tunnel is over 150 ~ 280m. Since 200m is usually known as the critical depth for rock burst to happen, stress measuring shall be conducted for the tunnel section with bury depth over 200m at next step to assess the issue of rock burst.

(6) Engineering geological assessment

(i) The foundation condition of the road is good and no soft ground has been found in the whole route area.

(ii) The basement rock is bare for most of the bridge location, most of which are weathered rock, except for some individual bridge location with surface of gravel and Sandy gravel layer with depth over 3 ~ 5m without soft weak layer underneath.

### 3.1.4 Earthquake

The earthquake intensity in this area is usually of VII degree.

## 3.2 Ecological environment assessment

### 3.2.1 Investigation and assessment of the current status of flora and fauna

Within the highway project area there are original cover plant of sub-tropic rain forest and broad-leaved forest (evergreen broad-leaved forest), most of which are in remote mountain area, far from the projected road. The secondary cover plants mainly are sub-tropic evergreen broad-leaved tree, secondary leaf-fall broad-leaved tree, secondary masson pine tree, Chinese fir, mixed broad-leaved and coniferous forest, bamboo forest. The main cover plants of cash forest are tea-oil tree, tung oil tree, tea garden, fruit tree, bamboo and etc. There are 242 families, 1,089 attributes and 2,698 genuses, of which 42 families, 87 attributes and 206 genuses for pteridophyta; 8 families and 22 genuses for gymnosperm; 192 families, 891 attributes and 2,438 genuses for angiospermous; and also included are 400 genuses of medical plant and 67 genuses of rare plant.

There are 19 species of animal, 20 species of bird, 39 species of fish, pests and other animals, of which 35 species are the wildlife protected by the State and the province.

Owing to the production activities and everyday life of the human being, within the road area there is no original forest and the wildlife under protection, and the cover plant in the area is dominated by planted woodland and agricultural crops, with the cover rate less than 30%.

### 3.2.2 Investigation and assessment of the current status of the land use

Total land area of Huaan county is 1,951,806 mu, of which 193,208 mu are farm land, accounting for 9.9%; 82,075 mu gardens, accounting for 4.2%; 1,161,889.1 mu

woodland, accounting for 59.53%; 47,186 mu water area, accounting for 2.4%; 426,102 mu unused land, accounting for 21.85%. The analysis based on the investigation shows that the main features of the land use in Huaan county are as follows.

(1) The hilly area is dominated by woodland, with some planted cash forest; and the farm land is dominated by paddy, followed by those for peanuts, sugarcane and tobacco.

(2) The land use rate is relatively high, with low plantation rate, with the land use rate for the whole county area being up to 78.17%, and the plantation rate being only 9.9%.

(3) There are many kinds of farm land, unevenly distributed and restricted by the landform. Most of the farm land are on both sides of the river, the basin area in the mountains, hillside, and the low land area, sporadically distributed, usually with deep gradient.

### 3.2.3 Investigation and assessment of the agricultural resources

Plantation is the major agricultural production in Huaan county and the main crops are rice, wheat, sweet potato, soybean, corn, potato; the cash crops mainly are tea, sugarcane and tobacco, followed by peanut, and cassava. The gross output value of agricultural product was CNY 410.16 million in 1997, of which CNY 46.12 million was the output of the forest industry, CNY 104.46 million of animal husbandry, CNY 19.21 million of fishery.

There are a number of soil types in the area, mainly including red soil, loess, alluvial soil, paddy soil, and etc.; of which the red soil is widely distributed.

### 3.2.4 Investigation and assessment of the current status of water and soil erosion

The area of water and soil erosion in the county once reached 244,674 mu. After many years efforts, the area with water and soil erosion being under control has been reached 172,231 mu. However due to limited investment and slow process of the cover plantation growing, it is necessary to strengthen control of water and soil erosion. The red soil loss is mainly caused by water erosion, mostly in hilly area, particularly for the red soil evolved from granite and purple sandy vanadinmica. The module of soil erosion is over 402.5 ~ 484.2t/km$^2$ · y.

### 3.2.5 Current status of the Jiulongjiang river water quality

The Jiulongjiang Beixi river, where the highway project is located, is not the First Class and the Second Class water source prection area. The nearest Huaan water source is 2km away at the upstream of the river. The water from the river nearby the road sections is mainly for industrial and agricultural use.

The Zhangzhou Municipal Environmental Monitor Station has set up 5 water quality monitor sections, two of which are in the road alignment area (Xinyu section and North 12 section). The water quality data monitored (provided in March, 1999) are summarized in Table 3-2-1.

**Table 3-2-1 Summary of monitored water quality data (Unit: mg/L)**

| Section monitored | Water period | Times | Sampling date | pH | SS | DO | Permanga-nate index | $BOD_5$ | Pb | Oil |
|---|---|---|---|---|---|---|---|---|---|---|
| Xinyu | High | 1 | 15/05 | 7.47 | 12 | 7.7 | 3.2 | 0.84 | 0.001 | 0.025 |
| | | 2 | 22/05 | 7.53 | 11 | 7.0 | 2.7 | 1.73 | 0.01 | 0.025 |
| | | Average | | 7.50 | 12 | 7.4 | 3.0 | 1.29 | 0.0056 | 0.025 |
| | Slacken | 1 | 18/09 | 7.70 | 23 | 7.1 | 2.6 | 1.02 | 0.001 | 0.025 |
| | | 2 | 24/09 | 7.47 | 14 | 6.0 | 3.3 | 0.85 | 0.001 | 0.025 |
| | | Average | | 7.63 | 18 | 6.6 | 3.0 | 0.94 | 0.001 | 0.025 |
| | Low | | 11/12 | 7.53 | 12 | 6.2 | 1.6 | 0.98 | 0.002 | 0.025 |
| | | | 18/12 | 7.72 | 10 | 6.2 | 1.5 | 1.59 | 0.002 | 0.025 |
| | | Average | | 7.62 | 11 | 6.2 | 1.5 | 1.44 | 0.002 | 0.025 |
| North 12 | High | | 15/05 | 7.48 | 12 | 6.5 | 3.5 | 1.67 | 0.001 | 0.025 |
| | | | 22/05 | 7.47 | 10 | 5.6 | 3.1 | 3.37 | 0.001 | 0.025 |
| | | Average | | 7.48 | 11 | 6.1 | 3.3 | 2.52 | 0.001 | 0.025 |
| | Slacken | | 18/09 | 7.80 | 23 | 6.3 | 3.1 | 0.91 | 0.001 | 0.025 |
| | | | 24/09 | / | 13 | 5.9 | 5.6 | 2.05 | 0.001 | 0.025 |
| | | Average | | 7.80 | 18 | 6.1 | 4.4 | 1.48 | 0.00238 | 0.025 |
| | Low | | 11/12 | 7.34 | 8 | 6.0 | 1.5 | 0.53 | 0.002 | 0.025 |
| | | | 18/12 | 7.45 | 10 | 7.9 | 2.3 | 1.81 | 0.002 | 0.025 |
| | | Average | | 7.40 | 9 | 7.0 | 1.9 | 1.17 | 0.002 | 0.025 |
| Class III water quality standard | | | | 6.5 ~ 8.5 | ≤ 150 | ≥ 5 | ≤ 6 | ≤ 4 | ≤ 0.05 | ≤ 0.05 |

It can be seen from Table 3-2-1 that all the monitored data from the two sections are within the standard limits of Class III of GB3838-88, which indicates that the river water quality is good to meet requirements for its function.

### 3.3 Current status assessment of acoustic environment and ambient air quality

Along the road area most are rural area with villages and some scattered resident spots in small scale. Only over some broad flat land such as Huangzao, Xinyu and etc., there are relatively densely populated resident areas, with the resident buildings on both sides of the existing Zhang-Hua road, forming street highway. The road traffic is the main source of the noise and the pollutants. On the whole the current status of the acoustic and air environment is good along the road area.

There are 13 acoustic environmental monitoring spots distributed at critical points,

along the Zhangzhou-Zhaoan expressway, of which the geographical and environmental features of the monitoring spots of Guanyinting, Waifenglou, Gaolin High School and Andou Primary School are similar to those of this highway project area, therefore according to the analogue method in the EIA, analogue method can be used to assess the current status of the acoustic and air environment, i.e. to assess the current status for the road project by use of the existing environmental monitoring results from the above mentioned four monitoring spots.

The measured results from the four monitoring spots are as follows: day time average noise level of 48.1dB(A) and that of night time 40.1dB(A); the day time average noise level around the schools 47.8dB(A) and night time average noise level of 40.6dB(A). The average value noise level is up to Class I standard level, which indicates good acoustic environment quality.

There are 4 ambient air monitoring spots at critical points, along the Zhangzhou-Zhaoan expressway, of which the geographical and environmental conditions of Guanyinting are similar to those of this highway project area, with measured results of one hour average concentration of CO over 0.75 ~ 1.12mg/Nm$^3$, daily average concentration of CO over 0.84 ~ 1.03mg/Nm$^3$; one hour average concentration of NOx over 0.005 ~ 0.015mg/Nm$^3$, daily average concentration of NOx over 0.005 ~ 0.012mg/Nm$^3$; daily average concentration of TSP over 0.018 ~ 0.048mg/Nm$^3$. It can be seen that the concentrations of the pollutants of CO, NOx, and TSP are relatively low, and the ambient air quality is good.

### 3.4 Current status assessment of social environment

#### 3.4.1 General condition

Huaan county is located in the far north mountain area of Zhangzhou municipality bordering on Zhangping county of Longyan municipality, with the mountain area accounting for 89% of the whole county. In accordance with the concrete situation a mountain area based economic development strategy has been formulated with the "North Stream 50 km Bamboo Industry Corridor" and the "18,000 mu Longan Belt along the River" as the emphasis to develop bamboo and wood products, fruits, edible fungus, vegetable, tobacco, sugar, aquatics breeding and green food products, with great achievements having been achieved. Total grain output reached 76,970 ton, 358 kg per mu and per capita output 0.485 ton in 1997, ranked in the second place in Zhangzhou municipality. The forestry industry is developing well with forest covering rate of 59%, with store volume of 3.5063 million m$^3$. The industry has got rich hydraulic power resource, with hydraulic power supply of 558,730,000 kwh in 1997. The Huaan Hydraulic Power Station is one of the large power plant with annual average power supply of 360,000,000 kwh. Three manufacturing industries of bamboo and wood, jade, and food have been developed, with total annual output value of CNY 280.75 million, accounting for 37.39% of the whole industry output. In addition, there are rich stone material resource in the area, particularly the calcareous-silica hornfelse

from "Jiulongbi" (nine dragon wall) is a typical decorative stone material, looks like marble, much better than granite in terms of appearance quality and dense texture, good for both handicraft articles and high grade buildings. At the foot of a hill and beside a river the county has potentials for its tourism resource.

The overall economic strength has been enhanced over the six years of 1992 ~ 1997, with gross domestic product increased from CNY 220 million to CNY 651.97 million (1990 constant value), increased by 196.35%, with annual average growth rate of 24.27%. The output value of industry and agriculture increased from CNY 363.58 million in 1992 to CNY 1149.85 million in 1997, increased by 216.26%, with annual average growth rate of 25.89%. Export oriented economy is also developing. In 1997 there are 4 newly established Chinese foreign joint ventures in the county with contracted foreign investment of USD 4.16 million and actual utilization of foreign capital of USD 3.1 million. Table 3-4-1 show the summary of the economic indicators. Table 3-4-2 show the economic indicators of the economic development program.

**Table 3-4-1 Main economic indicators of Huaan county**

| | 1985 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|
| GNP (CNY million) | 125.51 | 168.09 | 177.17 | 221.96 | 274.67 | 341.09 | 422.99 | 500.0 | 652.97 |
| GDP (CNY million) | | | | 220.76 | 272.13 | 339.84 | 421.99 | 500.0 | 651.97 |
| Gross output of I & A (CNYmillion) | 207.88 | 234.85 | 291.59 | 363.58 | 439.26 | 636.76 | 714.71 | 866.52 | 1149.85 |
| of which: Industry (I) | | | | 183.11 | 247.26 | 401.56 | 414.25 | 526.02 | 750.78 |
| Agriculture (A) | | | | 180.47 | 192.32 | 235.20 | 300.46 | 340.50 | 399.07 |
| Population (1000) | | | | 157.954 | 157.877 | 157.719 | 158.074 | 158.411 | 158.627 |
| per capital GNP (CNY) | | | | 1,405 | 1,740 | 2,160 | 2,676 | 3,230 | 4,116 |
| per capita gross output of I&A (CNY) | | | | 2,302 | 2,784 | 4,032 | 4,521 | 5,470 | 7,248 |
| Urban resident living cost (CNY) | | | | | | 1,594 | 4,652 | 5,368 | 5,748 |
| Farmer's net income (CNY) | | | | | 1,073 | | 1,597 | 2,102 | 2,495 |

**Table 3-4-2 Economic indicator of the economic development program**

| | | 1996 | 2000 | 2010 |
|---|---|---|---|---|
| GDP | CNY million | 500 | 1,295 | 2,790 |
| | Annual growth rate | 26.8% | 8.0% | |
| per capita GDP (CNY) | | 3,230 | 7,791 | 15,196 |
| Gross output of I&A | CNY million | 867 | 3,000 | 7,800 |
| | Annual growth rate | 36.4% | 10.0% | |

### 3.4.2 Assessment of current status of living standard

Due to the rapid economic development, the living standard is improving greatly and Table 3-4-3 shows the net income of the farmers.

**Table 3-4-3 Net income of the farmers over 1995 ~ 1997 (Unit: CNY)**

| | 1997 | 1996 | 1995 | Increased by (1997 over 1996) | Increased by (1996 over 1995) |
|---|---|---|---|---|---|
| County level average | 2,495 | 2,102 | 1,597 | 18.7% | 31.6% |
| Shuijian | 2,639 | 2,308 | 1,651 | 14.3% | 39.8% |
| Huafeng | 2,624 | 2,278 | 1,713 | 15.2% | 33.0% |
| Xinyu | 2,276 | 1,943 | 1,376 | 17.1% | 41.2 |
| Fengshan | 2,645 | 2,369 | 2,005 | 11.7% | 18.2% |

## 4. Expected Environmental Impacts and Protection Measures

### 4.1 Ecological environmental impact assessment

#### 4.1.1 Assessment of impact on land use

It is inevitable for the road project to occupy the land permanently or temporarily, and the land used for the road will lost its original function, which will have impact on the farm production, ecological environment, as well as the social economic system. Particularly, the farmland is precious in Huaan county with per capita land and farm land ownership only 12.32 mu and 1.22 mu respectively; and the per capita farm land ownership for the highway project area being less than 1.2mu. Total land occupation of the road project is 1,104 mu. In addition to the existing road, acquisition of 167.5 mu land will be needed, of which 33.1mu are farm land (including paddy, dry land and pool). According to the on-site investigation, the road alignment basically goes along with the Jiulongjiang river, confined by the landform. Therefore very little farm land will be included in the land acquisition, with some only for temporary use. And there are unused land which can be developed to mitigate the impact on the farm land loss.

As for the impact of the lead emissions from the traffic on the farm land soil on both sides of the road, according to the study report made by the Research Institute of Highway of the Ministry of Communications, the lead content in the farm land soil on both sides of the road will be very small, far less than the Class II standard limit as required in the State standard GB16518-1995 "Soil Environment Quality Standard" even in the long term operation period. At present more and more unleaded gasoline are used in China, and by the year of 2000, leaded gasoline will disappeared in the market as required by the State regulation. Therefore the impact of lead on the road side farm land soil will be very small in the road construction and operation period.

#### 4.1.2 Assessment of impact on fauna and flora

Owing to the land occupation and the cutting and filling work in the construction period particularly for the widened subgrade, some cover plant will have to be damaged. However, due to the fact that one side of the road is beside the Jiulongjiang river and the other side is at the foot of hill slope, where the cover plant is few; therefore, on the whole the impact arising from the road project on the cover plant is small, and the damage caused by the road project will be mitigated by plantation and greening engineering work, taking advantage of the local humidity and warm climate.

Because of the human being's activities along the road project area, there is no rare and big animals around the area. There will be impacts on small ones such frog, bird, pest during the construction period, which will migrate to other places for the time being and once the cover plants are resumed, they may come back.

#### 4.1.3 Assessment of impact on water and soil erosion

(1) Analysis of the factors to cause water and soil erosion

The main factors cause soil erosion during the road construction period are rainfall and engineering work.

The road project area is located in the transition area from the southern sub-tropic area to the mid sub-tropic area, with annual average rainfall of 1,631.3 mm and the rainy season from May to June with rainfall accounting for 40% of the year total. It can be expected that the months of May and June will be the period with most of the soil erosion during the construction period over the year of 1999 ~ 2001. The engineering work refers to the necessary cutting and filling work for subgrade, bridge, culvert, and tunnel. Proper treatment will have to be made to prevent the soil from being eroded. Table 4-1-1 lists the summary of the way of soil erosion caused by road construction.

**Table 4-1-1 Summary of the way of soil erosion caused by engineering construction**

| | Features | Way of erosion |
|---|---|---|
| Subgrade | 1. Stratified filling, compact, finish trim of side slope;<br>2. Stratified cutting, road trough trim and compact. | 1. Cutting and filling surface soil erosion, slight erosion on compacted pavement surface;<br>2. Dominated by rill erosion and planar erosion;<br>3. The extent of the erosion will increase with the growth of depth of cutting and filling;<br>4. The erosion area is wide. |
| Bridge | 1. Open cutting or piling for bridge foundation;<br>2. Subgrade treatment for culvert, or clear away the soft ground soil if it is necessary;<br>3. Water flow is usually around the bridge construction site | 1. Serious erosion for open cutting area of the foundation;<br>2. Underwater construction work will cause resuspension of the river bed deposits;<br>3. Great sand content in water for construction use;<br>4. Bridge abutment and tunnel portal are vulnerable to water and soil erosion. |
| Tunnel | 1. Cutting for tunnel;<br>2. Disposal of the spoils. | 1. Cutting and soil removal will cause serious erosion;<br>2. Local loss will be great. |
| Earth borrowing spoils disposal | 1. Borrowing and spoil disposal area with slope;<br>2. The spoils may damage the cover plant;<br>3. The spoils are usually slack and easy to be eroded. | 1. Dominated by planar erosion and rill erosion;<br>2. Local loss will be great. |

(2) Potential soil erosion intensity and erosion forecast

The mostly applied in the world, the U.S. universal soil erosion equation is used here to estimate the soil erosion.

$$A = R \cdot K \cdot Ls \cdot C \cdot P$$

where: A — erosion intensity (ton/km$^2$ · year);

R — rainfall erosion factor;

K — soil factor, for highway, K=0.42 ~ 0.46, here 0.44 is taken;

Ls — landform factor, a function of surface run-off and gradient, as follows

$$Ls = \left(\frac{L}{22.1}\right)^m \cdot (65.4\sin^2\theta + 4.56\sin\theta + 0.065)$$

where: L — lenght of the eroded slope (m);

θ — gradient of the eroded slope.

Since most of the highway sections are to be reconstructed based on the original road, with road subgrade of 12m, in hilly area, the area of 10m from both sides of the road center line shall be considered in the estimation. Before the highway construction $\theta=12°$, L=10.4m, m=0.5m; after the highway is completed $\theta=37.0°$ (gradient 1:1.5), L=4.8m, m=0.8m. The calculation shows that before the construction started, Ls=11.3, in the construction period, Ls=7.1.

C — surface coverage factor, since the existing road pavement and road side have cover plants, before the construction is started, C=0.4, in the copnstruction period the pavement and the cover plants are to be damaged, C=1.0.

P — water and soil retention factor, before the construction is started, the ground is flat and compacted, P=0.7, in the construction period, P=1.0.

To calculate the equation under the assumption of the given parameters, we can get the soil erosion intensity before and after the construction is started, and the changing rate of the growth:of the soil erosion intensity.

$$\frac{A_{2BF}}{A_{1AF}} = \frac{RK_2LS_2P_2C_2}{RK_1LS_1P_1C_1} = \frac{0.44 \times 11.3 \times 1.0 \times 1.0}{0.4 \times 7.1 \times 0.7 \times 0.4} = 6.3$$

The maximum soil erosion intensity in the construction period will be 6.3 time as much as that before the construction is started, i.e. the erosion will increased from 402.5 ~ 484.2ton/km$^2$ · year before the construction to 2,535 ~ 3,050ton/km$^2$ · year, which shows that the local soil erosion will be great and that it should not be neglected. Given the construction period of two years (May, 1999 ~ May, 2001), the width of the soil erosion area being twice as much as that of the subgrade, the soil erosion in the construction period may be up to about 2,538.0 ton ~ 3,055.0ton. However the actual soil erosion will be smaller than this figure; it is because that (i) cutting and filling area in the first year will be less than that of the estimation, and the subgrade will be compacted layer by layer; (ii) the side slope protection and the drainage engineering system will be carried out concurrently; (iii) the greening engineering work will be implemented to ensure resume of the cover plants, which will reduce the loss of soil erosion. But owing to the fact that many of the road section is close to the Jiulongjiang river, the soil erosion will have direct impact on the river water quality, it is necessary to take every measure to reduce the soil erosion in the construction period.

(3) Analysis of the spoils of the engineering work

The highway project is based on the reconstruction of the exiting road, with straightening and widening work, which will have moderate amount of cutting work, only limited to areas of widened subgrade areas. For reconstructed road the transport

conditions is relatively better, and the spoils from cutting may be used for fillings; therefore the amount of the spoils will not be great.

Most of the spoils come will from the two tunnels. The Hongqishan tunnel is 2,180m long, with earth and stone work amount up to 12,927m$^3$; the Xinanban tunnel is 170m long with earth and stone work amount up to 10,081m$^3$. To make full used of the cut earth and stone from the tunnels, and to deal with the spoils, high road embankment scheme is adopted at both ends of the tunnels, to have not only reduced the spoils to the minimum, but also improved the alignment of the highway. Therefore, the spoils disposal has been controlled quite well, but still effective should also be taken to reduce the negative impact arising from the spoils.

**4.1.4 Assessment of impact on water environment**

(1) The impact of soil erosion on water quality

The impact arising from construction of the road project on water environment, mainly include the affected rivers, farm land, ditches, and etc.; and the impact may be caused to happen in two ways: water and eroded soil flow from construction worksite directly into the nearby farmland; rill erosion of soil and sand flow into river or distant farm land by way of irrigation system.

There are several section of the highway being alongside the Jiulongjiang Beixi river, with culverts acrossing over four tributaries of Zhuxi, Tiangongxi, Xianxi, Luoxi and a number of farmland irrigation channels, which will not cause partition or cut-off of the exiting irrigation and river system. However, the construction of these bridges and culverts will cause soil erosions and impact on the water quality. The highway sections alongside the river are as the following.

(i) The section from K23+200 to K57

The start point and the section of K30 ~ K31 are alongside the river. Such measures as to build earth retaining wall should be taken to prevent the earth and stone from falling into the river during the construction period.

The rest of the highway sections are 20 ~ 100m away from the river, with the altitude of the pavement 15 ~ 25m higher tahn that of the water level; therefore the probability of direct falling into the river for the earth and stone is small; but still in rainy season the eroded soil may flow into the water body to cause turbid.

(ii) The highway section over K57 ~ K61

This section is the Hongqishan tunnel and its entry and exit areas. Although there is no direct impact on the river water area, the high embankment scheme will have potential soil erosion and indirect impact on the river water, particularly in rainy days. Therefore, construction of this section should not be done in rainy season.

(iii) The highway section from K61 to the end point of K64+930

This section is based on the the original temporary road used for the railway construction, which is far away from the river.

(2) Analysis of the impact caused by bridge construction and the labour camp

Local river substrate silt resuspension will occur in the beginning of the bridge construction caused by piling or cofferdam construction, which will have negative impact on water quality. Study shows that the "turbid flow" produced by construction of large bridge is usually 150 ~ 200m long. Taking inaccount of the characteristics of the Beixi river, which is narrow with swift flow, the impact area may be greater, but it is limited in hundreds of meters. Since the construction machine is usually powered by electric motor, without mineral oil leakage, only with little lubricant, the impact arising from gasoline spillage or leakage will be little on water quality.

The sewage and wastes from the labour camp and the construction site may be brought over into river to cause water pollution. Given the construction labours of 200 ~ 500, the daily water consumption will be 18 ~ 45 ton, so the daily sewages may have negative impact on the river water and should be treated properly.

The dusts arising from subgrade construction and construction material transport may also be brought over into the river, which will have impact on water quality. However, on the whole this kind of impact is temporary and slight.

(2) Analysis of the impacts during operation period

During the operation period, the emissions and dusts from the traffic will be dispersed with wind and drop into river to have impact on water quality; however, the quantity of the pollutants is very small, with little impact. The oil spillage over the road pavement and the particles from worn tires of road vehicles may also be brought into the river by way of the drainage system. The pollutants from pavement run-off mainly are suspended solids, oil, organic substance and lead, and etc., with their concentration depending on such factors as road traffic volume, rainfall intensity, dust deposition, duration of previous dry season, and etc..

Because the highway project area is abundant in rainfall with short period of dry season, the amount of the pollutants in the pavement run-off is relatively small. According to the measurement of the downstream river water quality from a number of bridge sites, the water quality indicators usually meet the Class III standard of GB3838-88, except for SS, which usually has slight exceedings over the Class I standard of GB5084-92. Since the highway has designed with drainage system, guiding the pavement run-off into the tributary streams of the Jiulongjiang river, the direct negative impact on the trunk part of the river will be avoided.

In addition, the Jiulongjiang river bed is wide, with its water flow being swift and

stable, which possesses strong dilution, dispersion and self cleaning capacity, the impact on water pollution cause buy the road project will be small, with slight impact on the Jiulongjiang water quality, even if it is under the extreme unfavorable rainfall conditions.

### 4.2 Forecast and assessment of acoustic environment

#### 4.2.1 Analysis of acoustic environment impact during construction period

The main noise source during road construction period is from road construction machinery, with the extent of the impact depending on such factors as work time schedule and progress, the equipment used, as well as the worksite location and the its distance from the sensitive points of village, school, and etc.. By way of on-site investigation and comparison analysis, the first raw of resident houses near the road will have the most significant impact, for the sensitive spots of Huangzao, Xinyu villages. Huangzao primary school and Xinyu primary school are near the road and will have certain impact

#### 4.2.2 Environmental impact assessment in operation period

(1) Forecast and assessment of traffic noise

The traffic noise forecast shall be made by using the forecast model as follows:

$$L_{eqi(d)} = L_{Ai} + 10\lg\left(\frac{N_i}{TV_i}\right) + 10\lg\left(\frac{r_o}{r}\right)^{1+\alpha} + \Delta S - 13$$

$$L_{eqi(n)} = L_{Ai} + 10\lg\left(\frac{N_i}{TV_i}\right) + 15\lg\left(\frac{r_o}{r}\right) + 10\lg\left(\frac{r_o}{r}\right)^{\alpha} + \Delta S - 13$$

The noise level grade of the overall traffic noise at point P shall be:

$$Leq(t) = 10\lg\sum_{i=1}^{3} 10^{0.1Leqi}$$

where: $L_{eqi(d)}$ equivalent noise level, produced by i-type vehicle at forecast point P by day (dB);

$L_{eqi(n)}$ the equivalent noise level as mentioned above by night;

$L_{Ai}$ average maximum noise level of i-type vehicle at reference point, (dB);

$N_i$ average hourly traffic of i-type vehicle, (Veh./h).;

$V_i$ average speed of i-type vehicle, (km/h);

$T$ average time (hour);

$r$ distance from reference point to driving line (m);

$r_o$ distance from forecast point to driving line (m);

$\alpha$ noise attenuation factor;

$\Delta S$ noise attenuation during transmission (minus);

It can be seen from the forecast model that, the traffic noise level during the operation period depends on the traffic volume, vehicle composition, vehicle speed, radiant acoustic power level of vehicle, longitudinal gradient, pavement texture, and etc., which can be identified as follows.

(i) Traffic volume

In accordance with the feasibility study report for the road project, the traffic forecast is summarized in Table 2-1. The co-efficient for the day time is taken as 90%.

(ii) Vehicle composition

Based on the feasibility study report, the vehicle composition of the road traffic is as follows: small vehicle accounting for 38.6%, medium vehicle accounting for 53.2%, and large vehicle accounting for 8.4%.

(iii) Vehicle speed

The technical standard of the road project is of Class II road, with design speed of 40km/h. It is assumed that vehicle speed of 30km/h for medium and large vehicles and 40km/h for small vehicle in traffic noise forecast.

(iv) Traffic noise intensity $L_{w,i}$

The average traffic noise intensity for different type of vehicle can be calculated as the following.

Large vehicle: $L_{w,l} = 77.2 + 0.18\ V_l$;
Medium vehicle: $L_{w,m} = 62.2 + 0.32\ V_m$;
Small vehicle: $L_{w,s} = 59.3 + 0.23\ V_s$;

(v) Attenuation factor

Taking into consideration of the fact that most land on both sides of the road are farmland and woodland, the attenuation factor $\alpha$ is taken as 0.5.

(vi) $\Delta S$

$\Delta S = \Delta L_{woods} + \Delta L_{building} + \Delta L_{ASA}$

a. $\Delta L_{woods}$ is the attenuation caused by barrier of woods, when the depth of the woods is 30m, $\Delta L_{woods}$ = 5dB; when it is 60m, then $\Delta L_{woods}$ = 10dB, which is the maximum attenuation.

b. $\Delta L_{building}$ is attenuation caused by barrier of building, which can be estimated as follows:

When the first raw of building occupying 40% ~ 60% of the area between the forecast point and the central line of the road, $\Delta L_{building}$ = 3dB; when it is 70% ~ 90%, then $\Delta L_{building}$ = 5dB; and when every additional raw of building is added, $\Delta L_{building}$ is

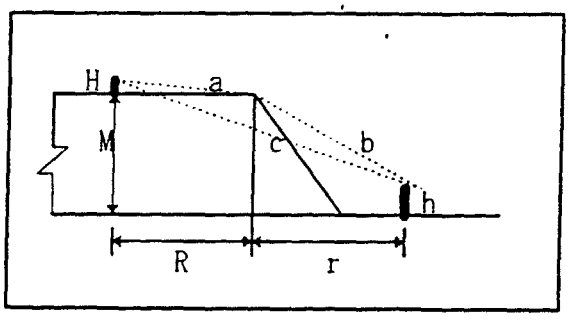
increased by 1.5dB, and the maximum is 10dB.

c. $\Delta L_{ASA}$ (ASA, acoustic shadow area) is the attenuation caused by acoustic shadow area arising from high embankment or low cutting.

When the forecast point is outside the shadow area, $\Delta L_{ASA} = 0$;

When the forecast point is inside the shadow area, $\Delta L_{ASA}$ is dependent on the difference of sound wave path $\delta = a + b + c$.

Figure 4-1-1 illustrates calculation of the sound wave path.




where: H — height of noise source, 0.8m;
M — height of road embankment or cutting (0.0 ~ 5.0m);
r — horizontal distance from forecast point to road shoulder;
h — height of the probe at forecast point, 1.2m;
R — half of subgrade width (12.0m).

**Figure 4-2-1 Illustration of calculation of sound wave path**

It can be seen from the Figure that the length of the sound shadow area for Huangzao primary school is 9.0m, and that for Xinyu primary school is 16.5m (no shadow area for other sensitive spots); and the correspondent noise attenuation can be find out from Fresnel curve. Based on the above mentioned model and parameters, the traffic forecast for operation period is summarized in Table 4-2-1.

**Table 4-2-1 Summary of traffic noise forecast for operation period**

| Year | Time period | Forecast of noise level at points with different distances from road (dB(A) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10m | 20m | 30m | 40m | 50m | 60m | 70m | 80m | 90m | 100m |
| 2000 | Day | 61.5 | 57.3 | 54.4 | 52.3 | 50.6 | 49.2 | 48.0 | 46.9 | 46.0 | 45.2 |
| | Night | 54.9 | 50.6 | 47.8 | 45.6 | 43.9 | 42.5 | 41.3 | 40.2 | 39.3 | 38.4 |
| 2005 | Day | 64.7 | 60.5 | 57.7 | 55.6 | 53.9 | 52.5 | 51.3 | 50.2 | 49.3 | 38.4 |
| | Night | 58.1 | 53.8 | 50.9 | 48.8 | 47.1 | 45.7 | 44.4 | 43.4 | 42.4 | 41.6 |
| 2010 | Day | 66.3 | 62.1 | 59.3 | 57.2 | 55.6 | 53.0 | 53.0 | 52.0 | 51.0 | 50.2 |
| | Night | 59.6 | 55.3 | 52.5 | 50.4 | 48.7 | 46.0 | 46.0 | 44.9 | 44.0 | 43.1 |
| 2015 | Day | 67.9 | 63.7 | 61.0 | 58.9 | 57.3 | 54.8 | 54.8 | 53.7 | 52.8 | 52.0 |
| | Night | 61.1 | 56.9 | 54.0 | 51.9 | 50.2 | 47.6 | 47.6 | 46.5 | 45.6 | 44.7 |

It can be seen from Table 4-2-1 that within the assessment area the noise level in the operation period will not exceed the standard limit as specified in the State standard GB3096-93 (day time 70dB(A), night time 55dB(A)). By the year of 2005 the night time noise level at points 20m from road will exceed the standard limit; and by the year of 2015, the distance of the points with exceeding noise level will be up to 30m, and the points outside the 30m distance area the noise level will not exceed the standard limit. Therefore the impact area is relative small, only limited to the first raw of the roadside building within the areas 30m from the road.

(2) Forecast and assessment of noise level at sensitive points

Forecast of the environmental noise level for the sensitive points can be made as the sum of the forecast traffic noise and the background noise, as follows.

$$Leq_{forecast} = 10\lg(10^{0.1Leq_{traffic}} + 10^{0.1Leq_{back.}})$$

where: $Leq_{traffic}$ — forecast traffic noise level at the sensitive point;

$Leq_{back.}$ — background noise level at the sensitive point.

Based on the above formula noise forecasts for each of the sensitive points along the road in different operation period can be made; and the forecasts and comparisons with the standard limits are shown in Table 4-2-2.

**Table 4-2-2 Summary of noise forecast for sensitive points and comparisons**

| Sensitive point | Forecast point | Time period | 2000 | | 2005 | | 2010 | | 2015 | | Standard |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $L_{Aeq}$ | Exceed. | $L_{Aeq}$ | Exceed. | $L_{Aeq}$ | Exceed. | $L_{Aeq}$ | Exceed. | |
| Taikou resident area | First raw building | Day | 58.2 | - | 60.9 | - | 62.4 | - | 63.7 | - | 70 |
| | | Night | 52.3 | - | 54.1 | - | 55.5 | 0.5 | 56.9 | 1.9 | 55 |
| Huangzao resident area | First raw building | Day | 59.8 | - | 62.9 | - | 64.4 | - | 66.0 | - | 70 |
| | | Night | 54.2 | - | 57.2 | 2.2 | 58.2 | 3.2 | 59.2 | 4.2 | 55 |
| Huangzao primary school | Inside school | Day | 53.7 | - | 55.3 | 0.3 | 56.8 | 1.8 | 58.3 | 3.3 | 55 |
| | | Night | 44.0 | - | 47.3 | 2.3 | 48.0 | 3.0 | 49.3 | 4.3 | 45 |
| Xinyu resident area | First raw building | Day | 60.8 | - | 63.9 | - | 65.4 | - | 67.0 | - | 70 |
| | | Night | 55.2 | 0.2 | 57.2 | 2.2 | 58.7 | 3.7 | 59.6 | 4.6 | 55 |
| Xinyu primary school | Inside 2-story building | Day | 55.0 | - | 57.2 | 2.2 | 58.6 | 3.6 | 59.8 | 4.8 | 55 |
| | | Night | 44.4 | - | 47.5 | 2.5 | 48.7 | 3.7 | 50.1 | 5.1 | 45 |
| Xinyu hospital | Insdie hospital | Day | 50.5 | - | 52.9 | - | 54.3 | - | 55.8 | 0.8 | 55 |
| | | Night | 42.8 | - | 43.8 | - | 45.0 | - | 47.5 | 2.5 | 45 |

It can be seen from Table 4-2-2 that

(1) By the year of 2000, there will be no exceeding of the noise level over the standard limit for all the sensitive points either by day or by night;

(2) By the year of 2005, there will be exceeding of 2.2dB(A) by night for the first raw building beside the road at the sensitive points of Huangzao and Xinyu; exceeding of 2.2dB(A) by day and 2.5dB(A) by night for Xinyu primary school; and exceeing of

2.3dB(A) by night for Huangzao primary school.

(3) By the year of 2010, there will be exceeding of different extent for all the sensitive points except for the Xinyu hospital by night , with the maximum exceeding of 3.7dB(A) (Xinyu and Xinyu primary school); and the maximum exceeding of 3.6dB(A) by day for the Xinyu primary school.

(4) By the year of 2015, the Xinyu primary school will have exceeding of 4.8dB(A) over the standard limit by day; and there will be some noise level exceeding over 0.8 ~ 5.1dB(A) for all the sensitive points by night, which show that the impact of the road traffic noise on the sensitive points is small in the initial operation period; the impact on the Huangzao primary school and the Xinyu primary school in the mid and long term will be increased to some extent, meanwhile, the residents close to the road will be affected to some degree.

### 4.3 Forecast and assessment of ambient air quality

#### 4.3.1 Analysis of the impact on ambient air during construction period

The impact of road construction on ambient air mainly caused by the construction machinery, such as the lime soil mixer and the vehicles for the materials transport usually produce suspension particle (TSP).

The TSP arising from material transport may be serious, with TSP concentration may exceed the Class II standard within the areas 150m from the roadside.

#### 4.3.2 Forecast and assessment of ambient air impact in operation period

(1) Forecast model

The pollutants from the road traffic during the operation period mainly are CO and NOx, and the pollutant emission intensity may be expressed by the following equation.

$$Qj = \sum_{i=1}^{3} Ai \cdot Eij / 3600$$

where: Ai = peak hour or by day hourly traffic volume of i type vehicle in forecast year;

Eij = individual vehicle emission factor for pollutant j from i type vehicle, mg / veh. · m.

The emissions from the road traffic usually form a linear pollution source. In the light of Gaussian dispersion system, the pollutant's concentration from the continuous linear source can be calculated by the following equations, taking into account of wind direction.

a. When the wind direction is perpendicular with the road

$$C(x,0,0) = \frac{2}{\sqrt{2\pi}} \cdot \frac{Q_L}{u\,\sigma_z(x)} \cdot \exp\left[-\frac{H_e^2}{2\,[\sigma_z(x)^2]}\right]$$

where: $C(x,0,0)$ — relation between surface concentration and wind direction;
$Q_L$ — intensity of the linear source, mg / $m^3$;
x — distance from calculating point to road center line (m);
u — wind speed;
$\sigma_z$ — vertical dispersion parameter, m;
He — average effective height of the linear source, m.

b. When the wind is in parallel with the road.

$$C(0,y,0) = \frac{Q_L}{\sqrt{2\pi}\,u\,\sigma_z(y)}$$

where: y — distance from calculating point to road center line (m);
$C(0,y,0)$ — relation between surface concentration and wind direction.

c. When the angle between the wind direction and the road is of any degree

When the wind direction changes there will be monotone increase or decrease of the effect, therefore, interpolation method can be used to get the pollutant's concentration, when the angle between the wind direction and the road is of any degree. $\theta(0° < \theta < 90°)$

$$C(\theta) = \sin^2\theta \cdot C_{90°} + \cos^2\theta \cdot C_{0°}$$

where: C — surface concentration in leeward direction, mg /$m^3$;
$\theta$ — the angle between the wind direction and the road, °;

(2) The forecast results and assessment

Based on the above mentioned model, on the local meteorological information of prevailing NE wind direction, with wind speed of 1.5m/s, type D stability of meteorological condition, the forecasts of hourly and daily average concentrations of the pollutants from the road traffic are summarized in Table 4-3-1.

It can be seen from Table 4-3-1 that in the operation period by the year of 2015, the maximum growth of the roadside daily average and one peak hour concentration of CO will be 0.079mg/$m^3$ and 0.138mg/$m^3$ respectively; when added with that of the background value, the total pollutant concentration will not exceed the Class II standard limit as specified in the State standard GB3095-1996 (4.0 and 10.0); and that the maximum growth of the roadside daily average and one peak hour concentration of NOx will be 0.025mg/$m^3$ and 0.040mg/$m^3$ respectively; when added with that of the background value, the total pollutant concentration will not exceed the Class II standard limit as specified in the State standard GB3095-1996 (0.10 and 0.15). Therefore, the impact of road traffic in operation period on ambient air is small.

**Table 4-3-1 Summary of forecast of traffic emission pollutants' concentrations (mg/m$^3$)**

| Pollutant | Time period | Year | Forecast of pollutant concentrations at points with different distance from road | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 10m | 20m | 30m | 40m | 50m | 60m | 70m | 80m | 90m | 100m |
| CO | one hour (Peak) | 2000 | 0.042 | 0.038 | 0.034 | 0.031 | 0.028 | 0.025 | 0.022 | 0.018 | 0.014 | 0.012 |
| | | 2005 | 0.068 | 0.062 | 0.055 | 0.050 | 0.046 | 0.041 | 0.036 | 0.029 | 0.023 | 0.020 |
| | | 2010 | 0.098 | 0.088 | 0.079 | 0.072 | 0.065 | 0.058 | 0.051 | 0.042 | 0.033 | 0.028 |
| | | 2015 | 0.138 | 0.125 | 0.112 | 0.102 | 0.092 | 0.082 | 0.072 | 0.059 | 0.046 | 0.039 |
| | daily average | 2000 | 0.024 | 0.022 | 0.019 | 0.018 | 0.016 | 0.014 | 0.013 | 0.010 | 0.008 | 0.007 |
| | | 2005 | 0.039 | 0.035 | 0.032 | 0.029 | 0.026 | 0.023 | 0.020 | 0.017 | 0.013 | 0.011 |
| | | 2010 | 0.056 | 0.050 | 0.045 | 0.041 | 0.037 | 0.033 | 0.029 | 0.024 | 0.019 | 0.016 |
| | | 2015 | 0.079 | 0.071 | 0.064 | 0.058 | 0.053 | 0.047 | 0.041 | 0.034 | 0.026 | 0.023 |
| NOx | one hour (Peak) | 2000 | 0.015 | 0.013 | 0.011 | 0.009 | 0.007 | 0.005 | 0.005 | 0.004 | 0.003 | 0.003 |
| | | 2005 | 0.021 | 0.017 | 0.014 | 0.012 | 0.009 | 0.008 | 0.006 | 0.005 | 0.004 | 0.003 |
| | | 2010 | 0.030 | 0.025 | 0.021 | 0.018 | 0.013 | 0.011 | 0.009 | 0.008 | 0.006 | 0.005 |
| | | 2015 | 0.040 | 0.033 | 0.028 | 0.023 | 0.018 | 0.014 | 0.012 | 0.010 | 0.009 | 0.007 |
| | Daily average | 2000 | 0.010 | 0.008 | 0.007 | 0.006 | 0.004 | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 |
| | | 2005 | 0.013 | 0.011 | 0.009 | 0.008 | 0.006 | 0.005 | 0.004 | 0.003 | 0.003 | 0.002 |
| | | 2010 | 0.019 | 0.016 | 0.013 | 0.011 | 0.008 | 0.007 | 0.006 | 0.005 | 0.004 | 0.003 |
| | | 2015 | 0.025 | 0.021 | 0.017 | 0.015 | 0.011 | 0.009 | 0.008 | 0.006 | 0.005 | 0.004 |

(3) Assessment of the impact on the sensitive points

Based on the current environment status and their relative geographical positions to the road, as well as the pollutant concentration forecasts, the pollutants concentrations at the sensitive points have been work out as shown in Table 4-3-2.

**Table 4-3-2 Pollutants concentrations at the sensitive points (Unit: mg/m$^3$)**

| Location | Sensitive point | Distance (m) | Pollutant | 2000 | | 2005 | | 2010 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | concentr. | exceeding | concentr. | exceeding | concentr. | exceeding | concentr. | exceeding |
| k28 | Taikou | 10 ~ 20 | CO | 0.792 ~ 1.822 | 0 | 0.818 ~ 1.848 | 0 | 0.848 ~ 1.878 | 0 | 0.0888 ~ 1.918 | 0 |
| | | | NOx | 0.02 ~ 0.0325 | 0 | 0.026 ~ 0.0385 | 0 | 0.035 ~ 0.0475 | 0 | 0.045 ~ 0.575 | 0 |
| k54 | Huangzao | 10 | CO | 0.792 ~ 1.822 | 0 | 0.818 ~ 1.848 | 0 | 0.848 ~ 1.878 | 0 | 0.888 ~ 1.918 | 0 |
| | | | NOx | 0.02 ~ 0.0325 | 0 | 0.026 ~ 0.0385 | 0 | 0.035 ~ 0.0475 | 0 | 0.845 ~ 1.907 | 0 |
| k53+600 | Huangzao pri. school | 40 ~ 50 | CO | 0.781 ~ 1.811 | 0 | 0.807 ~ 1.837 | 0 | 0.837 ~ 1.867 | 0 | 0.877 ~ 1.907 | 0 |
| | | | NOx | 0.014 ~ 0.0265 | 0 | 0.017 ~ 0.0295 | 0 | 0.023 ~ 0.0355 | 0 | 0.028 ~ 0.0405 | 0 |
| k55+800 | Xinyu | 10 | CO | 0.792 ~ 1.822 | 0 | 0.818 ~ 1.848 | 0 | 0.848 ~ 1.878 | 0 | 0.888 ~ 1.918 | 0 |
| | | | NOx | 0.02 ~ 0.0325 | 0 | 0.026 ~ 0.0385 | 0 | 0.035 ~ 0.0475 | 0 | 0.045 ~ 0.0575 | 0 |
| k55+800 | Xinyu pri. school | 20 | CO | 0.788 ~ 1.818 | 0 | 0.814 ~ 1.844 | 0 | 0.844 ~ 1.874 | 0 | 0.884 ~ 1.914 | 0 |
| | | | NOx | 0.018 ~ 0.0305 | 0 | 0.022 ~ 0.0345 | 0 | 0.03 ~ 0.0425 | 0 | 0.038 ~ 0.0505 | 0 |
| k56 | Xinyu hospital | 50 | CO | 0.78 ~ 0.181 | 0 | 0.81 ~ 1.84 | 0 | 0.84 ~ 1.87 | 0 | 0.88 ~ 1.91 | 0 |
| | | | NOx | 0.013 ~ 0.0255 | 0 | 0.016 ~ 0.0285 | 0 | 0.022 ~ 0.0345 | 0 | 0.027 ~ 0.0395 | 0 |

It can be seen from Table 4-3-2 with reference to the Class II standard of GB3096-1996 that CO and NOx concentrations at the sensitive points will increase along with the road traffic development, but still below the standard limit, which shows that there will be more environmental capacity and that the impacts on the ambient air quality caused by the road traffic is small.

### 4.4 Assessment of social environmental impact

#### 4.4.1 Social benefit analysis

(1) The reconstruction of the road is to meet the requirement of the local economic development for transport. Since implementation of reform and open policy, along with the economic and social development, the transport volume in Huaan county has been increasing rapidly, with annual growth rate of 11.6% for both passenger and freight traffic, and the annual average growth rate of GNP high up to 20.2%, over the 8th five-year plan period. Huaan county located in the north mountain area, the existing road transport condition is constrained by the natural and geographical condition, characteristic of narrow pavement, abrupt turning curvature, steep gradient, low capacity, which cannot meet the actual demand, a bottleneck for social economic development. Improvement of the road will greatly ease the traffic condition and to promote road transport as well as social economic development.

(2) In viewpoint of the geographical position of the road and the road network development, Huaan is located at the border area of the western, mid and southern Fujian province. The road from Zhangping to Huaan in the western of the province was improved up to the Class II standard in 1996, and improvement of the road from Tankou via Huaan to Xiaoji is being underway. Therefore it necessary and urgent to improve the road from Tankou to Huaan Chengguan to promote the local economic development.

(3) Improvement of Tankou-Chengguan road is necessary to integrate the local road network. In Huaan county there are a total of 809km of roads, including the provincial road No.306 and 6 county roads, with road density of 44.8km per square kilometer; but most of the roads are of low standard with low capacity. Therefore reconstruction of road from Tankou to Huaan Chengguan is part of the network improvement, so as to bring into full play of the road network system.

(4) In viewpoint of reasonable transport route, the projected road is the southern corridor for Huaan county, to connect with Zhangzhou via Tankou (Tankou is 32 km from Zhangzhou), and it is only 14km from Tankou to get on the Zhangzhou-Longyan expressway via Shiting interchange, where it is only 20 km to reach Zhangzhou-Zhaoan expressway. At the moment, construction of both Zhangzhou-Longyan and Zhangzhou-Zhaoan expressway is being underway; the Zhangzhou section of Zhangzhou-Huaan road with the subgrade up to 23m is almost completed; therefore, reconstruction and improvement of the Huaan section from Tankou to Chengguan will improve its link with the neighbouring cities of Zhangping, Anxi, and Yongan, as well

as link to the expressways to get on the national trunk road in the coast area, which will greatly reduce the time and distance for road transport and improve transport efficiency, which is of great significance to the local economic and social development.

### 4.4.2 Analysis of the impact on local people's living standard

(1) Land acquisition and resettlement

Total land occupation of the road project is 1,104 mu, most of which are existing road, and 167.5 mu permanent land acquisition is needed with a total relocation building of 10,192m$^2$.

On the whole, the occupation of farmland is little and scattered over 4 towns and villages; therefore negative impact on local people's living standard is small. It can, however, be expected that rapid economic development followed by the improvement of the road transport condition, hence the improvement of investment environment and more opportunity of employment will have positive impact on the local people's living standard.

Relocation of some of the buildings is mainly caused by widening of the road subgrade, some of which are resident houses, and some are small shops. General principle for relocation is to arrangement the resettlement locally with land grants from the local government and compensations from the owner of the road, so as to reduce the negative impact as much as possible. Although resettlement will cause some inconvenience to the local people for the time being, eventually the local people's living environment will be improved.

(2) The impact on local people's communication

Since the road project is to improve the existing road up to Class II standard, there is no access control of the road; and there is no impact of partition of the local communities. With the improvement of the road transport condition, it is more convenient and efficient for the local people's communication.

Along the road area there are Huangzao primary school and Xinyu primary school, which are close to the roadside. When the road traffic volume is high, the risk of road accident will be increasing for the student. Road safety signs or signals should be set in the junctions of the road.

## 4.5 Environmental impact prevention and control measures

### 4.5.1 Design period

(1) The greening plantation on both sides of the road should be done in conjunction with and taking into consideration of the road subgrade protection, noise and air pollution mitigation, as well as water and soil retention.

(2) The green beautification of the road area should be done in conjunction with and taking into account of ecological tourism development.

(3) To make full use of the earth and stone from cutting, so as to reduce earth borrowing and to reduce spoils disposal as much as possible;

(4) Detailed design and construction arrangement should be made for the drainage system, to balance the earth and stone work as far as possible;

(5) Water drainage ditch should set on both sides of earth borrowing and quarry areas; an interception ditch should set for worksite side slope, so as to reduce soil erosion by rainfall;

(6) Before commencement of the road project, special organizations for land acquisition and resettlement should be established;

(7) Detailed investigation should be made for the land acquisition and resettlement, to work out appropriate resettlement and compensation program;

(8) To carry out the resettlement program and make sure proper compensation to be delivered to the people resettled;

(9) The resettlement should be accomplished before commencement of the road construction;

(10) The resettlement program should be consistent with overall land use development program approved by the local government, to prevent any abuses of land use;

**4.5.2 Construction period**

(1) Special arrangement for construction work in rainy season should be made, such as by use of sand bag or straw to be placed on the slope to protect the surface, and to stop construction work in rainy days;

(2) Waste water should be placed in sand deposition pool before it is discharged; and the spoils should be disposed in designated area with consent from local EPB and soil retaining wall should be built when it is necessary;

(3) To plant grass or other greening measures over the surface of earth borrowing, quarry, spoils disposal areas, to prevent soil from being eroded by rainfall;

(4) In the process of bridge construction the waste silt generated by drilling shall be disposed at a designated site by barge;

(5) To use electric motor powered machine to reduce water pollution by oil spillage as much as possible;

(6) The labour camp should be 200m away from the trunk stream of Beixi river and the branch streams and should have septic tanks for proper treatment of the wastes and sewage from the worksite labour camp, to dispose the wastes in designated area.

(7) Thoughtful arrangement of construction schedule should be made when there is resident area within 150m from construction work site, e.g. no operation of construction machine during by night (22:00 ~ 6:00); and when the worksite is close to school, special time schedule should be arranged to reduce the impact;

(8) The mixers for bitumen concrete and lime soil materials shall be set up at open place 300 meters away in the leeward of the prevailing wind direction from the resident area. The mixers should be equipped with closed dust collection device, and bitumen heating and mixing should be in a tightly closed device. Labour protection measures shall be provided for operators of the machine;

(9) The materials should be covered during transportation and on the work site to reduce spillage and dust;

(10) To sprinkle water around the construction work site to reduce dusts arising from material transport, and to strengthen traffic safety training, education and traffic management;

**4.5.3 Operation period**

(1) To set up warning sign to ban horn noise around the road areas of the Huangzao and Xinyu primary schools, as well as speed limit sign;

(2) It is recommended that the enclose wall of the Huangzao primary school and Xinyu primary school be heightened; and for the sections of Huangzao anf Xinyu, in front of the resident houses close to the road a green belt of trees of 200m long and 20m wide be planted to mitigate the impact of traffic noise and the dusts.

(3) To carry out greening beautification on both sides of the road area, so as not only to resume the cover plant damaged during the construction period, but also improve the road landscape and the ecological environment.

(4) To strengthen management of the dangerous goods transport, with strict enforcement of the "Regulations for Road Transport Dangerous Goods" issued by the MOC JT3130-88, to prevent accident;

(5) The land use planning department should not allow newly built environmental sensitive buildings, such as resident houses, schools and hospitals in the areas 50m from both sides of the highway.

(6) To carry out the environmental monitoring work according to the environmental monitoring action plan, to work out additional measures to mitigate the negative impact when it is necessary.

## 5. The Alternative Schemes

### 5.1 Introduction to the alternative schemes

(1) k39 ~ k42 Nankenshan alternative schemes

Scheme I: straightening and widening based on the existing road, on the outside of Nankenshan along the Jiulong riverside, with route length of 2.9km.

Scheme II: To be away from the existing road at k39, newly build ascending grade on the inner side of Nankenshan, climbing over Yakou, then descending to connect with the existing road.

(2) k52 ~ k55 Xinanban alternative schemes

Scheme I: To be away from the existing road at k52, ascending via back area of Nanban mountain, to build a 170m tunnel to reach the Jiulongjiang river side, then cross over newly built Huangzao large bridge to get to the opposite river bank; passing through the resident area of Liuzhong, then to cross with railway by way of separate interchange at k53+800 , after which it continue to follow the right side slope until k55 to be connected with the existing road.

Scheme II: To follow the existing road around the southern Nanbanshan spur, to get to Huangzao bridge to make use of the existing bridge, via Xiajing, after getting to Huangzaoban resident area, the road will be along the left side of the railway until the railway interchange bridge, after crossing over the railway, the road shall follow the river in upstream direction to be connected with the existing road at k55.

(3) k56 ~ k63 Hongqishan tunnel alternative schemes

Scheme I: After Xinyu, the road shall follow the existing road for 600 ~ 700m, then ascending until to get to Hongqishan Yakou (back side of the power plant), passing through 2,180m tunnel, entering the tunnel at k57+900, with elevation of 85.90m, ascending gradient of 1.5%, climbing up to the power plant, 110m from the right side of Qianci, exiting the tunnel at k60+080, with elevation of 117.7m, after which the road shall descending to the point of k62, then to make use of the existing road with some modification and reconstruction of the existing road, to cross over Wuyatongkou, to be connected with the existing road, with total length of 6.17 km.

Scheme II: After Xinyu, the road shall continue to follow the Jiulongjiang river side in upstream direction, via Shapuwei, Baifu, to get to Jinshan woodland; where it turns to the north direction continue upstream along the river, via Chiling, Yalidong, to get to k62, bypassing the mountain spur abrupt turning and descending area down to Wuyadongkou, to be connected with the existing road; this road section making full use of the existing road with modification of straightening, widening, and with total length of 15.71 km.

## 5.2 Comparison analysis of the engineering factor

(1) k39 ~ k42 Nankenshan alternative schemes

Table 5-1 lists the comparisons of the alternative schemes in terms of engineering factor.

**Table 5-1 Comparisons of k39 ~ k42 Nankenshan alternative schemes**

| | | Scheme I (recommended) | Scheme II (alternative) |
|---|---|---|---|
| Length (km) | | 3.00 | 2.55 |
| Subgrade earth & stone work | Earth ($m^3$) | 64,400 | 173,800 |
| | Stone ($m^3$) | 130,600 | 183,900 |
| Stone paving ($m^3$) | | 3,800 | 6,400 |
| Large-medium bridge (m / No.) | | 30 / 1 | 45 / 1 |
| Tunnel (m) | | | |
| Merits and demerits | | Merits: little grade undulations, less earth & stone work.<br>Demerits: more turnings, difficult for traffic | Merits: Shorter and straight, good for traffic.<br>Demerits: More engineering work, with great undulations. |

(2) k52 ~ k55 Xinanban alternative schemes

Table 5-2 lists the comparisons of the k52 ~ k55 Xinanban alternative schemes in terms of engineering factor.

**Table 5-2 Comparisons of k52 ~ k55 Xinanban alternative schemes**

| | | Scheme I (recommended) | Scheme II (alternative) |
|---|---|---|---|
| Length (km) | | 3.00 | 3.90 |
| Subgrade earth & stone work | Earth ($m^3$) | 94,500 | 136,200 |
| | Stone ($m^3$) | 94,500 | 131,600 |
| Stone paving ($m^3$) | | 2,400 | 5,800 |
| Large-medium bridge (m / No.) | | 276 / 2 | 50 / 1 |
| Tunnel (m) | | 170 | |
| Merits and demerits | | Merits:0.9km less, much better alignment, avoid difficult condition of the existing large bridge at Zhangzhou, safe intersection with railway.<br>Demerits: less land use of existing road, new large bridge, new short tunnel, more costs. | Merits: to make ful use of the existing road and bridge to reduce cost.<br>Demerits: longer in length, more grade intersection with railway and passing through resident areas with more risk of traffic safety |

(3) k56 ~ k63 Hongqishan tunnel alternative schemes

Table 5-3 lists the comparisons of the k56 ~ k63 Hongqishan tunnel alternative schemes in terms of engineering factor.

**Table 5-3 Comparisons of k56 ~ k63 Hongqishan alternative schemes**

| | | Scheme I (recommended) | Scheme II (alternative) |
|---|---|---|---|
| Length (km) | | 6.17 | 15.71 |
| Subgrade earth & stone work | Earth ($m^3$) | 110,000 | 106,830 |
| | Stone ($m^3$) | 333,500 | 320,500 |
| Stone paving ($m^3$) | | 8,150 | 31,950 |
| Large-medium bridge (m / No.) | | 115 / 3 | 140 / 5 |
| Tunnel (m) | | 2,180 | |
| Merits and demerits | | Merits: much better alignment, much less mileage.<br>Demerits: more tunnel cost, more difficult engineering work, impact on power plant. | Merits: less cost by use of the existing road,<br>Demerits: 9.54km longer, lower standard of the alignment, not good for traffic. |

It can be seen from the comparisons that although the scheme I has more costs, long term benefit will be much better due to shorter distance and better alignment with greater social economic benefits; in contrast, although the scheme II costs less at present, it has extreme limits for future improvement.

### 5.3 Comparison analysis of environmental factor

(1) k39 ~ k42 section

The merits of the scheme I are with less land acquisition and earth/stone work, less damage to cover plants and less soil erosion by making full use of the existing road; and the demerit is that water and soil erosion arising from construction work would pollute the river water because it is close to the Jiulongjiang river.

The merits of the scheme II are better alignment and less impact on Jiulongjiang river; but there will be more engineering work with more damage to cover plants and soil erosion, more land acquisition, and some of the section may cause water pollution of the Jiulongjiang river.

Based on the comparison, both of the two schemes have pros and cons in terms of environmental protection, there is no conspicuous difference; environmental measures need to be strengthened for both of the schemes.

(2) k52 ~ k55 section

The merits of the scheme I are better alignment, less earth/stone work, safer owing to having avoided the difficult condition (traffic bottleneck) of existing bridge, less risk of water pollution because of in a distance from Jiulongjiang river for most of the section; and the demerits are more land acquisition, more damage to hilly area cover plant and the damage arising from tunnel construction.

The merits of the scheme II are less environmental impact due to use of existing road; and the demerits are more risk for traffic safety and more earth/stone work along the river area.

Comparison shows that both of the scheme have the demerits of many resettlement and close to schools without big difference, so it is agreed to recommend the scheme I in principle, and suggest that more efforts should be made in the design stage to mitigate environmental impact.

(3) k56 ~ k63 section

The merits of the scheme I are better alignment, much shorter in length, less damage to cover plant for the tunnel , less impact on buildings on both sides of the existing road; and the demerits are more resettlement work and more difficulties for the tunnel construction.

The merits of the scheme II are less costs by use of the existing road, but it is of low standard with more risk for traffic safety, and there will be great impact on buildings on both sides of existing road when the road is straightened and widened, with most of the section too close to the Jiulongjiang river, with more risk of water pollution.

Based on the comparison, it is agreed to recommend the scheme I.

## 6. Cost-benefit Analysis

### 6.1 Engineering economic cost-benefit analysis

Completion of the road project shall improve greatly the road transport conditions for the local area with significant social economic benefits, including less transport cost, shortened distance, less travel time and less traffic accident risk (Table 6-1).

**Table 6-1 Summary of social economic benefits of the road project**

| Year | Benefit from better road conditions | Benefit from shorter distance | Passenger & freight transport benefits | Benefit from reduced accident | Benefit from easier existing road traffic | Total |
|---|---|---|---|---|---|---|
| 2005 | 2,038.60 | 2,320.13 | 1,218.81 | 27.70 | 0.0 | 5,605.24 |
| 2010 | 2,933.37 | 3,432.67 | 2,518.26 | 39.53 | 0.0 | 8,923.83 |
| 2020 | 5,114.04 | 6,643.66 | 8,412.37 | 73.06 | 0.0 | 20,243.13 |

### 6.2 Cost estimation for environmental protection

The cost estimation of the cost for environmental protection measures taking into consideration of the features of the road project is shown in Table 6-2.

**Table 6-2 Summary of cost estimation for environmental protection measures**

| Item | Content | Quantity | Unit cost (CNY) | Total cost (CNY 1000) |
|---|---|---|---|---|
| Plant of noise mitigation belt | Huangzao, Xinyu, 200m long, 20m wide | 4,000m$^2$ | 100,000/m$^2$ | 40 |
| Heighten enclosing wall | Huangzao & Xinyu primary school | 200m | 400 / m | 80 |
| Speed limit & no horning sign | Huangzao, Xinyu, and school | 8 | 1,000 each | 80 |
| Construction stage EP | Sprinkle, garbage disposal, septic tank | | | 180 |
| Environmental monitoring | construction period: noise, TSP, water quality<br>operation period: noise, water quality | 2 years<br>15 years | 15,000/year<br>10,000/place | 30<br>75 |
| EP training | take part in the Zhang-Zhao expressway construction period of 1999 environmental protection (EP) training | once | 2/person | 20 |
| Others and unforeseen expenses | | | | 100 |
| Grand total | | | | 533 |

### 6.3 Cost-benefit analysis of environmental protection investment

(1) Direct benefit

The impact on ambient air quality and acoustic environment arising form road construction and road traffic emissions is complex and has many implications for social, economic, and ecological environment. Therefore effective environmental protection measures may reduce or mitigate the negative impact to reduce social and economic loss, the direct benefit from which is obvious but is difficult to be estimated in monetary terms.

(2) Indirect benefit

The environmental protection measures taken for the road project will have the following indirect benefits: to create good environment for schools to ensure quality

work of education, to create good environment for local residents beneficial to their innovative and effective work and stability of social life, the benefit of which will be of long term and huge and also is difficult to be estimated in monetary terms, it is, however, an important part of the outcome of the environmental protection investment.

## 7. Environmental Protection Management and Environmental Monitoring Plan

### 7.1 Environmental management organization

The Fujian Provincial Expressway Construction Headquarters is responsible for the management of environmental protection for the road project in construction period. The Fujian Expressway Co. Ltd. is responsible for the management of environmental protection for the road project in operation period, with the Huaan County Communications Bureau and the Environmental Protection Bureau responsible for coordination and implementation of the action plan. Figure 7-1 shows the organization chart.

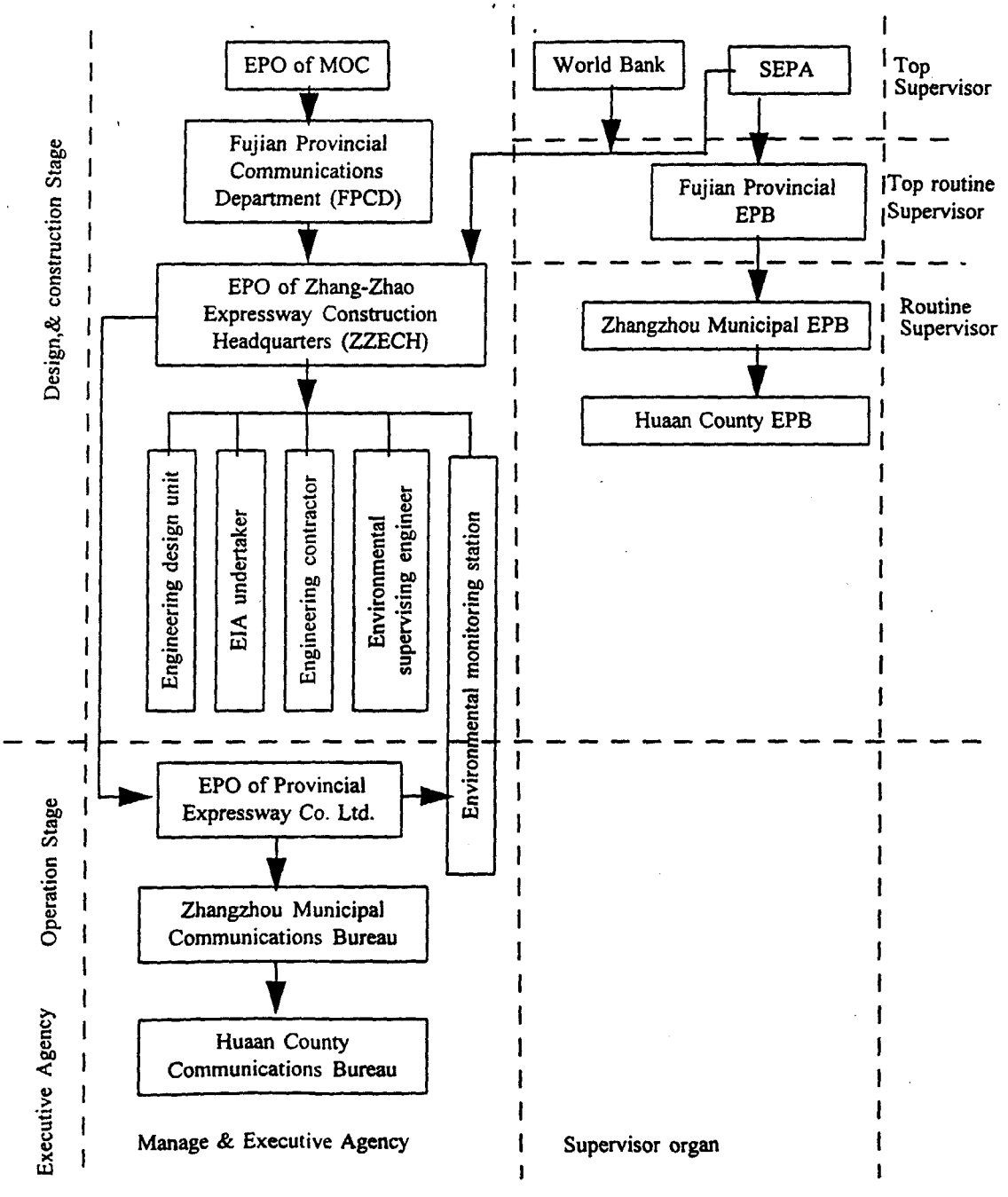



**Figure 7.1 Environmental protection management organization**

## 7.2 Action plan for environmental protection and management

**Table 7-1 Summary of the environmental management action plan for the road project**

| EA factor | Environmental protection measures | Action | In charge | Paragraph No. |
|---|---|---|---|---|
| A. Design stage | | | | |
| 1. Route selection | - land occupation as less as possible;<br>- away from sensitive points as far as possible such as school and resident area;<br>- avoid poor geological area and culture relics as far as possible;<br>- public promotion of the road project. | Design unit, Contractor | ZZECH<br>Huaan county Government | 4.5.1 (6)<br>4.5.1 (7) |
| 2. Soil erosion | - proper selection of quarry, earth borrowing, spoil disposal area;<br>- proper drainage design;<br>-to avoid high filling and cutting as much as possible. | | | 4.5.1 (1)<br>4.5.1 (5)<br>4.5.1 (4) |
| 3. Land acquisition & resettlement | - proper arrangement of the resettlement;<br>- fair compensation for the resettlement | | | 4.5.1 (6)<br>4.5.1 (7) |
| B. Construction stage | | | | |
| 1. Noise pollution | - stop machine work at night when there is resident area nearby;<br>- proper arrangement of construction work, personnel training for machine;<br>- abide by the industrial noise standard, to take protection measures for worker. | Contractor, Construction unit | Supervision company, ZZECH | 4.5.2 (7)<br>4.5.2 (7)<br>4.5.2 (8) |
| 2. Air pollution | - Proper arrangement of mixing plant 300m from sensitive points;<br>- to use stationary mixing plant as much as possible, with dust remove device;<br>- proper arrangement of material storage area;<br>- sprinkle over work site and unpaved road surface to reduce dust. | | | 4.5.2 (8)<br>4.5.2 (8)<br>4.5.2 (9)<br>4.5.2 (10) |
| 3. Ecological environment | - proper planning of temporary land use, timely back to original use;<br>- proper planning of earth and stone work to reduce damage to cover plant as much as possible, timely plantation of damaged cover plant;<br>- proper arrangement of bridge construction, ensure farm land irrigation and flood control;<br>- proper treatment of worksite wastes;<br>- subgrade drainage system | | | 4.5.2 (2)<br>4.5.2 (1)<br>4.5.2 (4) |
| 4. Others | - temporary communication line be set to ensure free flow of the communication system;<br>- hygiene issues in labour camp to ensure public health;<br>- strengthen traffic management in construction period for safety and mobility;<br>- personnel training of safety knowledge. | | | 4.5.2 (6)<br>4.5.2 (10) |
| C. Operation stage | | | | |
| 1.Noise mitigation & greening | - Huangzao, Xinyu & school areas speed limit & safety sign, heightening of enclosing wall & greening belt to mitigate noise. | Contractor | PECH | 4.5.3 (1) ~ 4.5.3 (3) |
| 2. Land use planning | - for areas within 100m from both sides of road, no environmental sensitive buildings shall be arranged. | Land use planning dept. | Zhangpu Cons. Land Bureau | 4.5.3 (5) |
| 3.Traffic control & road maintenance | - strengthen traffic management and road maintenance. | Zhangzhou, Huaan, PSB, Municipal Communica-tions Bureau | Local PSB department, | 4.5.3 (4) |
| 4.Dangerous goods transport | - implementation and enforcement of dangerous goods transport regulations | | | |
| 5. Environmental monitoring | - in accordance with the environmental monitoring plan to carry out the environmental monitoring work. | ZMEMS | ZZECL | 4.5.3 (6) |

## 7.3 Environmental monitoring plan

The environmental monitoring work for the road project is to be conducted by the local environmental protection monitoring station in accordance with the monitoring plan (as shown in Table 7-2) entrusted by the Owner. The measured records done by the monitoring station will be submitted to the trustor, then it will be submitted to the higher level authorities.

The cost for the environmental monitoring is estimated at CNY 30,000 in the construction period, and CNY 5,000 per year in operation period, with 15 years' total of CNY75,000, therefore the total cost is CNY 150,000.

**Table 7-2 Environmental monitoring plan**

| Item | Period | Location | Frequency | Action organ | Supervising organ |
|---|---|---|---|---|---|
| Noise | Construction | 1 point inside Huangzao primary school;<br>1 point inside Xinyu primary school;<br>1 point inside Xinyu hospital;<br>1 point for each of the first raw building at Huangzao, Taikou, and Xinyu resident area | construction period, once a month, & one day for each time, by day & night | ZMEMS | ZZEH<br>Zhangzhou EPB |
| | Operation | 1 point inside Huangzao primary school;<br>1 point inside Xinyu primary school;<br>1 point inside Xinyu hospital;<br>1 point for each of the first raw building at Huangzao, Taikou, and Xinyu resident area | 2001 – 2015, once a year, in two days | ZMEMS | ZZECL |
| Ambient air TSP | Construction | 1 point inside Huangzao primary school,<br>1 point inside Xinyu primary school | Randam as required | ZMEMS | ZZEH<br>Zhangzhou EPB |
| Water quality pH, COD, oil DO, SS | Construction | 1 section at the downstream 50m from the Huangzao bridge. | Random measuring, 2 days | ZMEMS | ZZEH<br>Zhangzhou EPB |

## 8. Public Participation

Since the proposed road project will bring about great economic and social benefit to the road area, the local people's government along the road areas and relevant departments actively support the proposed road project.

To fully canvass the opinions of the people and departments along the road area, and to protect the interests of the public who will be affected, investigations were made during the preparation of the EIA report, with great assistant from relevant department and the design unit at the end of December 1998; many departments were visited, including the local, local people's governments at municipal and county levels, communications bureau, agricultural department, land administration commission, water conservation department, meteorological and environmental protection bureau etc., with opinions and comments collected from the experts and the general public. Meanwhile the significance and the outlines of the project have been made known to the general public. To fully understand the opinions and proposals from the general public, sampling survey was conducted, and 50 inquiry forms were issued with 100% of the inquiry forms completed and returned. The people inquired include workers, farmers, civil servants, teachers and etc.. Table 8-1 shows the summary of the public opinion, with the details as follows.

(1) Most of the people expressed their support of the proposed road project, and recognized the great significance of the road project to the regional economic development and the public interest, so it is the needs of the development and also the wish of the people.

(2) The local people's governments and residents along the road area showed their great enthusiasm and willing to contribute to the proposed road construction and will fully support and assist the road project.

(3) Most of the people to be resettled accept the resettlement arrangement and require that the resettlement should be done in accordance with government policy with the compensations being made in time in lump-sum payment.

(4) The other problems talked about during the survey along the road area mainly are as followed:

A. Any damage to the existing infrastructure facilities such as transport, road, bridge, water irrigation, power supply and foot path or bridle way should be repaired timely.

B. Underpasses and flyovers should be provided for the local residents severed by the road.

C. Speed limit and warning signs for safety purpose should be set up around the school areas (such as Huangzao primary school, Xinyu primary school, etc.) close to the road.

Based on the above mentioned information, the construction unit has taken into account of the opinions and requests and made every effort possible to accept the suggestions.

**Table 8-1 Summary of the public opinion survey for the road project**

| | Answer | Share (%) | Remarks |
|---|---|---|---|
| 1. In favour of or against the road project | in favour of, | 100 | |
| | against or no idea | 0 | |
| 2. Who will be beneficial from the highway | individuals | 96 | |
| | collective | 100 | |
| | state | 100 | |
| 3. If you know anything of the road project in connection with you? | clear | 62 | |
| | not too clear | 36 | |
| | no idea | 2 | |
| 4. If you know the land acquisition/resettlement compensation policy? | clear | 0 | |
| | know some | 80 | |
| | no idea | 20 | |
| 5. If you accept the land acquisition/resettlement arrangement | accept | 16 | |
| | on condition | 84 | |
| | not accept | 0 | |
| 6. Is there any requirement for the compensation of the resettlement? | monetary | 100 | |
| | locally employed | 100 | |
| | change of work | 0 | |
| 7. What affect you most for the road project? | noise | 100 | |
| | emissions | 68 | |
| | dusts | 90 | |
| | severance | 78 | |
| | others | 0 | |
| 8. Suggestions to mitigate the impact. | greening | 98 | |
| | noise barrier | 8 | |
| | away from village | 10 | |
| | others (safety) | 88 | |

The proposals based on the survey can be summarized as the following.

(1) Effective means should be taken to make publicity of the government policy of economic development, resettlement and compensation for the proposed road project along the affected road area by the road authorities in cooperation with the local government departments and social organizations.

(2) Although the local governments have full authority to handle resettlement work, the competent authority for this road project should also listen to the affected residents seriously to coordinate the work in accordance with the laws and regulations,

to make sure the living standards not to be lowered after the resettlement and to get more support from the public.

## 9. Conclusions

### 9.1 Ecological environmental impact assessment

(1) The land occupation of the road project is 1,104 mu, most of the land is from the existing road, with newly acquired land only 167.5 mu, including 33.1mu farm land. The impact of the land occupation can be mitigated by improvement of making into full play the potentials of existing productivity and to develop the unused land.

(2) The cover plant on the road side close to the river will be damaged during the construction period, and the cover plant over the cutting area will also disappear. However, the measures of plantation (mán made greening) will be carried out to effectively mitigate the impact, to restore the cover plant eventually. Therefore the impact of the road reconstruction on the cover plant will be mitigated.

(3) Since un-leaded gasoline will be used, the impact of lead pollutant from the road traffic emission on the road side soil will be little.

(4) Great amount of earth and stone work will damage the cover plant, which makes soil erosion more serious. The estimation shows that the soil erosion during the construction period will be 6.3 times as much as that before the construction, with possible loss of soil up to 2,538.6 ~ 3,055.0 ton.

(5) The water and soil erosion in the construction period will pollute the river water of the Jiulongjiang Beixi river and its branch streams and the pollution will have impact on the irrigation system to certain extent. During the period of bridge construction, the river silts resuspension will have impact on the water quality. Disposal of the silts by barge to designated site will mitigate the impact. Daily discharge of sewage water from labour camp and work site will be about 15 ~ 45 ton, which should be treated before being discharged. The impact of pavement run-off on the water quality will be slight and acceptable in the road operation period.

(6) The spoils from road cutting and tunnel engineering work will be mostly used in the road construction with relatively moderate amount for disposal, but during the transport of the spoils there will be spillages of the spoils along the work site area to cause impact on the environment.

### 9.2 Acoustic environmental impact assessment

(1) The main sources of noise during the construction period are construction machines. The sensitive spots of resident area, Huangzao primary school, Xinyu primary school near to the road side will have more impact. Proper arrangement of construction work time schedule will be necessary to mitigate the impact.

(2) The day time traffic noise in the road operation period will not exceed the Class IV standard limit specified in the State standard GB3096-93, and the distance

for night time noise to exceed the standard limit will be less than 30m by the year of 2015; therefore, the area affected by the noise from the road traffic is small.

(3) In the operation period, the sensitive spots of the first raw houses of the resident areas at Huangzao and Xinyu will be affected by the night time noise from the road traffic, with little impact by day. The teaching environment of the Huangzao primary school and Xinyu primary school will be affected by the road traffic noise by day; and since there is no people live in the schools overnight, the night time noise has little impact.

(4) To mitigate the noise impact it is recommended that the enclosing wall of the Huangzao and Xinyu primary schools be heightened up to 3m; and for the first raw resident building close to the road side a green belt of trees be planted in front of the buildings (200m long and 20m wide), which is good to mitigate dust impact.

(5) To take effective measures to ensure traffic safety for the Huangzao primary school and the Xinyu primary school, such as to set up warning, no horning, speed limit signs, and etc., at the road section around the school area.

**9.3 Ambient air environmental impact assessment**

(1) TSP is the main pollutant in construction period. The TSP pollutant arising from material transport may cause serious pollution along the construction site; and the ambient air quality in areas 150m from the roadside may exceed Class II standard limit.

(2) CO and NOx concentrations, both daily average and hourly concentration, will not exceed the Class II standard in the operation period by the year of 2015, which indicates that the impact on ambient air quality is small.

(3) The ambient air quality is good for the sensitive points, with CO and NOx concentrations not exceeding the standard limits.

**9.4 Social environmental impact assessment**

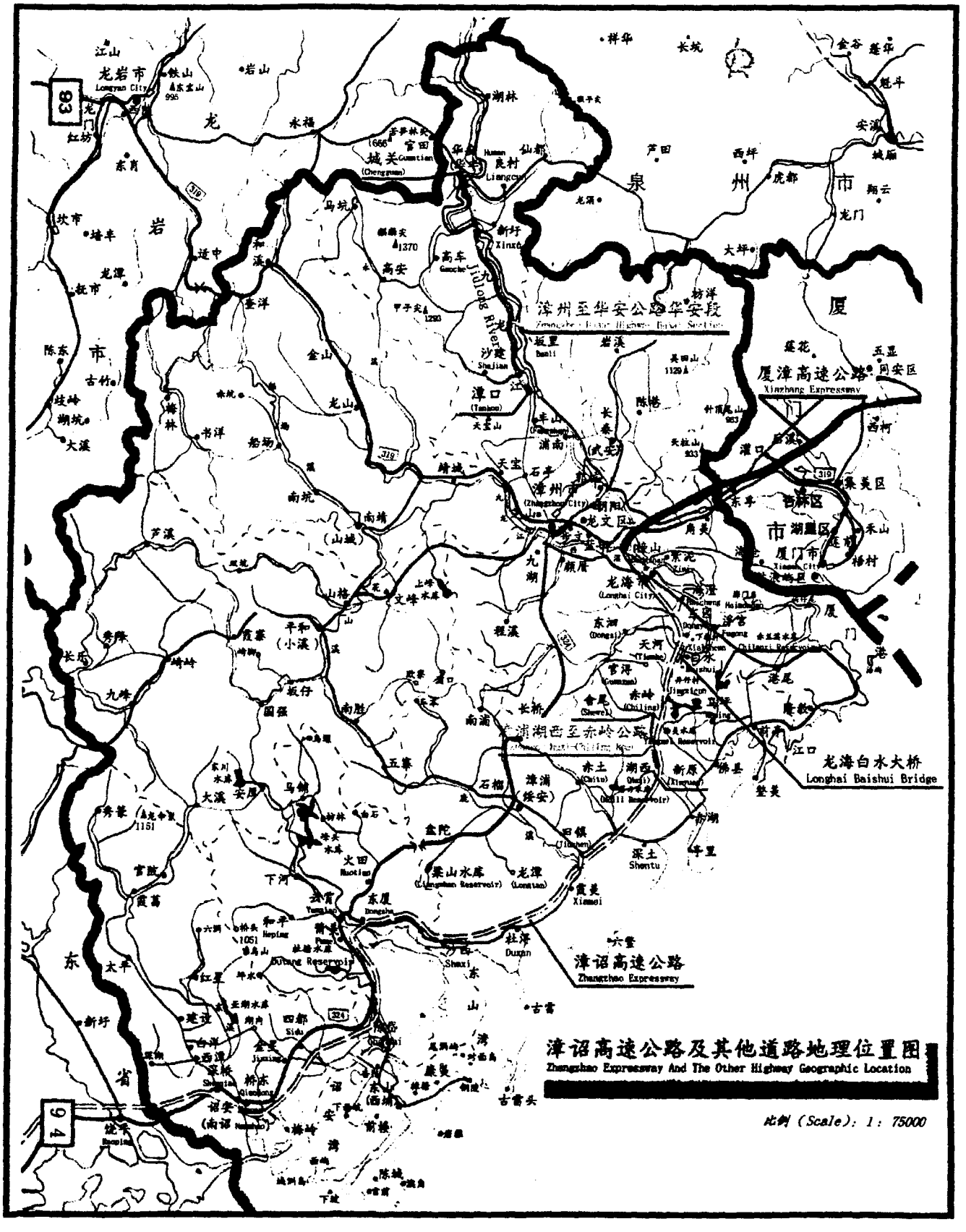
(1) The proposed road project will produce great socio-economic benefits, by improved transport conditions, investment environment, mountain area's development, land use, tourist and natural resources' exploitation along the road areas.

(2) Total land acquisition shall be 167.5 mu for the road project with resettlement buildings of 10,192m$^2$. Reasonable compensations will be provided by the construction unit for the resettlement in accordance with the State policy so as to minimize the adverse impact to the minimum possible.

(3) The road project will improve the road and road transport conditions, which will enhance the living standard for the people along the road area.

### 9.5 Overall conclusion

Based on the ecological, acoustic, air, societal environmental impact assessment for the Huaan road section (Tankou-Chengguan) construction project, the negative impact arising from the construction and operation of the road can be reduced to the minimum, so long as effective measures are to be taken as recommended in this statement, and the road project has significant economic, societal and environmental benefit for the local people; therefore, the road project is feasible in terms of environmental factor.



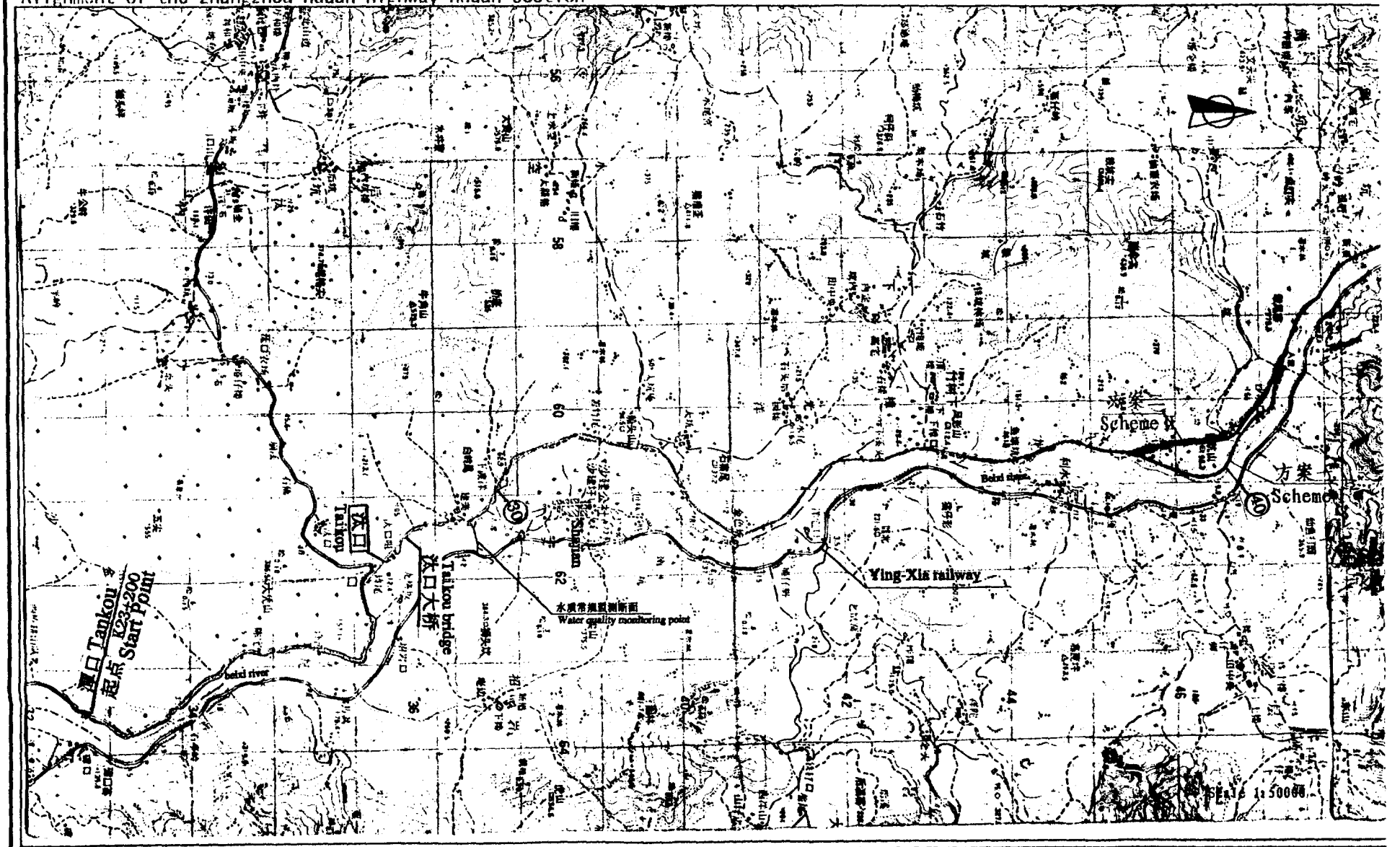

漳诏高速公路及其他道路地理位置图

Zhangzhao Expressway And The Other Highway Geographic Location

比例 (Scale): 1: 75000

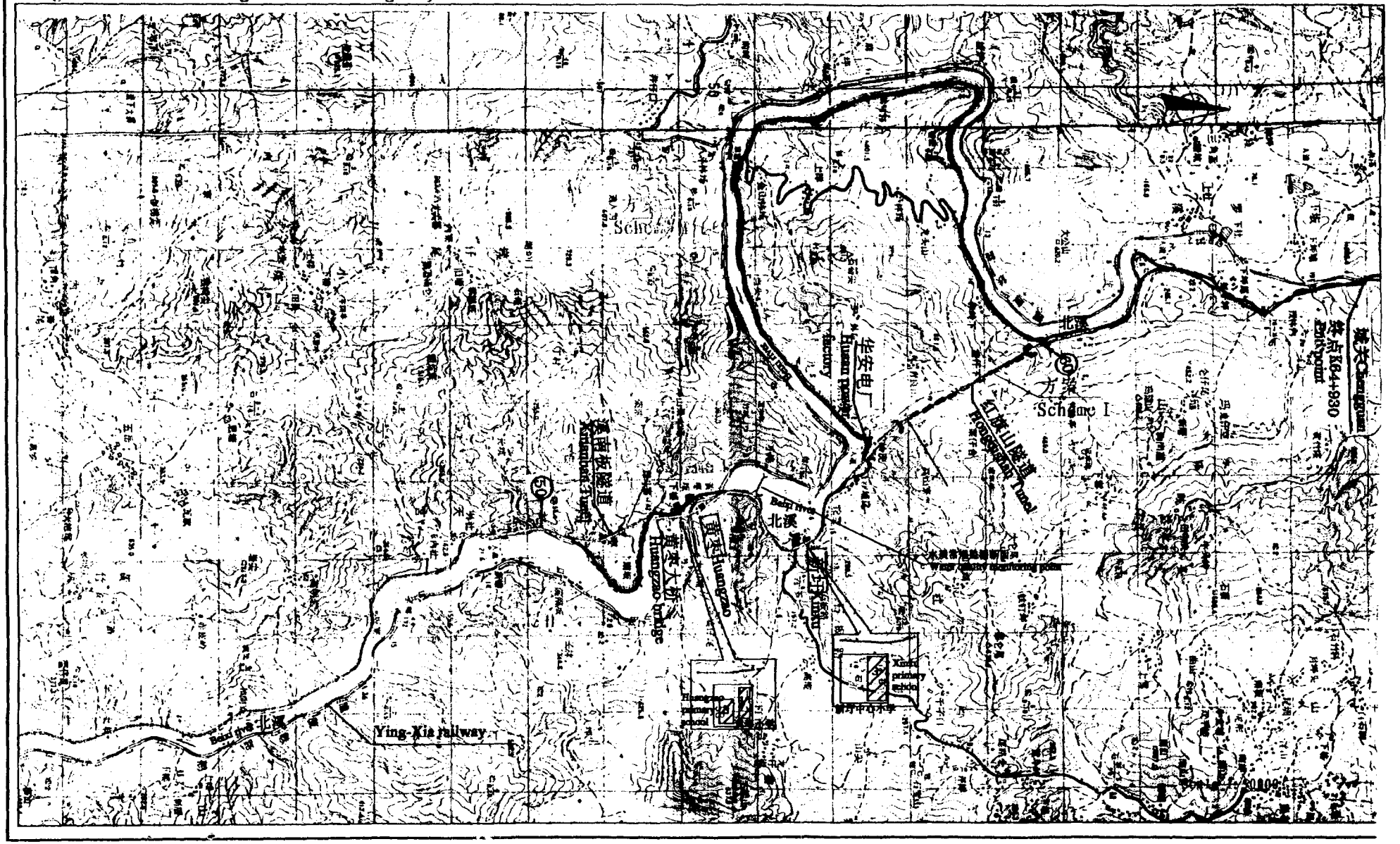
附图2 漳州～华安公路华安段路线走向图

Alignment of the zhangzhou-huaan highway huaan section



续图图2 漳州～华安公路华安段路线走向图

Alignment of the zhangzhou-huaan highway huaan section



# 公路沿线公众参与调查表（户级访谈）

| 访谈对象姓名 | 郭丁勇 | 单位或住址 | 黄寺小学 |
|---|---|---|---|

| 性别 | 男 | 年龄 | 31 | 民族 | 汉 | 职业 | 教员 | 职务 | | 文化程度 | 中专 |
|---|---|---|---|---|---|---|---|---|---|---|---|

| 户籍人口　人，其中劳动力　个 | 耕地面积　，亩 | 住房：<br>砖混　间　m²；砖木　间　m²；<br>土木　间　m²；简易　间　m²。 |
|---|---|---|

| 家庭年均纯收入（元） | 主要收入来源（元） | 种植业（粮，菜，经济，果，林） | 养殖业（饲养，鱼） | 副业（建筑，贩运，外出打工） | 企业（小加工厂，作坊） | 水产业（捕捞，养殖） |
|---|---|---|---|---|---|---|
| | | | | | | |

| 主要生产、交通工具，家用电器 | 拖拉机 | 汽　车 | 摩托车 | 电视机 | 农　具 | 其它（自行车、缝纫机、家电） |
|---|---|---|---|---|---|---|
| | | | | | | |

| 修建该公路与你户相关受影响类型 | 征　地 | 拆　房 | 征地、拆迁 | 不征地、不拆访房 | 其　它 |
|---|---|---|---|---|---|
| | | | | | ✓ |

| | | | |
|---|---|---|---|
| 是否赞同修建该公路 | 赞同✓ | 不赞同 | 不知道 |
| 修建该公路对谁有利 | 国家 | 集体✓ | 个人✓ |
| 修建该公路要占部分田地，要拆迁一些住房，你对此有无意见 | 没有✓ | 有 | 不知道 |
| 是否了解公路建设征地、搬迁、安置的补偿政策 | 了解 | 了解一些✓ | 不了解 |
| 是否服从征地、拆迁和重新安置 | 服从✓ | 有条件服从 | 不服从 |

| | | | | |
|---|---|---|---|---|
| 公路建设带来何种环境污染对你影响较大 | 噪声✓ | 汽车尾气 | 灰　尘 | 其　它 |
| 建议采取何种措施减轻影响 | 公路绿化✓ | 隔离墙 | 远离村庄 | 其　它 |

| 其它意见和建议 | 尽早修建该条公路。<br>2. 做好校门口前人交叉路口安全设置。 |
|---|---|

注：1. 凡问答一栏请用“✓”表示符合对每个问题的态度，如赞同“✓”等；
2. 对于其它意见和建议以及一些具体要求，请书面表达，可附纸说明。

访谈对象（签名）：郭丁勇　　访谈人（签名）：　　访谈日期：98年11月27日

# 公路沿线公众参与调查表（户级访谈）

| 访谈对象姓名 | 杨碧娟 | 单位或住址 | 华安县新圩中心小学 |
|---|---|---|---|

| 性别 | 女 | 年龄 | 22 | 民族 | 汉 | 职业 | 教师 | 职务 | | 文化程度 | 中专 |
|---|---|---|---|---|---|---|---|---|---|---|---|

| 户籍人口 2 人，其中劳动力 个 | 耕地面积 亩 | 住房：<br>砖混 间 m²；砖木 间 m²；<br>土木 间 m²；简易 间 m²。 |
|---|---|---|

| 家庭年均纯收入（元） | 主要收入来源（元） | 种植业（粮，菜，经济，果，林） | 养殖业（饲养，鱼） | 副业（建筑，贩运，外出打工） | 企业（小加工厂，作坊） | 水产业（捕捞，养殖） |
|---|---|---|---|---|---|---|
| | | | | | | |

| 主要生产、交通工具，家用电器 | 拖拉机 | 汽车 | 摩托车 | 电视机 | 农具 | 其它（自行车、缝纫机、家电） |
|---|---|---|---|---|---|---|
| | | | | | | |

| 修建该公路与你户相关受影响类型 | 征地 | 拆房 | 征地、拆迁 | 不征地、不拆访房 | 其它 |
|---|---|---|---|---|---|
| | | | | | |

| | | | |
|---|---|---|---|
| 是否赞同修建该公路 | 赞同✓ | 不赞同 | 不知道 |
| 修建该公路对谁有利 | 国家✓ | 集体 | 个人 |
| 修建该公路要占部分田地，要拆迁一些住房，你对此有无意见 | 没有✓ | 有 | 不知道 |
| 是否了解公路建设征地、搬迁、安置的补偿政策 | 了解 | 了解一些✓ | 不了解 |
| 是否服从征地、拆迁和重新安置 | 服从 | 有条件服从✓ | 不服从 |

| | | | | |
|---|---|---|---|---|
| 公路建设带来何种环境污染对你影响较大 | 噪声✓ | 汽车尾气 | 灰尘 | 其它 |
| 建议采取何种措施减轻影响 | 公路绿化✓ | 隔离墙 | 远离村庄 | 其它 |

| 其它意见和建议 | |
|---|---|

注：1 凡问答一栏请用“✓”表示符合对每个问题的态度，如赞同“✓”等；
2 对于其它意见和建议以及一些具体要求，请书面表达，可附纸说明。

访谈对象（签名）杨碧娟 访谈人（签名） 访谈日期 98年12月23日

# 公路沿线公众参与调查表（户级访谈）

| 访谈对象姓名 | 李昭梅 | 单位或住址 | 漳州市华安县第六中学 |
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| 性别 | 女 | 年龄 | 24 | 民族 | 汉 | 职业 | 教师 | 职务 | 教师 | 文化程度 | 大专 |
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| 户籍人口　人，其中劳动力　个 | 耕地面积　亩 | 住房：<br>砖混　间　m²；砖木　间　m²；<br>土木　间　m²；简易　间　m²。 |
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| 家庭年均纯收入（元） | 主要收入来源（元） | 种植业（粮，菜，经济，果，林） | 养殖业（饲养，鱼） | 副业（建筑，贩运，外出打工） | 企业（小加工厂，作坊） | 水产业（捕捞，养殖） |
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| 主要生产、交通工具，家用电器 | 拖拉机 | 汽　车 | 摩托车 | 电视机 | 农　具 | 其它（自行车、缝纫机、家电） |
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| 修建该公路与你户相关受影响类型 | 征　地 | 拆　房 | 征地、拆迁 | 不征地、不拆访房 | 其　它 |
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| 是否赞同修建该公路 | 赞同✓ | 不赞同 | 不知道 |
| 修建该公路对谁有利 | 国家✓ | 集　体✓ | 个　人✓ |
| 修建该公路要占部分田地，要拆迁一些住房，你对此有无意见 | 没有 | 有 | 不知道 |
| 是否了解公路建设征地、搬迁、安置的补偿政策 | 了解 | 了解一些✓ | 不了解 |
| 是否服从征地、拆迁和重新安置 | 服从 | 有条件服从 | 不服从 |

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| 公路建设带来何种环境污染对你影响较大 | 噪　声✓ | 汽车尾气 | 灰　尘 | 其　它 |
| 建议采取何种措施减轻影响 | 公路绿化✓ | 隔离墙 | 远离村庄 | 其　它 |

| 其它意见和建议 | 由于本校学生在此公路往返次数较多，故有以下建议：<br>①修建过程中是否派专人在此维护秩序<br>②出示一些警示牌以引起司机、学生、群众的注意力。 |
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注　1　凡回答一栏请用"✓"表示符合对每个问题的态度，如赞同"✓"等；
　　2　对于其它意见和建议以及一些具体要求，请书面表达，可附纸说明。

访谈对象（签名）　　访谈人（签名）李昭梅　访谈日期 1998年12月29日