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Yichang Changfeng Hydropower Development Co., Ltd.

Changfeng Hydropower Project

Environmental Impact Report

(For Approval)

Construction by：Yichang Changfeng Hydropower Development Co., Ltd.

Prepared by: Scientific Research Institute for Environmental Protection of Xiangfan City

Yichang Environmental Protection Design and Research Institute

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Attachment 1：Changyang Tujia Autonomous County Bureau of Development and Planning，CJ No. [2004]30, Approval for the Project Proposal of Changfeng Hydropower Station and Lengshuiqiao Hydropower Station by Bureau of Development and Planning, March, 29th, 2004.

Attachment 2：Letter of Authorization on Writing the Report for Environmental Impact of Changfeng Hydropower Station by Yichang Changfeng Hydropower Development Co., Ltd.

Attachment 3 ：Approval of executive standard for Report on Environmental Impact of Changfeng Hydropower Project by Yichang Changfeng Hydropower Development Co., Ltd.

Appendix 4: Commitment Made by Villagers' Committee of Bajiaomiao on Drinking Water Problem for Human Beings and Livestock within Construction Influence Area of Changfeng Hydropower Project;

Appendix 5: Commitment Made by Changyang Tujia Autonomous County Government on Resident Relocation within Construction Influence Area of Changfeng Hydropower Project;

Appendix 6: Approval for Assessment Outline and Experts' Review Comments on It;

Attachment 7: Review Comments and Member List of Experts for Report on Environmental Impact of Changfeng Hydropower Project by Yichang Changfeng Hydropower Development Co., Ltd.

Appendix 8: Approval Sheet for Environmental Protection of Construction Project.

1. Introduction

1.1 Project Outline and Background

Changyang Tujia Autonomous County is located at southwest mountain area in Hubei Province, at the middle and downstream of Qingjiang River Valley. The county is at longitude 110°21′-111°20′ E and latitude 30°12′-30°46′ N, covering an area of 3430 km^2, which is governed by Yichang municipal government, Hubei Province. Changyang Tujia Autonomous County has 11 towns, which include 154 villages with population of 415000 in total. This county is mainly located at mountain area, with Qingjiang River running through it from west to east. The county boasts abundant resources, especially water energy, minerals, forestry and tourism. Changyang Tujia Autonomous County has achieved great development both in social and economic aspect. With more and more industrial enterprises, stronger economic power and increasingly improved infrastructures including transportation, communication and energy industry, the county is ready for new industry. The total GDP of the county has reached 2.6 billion in 2002.

Ganhe Creek is the largest branch at the left bank of downstream from Zhaolai River, the secondary branch of Qingjiang Water System, which originates from Guanjianao at 1998m altitude. The main watercourse of Ganhe Creek is 34.2m long, covering 183.5km^2 drainage areas, with height difference of 1694m, and weighted average watercourse descent of 34‰. The theoretical reserves of the main stream are 23000kw, among which the theoretical reserves of river running through Changyang are 19400kw. Changyang has rich hydropower resources. Ganhe Creek water energy development is planned as follows: the first level runoff hydropower station on Zhichang Creek upstream from the River, Longtan hydropower station has 2×320kW installed capacity; the planned secondary hydroelectric power station, Changfeng hydropower station has 2×5000kW installed capacity; the planned third-level runoff hydropower station downstream Zhichang Creek, Dengjia River hydropower station has 2×200kW installed capacity; the Qiyan Creek hydropower station has 2×1000kW installed capacity and the Ganhe Creek hydropower station has 2×1250kW installed capacity. Yichang Water Resources & Hydropower Bureau has approved the above plan by issuing the YSS [2004] document.

In May 2004, Yichang Changfeng Hydropower Development Co., Ltd. entrusted Yichang Qingjiang Design and Investigation Institute of Hydropower to finish the preliminary design report for Changfeng Hydropower Project in Changyang, Hubei. According to applicable local and national laws and regulations for environmental protection, Yichang Changfeng Hydropower Development Co., Ltd. entrusted Yichang Environmental Protection Design and Research Institute of on July 19th, 2004 to assess environmental impact of the project. With field exploration, investigation and information collection, Yichang Environmental Protection Design and Research Institute finished Assessment Outline for Environmental Impact of Changfeng Power Station and Lengshuiqiao Power Station built by Yichang Changfeng Hydropower Development Co., Ltd. (thereafter referred to as the assessment outline) The assessment outline is made according to Law on Environmental Impact Assessment of People's Republic of China and Technical Guidelines for Environmental Impact Assessment, Decree No.253 of the State Council of the People's Republic of China, Regulations on the Administration of Construction Project Environmental Protection, and the industrial standard of environmental protection of People's Republic of China. On August 19th, 2004, experts from Yichang Bureau of Environmental Protection examined the assessment outline and gave comments on it. The Report on Environmental Impact of Changfeng Hydropower Project with Yichang Changfeng Hydropower Development Co., Ltd. is made based on the above comments from experts. On September 24th, 2004, Yichang Bureau of Environmental Protection held a meeting to appraise the report and amended it according to the group suggestions of the attended experts. The report is handed over to the construction company to be submitted to relevant authority of environmental protection for further examination and approval.

1.2 Purpose of Assessment

Through field exploration, investigation and inspection on environment status quo and public survey, we investigated the natural and social environment of Changyang Tujia Autonomous County in Hubei Province, where Changfeng Hydropower Station is located, analyzing the main environmental problems and giving thorough and systematic assessment on the positive and negative impact on natural environment, social environment and ecological environment of project construction, reservoir inundation and project operation. Regarding the negative environmental impact of the project, we raise practical measures for environmental protection and remedy measures to reduce the negative impacts, so

as to fully display the positive impact. All measures aims to ensure that the project improves social and economic development and protect local ecological environment as well.

The assessment on environmental impact of the project can also be used as evidence for environmental feasibility of the project. The assessment helps to complete the design documents of the project and promotes project construction. The assessment also provides scientific evidence for environment management, supervision and examination.

1.3 Reference documents

1.3.1 Laws and Regulations

(1) Environmental Protection Law of the People's Republic of China (1986.12)

(2) Law of the People's Republic of China on Appraising of Environmental Impact (2003.9)

(3)Water Law of the People's Republic of China (2002.8 revised)

(4) Land Administration Law of the People's Republic of China (1998 revised)

(5) Law of the People's Republic of China on the Prevention and Treatment of Infectious Diseases (1989.2)

(6) Law of the People's Republic of China on Water and Soil Conservation (1991.6)

(7) Forest Law of the People's Republic of China (1998 revised)

(8) Law of the People's Republic of China on the Protection of Wild Life (1988.11)

(9) Fisheries Law of the People's Republic of China (2000.10)

(10) Law of the People's Republic of China on the Prevention and Control of Water Pollution (2002.11)

(11) Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution (2000.4 revised)

(12) Law of the People's Republic of China on the Prevention and Control of Environmental Noise Pollution (1997.3)

(13) Regulations on the Administration of Construction Project Environmental Protection (1998.11)

(14) Administration Measures for Water and Soil Conservation Plan of Construction Project (1994.11)

(15) Regulations on the Sanitary Administration in Public Places (1987.4)

(16) Measures for the Implementation of the Law of the People's Republic of China on the Prevention and Treatment of Infectious Diseases (1991.12)

(17) Classified Administration Directory for Construction Project Environmental Protection (Decree No.253 of the State Council, 1998)

(18) Notice on Improving Public Consultation for Environmental Impact Appraising of Construction Project (EHB No.2003) and other applicable regional and national laws and regulations.

1.3.2 Technical Guidelines

(1) Technical Guidelines for Environmental Impact Assessment, Non-Polluted Ecological Impact (HJ/T19-1997)

(2) Technical Guidelines for Environmental Impact Assessment (HJ/T2.1~2.3-93)

(3) Technical Guidelines for Environmental Impact Assessment-Noise Environmental Impact (HJ / T2.4-1995)

(4) Technical Guidelines for Environmental Impact Assessment on Water Conservancy and Hydropower Projects (SDJ88-2003)

(5) Technical Guidelines for Environmental Impact Assessment-Water Conservancy and Hydropower Projects (HJ/T88-2003)

(6) Technical Specifications for Medical Assessment of Environmental Impart on Water Conservancy and Hydropower Projects (GB/T16124-1995)

(7) Technical Regulations on Water and Soil Conservation Plan of Development and Construction Projects (SL204-98)

(8) General Rules of Planning for Comprehensive Control of Water and Soil Conservation (GB/T15772-1995)

(9) Technical Regulations for Comprehensive Control of Water and Soil Conservation (GB/T16543-1996)

(10) Lists of Wild Plants under Special State Protection (first list) (1999.8)

(11) Lists of Wildlife under Special State Protection (1989.1)

(12) Lists of Terrestrial Wildlife under Special Protection of Hubei Province (1994.6)

(13) List of Aquatic Animal under Special Protection of Hubei Province (1994.12)

(14) Technical Standard for Disinfection (Promulgated by Ministry of Health in 1992)

(15) Technical Specifications Requirments for Monitoring Surface Water and Waste Water (HJ/T91-2002)

(16) Sanitary Standard for Drinking Water Quality (2001.6) and other technical regulations

(17) Rules for Environmental Assessment of Rural Hydropower Station

(18) Standards for Classification and Gradation of Soil Erosion (SL190-96)

1.3.3. Relevant Documents

(1) CJ No. [2004]30, Approval for the Project Proposal of Changfeng Hydropower Station and Lengshuiqiao Hydropower Station by Bureau of Development and Planning, Changyang Tujia Autonomous County, dated March, 29th, 2004. See Attachment 1.

(2) Assessment Outline on Environmental Impact of Changfeng Hydropower Station and Lengshuiqiao Hydropower Station of Yichang Changfeng Hydropower Development Co., Ltd. finished by Yichang Research Institute of Environmental Protection in August 2004.

(3) Letter of Authorization on Writing the Report for Environmental Impact of Changfeng Hydropower Station by Yichang Changfeng Hydropower Development Co., Ltd., dated July 19th, 2004. See Attachment 2.

(4) Approval of Assessment Criteria for Environmental Impact of Changfeng Hydropower Station. See Attachment 3.

(5) Letter of Examination for the Environmental Impact Assessment of Hydropower Station Construction Project at Changfeng, Lengshuiqiao and Changshatou by Yichang Changfeng Hydropower Development Co., Ltd., issued by Yichang Bureau of Environmental Protection, dated September 6th, 2004, see Attachment 4.

(6) Review Comments and Member List of Experts for Report on Environmental Impact of Changfeng Hydropower Project by Yichang Changfeng Hydropower Development Co., Ltd., dated September 24th, 2004, see attachment 5.

1.3.4 Design Documents

(1) Draft Design Report of Changfeng Hydropower Project at Changyang, Hubei Province, prepared by Yichang Qingjiang Design and Investigation Institute of Hydropower dated May, 2004.

(2) Report on Water and Soil Conservation Plan of Changfeng Hydropower Project at Changyang Hubei Province, prepared by Yichang Qingjiang Design and Investigation Institute of Hydropower dated April, 2004.

1.4 Objective of Damage Control and Ecological Environment Protection

(1) Water Quality: control the waste discharge in order to protect the reservoir water quality. During the construction period, the discharge density of waste water should be controlled in accordance with GB8978-1996 Integrated Wastewater Discharge Standard Level I. During Operation, the reservoir water quality should reach GB3838-2002 Environmental Quality Standard for Surface Water Level II.

(2) Surrounding Atmosphere Quality and Noise Environment

It should be ensured that project construction will not cause obvious damage to surrounding atmosphere quality and noise environment. The surrounding atmosphere quality inside the construction spot should meet the Standard for Surrounding Atmosphere Quality (GB3095-1996) level II and the noise environment should meet the Standard for Urban Regional Noise Environment (GB3096-93) level I.

(3) Water and Soil Loss: due to the excavation, filling, building and occupying occurred during the project construction, the water and soil conservation function of the land may be damaged or deprived, measures will be taken in time to recover or improve the function and ensure that the treatment for water and soil conservation will reach 85% at least. By precautions and treatment for additional water and soil loss, the control rate of water and soil loss will be above 80% and the treatment rate of land disturbance will be more than 60%. The waste residue will be well disposed. Thus the water and soil loss can be controlled and treated.

(4) Vegetation: by controlling the damage to vegetation during project construction, the vegetation on exposed soil surface inside the construction area will be mostly recovered and reduces the negative impact on aquatic wildlife due to changed hydrological condition.

(5) Land resources: reduce waste residue disposal during project construction by land reclamation, so as to reduce land loss due to the project construction.

(6) Society and Economy: make a complete population health plan for the construction period and prevent any possible epidemic diseases during construction, work to reduce the impact of air and noise pollution on construction staff and local residents.

Main Objectives for Environmental Protection (See Table 1-1)

Table 1-1 Objectives for Environmental Protection of Changfeng Hydropower Project

Object Protected	Distance	Position	Span	Protection Level
Ganhe Creek	-	-	River from 2km upstream end of the dam site to hydropower station outlet	Standard for Surface Water Quality Level II
Lengshuiqiao Restraurant and local residents	Within 500m to Lengshuiqiao hydropower station	nearby	2-3 resident houses，small restaurants	Surrounding Atmosphere Quality Level II, improved life quality

1.5 Grade and Scope of Assessment

1.5.1 Water Environment

Changfeng Hydropower Project hardly discharges any waste water during construction period, the project only impacts water environment during preliminary stages of construction and and reservoir filling.

Water environment assessment standards: waste water discharge: according to the report of project feasibility study, waste water discharged during construction mainly concludes washing waste from sandstone filling device, waste water discharged by concrete production system and regular pit discharge, and domestic wastewater produced by construction staff. During major construction period, wastewater discharge is 1758.7m^3/d; complexity of wastewater quality: the main pollutant of wastewater discharged during construction is SS, main pollutants of domestic are BOD_5, COD and NH_3-N, the complexity of the wastewater quality is medium; scale of surface water: average annual flow of Ganhe Creek is 0.99m^3/s, the scale of surface water is small river; requirement of surface water quality: the water quality in the project area should reach Standard for Surface Water Environment Quality (GB3838-2002) level II. According to the criteria of

Technical Guidelines for Environmental Impact Assessment-Surface Water Environment (HJ/T2.3-1993), the water environment in construction area is Grade III.

1.5.2 Ecological environment

Since hydropower is clean energy, little waste is discharged during station operation. Therefore, the project construction causes non-polluting ecological impact on the environment. According to preliminary survey result, the reduction of species, number of living creatures and species variety due to project construction will be far less than 50%. No endangered species will extinct due to project construction. Though the land connectivity will be reduced, the reduction rate will be controlled within 1/2, thus the chemical and physical property of water and soil will not deteriorate and there is no sensitive zone in the construction area. The impact area of the project construction is about 0.36$km^{2,}$ which is less than 20km^2. According to Technical Guidelines for Environmental Impact Assessment-Non-pollution Ecological Impact (HJ/T19-1997), the ecological environment impact of the project is assessed as Grade III.

1.5.3 Atmospheric Environment and Noise Environment

Due to the construction of main works and road, it will cause some impact on atmospheric environment and noise environment of the construction filed and areas nearby the road and the field. Since the three households in the dam site have been moved, there is no resident within 2km from the dam site. There are only 2-3 households and activity places within 500m from the hydropower station, and nothing sensitive to atmospheric environment and noise environment exits in this area. There are no other sensitive receivers such as households or schools along the road under construction. Therefore, only brief assessment is needed for the impact on atmospheric environment and noise environment. The major assessment scope is the construction field and its nearby zone, covering an area of about 1km^2.

1.6 Assessment Standard

1.6.1 Environmental Quality Standard

(1) GB3838-2002 Environmental Quality Standard for Surface Water, Class II

(2) GB3095-1996 Environmental Air Quality Standard Level II

(3) GB3096-93 Environmental Noise Standard for Urban Region, Class I, IV

1.6.2 Pollutant Discharge Standard

(1) GB8978-1996 Integrated Wastewater Discharge Standard Level I

(2) GB12523-90 Noise Limits for Construction Sites

(3) GB16297-96 Integrated Emission Standard for Air Pollutants Level II

1.7 Assessment Period

The environmental impact assessment for the project includes construction period and operation period. The year of existing condition assessment is 2004 while the level year of prediction assessment is 2010.

1.8 Main Points of Assessment

Based on the nature, scale and scope of impact, we take environmental impact assessment for hydropower project of the same kind as reference. The main points of this assessment are water environment, immigration, ecological environment and construction site environment, while local climate, water, sediment, geology and public health are of average assessment.

2 Project Overview

2.1 Valley Overview

Ganhe Creek is the largest branch downstream Langping River on its left bank, which starts from Guanjianao at 1998m altitude and outflows to Zhaolai River Hydropower Station Reservoir after running through Longtan, Zhichang Creek, Dengjia River, Qiyan Creek and Ganhe Creek. It has 34.2km long watercourse, a 183.5km^2 catchment area, a 1694m height difference and weighted average watercourse descent of 34‰. The vegetation within the watercourse is fine. The upper reaches of the river is narrow with slow channel descent while the middle and lower reaches of the river has steep channel descent. The theoretical reserves of the main stream are 23000kw, among which the theoretical reserves in Changyang are 19400kw. Only Xiufengqiao hydropower station is to be built at middle reaches of the river with installed capacity of 2×40kW.

Hydropower development in this valley adopts trans-basin water diversion. Built a reservoir at the section of Zhichang Creek in Ganhe Creek Valley (elevation 1078m) for water reserve, then build a hydropower station at Changfeng River with trans-basin water diversion, and generate power in the station at lower reaches of the river. The average flow rate of Zhichang Creek during past years is 0.99m^3/s, by inducing water to Jiangjiawan hydropower station (tail water elevation 345m), its theoretical reserves are 6759kw and its annual hydraulic energy is 59.21million kWh.

The first level runoff hydropower station, Longtan Hydropower Station, built at Zhichang Creek, which is on upper reaches of Ganhe Creek, has 2×320kW installed capacity with annual energy output of 2663800kWh; the secondary hydropower station, Changfeng hydropower station has 2×5000kW installed capacity with annual energy output of 34525800 kWh. The third level runoff hydropower station, built at lower reaches of Zhichang Creek, Dengjiahe Hydropower Station, has 2×200kW installed capacity with annual energy output of 1651300 kWh; Qiyan Creek hydropower station has 2×1000kW installed capacity with annual energy output of 8114400 kWh and Ganhe Creek

hydropower station has 2×1250kW installed capacity with annual energy output of 10432500 kWh.

Power generation by trans-basin water diversion is good for the peak load regulating power station and benefits more from peak load regulation. With trans-basin water diversion, head available for first level power generation is 580m, with designed flow rate of 2.4m^3/s and installed capacity of 10000kW. Its main construction includes 5284.91m pressure water transfer tunnel and 1321m penstock besides the reservoir and power house. The distance that the tunnel and the penstock go through is short and the areas are of good geological condition. If a peak load regulating power station of the same capacity is built in the original basin, besides the construction of reservoir, and penstock an 11.3km pressure water transfer tunnel is need, which is as twice long as the tunnel in the first plan (i.e. 5220m longer). Regarding to transportation condition, the powerhouse in first plan of trans-basin water diversion is situated along the 318 national highway, which is rather convenient in transportation. This plan is also good for improving the efficiency of hydropower station. With trans-basin water diversion, tail water of the power station flows into the channel of the Jiangjiawan hydropower station (installed capacity: 2×2500kW) at lower reaches, which helps to regulates the efficiency of Jiangjiawan hydropower station. Ganhe Creek valley only has a 80kw hydropower station that has been running for almost 20 years, which is to be rejected. Yichang Water Resources & Hydropower Bureau has approved the above plan.

2.2 Location, Tasks, Scale and Layout of the Project

2.2.1 Project Location

(1) Dam Site

Changfeng hydropower project is one of the major cascade development projects in Langping River valley. The project is mainly focused on power generation, which also provides sand shelter, drinking water for residents and domestic animals. The project is to regulate 3 hydropower stations at lower reaches, i.e. Changfeng hydropower station, Langping hydropower station and Jiangjiawan hydropower station, the water head of the regulating station is 780m. The dam site is situated at Zhichang Creek upstream the Ganhe

Creek, 2.2km away above Xiufengqiao town, and 0.4km from the lower reaches of Hongtu Creek outlet. The river flow direction is from northeast to southwest (SW200°) upstream the dam axis and from northeast to southwest (SW220°) downstream the dam axis. The valley is U shaped, with valley bottom of 20-30m wide, and the valley bottom starts to be flat and wide 20m away upstream dam axis. The valley inside the dam is quite straight, elevation of the hill top is 1580-1600m and the water level of the river is 1075-1078m, with 4-8m wide water surface and 0.1-0.6m deep water. It is a tangential valley. The slope toes on each side of the dam and the bedrock of the river bed are first to thirteen layer of Shilongdong Formation of Cambrian system (□11shl ~ □131shl), which are mostly layer structure and the rocks are mainly limestone, Dolomitic limestone and some shale. The rock structures are basically fractures and layers, which are well integrated. Between some layers, there are sheared zones. The rocks are mostly Class III. In some position with more shale and coal line (□101sh), the rocks is classified to Class IV.

(2) Power House Location

The power house is located at Lengshuiqiao, from the dam site to the surge shaft, there are 5319.4m long pressure tunnel, 1321m long penstock , 571.65m designed water head, 10000kW installed capacity and 34525800 kWh annual energy output. There is a spring in the powerhouse site, whose average flow rate during past years is 0.6m^3/s. The power house location is good for graded terrace development, which is to fully use the water energy and well complies with the Hydraulic Energy Development Plan Report for Langping River Valley.

(3) Route of Water Diversion

According to the selected dam site and power house location, the straight route is adopted for water diversion after overall consideration. A straight tunnel will connect the dam site and the surge shaft for water diversion. The water diversion tunnel is 5319.4m long.

Besides, in the office area of Changfeng hydropower project at Lengshuiqiao, there is a spring, where a 200kW power station is to be built in order to provide electricity for office. See figure 1 for location of main projects.

2.2.2 Tasks and Scale of Project

(1) Project Tasks

Changfeng hydropower project adopts trans-basin water diversion. Water is induced form upstream Ganhe Creek to the middle reaches of Changfeng River for power generation. This also regulates the power load of the downstream power station, which is good for peak load regulating and improves the efficiency of existing hydropower station.

The main task of the project is power generation in order to provide electricity necessary for local living and production. Electricity will also promote the development of local forestry, pharmacy, specialty and mining industry, which helps to increase the income of local farmers and gradually replaces fire woods with electricity. The tasks is obviously helpful for local forest conservation and restoration.

After considering the proportion between hydropower station capacity and electricity system capacity, the regulating function of designed hydropower station and the capacity range, the design probability of this power station is 85%.

(2) Project Scale

The reservoir capacity of Changfeng Hydropower Station project at normal pool level (1125m) is 3815900 m^3, and its capacity is 545500 m^3 at dead storage level, the regulating reservoir capacity is 3270400 m^3, the reservoir capacity factor β=10.43%. It is an annually regulated reservoir. After calculating the flood regulation, its flood regulating level is 1125.96m and total reservoir capacity is 4001000 m^3.

Changfeng Hydropower Station is a reservoir hydropower station. During drought period the station is to regulate peak load and used as standby mechanism. The installed capacity is 2×4000kW after technical and economic comparison, the average annual energy output is 35,000,000kWh, annual utilization hours reach 3453h and the firm power (P=85%) is 1675kW.

According to Standard for Flood Control of the People's Republic of China (GB50201-94) and Standard for Classification and Flood Control of Water Resources and Hydroelectric Project (SL252-2000), the project scale is class 1.

2.2.3 Project Layout

(1) Dam Type and Project Layout

Since the dam site of Changfeng Hydropower Station is in good topographical and geological condition, thus concrete arch dam is adopted in the plan.

Concrete arch dam adopts log spiral shape concrete double curvature arch dam, the dam top elevation is 1128.0m, the elevation of valley bottom is 1067.5m and the max dam height is 60.5m. The included angle between symmetrical central axis of arch dam and central axis of flood releasing outlet is 1.5°. The orientation angle on the symmetrical central axis of arch dam is 221.8°, which goes through Point K (Geodetic Coordinate Xk = 60737.5m，Yk = 65542.7m); The axis of double curvature arch dam (the arc upstream the top arch) is 102.7m away from point K. The bottom arc of the upper dam surface is 15.9m long; the top arc (arch dam axis) is 139.1m long, among which the left half arch is 65.4m and the right half arch is 73.7m. The dam is divided into 9 sections by 8 full-bore transverse joints. Since max dam thickness is only 12m, there is no longitudinal joints. On upper reaches of the dam top, there are maintenance gate on sediment hole and hydraulic hoist of orifice working gate. The basic riverbed grout gallery is situated at elevation 1075.0m in city gate section with W2.5×H3.5 (m). On its lower reaches, there is collecting gallery for leakage water and discharge pump room. The basic grout gallery goes up to elevation 1110m to connect with relevant grout tunnel and observation-transportation gallery on the same elevation when flows out through the downstream radial gallery.

The angle between the central line of surface hole and the dam axis is 1.5°. there are 2 surface holes on the dam. Each hole is 6m wide, the intermediate pier on the upper reaches is 4.5m and the side pier is 3.0m. The weir crest is at 1118.8m elevation, with arc steel gate control and cable hoist, the hoist is at 1133.0m elevation. Discharge of a single hole in flood regulation level is 229m^3/s. In order to simplify the structure for easy construction, the surface hole adopts ski-jump energy dissipation. In order to protect dam toe, a 30m-long apron slab will be put in the riverbed of the lower reaches, the slab is 2.0m thick. The foundation rock is combined with anchor bar.

(2) Water Diversion Building

Water diversion building is mainly made of inlet, shaft, pressure tunnel, surge shaft and penstock.

By comparing the tower intake and shaft inlet for pressure inlet, the shaft inlet is finally adopted after analyzing investment and production management. The inlet is arranged on the right slope, which has inlet section, gate chamber and transition section. The inlet tunnel is a round pressure tunnel with excavation diameter of 2.30m and laid with 0.30m-thick steel bar concrete.

The excavation diameter of shaft is 3.0m, and its tunnel liner is 40cm thick. A steel gate is fixed in the gate chamber for maintenance. There is no operation gate, which will be replaced by the main valve on the end of the penstock. At 1128m elevation of shaft, a hoist chamber will be build with 3.0m long and 3.0m wide. A hoist is in the hoist chamber. Max width of the hoist is 1.36m, which is laid in the center of the shaft. The width of the passage had met the requirement.

The pressure tunnel is 5284.91m long from the shaft center (0+34.50) to surge shaft (5+319.41) with longitudinal slope designed 4/1000. It has round section with diameter of 1.7m. In order to lower the construction difficulty and increase water catchment area, a skew tunnel is designed at Huangyangping, with horizontal distance of 745m and height difference of 321.33m. The skew tunnel uses city gate shape, which is 1.8m wide, 2.0m high with arch camber of 0.4m.

The surge chamber adopts simple cylinder structure lined with steel bar concrete. The internal diameter of surge chamber is 4.0m with 0.5m thick liner. The highest water level of the surge chamber elevation during check working condition is 1130.95m and the water level is 1132m by adding 1m.

The power install 2 sets, the pressure steel pipeline is 1321.04m long from the surge chamber to branch pipeline center, with diameter of 800mm. The center of branch pipeline is 8.92m from unit 1#, and the center of branch pipeline is 15.61m from unit 2# with pipeline diameter of 500mm.

(3) Power House and Switching Station

The power house is diversion type ground powerhouse with installed capacity of 10000kW. the mian power house includes machine hall and installation yard. The mian power house is 30.4m long and 12.4m wide with elevation of 543.2m. Total elevation of the main power house above ground level is 10.52m. The auxiliary power house is 30.4m

long, 6.0m wide and 4.5m high with ground elevation of 543.60m.

The booster station is on the slope west to the power house, whose size is 23m Long ×15m Wide, 1m away from the retaining wall in every direction. There is a master transformer（12500kVA） in the station.

Figure 2: general floor plan of the project, Figure 3: floor plan of dam site; Figure 4: floor plan of power house

2.3 Reservoir Inundation and Permanent Land Use

2.3.1 Reservoir Inundation and Loss

Changfeng Hydropower Station is situated at Langping Town, Changyang, which adopts trans-basin water diversion. The dam is located at upper reaches of Ganhe Creek and the power house is at middle reaches of Changfeng River. 2km away from Xiufengqiao Town, the concrete double curvature arch dam has max height of 60.5m. Normal water level of Changfeng reservoir is 1125m, and the check flood level is 1125.96m. Downstream check flood level, on the left and right bank are woodlands, there is no minerals worthy of mining or other inundation loss.

Based on Design Guidelines for Reservoir Inundation Treatment of Water Conservancy and Hydropower Projects, the use land area should zoned according to the wave impact at normal water level plus 0.5m and 5-year-return-period flood level on reservoir end; the immigration area should be zoned according to wave impact at normal water level plus 1.0m and 10-year-return-period flood level on reservoir end. Since the inundation area is small, the use land area and immigration area are both zoned according to wave impact at normal water level plus 1.0m and 10-year-return-period flood level on reservoir end. Due to the short reservoir area and gorge at reservoir end, there is no inundation loss of cultivated land or non-wood forest or immigration, thus no return water is counted.

Compensation for land use will be calculated according to CZBF No. [2003]12 Document, compensation standard for land occupation and immigration of Changyang section project, Wuhan gas pipeline and Yichang Highway is as follows:

(1) paddy field and dry land: 12500 RMB/mu (annual output 1000 RMB/mu, land use compensation is 1:6, immigration subsidy is 1:5.5, young crop compensation is 1:1)

(2) Orange and tea plantation: RMB12000 /mu (annual output RMB1000/mu, land use compensation is 1:6, immigration subsidy is 1:5.5, young crop compensation is 1:0.5, ground attachments compensation is made according to real value)

(3) Timber forest: RMB6000 /mu (annual output RMB500 /mu, land use compensation is 1:5, immigration subsidy is 1:4, timber compensation is RMB150 /mu)

(4) Fuel forest: 4400 RMB/mu (annual output RMB400/mu, land use compensation is 1:5, immigration subsidy is 1:4, firewood compensation is RM 800 /mu)

(5)Barren hills and uncultivated lands: RMB2100/mu (annual output is RMB200 /mu, land use compensation is 1:5, immigration subsidy is 1:4, stubble compensation is RMB300 /mu)

(6) Collective construction land including ditches and roads: complete compensation of RMB 2500 /mu

(7) Housing land: RMB11500/mu (land use compensation and immigration compensation is calculated according to the standard for cultivated land)

(8) Temporary land use and farmland: annual young crop compensation is 1000RMB/mu, land attachment compensation is made according to real number, other land attachments compensation is calculated according to the land occupation standard, and recovery payment for temporary land use is for owner's account.

Compensation for moving house and attached facilities

Brick-concrete principal house RMB230/ m^2, wood frame principal house 120RMB/m^2, wood frame attached house RMB60/m^2, brick wall fence (fence area) 23RMB/ m^2, ceramic kitchen stove with chimney RMB200/stove, traditional stove RMB90 /stone, mortar laid pond RMB80/m^3, mortar laid manure pit RMB55/ m^3, cement floor RMB22/ m^2, creeper tank RMB80, methane tank RMB750, average grave RMB300, grave with tombstone RMB400. Non-wood forest compensation is calculated as 20% of land occupation compensation.

Total compensation for reservoir inundation is RMB1,477,600. Table 2-1 Index of Detailed Inundated Items

Table 2-1 Index of Reservoir Inundated Items

Name of inundated item		Unit	Unit compensation price (RMB)	Quantity	Cost (RMB)
Cultivated land	Dry land	mu	12500	22.65	283100
Woodland	Barren hill	mu	2100	102.31	214800
	Timber land	mu	6000	30.30	181800
	Fuel forest	mu	4400	121.5	534600
Housing land		mu	11500	0.9	10400
Land development cost		mu	2500	22.65	56600
Tax on cultivated land occupation		mu	3000	22.65	68000
House moving		M^2	120	650	78000
Farms immigration subsidy		/person	2100	12	25200
Enclosed house		M^2	60	135.45	8100
Wire pole		pole	500	25	12500
grave		pc	300	15	4500
shoal		mu	0	19.34	0
Total		/	/	/	1477600

2.3.2 Permanent Land Use

Permanent land use of project includes building premises and controlled zones. To ensure safety operation of the project, area within 50m from the building is control zone of the power station.

Permanent land use of cultivated land covers 22.65mu, which costs total compensation of RMB283200 for RMB12500 /mu; permanent land use of barren hills and uncultivated lands covers 181.35mu, which costs total compensation of RMB 380800 of RMB2100/mu; permanent land use of houses covers 400.2m^2, which costs total compensation of 48000 RMB of 120RMB/m^2. Total compensation for permanent land use of project costs RMB711900.

Temporary land use of cultivated land covers 29.1mu, its compensation for young

crops for two years adds up to RMB58200 of RMB1000/mu every year; temporary land use of barren hills and uncultivated lands covers 0.9mu, its compensation for two years add up to RMB5400 of RMB300/mu every year; temporary land use of fuel forest covers 24.9mu, its compensation for tow years adds up to RMB39800 of RMB800/mu every year; total compensation for temporary land use is RMB103400. The above compensation, excluding reservoir inundation compensation, totals RMB815300.

工程永久占地和临时占地详见表 2-2。

Table 2-2 Permanent and Temporary Land Use of Project

Table 2-2 Permanent and Temporary Land Use of Project

No	Item	Temporary land use (hm^2)					Permanent land use (hm^2)						Total
		Cultivated land	Timber forest	Fuel forest	Uncultivated land	Shoal	Cultivated land	Timber forest	Barren hill	Fuel forest	Shoal	House	
1	Reservoir area						1.51	2.02	6.82	8.10	1.29	0.06	19.8
2	Arch dam					0.06			0.13				0.19
3	Diversion tunnel								0.01				0.01
4	Penstock						0.20		1.03				1.23
5	Power house & booster station						0.23					0.04	0.27
6	Waste disposal area	1.94		1.66		0.72							4.32
7	Work shed and material storage area				0.6								0.60
8	Construction road						1.08		10.92				12.00
	Total	1.94		1.66	0.6	0.78	3.02	2.02	18.91	8.10	1.29	0.1	38.42

2.4 Project Construction Plan

2.4.1 Construction Condition

The dam of Changfeng hydropower project is 2km from Xiufengqiao town, 12km from Langping town, 110km from Changyang County and 111km from Yichang City. The power house is 7km from Langping town, 100km from Changyang County and 101km from Yichang, which is rather convenient in transportation.

The terrain 400m upstream the dam site is wide and flat, which is available for

building work shed and repair yard. The vacant houses in Leyuan Government can be used as warehouse. In front of every entrance (or branch entrance) of water diversion tunnels, there are slow slopes, which can be used for setting up work sheds, air pressure station, etc. Since the power house is close to 318 National Highway, there is enough vacant lot for setting up work sheds. The hydrological and meteorological condition is adequate for hydropower project construction.

The project needs 15000tons of cement, which can be purchased from cement factory in Changyang County or in Yidu Huaxin Cement Factory; the dam concrete is made of dam silicate cement from Jingmen. Steels can be purchased from construction marterial market in Yichang or Changyang. Woods will be supplied nearby by local forestry department. Fire work materials will be supplied by local chemical construction company or through local public security station. The gasoline and diesel used in construction will be purchased by the construction organization. The electricity needed for construction of the dam and tunnel extrance is to be provided by Leyuan transformer station by setting up a 2km-long 10KV line with a 1000KVA transformer. The electricity needed for tunnel exit is provided by setting up a 1.5km long 10KV line at Lengshuiqiao with a 180KVA transformer. The power electricity needed at power house area is provided through T shaped connection. Sandstones needed for construction will adopt artificial aggregate.

2.4.2 Construction and Diversion

According to scale and features of construction, diversion period is set from November to April in the next year. Diversion standard (return period) is 5 years, relevant flood flow rate is 45.7m^3/s. When construction period is extended, then flood season should be taken into account. The standard for flood season (return period) is 10 years, the relevant peak flood flow rage is 235m^3/s.

Based on local hydrological features, geological condition and project layout, the project construction adopts the plan of building a weir and diversion water through tunnel. Diversion building is used for water transfer during preliminary dam excavation, preliminary treatment and dam concrete placing. Using earth-rock weir, it obtains material from local source, reduces investment and has easy construction. The diversion tunnel is located on the right bank, the elevation of tunnel floor at entrance is 1082m, elevation of

tunnel floor at exit is 1080m, and the tunnel bottom slope is 1/50. The tunnel body section is of city gate shape, with 3m-wide bottom, 2.5m-high straight wall, 2.12m-radius upper arch and 0.62m-high rise. Suppose we mark the stake at weir inlet with 0+000m, then No. 0+000m to No.0+060m stakes are the in open channel, the open channel is facing the diversion tunnel, with 0.3m more in height, it has extra safety. The open channel uses M7.5 stone blocks. No. 0+060m to No. 0+170m stakes are in tunnel. The tunnels are lined with rebar concrete, with 0.3m-thick bottom and straight wall, 0.5m arch top. There is a stop log gate at tunnel entrance, which is used to block the diversion tunnel.

2.4.3 Construction of Main Buildings

(1) Dam Construction

Excavation both dam banks with 100- type drill bit, pre-splitting blasting plus $1m^3$ backhoe, $3m^3$ load truck for waste residue disposal. The waste residue will be transported to waste disposal area in truck. Dig the dam base cover with $1m^3$ backhoe and direct truck transport. Dig the strong weathered layer of dam basin with hand held air drill for hole forming, blast and transported by load truck.

The dam basic consolidation grouting starts after concrete placing in underlying layer. With 6m-deep hole, the grouting holes are spread in quincunx layout with 3m-long row distance. Grouting is carried out in two steps. Total footage of consolidation grouting is 2150m, which is made by SGZ-1 hydraulic driller and BW250/50 grouting pump through full grouting in one time. Preliminary consolidation grouting alternates with concrete placing.

Preliminary curtain grouting uses single-row curtain with 2m row pitch and total footage of dam curtain is 6800m. The preliminary curtain grouting of dam is made by cement grout in three steps. While drilled by SGZ-1 hydraulic driller, grouted by BW250/50 grouting pump with grout made by $0.25m^3$ compulsory mixer and grout density adjusted through pressure water test, the curtain grouting hole is drilled in one time and grouted from bottom to top in steps.

Pit water pumping is made by 2 centrifugal pumps (one standby pump) with pumping capacity of 100m3/h. Set a collection sump at upper reaches of pit, and pump the leaking water to the diversion channel.

Dam concrete is transported by tower crane. The dam concrete intensity should be enough to bear operation load and anti-split during operation. For holes inside the dam and flood releasing positions, high graded concrete can be used. For elevation below 1077.5m, it adopts preliminary concrete placing of about 6000m^3. Since it is main foundation consolidation part, the concrete placing must be made in winter and spring. Dam concrete placing is separated into different layers. The thickness of preliminary consolidation dam at riverbed and concrete in flood season is 1.5m. Above the consolidation layer, the thickness is 3.0m. The dam bank is 3.0m thick.

(2) Construction of Diversion Power Tunnel

Dig the shaft platform and water inlet by hand held air drill. Since it is a small project (329m^3), stone ballasts can be transported to the riverbed (below dead storage level). The tunnel is 5284.91m long with designed longitudinal slope of 4/1000 and round section. With 2.2m excavation diameter, 3.8m^2 section area, 22220m^3 earth excavation, 4 actual working faces of tunnel excavation, 1321m average excavation distance of single face, 2000m initial excavation distance at inlet, 1800m excavation distance at outlet, the excavation distance at two working faces of the adit is 1484.91m (752m without adit). The tunnel construction uses hand held air drill. After full section boring, smooth blasting and manual waste residue load, the waste residue is transported by 10t driving machine with mining truck on light rail. Concrete placing is made by 0.8m^3 mixer (placed at tunnel intake), carried by mining truck, placed manually and shake by internal vibrator.

(3) Construction of Surge Shaft and Penstock

The surge shaft is constructed through pilot shaft method, which digs a 58.86m-long hole in one time. It uses hand held air drill enlargement, smooth blast, and discharge waste residue through tunnel in shaft bottom, the waste residue is loaded by manpower and carried to waste disposal area outside the tunnel by mine truck .The concrete construction uses 0.8m^3 compulsory mixer, concrete delivery pump, internal vibrator and 1500×150×55 steel form composition.

The penstock excavation adopts hand held air drill digging blast from top to down and 1m^3backhoe. The waste residue will be transported to waste disposal area by tractor. Steel pipes are installed from bottom to top after concrete placed at anchorage block and rest pier.

It is drawn by 10t cable hoist on rail and welded on spot.

(4) Construction of power house and booster station

The excavation of power house begins when the excavation of penstock is finished. The excavated stone building is 8410m^3 and the booster station is 1850m^3. With 1m^3 backhoe excavation and loaded on trucks for transport to waste disposal area. For excavation of rock mass should adopt silent blast and air pick operation since there is much population and housing at the power house location, and it is on a heavy traffic road. The construction of house building will conduct the national standard.

(5) Metal Structure and Machinery Production

Arch gate is manufactured, hoist will be purchased, pressure steel pipe will be manufactured before installed and welded on spot.

2.4.4 Construction Layout

Since the project building is rather dispersed, the construction organization should also be dispersed. The sandstone aggregate system and concrete mixing system should be independently located except the dam.

Steel bar and timber processing can be located at Xiufengqiao and Lengshuiqiao. The steel forms, standard products and steel structure used in construction should be provided by professional manufacturers. There is only a maintenance yard at every construction site.

Since the construction period is short, no new houses will be built for construction staff and nonlocal staff. Rented local houses and temporary work shed will be the accommodation for staff. Most rented local houses are located in Xiufengqiao and Lengshuiqiao. Others are scattered.

2.4.5 Earth Rock Volume and Construction Volume

The major construction volume of the project includes 28000m^3open cut earth, 62000 m^3 open cut rock, 28000 m^3 tunnel excavated rock, 2000 m^3 filled earth, 1000 m^3 mortar laid block stone, 53000 m^3 concrete, 995t steel bar production and installation, 460t metal structure installation, 3492m curtain grouting, 5745m consolidation grouting, 4175m^2 backfill grouting and 720m^2 contact grouting.

In addition, the project construction need 15433t cement, 1030t steel bar, 731t steel

material, 398m^3 timber, 117t explosives, 129940 detonators, 140389m wires，19t gasoline, 293t diesel, 794m^3 block stone, 29575m^3 sand, 55881m^3 cobbles, and 3743t coal ash。267410 total working days and 49347 machine operators.

Figure 5 General Floor Plan of Project Construction

2.5 Waste Residue Plan

Based on the principle of “everything useful should be used”, the earth rock waste residue volume is 117400 m^3.

Waste residue from water intake project is 41800 m^3. Since there is no waste vacant yard near the lower reaches of dam site, all these waste residue must be transported to a cultivated land 2.5km away from downstream dam site, which is the only low lying land near the shoal. It is 4# waste disposal area. Water diversion tunnel (including water intake, surge shaft and inclined shaft) construction produces 18100 m^3 waste residue, among which 4700 m^3 near the tunnel intake is transported to 4# waste disposal area downstream of the dam site; 4700 m^3 near the tunnel outlet is transported to 3# waste disposal area, a low lying valley on the right side of tunnel outlet; the remaining 8700 m^3 from inclined shaft is transported to 5＃waste disposal area. Measures for project and plants are taken to prevent the waste residue being washed away.

The excavation of penstock produces 33200m^3 waste residue. According to the actual terrain, the waste residue is separately disposed. The 12300m^3 waste residue produced between 1-3# anchorage block are all transported to 3# waste disposal area on the right of tunnel outlet. The 8200m^3 waste residue produced below 10# anchorage block are transported to 1# waste disposal area, and the 12700m^3 waste residue produced below between 3-10# anchorage block can only be separately disposed on the low lying land on the left of penstock due to the terrain and transportation limit. Measures for project and plants are taken to prevent the waste residue being washed away.

Excavation of power house produces 7500 m^3 waste residue, which are transported to 1# waste disposal area outside the power house area. Measures are taken to retain the waste residue and greening measures when project is finished. The excavation of road

construction also produces waste residue which are separately disposed. See table 2-3 for details of waste disposal areas.

Table 2-3 List of waste disposal areas

No. of waste disposal area	Location	Volume of disposed waste residue (m^3)
1#	Power house area	15700
2#	Along the penstock	12700
3#	Low lying valley at right of tunnel outlet	17000
4#	2.5km downstream dam site	46500
5#	Inclined shaft outlet	8700
6#	Along the road	16800
total	/	117400

Plan of waste residue is made according to the construction volume calculated in general construction distribution and Feasibility Study Report provided by the owner. The construction volume of diversion tunnel is calculated according to length of main tunnel and branch tunnel in the general construction distribution made by the owner. The construction volume of main tunnel and branch tunnel are calculated by $4.0m^3$/m tunnel stone excavation, concrete lined $1.87m^3$/m. According to the organization and design for construction, the sand and gravel used in construction are all processed by machines. According to the feasibility study report, the concrete lined in diversion tunnel is calculated by 20% of the tunnel length, while the sand and gravel are all from excavation. The waste residue mainly include waste earth and waste stone from excavation, dam cleaning and slope cutting. Based on the principal of "everything useful should be fully used" , the waste earth and stone disposal of the construction amounts to $81100m^3$ (bank measured volume) , among which the earth excavation volume is 17100 m^3 and stone excavation volume is 64000 m^3, or all together 107900 m^3 in loose measured volume.

2.6 General Construction Schedule

The construction period of the project is 2 years. The dam construction starts from November 2009 and finishes before December 31st 2010; The construction of diversion tunnel starts from July 1st 2009 and finishes before December 31st 2010; the penstock

construction starts from early August in 2009 and finishes before February 28th 2011; the booster station in the power house should begins construction after the excavation of the penstock is finished. The machine units are installed from September 1st 2010 to December 31st 2010.

2.7 Project Management

2.7.1 Project Management

According to the technical guidelines and rules of marketing economy, the owner has set up Yichang Changfeng Hydropower Development Co., Ltd. The management will include 11 persons.

The management of Changfeng hydropower station covers dam, water diversion building, and power house. The station is managed without guard. The reservoir regulation only concerns about power output efficiency. As required by the owner, no office and accommodation in the power house area. The powerhouse is close to 318 National Highway, which is 7km to marketing town, 100km to the county, and 101km to Yichang. Only 2 vehicles are needed for transportation. The power house also needs 3 program controlled telephones and 20 internal program controlled telephones.

2.7.2 Labor Safety and Industrial Sanitary Design

According applicable regulations in Labor Law of the People's Republic of China (effected on January 1st, 1995) and Design Code for Labor Safety and Industrial Sanitation of Water Conservancy and Hydropower Projects (DL5061-1996), labor and industrial sanitation measures are worked out. The labor safety measures mainly cover fireproof, anti-explosion, electric injury avoiding, mechanical injury avoiding, anti-falling, flood control, anti-drowning. The industrial sanitation measures cover noise and vibration proof, temperature and humidity control, lighting and illumination, dust proof, anti contamination, corrosion resistant, gas proof, and electromagnetic radiation proof.

2.8 Investment and Profit

The statistic investment for Changfeng hydropower project amounts to RMB78.7682 million, and its total investment is RMB81.8496 million including construction period

interest. The investment for transmission project is RMB22.70 million, the total investment for project is RMB 104.5496 million. The project mainly obtains its needed capital through self financing and loan. Total loan amount is RMB43.9491million and capital from self financing is RMB21.7781million.

Economic assessment includes financial assessment and national economic assessment. The assessment is made according to Economic Evaluation Code on Small Hydropower Projects (SL16-95), Guidelines for Economic Assessment on Water Conservation Projects (SL72-94) and the existing national financial and tax measures.

The national economic assessment index is economic internal rate of return EIRR=13.77% **>** 12%; the economic net present value ENPV=RMB8.01 million **>** 0, the economic benefit-cost ratio EBCR=1.11 **>** 1. All indexes meet the requirements of the above guidelines.

The financial assessment index is financial internal rate of return before income tax FIRR=9.17% **<** 10%; The financial assessment index is financial internal rate of return after income tax FIRR=7.59%; the financial net present value before income tax FNPV=RMB4.0194 million; the financial net present value after income tax FNPV=RMB-10.8565 million; the fixed asset investment load payback period Pd=12.1years. All indexes meet the requirement of the above guidelines.

2.9 Project Characteristics

See table 2-4 for project characteristics

Table 2-4 Characteristics of Changfeng Hydropower Project

Item	Unit	Quantity	Remark
I.Hydrological			
1. Catchment area			
Full catchment	km^2	183.5	
Above dam site	km^2	43.1	
2. Utilizing hydro-sequence age limit	yearly	42	Year of measured, interpolation and extending of hydrological data
3.Average annual radial flow rate	*10000 m3	3136.99	

4.Representative flow rate			
Average annual flow rate	m^3/s	0.99	
Max measured flow rate	m^3/s		Measured date
Min measured flow rate	m^3/s		Measured date
Designed flood flow rate (P=2%)	m^3/s	525.8	
Check flood flow rate(P=0.5%)	m^3/s	677.6	
(P=0.5%) Construction diversion flow rate (P=5 %) (P=0.5%)	m^3/s	45.7	Drought period
5.Flood flow			
Max measured flood flow	*100,000,000 m^3		Measured date
Designed flood flow	*10000 m3	617.56	
Check flood flow	*10000 m3	800.8	
6.Sediment			
Average annual sediment rate	kg/m^3	0.67	
Max measured sediment rate	kg/m^3		
Average annual suspended sediment discharge rate	万 t *10000t	2.1033	
Average annual bed load sediment discharge rate	万 t *10000t	0.3155	
7.Natural water level			

Table 2-4 Characteristics of Changfeng Hydropower Project

Item	Unit	Quantity	Remark
Min measured flood level (relative flow			
Max measured flood level (relative flow			
Max flood level examined (relative flow,	m	1079.64	
II. Reservoir			
1.Reservoir water level			
Check flood level	m	1125.82	
Design flood level	m	1125.00	
Normal storage level	m	1125.00	

Flood control high water level (P= %)	m		
Flood control limited water level			
Dead storage level	m	1098.20	
2.Reservoir area at normal storage level	*10000 m^2	19.21	
3.Return water distance	m	1790	
4.Reservoir capacity			
Total capacity	*10000 m^3	397.36	
Reservoir capacity below normal storage level	*10000 m^3	381.59	
Regulated reservoir capacity	*10000 m^3	327.04	
Flood control reservoir capacity	*10000 m^3	15.77	
Beneficial reservoir capacity	*10000 m^3	327.04	
Dead storage reservoir capacity	*10000 m^3	54.55	
5.Reservoir capacity index	%	10.43	
6. Regulating characteristic		Annual regulation	Indicate characteristics
7、Use of water flow coefficient	%	93.47	
III. Discharged flow and related downstream water level			
1.Max discharge flow at design flood level	m^3/s	525.8	
Related downstream water level	m	1079.77	
2.Max discharge flow at check flood level	m^3/s	677.6	
Related downstream water level	m	1080.01	
3.Regulating flow(P= %)	m^3/s		
Related downstream water level	m		
Min. flow	m^3/s		

Table 2-4 Characteristics of Changfeng Hydropower Project

Item	Unit	Quantity	Remark
Related downstream water level	m		
IV.Project benefit index			
1.Flood control benefit			
Protected land area (P= %)	*10000mu		
Protected town and plant area (P= %)	Km^2		
2.Power output benefit			
Installed capacity	kW	2×5000	
Firm output (P=85%)	kW	1768	

Average annual power output	*10000kW.h	3676.62	
Number of hours used per year	h	3676	
3.Irrigation benefit			
Area (P= %)	*10000mu		Separately listed for paddy field, dry land and grassland
Max. quotative flow	m^3/s		
Gross annual water consumption (P= %)	亿 m^3 *100million m^3		
4. Flood control benefit			
Area (P= %)	*10000mu		
Drainage discharge	m^3/s		
5.Water supply benefit			
Max. quotative discharge(P= %)	m^3/s		
Gross annual water consumption			
6. Navigation and log passing benefit			
Improving channel mileage	km		
Ship passing tonnage	t		
Design annual tonnage capacity	t		
Wood/bamboo raft size	m		
Design annual wood/bamboo traffic volume	m^3		
7. Aquaculture benefit			
V.Inundation loss and permanent land use of project			
1.Inundated cultivated land	mu	22.65	
2.Immigration	person	12	
3.Inundated house	m^2	650	

Table 2-4 Characteristics of Changfeng Hydropower Project

Item	Unit	Quantity	Remark
4.Moved grave	pc	15	
5.Inundated timber forest	mu	30.30	
6.Inundated barren hill	mu	102.31	
7.Inundated timer forest	mu	121.50	
8.Permanent land use (exclude reservoir inundation)	亩 mu	204.60	
VI. Main structures and facilities			
1.Water retaining building			

Type			Concrete double curvature arch dam
Foundation rock type			Grey rock of Shilongdong formation of Cambrian system
Dam top elevation	m	1128.00	
Max dam height	m	60.5	
Dam axis length	m	139.1	
Seismic basic intensity/ seismic fortification intensity			□/□
2.Discharge building			
Type			Open flood discharge channel
Foundation rock type			Grey rock of Shilongdong formation of Cambrian system
Weir crest elevation	m	1117.06	
Length of discharge flow (size and number of gate hole)	m	2×6	
Size of flood discharge tunnel	m		
Unit width flow rate	m^3/(s.m)	43.8	
Energy Dissipation measures		ski-jump	
Gate size	m	6×8.5	
Hoist type			Cable hoist
Weight of hoist	t	2×3.2	
3. Water diversion building			
Designed diversion flow	m^3/s	2.36	
Max diversion flow	m^3/s	2.5	
Intake type			Shaft
Foundation rock type			Grey rock of Shilongdong formation of Cambrian system

Table 2-4 Characteristics of Changfeng Hydropower Project

Item	Unit	Quantity	Remark
Base plate elevation	m	1094.40	
Gate type		Ceiling chain wheel type	
Hoist type			Screw type
Hoist capability	t	30	
Diversion pipeline type			Pressure diversion tunnel
Foundation rock type			Carbonates
Length	m	5419.41	
Excavation face size	m	D2.2	
Lined face size	m	D1.7	
Max. design water head	m	58	

Surge shaft type			Simple cylinder structure
Shaft inner diameter	m	4.0	
Shaft height	m	58.86	
Penstock type			Surface stee pipeline
Foundation rock type			Ordovician system carbonates
Main pipe length	m	1321.04	
Main pipe inner diameter	m	0.9	
Number and length of branch pipe	m	1×15.6 1×8.92	
Inner diameter of branch pipe	m	0.6	
Bifurcated pipe type			Crescent rib reinforced
4.Power house			
Type		Ground type	
Foundation rock type		siltstone	
Size of main power house (L*W*H)	m	30.4×12.4×11.6	
Installed elevation of hydraulic turbine	m	543.84	
5.Switch station			
Type	Ground type		
Foundation rock type	Siltstone		
Area (L*W)	m^2	23×15	
6.Main electromechanical facilities			

Table 2-4 Characteristics of Changfeng Hydropower Project

Item	Unit	Quantity	Remark
A. Hydraulic turbine type	CJA237-W-125/2×9		
Qty	Set	2	
Rated output	kW	5263	
Rated speed	r/min	750	
Rated flow	m^3/s	1.18	
Max. working water head	m	581.65	
Min. working water head	m	529.05	
Exsuction lift head	m		
Rated water head	m	529.05	
Specific speed of turbine	m.kW	13.9	
B.Generator type	SFW5000-8/1730		
Qty	Set	2	
Rated output	kW	5000	
Rated speed	r/min	750	
Rated voltage	kV	6300	
Rated power factor	cosφ	0.8	

C.Main transformer	Type	S9-12500/35	
Qty	Set	1	
Rated capacity	kVA	12500	
Voltage ratio	kV	35±3×2.5%/6.3	
D. Intake valve type	Z941H-25-φ500		
Diameter	m	600	
Max. water head	m		
E.In-plant crane type	LD20-10.5		
Span	m	10.5	
Lifting capacity	t	20	
7.Power transmission line			
Voltage	kV	35	
Loop	Loop	1	
Transmission destination			
Transmission distance	km	7	

Table 2-4 Characteristics of Changfeng Hydropower Project

Item	Unit	Quantity	Remark
8. Navigation structure			
Type			Listed in accordance with different types of struture
Main size	m		
Ship tonnage	t		
Annual traffic capacity	10000t		
Navigation discharge	m^3/s		
9.Log and raft passing structure			
Type			
Main size	m		
Annual traffic capacity	*10000t		
Wood/bamboo passing discharge	m^3/s		
10. Other structure			
Construction			
1.Main construction volume			
Filled earth	*10000 m^3	1.21	
Earth-rock excavation	*10000 m^3	13.8	
Mortar laid block stone	*10000 m^3	0.10	
Backfill grouting	*10000 m^2	0.50	
Consolidation grouting	*10000m	0.77	
Land area	m^2	2061	
Construction area	m^2	1944	

Concrete	*10000 m^3	6.62	
Curtain grouting	*10000m	0.68	
2.Main construction material			
Detonator	*10000pcs	12.99	
Cement	*10000t	1.53	
Steel bar	t	1029.66	
Steel material	t	731.19	
Timber	m^3	397.82	
Explosives	t	116.79	

Table 2-4 Characteristics of Changfeng Hydropower Project

Item	Unit	Quantity	Remark
Fuse	*10000m	14.04	
Gasoline	t	19.12	
Diesel	t	292.99	
Coal ash	t	3743	
Block stone	m^3	794	
Cobble	*10000 m^3	5.59	
Sand	万 m^3 *10000 m^3	2.96	
3.Labor needed			
Total working days	*10000 working days	26.741	
Average staff number	Person	245	
Peak staff number	Person	367	
4.Construction temporary house			
5.Construction power			
Electricity	kW	1×800、1×150	
Other power facilities	kW		
5.External transportation	km	8	
6.Construction diversion			
Diversion type		Weir, open channel, tunnel	
Type of building		City gate type tunnel	
Major size	m	3×3.1	
9.Construction land use	mu	74.7	
10.Construction period			
Construction period	month	12	
Total period	Year	2	

Ⅷ. Economic index			
1.Total statistic investment	*RMB10000	7876.82	
Total investment	*RMB10000	8184.96	
Construction project	*RMB10000	4351.08	
Mechanical facilities and installation	*RMB10000	882.11	
Metal facilities and installation	*RMB10000	745.55	

Table 2-4 Characteristics of Changfeng Hydropower Project

Item	Unit	Quantity	Remark
Temporary project	*RMB10000	482.39	
Compensation for reservoir inundation	*RMB10000	147.76	Single
Other cost	*RMB10000	592.28	
Basic budget reserve	*RMB10000	352.67	Only calculating the key project part
Price variation	*RMB10000		
Load interest during construction period	*RMB10000	293.44	Only calculating the key project part
1.Main economic index			
Investment per kW	RMB/kW	7877	
Investment per kWh	RMB/kWh	2.14	
Power output cost	*RMB10000	996.3	
Economic internal rate of return	%	13.77	
Financial internal rate of return	%	7.59	Before income tax
Power purchase price	RMB/kWh	0.28	
Loan payback period	a	12.1	
Back-calculation power price （FIRR=10%）	RMB yuan	0.322	

2.10 Construction Pollution Analysis

2.10.1Main factor and measures of environmental impact during construction period

2.10.1.1 Analysis on Earth-rock Volume Balance, Construction Waste Residue and

Domestic Wastes

(1) Analysis on earth-rock volume balance and utilization of waste residue

See table 2-5 for earth-rock volume balance of construction waste residue

Table 2-5 Earth-rock Volume Balance of Construction Waste Residue

Unit: *10000 m^3

Project	Earth excavation			Rock excavation			Total wasted volume
	Excavated volume	Used volume	Wasted volume	Excavated volume	Used volume	Wasted volume	
Water intake works	0.93	0.10	0.83	3.51	0.15	3.35	4.18
Water diversion tunnel				2.98	1.17	1.81	1.81
Penstock	1.01		1.01	2.45	0.14	2.31	3.32
Powerhouse	0.46		0.46	0.56	0.28	0.29	0.75
Construction road	1.68	0.67	1.01	3.12	2.45	0.67	1.68
Total	4.08	0.77	3.31	12.62	4.19	8.43	11.74

Disposal Measures for Domestic Wastes

The number of working staff per daily during peak construction period is about 367 persons, if one person produces 1.0kg wastes per day, then max domestic wastes production per day is about 0.367t. The whole construction needs 18 months with average number of working staff per day of 245 persons, then total domestic wastes produced during construction is about 132.3t. If these wastes are not properly disposed, they may produce many mosquitos, flies and lead to second pollution.

Thus domestic wastes should be classified and kept in a special yard and to be disposed as compost after recycling the useful part.

2.10.1.2 Water Supply and Sewerage During Construction and Analysis on Main Pollutants Discharge

Total water consumption of Changfeng hydropower station project during construction is 221300m^3, and total wastewater discharge is 177040m^3, including sewerage of construction wastewater and domestic wastewater.

(1) Water Used in Construction, Major Wastewater Pollution Source and Pollutants

Total water used in construction amounts to 194840m^3 and total wastewater discharged during construction is 155872m^3. Wastewater discharged during construction

mainly comes from concrete placement and conservation, washing water of the sandstone processing system, washing water from machines and vehicles used in construction and so on. In addition, during construction there is also a lot of wastewater from foundation pit, which mainly comes from rainfall and weir water leakage, which amounts to 200m^3/d during peak period. Since project construction adds more suspensions to the water in foundation pit, a catchment pit will be built, in which wastewater will be settled for more than 2 hours before its suspension concentration is below 70mg/L and then discharged by pump, thus it reduces its impact on surface water environment.

• Wastewater from Concrete Placement and Conservation

Due to concrete placement, conservation and grouting, the suspension concentration of its wastewater is quite high and its PH value may reach 11~12.

• Washing Water for Sandstone Processing System

The procedures for sandstone processing system is: mining in material yard→raw material yard→filtration→semi-finished material yard→filtration station→finished aggregate yard→gravel sand processing →mixture→finished gravel sand. Usually processing 1t concrete aggregate costs about 2.7m^3 water. If the average sand content in gravel sand is 8%, then the suspension concentration of the washing water for gravel sand is about 2.5×10^4mg/L based on the principal of material balance. The water loss due to material surface water, evaporation and leakage makes 20% of the total water consumption, while the rest 80% is production wastewater which is about 110m^3/h.

- Washing water from machines and vehicles used construction

According to the design by construction organization and compared to other hydropower projects of similar scale, main machines and vehicles used in construction area are about 40, which are parked together. Suppose washing a vehicle once produce 0.6m^3 wastewater and the washing rate is 50% per day, then oily wastewater produced per day is about 12.0m^3 and total wastewater produced during construction is 6480m^3.

There is no specific treatment for construction wastewater in the feasibility study report of the project. Referring to regular measures for similar wastewater treatment, we suggest in this assessment that the production wastewater should be disposed as follows: since main pollutants in the wastewater of gravel sand processing is SS, it should disposed

by rectangular sediment tank; since PH value of wastewater of concrete placement and conservation is 11~12, it should adopts neutralizing sediment tank; since washing water of machines and vehicles used in construction is oily wastewater, it should be disposed by oil separating tank. With the above treatments, the wastewater can reach the standard for discharge. See table 2-3 for production and discharge of construction wastewater and its main pollutant of Changfeng hydropower project.

Table 2-3 Production of Construction Wastewater and Main Pollutants

Item	Wastewater catalogue	Wastewater in peak period (m^3/d)	Total wastewater during construction	Before treatment	After treatment
1	Wastewater from gravel sand processing	1600	142992(1091.6)	SS：2.5×10^4mg/L，27290kg/d	SS：70mg/L，76.41kg/d
2	Wastewater from concrete placement and conservation	80	6400(10.7)	SS：5000mg/L 53.5kg/d	SS：70mg/L 0.749kg/d
				pH：11-12	pH：6-9
3	Washing water of machines and vehicles used in construction	20	6480(12.0)	Petroleum: 15mg/L 0.18kg/d	Petroleum: 5mg/L 0.06kg/d
				SS：300mg/L 3.6kg/d	SS：70mg/L 0.84kg/d
Total		1700	155872(1114.3)	/	/

Note: wastewater in foundation pit mainly comes from rainfall and weir water leakage, which is not calculated in the wastewater of construction. Data in ()is average wastewater discharge per day, and the concentration after treatment is calculated by standard concentration.

(1) Domestic water and sewerage

It mainly includes domestic wastewater of construction staff. The max number of working staff per day in the peak period of construction is 376 persons, and the average number of working staff per day is 245 persons. Based on the regular domestic water consumption of construction staff for hydropower projects, the average water consumption per day of construction staff is about 200L and the total water consumption is about 26460m^3 during the whole construction period, and 80% of which will be discharged as sewage. The sewage discharge standard is 160L/d, and the max domestic sewage discharge

per day is 58.7m^3, the average domestic sewage discharge per day is 39.2m^3, the total domestic sewage discharged during construction period is 21168m^3. Its main pollutants are COD, BOD_5, SS, NH_3-N.

The construction site is located in barren mountains, which is far always from villages and cities. By considering the general condition of construction site and existing regional environment, temporary toilets and simple constructed septic tank built near the construction site will fit the existing objective and technical condition.

See table 2-4 for discharge of domestic sewage and its main pollutants.

Table 2-4 Discharge of Domestic Sewage and Main Pollutants during Construction

Wastewater amount		Pollutant	Before treatment			After treatment		
			Concentration mg/L	Production amount		Concentration mg/L	Discharge amount	
m^3/d	Total construction period m^3/a			kg/d	合计 T		kg/d	合计 T Total T
39.2	21168	COD	400	15.68	8.467	160	6.272	3.387
		BOD_5	200	7.84	4.234	80	3.136	1.693
		SS	220	8.624	4.657	66	2.587	1.397
		NH4	15	0.588	0.318	15	0.588	0.318

2.10.1.4 Waste Gas Pollution Source and Pollutants in Construction

The waste gas pollution source in construction mainly includes flying dust produced by concrete mixing system, powder produced by manmade gravel stone crashing system, waste gas produced by excavating machine and blasting, waste gas produced by domestic coal burning, dust and tail gas of transportation, powder of concrete and coal ash transportation and flying dust of earth-rock excavation. Its main pollutants are particle suspension (TSP), SO_2, CO, etc.

Based on the designed of construction organization and estimation, the fuel used in construction site is fuel oil, and total oil consumption in 18 months is 312.11t. According to the pollutant discharge coefficient, the major types and numbers of pollutants produced by construction fuel oil are listed in table 2-5.

Table 2-5 Type and Number of Main Pollutant Produced by Fuel Oil in Changfeng Hydropower Project Construction

Characteristic	Oil	Number and type of main pollutants of fuel oil emission(t)

amount	consumption (t)	SO_2	NO_2	CO
Daily average amount	0.58	0.655	9.965	16.39
Total amount in construction period	312.11	353.7	5381.1	8850.6

Since it is a small scaled project with scattered construction site, the pollutant source intensity is also dispersed, thus the project construction has small impact on regional air environment, however it has certain impact to the construction part and staffs on site, thus treatment measures should be taken to reduce its negative impact.

The air impact of the project is only limited to its construction period, which will be eliminated when the construction is finished.

2.10.1.5 Facility and Noise

See table 2-6 for main construction facilities

Table 2-6 Main Mechanical Facilities for Construction

Catalogue	Name and specification	Unit	Quantity
Load machine	Single bucket excavator, oil actuated 1.0m^3	set	5
	Loader 3.0m^3	Set	3
	Bulldozer 59kW-74kW	set	4
Rock drill machine	Hand held air drill	set	6
	Air feed leg drill	set	15
	Drill bit type 100	set	5
	dresser	set	5
Drills	Hammer drill	set	2
	Geological drilling rig, oil hydraulic handle type 150	set	3
	Grouting pump for low pressure grout	set	5
	Grout mixer	set	2
	Mortar mixer	set	5
Aggregate processing	Jaw Crusher 600×900mm	set	5
	gyratory crusher bottom φ1650mm	set	3
	gyratory crusher bottom φ1750mm	set	3
	Ball mill φ2150mm×φ3600mm	set	2
	Single screw sand washer φ1200mm	set	2
	Spiral classifier φ1200mm	set	2
	Heavy duty shaker 1500×3000	set	1
	Heavy duty shake 1750×3500	set	1

	Disk feeder DB-1600	set	2
	Chute feeder K3-500t/h	set	1
	Electromagnetic feeder 45DA	set	1
Concrete construction	Concrete mixing building （2×1.0）45DA	set	2
		set	2
	Concrete mixer discharge 0.8m^3	set	2
	Concrete mixing truck capacity 3.0m^3	Set	2
	Concrete transport pump 30m^3/h	set	2
	Concrete sprayer HPZ-30B	set	3
	Vibrator Z2D-100	set	1
	Concrete bucket capacity 3m^3	set	3
	Wind consumed of sand water gun 2-6m^3/min	set	10
	Internal vibrator HZ6X-70		
Transportation	Truck, gasoline 5t	set	5
	Pumper dump truck, diesel 10-12t	set	5
	Dumper truck diesel 15-18t	set	5
	Tractor 59kW	set	4
	Tractor 74kW	set	4
	Battery locomotives (small narrow gauge)	set	4
	Tower crane	set	1
	Spiral air delivery pump 65t/h	set	1
Other machines	Hoist 10t	set	1
	Centrifugal water pump	set	3
	Submerged pump	set	2
	Reversible axial flow ventilator 37kW	set	3
	Welding machine	set	5

From table 2-6 and other main construction facilities, we can see that the noise of the construction mainly comes from 140 equipments, including earth-rock machines (such as drill bit, excavator, loader, stone crusher, etc.), concrete equipments (such as crawler crane, concrete pump, concrete bucket, etc.), drilling and grouting equipments, concrete production equipments (crusher, shaker, sand washer, concrete mixing building) and auxiliary processing equipments (wood works, mechanical maintenance, air compressor, water pump, transformer). According to the performing features of the machines, the noise source can be divided into two catalogue: fixed source and mobile source.

According to the measured value and estimation of machine noises of similar construction period, the noise sources intensity of the project are listed in table 2-7.

Table 2-7 Sources and Levels of Main Project Noise

Type of noise source	Machine name	Equivalent sound level dB (A)
Fixed point source	Excavator, loader, mixer, grouter, etc.	95-100
Mobile line source	Truck, bulldozer	85-95
Blasting noise	Blast	130

Since the construction site is in the valley, the noise spread is cut off by surrounding mountains; therefore its impact is limited to areas nearby the construction site only. The construction noise mainly has influence on the working staff. The tunnel excavation and mountain blasting will break the silence in the mountainous area, which may disturb the wild life, however, the impact is limited to the construction period only.

2.10.2 Reservoir Inundation Period

The reservoir inundation area of Changfeng hydropower project only covers one county (town) , since its construction site is in the deep mountain valley areas, the mian inundated land are bush land and barren land. The total inundated land is 276.76mu, among which cultivated land is 22.65mu, fuel land is 121.5mu, timber land 30.3mu, barren hills 102.31mu; permanent land use of construction is about 204mu, and temporary land use is 54.9. In the reservoir inundation area, there are 3 households to move and 120 m^2 housing to be moved. There is mining area, cultural or historical relics in the reservoir inundation area.

According to the Design Guidelines for Reservoir Inundation Treatment of Water Conservancy and Hydropower Projects, the design standard of the project reservoir inundation is that land occupation is made according to normal reservoir water storage. The inundation area is decided on the above water level. The index of inundated items should be investigated and provided by the owner.

Reservoir water storage inundates some vegetation and changes the number of plant biomass; the enlarged area of aquatic organism changes the types and distribution of aquatic organism and fishes; reservoir storage inundates land and reduces living areas for wild life. During the preliminary stage of reservoir water storage, the inundated soil and

decomposition of vegetation organism will release nutrition to the water, which may cause water environment problems. In addition, reservoir water storage may lead to landslide, leakage and other environmental geological problems.

In summary, reservoir inundation has some impact on environmental factors such as terrestrial plants, terrestrial animals, ways of land use, aquatic environment, and environmental geology.

2.10.3 Project Operation Period

The project operation is the process of water storage, power output and water discharge. The project itself discharges no wastewater or other pollutants. When the project is finished, the reservoir operation and dam separation will bring some irreversible impact on the environment.

When the reservoir stores water, the water level will rise and flow rate will slow down, silt will settle in the reservoir, and the water temperature will be different from natural state, which will turn the upstream water of Ganhe Creek above Changfeng hydropower station from the natural river into an artificial lake, thus its hydrological conditions including water level, flow rate, water temperature and silts will change. Since the reservoir flow rate will slow down, the self-cleaning ability of the water is will reduced, which may lower the water quality. Meanwhile, the reservoir water storage will change the connectivity of the upstream and downstream rivers at the dam site, which has quite major effect on environment of aquatic organism. Due to reservoir regulation, there will be a water-level-fluctuating-zone, where the ecological environment is impacted.

3 Existing Environment

3.1 Natural Environment Introduction

3.1.1 Natural Condition

Changfeng hydropower project is situated at upper reaches of Ganhe Creek, 2km from

Xiufengqiao, 29km from 318 National Highway, 110km from Changyang County and 111km from Yichang City.

Ganhe Creek is the largest branch at the left bank of downstream from Zhaolai River, the secondary branch of Qingjiang Water System, which originates from Guanjianao at 1998m altitude and outflows to Zhaolai River Power Station Reservoir after running through Longtan, Zhichang Creek, Dengjia River, Qiyan Creek and Ganhe Creek before going to the reservoir of Zhaolai river hydropower station. The main watercourse is 34.2m long, covering 183.5km2 catchment areas, with height difference of 1694m, and weighted average watercourse descent of 34‰. The upper reaches of the river is narrow with slow channel descent while the lower reaches of the river has steep channel descent. The theoretical reserves of the main stream are 23000kw, among which the theoretical reserves in Changyang are 19400kw. Only Xiufengqiao hydropower station is to be built at middle reaches of the river with installed capacity of 2×40kW, which has been in operation for nearly 20 years. Changfeng hydropower project controls 43.1km^2 drainage area and weighted average channel descent of 51.6‰.

The river basin is fan shaped, along which stands many mountains and peaks arising one after another. It has narrow watercourse and large channel descent, which is mountain stream. The terrain of the river is descending from east to west which most watersheds above 1600m altitude. The altitude of Guanjianao in the east is 1998m, while the altitude of Zhaojia Bay in the south, Xiaoguanmen in the west and Tanjia Bay in the north are 1637m, 1689m and 1810m respectively. The riverbed is 15-60m wide with most U shaped river valley and some V shaped river valley. Most rocks on both banks of the riverbed are exposed which adds more natural advantage to the reservoir construction.

The vegetation in the river basin is good, with forest coverage rate above 70%. From river valley to mountain, it is always green and luxuriant with pine trees, cypress, hard large-leaved forests, firs, bushes, arbors, deciduous forest and evergreen forest. Good vegetation efficiently prevents water and soil loss and reduces sand concentration of the river.

3.1.2 Climate

Ganhe creek basin is located in subtropical humid monsoon climate area in the

Northern hemisphere, with obvious winter-summer monsoon, absolutely distinct four seasons, adequate sunshine, abundant rainfall, changeable spring, rainfall summer, dry autumn and cold winter, which is obviously mountain climate. The river basin has crossed river valleys, multiple terrains, complicated landforms, stable river valley climate and long frost-free period, while the high mountain area has more rainfall, less heat, long frost period. With obvious vertical distribution of hydrological climate factors, the same river basin may have different climates.

Ganhe creek basin has no weather station, thus its weather information comes from Changyang weather station. Changyang weather station (at altitude 120m), was set up in 1956 by Hubei Meteorological Bureau and began to measure surface meteorological factors from 1957 including air temperature, humidity, air pressure, wind direction, wind velocity, rainfall, sunshine, cloud condition, visibility, evaporation, and ground temperature at different depth. Changyang weather station is one of primary national weather stations in Hubei province, whose measured information is edited and printed by Hubei Meteorological Bureau, which is reliable, precise and can be taken as reference by nearby regions. According to statistics, the average annual air temperature is 16.4□, the highest average monthly air temperature is in July reaching 27.6□, and January has the lowest average monthly air temperature of 4.6□. The extreme highest air temperature was on August 6th, 1966 reaching 42.1□ and January 31st, 1977 saw the lowest air temperature of -12.0□. The average annual sunshine hour reaches 1553h. The average annual relevant humidity is 80% and the absolute humidity is 16.3mb. The average annual wind velocity is 1.5m/s with prevailing wind direction towards east. July 22nd 1975 saw the max wind velocity of 16m/s with south east wind direction. The frost period usually occurred during November to March in the next year, and average annual frost-free period is 282d, and average annual rainfall is 1347.2mm.

In addition there is a Huoshaoping weather station to the south east of construction site, only 12.5km from the site, at altitude of 1800m, with 30 years of meteorological documents, which shows that the average annual air temperature is 7.4□, and the highest monthly air temperature is in July reaching 18□, while the lowest monthly air temperature is in January of -3.3□. The extreme highest air temperature is 29□ while the extreme

lowest air temperature is -20.1□. Average annual sunshine hour is 1800h, average annual frost-free period is 192d, and average annual rainfall is 1485mm.

Changfeng hydropower project is at altitude of about 1100m, where the meteorological parameters of Changfeng hydropower project site can be estimated according to similar construction experiences. See table 3-1 for details.

Table 3-1 Meteorological Parameters of Changfeng Hydropower Project Site

No.	Item	Unit	Value	remark
1	Average annual air temperature	□	12.5	
2	Average lowest monthly air temperature	□	0.7	January
3	Average highest monthly air temperature	□	23.2	July
4	Extreme lowest air temperature	□	-16.5	January 30th, 1977
5	Extreme highest air temperature	□	37.6	August 6th, 1966
6	Average annual absolute humidity	mb	16.3	
7	Average annual relevant humidity	%	80.0	
8	Average annual wind velocity	m/s	1.3	
9	Max wind velocity	m/s	16.0	
10	Prevailing wind direction		E	
11	Average annual sunshine hour	h	1697	
12	Average annual frost-free period	d	245.0	
13	Average annual rainfall	mm	1129.2	Adopts the information from Xiufengqiao station

There is Xiufengqiao rainfall station and Baozhen railfall station near the river basin controlled by Changfeng reservoir, and basin center is close to the midpoint between the two stations. Up to the end of 2002, the average annual rainfall measured by Xiufengqiao

precipitation gauging station is 1129.2mm and the average annual rainfall measured by Baozhen precipitation gauging station is 1721.3mm. Through weighted average, we work out the average annual rainfall of the river basin controlled by Changfeng reservoir of 1425.3mm. Meanwhile we looked into Yichang Average Annual Rainfall Isoline Map from 1956-1990 and found its average annual rainfall of 1500mm, which only has 5% difference with the above calculated value and meets the design requirement. The rainfall distribution is related to the river basin elevation. When the elevation turns higher, there is more rainfall. Baozhen near the river basin is a well known rainstorm area in west Hubei province, where its max annual rainfall is 2307.4mm (1983) The rainfall fluctuates greatly between years, the year with more rainfall usually has flood while the year with less rainfall is usually drought.

See table 3-2 for detailed rainfall distribution in a year of Changfeng reservoir controlled river basin

Table 3-2 Rainfall Distribution in a Year

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
Rainfall	32.3	40.3	77.2	124.7	169.6	194.5	256.1	200.4	134.5	106.9	66.9	26.7	1425.3
Distribution rate	2.3%	2.8%	5.4%	8.7%	11.9%	13.6%	18.0%	14.1%	9.4%	7.5%	4.7%	1.9%	100.0%

The features of rainfall distribution is that from April to October is the rainfall high water period, which has 83.1% rainfall of the year reaching 1184.3mm, while from November to March in the next year is rainfall low water period, which has 16.9% rainfall of 241.0mm.

In addition, from the Yichang evaporation isogram chart, the reservoir water surface evaporation is 700mm and the land evaporation is 600mm.

3.1.3 Regional Geological Environment

3.1.3.1 Landform and Geomorphy

The construction site is at folded mountain area in south west Hubei province. The elevation of mountains in the construction site is 1300~1600m. The mountains are going east to west, which is same as the regional structure. Most river valley types are gorge and

a open river valley is formed near Langping with valley bottom elevation of 500~600m.

3.1.3.2 Stratum Lithology

The whole area is made of sediment rocks and the exposed stratum is grey rock, dolomite, and shale of Cambrian and Ordovician system in palaeozoic group as well as sandstone and shale of the Silurian system. It is mostly made of grey rock and shale of the Cambrian system along the dam site, while in the power house area is siltstone of Silurian system. Quaternary system over burden is scattered with thickness of 0~20m.

3.1.3.3 Structure and earthquake

(1) Geological Structure

The site is located in the third uplift belt of Neocathaysian system with Huaiyang epsilom type west reflex arc to the northeast-Huangling anticline and betwixtoland. See figure 6 for regional geological environment.

The structure style includes close linear fold and open fold with non-developed fault. The folds have clear direction going from east to west in parallel alternating with linear anticline and syncline-Changyang anticline, syncline area in the middle, Wufeng anticline, Liulihuang syncline, Quanping anticline, etc. The whole construction site is located in Changyang anticline. Other folds have no direct influence on the construction site. There are obviously five planation surfaces with elevations of level I 1700~2000m, level II 1250~1550m, Level III 950~1000m, level VI 750~900m and level V 250~500m. the diversion tunnel and dam site is located between level III to level II, while the power house is at level V planation.

(2) Earthquake

Based on the historical earthquake data near the measured area (Yuan'an, Dangyang, Yichang and Changyang), the measured area in located in historical weak earthquake area with earthquake intensity below level IV and some area is level V. during 1905 to 1947, seven earthquakes occurred with earthquake intensity of 4-5, some particular earthquakes occurred in areas near NNW Tongyu River fault and EW striking Tianyangping fault can reach earthquake intensity of 6-7. According to Seismic Ground Motion Parameter Zoning Map of China scaled 1:4,000,000 (GB18306~2001), the peak acceleration of seismic ground motion in this area is 0.05g, and the characteristic period of the seismic response

spectrum is 0.35s, which is equivalent to basic earthquake intensity of level VI.

3.1.4 Geological Environment of Reservoir Construction

(1) Landform and Geomorphy

Most river valleys in the reservoir site are narrow with width of 15-30m, except for the one 200m from the dam site (width 40-160m). On both sides of the river bank, there are steep hills, most of which are exposed bedrock. They are middle and high mountains with crest elevation of 1500-1600m and good vegetation. At normal pool level of 1130m (dam height of 50), the reservoir back water is about 2.1km long.

(2) Stratum Lithology

The reservoir stratum is made of lower Cambrian system carbonates and its periphery areas are made of middle Cambrian system-lower Ordovician system carbonates.

(3) Geological Structure

Controlled by Huaiyang epsilom type west reflex arc, the reservoir is located at south of near the core of the Changyang anticline, with monocline structure, the faults and sub-level folds in the reservoir site are not developed. The structure style is joint style. Some joints extend longer, and regular karst develops along the joint surface.

(4) Karst

The stratum lithology of banks of reservoir site, the Cambrian system on periphery and the Ordovician system are mainly carbonates. These rocks develop karst. Relatively, the karst development in Honghuayuan formation and Najinguan formation of lower Ordovician system are strong while the karst development of Shibei and Shilongdong formation inside the reservoir basin are weak. The karst scale are different and has various shapes such as discharge tunnel, underground driver, blind valley, karst cave, karst hole, karst fissures, etc.

According to the survey, most visible surface karst caves are located above the reservoir water level and are dry caves. The biggest kasrt cave is Huangyangping karst cave, with 1430m cave entrance elevation, 30 wide, 12m high, 15m deep. In the cave, there is water year around and sand loam. Near Huangyangping, there are many water discharge caves and groundwater is deeply laid hidden in earth. These water discharge caves have elevation of about 1380~1450m. There is no big exposed spring on the northern (right)

bank of reservoir, while there is a big exposed spring in Lengshuiqiao, with estimated flow rate of 90L/S, which has some hydraulic connection with ground water in Huangyangping. During level period, Huangyangping area will be dried up to be a blind valley.

Karst caves in the reservoir basin are small, from tens of centimeters to 1.5m, which are blind caves filled with clay and less connected to the nearby area. At the two river mouths, there is a 20m-wide-120m-long strong karst belt and karst fissures are developing along the stratum surface, or small karst caves are developed along vertical fissures with size of 5~15cm. The karst belt mainly has shallow development, which is less extended to nearby area and less connected to other karst caves. In summary, the stratum karst in the reservoir basin is not developed.

(5) Hydrogeology

Groundwater has three ways of storage: pore water in loose stratum, fissure water in bed rock, karst fissure water and penstock water. There are 3 karst outlets in the reservoir zone, all of which are running into the reservoir zone. There is no karst outlet within 2km downstream reservoir zone. There is a big exposed spring at Lengshuiqiao in the near valley, which has no direct hydraulic connection with the reservoir zone.

3.1.5 Engineering Geological Condition of Dam Site

Generally speaking, the bed rocks expose well within the dam site. In this stage, it originally lays 7 drill holes, 2 adits and 1 exploratory trench. After finishing drilling ZK1, ZK4, ZK5, the owner and the designers concluded from site investigation that 6 drill holes can meet the requirement. Therefore, 6 drill holes are actually used in construction, with total advance of 297.6m, 2 adits with total advance of 45.50m and 1 exploratory trench. The above has basically meet the design requirement for this stage.

(1) Landform and Morphology

The dam axis is at 100~120m upstream to Xiufengqiao intake dam. The general flow direction of the river is as follows: from northern east to southern west (SW200°) of upstream to dam axis, and from northern east to southern west (SW220°) of downstream to dam axis. The river valley is U shaped, with valley bottom of 20-30m wide. Valley at 20m upstream to dam axis are wide and flat, while valley in the dam site is straight, with mountain top elevation of 1580~1600m, river water level of 1075~1078, water surface

width of 4~8m and water depth of 0.1~0.6m. It is a tangential valley.

The landforms of the banks are quite complicated. On the left bank upstream to dam axis, there is a west-east small watershed, which is free surface of upstream to the dam abutment rock. At 40~60m downstream to the dam abutment is a south-north watershed. The dam abutment rock between two watersheds within elevation of 1085~1130m, is a upside-down cone. The natural slope angle near the dam axis is 40~50°.

It is valley slope on convex bank on the right and stepped steep slope near the dam axis. Below elevation of 1130m, is natural slope with angle same as stratum dip angle, 40~50°. On the upslope side of hole ZK5 is a 3m-high steep ridge, while above 1130m elevation is 80-high steep cliff. After 30m upstream to the dam axis, the slope starts to become slow, and the bank slope downstream to the dam axis is contracting toward internal bank. There is a small watershed at the water intake dam in Xiufengqiao village with large gradient and shallow cutting. The river valley inside mainly has much more erosion than less deposit with over burden thickness of 3~4m and no river terrace.

(2) Stratum lithology

The exposed stratum at the dam site is mainly Shilongdong formation of the lower Cambrian system, which is divided into 13 layers with total thickness of more than 200m. On the left bank of elevation above 1120m, there is Tanjiamiao shale of the middle Cambrian system with thickness of 4.60m.

(3) Geological structure

The geological structure of the dam site is quite simple, there is no big fracture structures going through the dam site. The dam site is located near the core of Changyang anticline to the south with geological structure style of small faults, joints and shear zone between layers.

The stratum of dam site is monocline, with steep rock dip angle. The attitude of rocks: striking 281~286°, dipping SW with dip angle of 45~46°. The attitude of rocks is basically stable. See attached figure 7 for engineering geological conditions of dam site.

(4) hydro-geology

The groundwater of dam site includes fissure water of loose stratum and fissure karst water in bed rock. The pore water is in alluvium, proluvium, eluvial deposit and slope

deposit, and stays as perch groundwater and phreatic water, which is greatly effected by rainfall, and discharge through evaporation and discharge to low lying area at lower reaches. It is not developed at dam site. The fissure kasrst water in bed rock is also not developed at dam site. The stratum in the dam site is limestone, dolomite limestone, shale and argillaceous rocks. The former has good water permeability or water bearing while the latter has bad water permeability or water bearing and can separate water partly. Since the two stratums are close, the karst water is not developed. Due to its structure and weathering, the shallow bed rock in the dam site has developed fissures, which will store some fissure water.

The general trend of recharge and discharge of groundwater in dam site: the ground water is recharged by rainfall and the ground water at both banks recharges the river. the chemical type of ground water in dam site is heavy calcium magnesium carbonate, which is same as the river and is not erosive to concrete.

3.1.6 Runoff and sediment

3.1.6.1 Runoff

In the river basin where Ganhe Creek situates, there is a Zhailai River Hydrometrical station downstream to Zhailai River. Inside and near the river basin, there are Xiufengqiao and Baozhen precipitation gauging station, which can calculate the runoff result at the dam site of Changfeng hydropower project by using hydrological area comparison and precipitation gauging correction. Its average annual flow rate is 0.99m^3/s, its average annual runoff of 31369900 m^3 , average annual runoff depth of 727.8mm and runoff modulus of 0.023m^3(s.km^2), Cv=0.35, Cs=2Cv.

We sort the annual runoff document of bench mark station-Zhailai river hydrometrical station in 1960-2002 by frequency, and use P-III curve fitting to get the result Qa =16.46m^3/s, Cv=0.35, Cs=2Cv. The average annual flow rate of Rainy year (P=15%) Qf==23.20m^3/s; the average annual flow rate in average year (P=50%) Qp=16.46m^3/s; and the average annual flow rate in dry year (P=85%) Qk=10.78m^3/s. From the runoff data, we choose a year as typical year, which has flow rate similar to the representative year and is badly distributed: the typical rainy year is April 1973 to March 1974, whose flow rate Qfd=23.63m^3/s; the typical average year is April 1970 to March 1971, whose flow rate

Qpd=16.82m^3/s; the typical dry year is April 1978 to March 1979, whose flow rate Qkd=10.26m^3/s. To correct the daily runoff data in the typical year from Zhailai river hydrometrical station, we adopts hydrological area comparison and precipitation gauging correction and difference correction between data of typical year and representative year. This is the how we calculate the daily runoff of Changfeng hydropower station.

3.1.6.2 sediment

There is no measurement data of sediment in Ganhe creek. We adopts the sediment data of Zhailai river hydropower project at the lower reaches, whose average suspended load sediment transport modulus is 488t/km^2. The suspended and transport sediment capacity is 1.3t/m^3 and 1.5t/m^3 separately. The sediment detention rate estimated according to the reservoir capacity is 80% and the average sediment into reservoir is 14600 m^3.

According to No.4.7.4 of Design code for small hydropower station (GB50071-2002) , the sediment deposition limit of the project is 20 years with sediment into reservoir of 292500 m^3, and deposition height before dam site is 1093.4m.

3.1.7 Soil

The soil of construction area mainly consists of yellow brown soil, brown soil, limestone soil and river alluvial deposits in modern times. The yellow born spreads mostly in mountains, which is acid and sorted as transition soil. The brown soil spreads mostly in mountains with thick soil and good vegetation, which is good for growing hardy plants. The limestone soil is lithological soil developed on limestone subsoil, whose soil is usually thin with gravels, which is good for deciduous broad leaf forest and coniferous broad leaf mixed forests in northern subtropical area, such as pine, cypress, fir, oak, etc.

3.1.8 Vegetation and aquatic organisms

3.1.8.1 Vegetation

(1) Natural vegetation zone

The county has total forest land of 3602400mu, covering 70% of total county land area. Due to climate influence, the subtropical and temperate zone plants distributed from river valley to mountain has a vertical distribution. Below the lower mountain area, the total forest land area covers 31.3% of total land area with main vegetation of evergreen broad leaf mixed forest and scattered with Chinese red pine, bamboo, cypress, etc; In semi

high mountain area, the forest land covers 22.2% of total area with main vegetation of evergreen broadleaf forest and coniferous missed forest; In the high mountain area, the forest land covers 16.8% of total land area, with main vegetation of evergreen broad leaf forest and dark coniferous leaf mixed forest. The Leyuan forest at 1000-1900m altitude has more than 20 species of rare precious trees community. The Bengjianzi Mountain in Machi village at altitude above 2000m has rare Rhododendron pulchrum community.

(2) Artificial vegetation zone

The county has total cultivated land of 748909mu, covering 14.58% of total land area of the county. The crops in various climate zones are different due to different terrain and climate. The low hill river valley has paddy rice, wheat, sweet corn, sweet potato and oil crop, which covers total cultivated land area of 170400mu, 30.24% of total reported cultivated land area of the county. The area mainly grows paddy rice and wheat of two crops a year, and dry land crops of three crops a year. The low mountain area mainly grows wheat, sweet corn, oil crops and other dry land crops, covering total cultivated area of 126700mu, 22.5% of the total cultivated land area of the county. The paddy field is 9900mu, which covers7.8% of cultivated land area. The whole area is the early season crop field, which mainly grows three-crops-a-year plant through intercropping. On mountainside, there are 154900mu cultivated land areas for sweet corn, potato and soy bean, covering 27.5% of total cultivated land area of the county. There is 8000mu paddy field, covering 5.2% of total cultivated land area. The area and output of sweet corn and potato covers the largest part in the county. The plant period is between one crop and two crops a year. On the high mountain, there are field of potato, sweet corn and soy bean covering 111500mu cultivated land area, 19.8% of total cultivated land area of the county.

(3) Plant species

Influenced and limited by geology, geomorphy, climate, latitude and other factors, there are a lot of plant species. According to the forestry survey of trees, there are 561 species of 253 genuses in 90 families. According to the statistics of special plants, there are 1438 species of 718 genuses in 207 families of 6 categories.

3.1.8.2 Animal

Animals, especially wildlife such as precious animals including tigers and deer are

extinct due to the increasingly explored mountain area, smaller forest vegetation area, smaller activity zone and excessive hunting.

3.1.8.3 Plants and animals in construction area

Ganhe Creek river basin is located in ecological system area of humid subtropical forest, which mostly grows evergreen broad leaf forest ecological system, including over 200 plants varieties. The timber forest mainly consists of pine, Chinese fir, chestnut and cypress.

The project area is transiting from high mountains to low mountains, with vegetation changing from forest land to scattered woodland. The high mountain area mainly grows coniferous forest while low mountain area grows coniferous broad leaf mixed forest. The coniferous trees include cryptomeria, pine and cypress and the broad leaf trees include Chinese toon trees, Campthotheca Acuminata Trees and tung oil trees. This area has forest coverage of 60.59% and its ecological water use mainly comes from rainfall.

Ganhe Creek is a stream river with clear seasons and rapid flow rate. The river bed is made of rocks or cobbles, with less organic sediment. The floating plants in the river are chrysophyta, bacillariophyta, chlorophyta, cyanophyta, euglena, etc. The floating animals are protozoan, trochelminrhes, copepoda and cladocera; Benthic animals mainly include oligochaeta such as tubifex worm. The aquatic insect is chironomus plumosus. The mollusca include nacrobrachium, anodonta, parafossarulus, cipanopaludina, etc. The arthropoda in the area is crab. The fishes in the area are Onychostoma, black porgy, loach and other fresh water fishes. There are few fishes, which are not evenly distributed. There is no migration or half migration fish in the area.

The terrestrial animals in the area are small beasts and birds, including hare, wild hog, sand badger, otter, yellow weasel, bat, mouse, etc. Domestic animals in this area are pig, cattle, sheep, rabbit, dog, cat, etc. Wild birds in this area are turtledove, sparrow, pigeon, wild duck, quail, etc, while domestic birds are chicken, duck and goose. There are no plants or animals under level II provincial special protection or above.

3.2 Water & soil loss and water & soil conservation

3.2.1 Existing water and soil Loss in project site

According to the Announcement on Major Controlled Zone of Water and Soil Loss by Hubei Municipal Government, the construction site is located at Qingjiang river basin, one of the eight major controlled zones in Hubei province. On the upper reaches of Qingjiang River, the resident population is quite dense, while the water ands oil loss is relatively serious.

The water and soil conservation in Changyang County is mainly displayed in surface erosion and gully erosion with considerable landslides, collapse, collapsing hills. The total land area of Langping Town in the construction site is 531.3km^2, among which the area of water and soil loss is 225.9km^2, covering 45% of total land area. The water and soil loss has low intensity, moderate intensity and high intensity. Among the total area of water and soil loss, the low intensity loss area is 55.8km^2, covering 24.7% of total loss area; the medium intensity loss area is 9km^2, covering 48.3% of total loss area; the heavy intensity loss area is 48.3km^2, covering total 20.5% of total loss area; the extreme high intensity loss area is 9km^2, covering 4% of total loss area; the violent intensity loss area is 5.9km^2, covering 2.6% of total loss area. The total annual water and soil loss is 1,005,000t. The large water soil loss results in scouring of surface soil in the field and rich soils are scoured, which has direct impact on agricultural production, leading to less output with more agricultural input.

In the project construction area, the water and soil loss is mainly caused by artificial excessive forest destroy and timber cutting in forests, which leads to barren mountains. Large area of cultivating in mountain slope, as well as excessive earth rock excavations from house building, quarrying, mining and road building as well as disordered piling of waste residue, seriously damages surface vegetation, lowers forest retaining and increases water and soil loss on slopes. Mountain landslide and other natural factors also lead to water and soil loss.

3.2.2 Existing water and soil conservation in project site

The vegetation on upstream of dam site in project site is improving in recent years. Some terrace and cultivated lands are distributed at both banks in the area, and there are also some scattered slope cultivated lands in mountains. The water and soil loss in this area is mainly caused by cultivating, road building and project construction; the soil erosion

modulus is about 2584t/km^2.

The controlled water and soil loss in the project site is 2024.4 hectare, among which basic farmland is 198.2 hectare, water conservation forest is 200.7 hectare, non-wood forest 168.2 hectare, and forest conservation area is 754.6 hectare.

3.3 Social environment

3.3.1 Social economic condition of Changyang County

(1) Existing Social economic condition

The natural land area of the whole Changyang County is 3430 km^2, which is home to 400800 persons including 355100 agricultural population from 127483 households divided into 992 villager groups of 154 villages in 11 towns. Changyang County has population of multi-nationality, among which the most population belongs to Tujia nationality and the second is the Han nationality. Agriculture is the basic industry of Changyang County. The total agricultural output of the country is RMB0.871 with farmer's net income per capita of RMB1809. The GDP of Changyang County is RMB2.619 billion.

(2) Industrial distribution

Through painful experience of marketing economy and restructuring reform, the economy of Changyang County sees its new vitality and energy with increasingly enlarged general enterprise scale and strengthened general industrial economic power. The industrial increase amounts to RMB1.36 billion at average annual increase rate of 8.1%. The industry contribution rate in economic development is rising to 7.6%, with industrial profit of RMB11.72million and industrial economic profit composite index of 97.3%.

The county has low industrialization rate with agricultural increase reaches 19.3% of GDP, which is 4.3% higher compared to the international standard of 15%. The farm employment covers 64.9% of total employment, which is 44.9% higher than the international standard of 20%. The urban population rate is13.8%, which is 46.2% lower compared to the international standard of 60%.

(3) Agricultural development

Changyang County mainly focuses on increasing income of farmers by putting

agriculture development and agricultural economy first by completing family based contracted responsibility system, developing market economy, strengthening social service system, optimizing agricultural industrial structure and agricultural product structure, stabilizing food production and emphasizing production multiple cash crops. The county develops large area mountain non-pollution vegetable without reducing food production. The agricultural products are sold to various cities throughout the country, which brings great economic benefit to farmers. The average net income of farmers per capita is RMB1809 and the average living expense per capita is RMB1263 by annual increase of 6.0%.

By adhering to market orientation, Changyang County uses resource advantage in structure adjustment. It reinforces industrialization by developing six featured industries including vegetables, fruits, medical materials, tea, goats and Qingjiang fish, which has obtained great achievement. At present, the county has developed 106mu greenhouse vegetables, 3068mu orange fields, 533mu clonal tea gardens, 8119mu medical material field, 2070mu pasture, 3708 mu improved orange & tangerine fields, 2477 improved tea garden and 63900 goats. Based on the featured industry, the county mainly supports the development of leading enterprise such as Yishui Natural Pigment Factory, Qingjiang Alcohol Factory, Mushroom Processing Factory, Lamb Processing Factory, Big Qingjiang Company, Qingjiang Ponkan Company and Qingjiang Whitebait Company. A non-pollution agricultural product processing park is being established in Langping, Hejiaping as well as other villages and towns.

(4) Existing regional power system

Up to the end of 2002, Changyang has established 3 transformer substation of 110kv, i.e. Jinyangkou transformer substation, Taoshan transformer substation, Gaojiayan transformer substation, whose capacity is 2×20000kVA, 1×16000+1×6300kVA and 1×16000kVA respectively. There also established 9 transformer substations of 35KV, namely the Baishiping transformer substation, Moshi transformer substation, Dayan transformer substation, Zhuangxi transformer substation, Yazikou transformer substation, Huoshaoping transformer substation, Leyuan transformer substation, Hejiaping transformer substation and Langping transformer substation.

The transformer substations are divided into two groups according to its regions, the Qingjiang region and Houhe region. In the Qingjiang region, there are Qingtaoxian transformer substation and Taoshan transformer substation, which is mainly responsible for transforming power electricity from west to east. These two transformer substation are established in 1980s. By considering the Hongyao power station in the network, the designed wire diameter is quite narrow and the designed transformer capacity is small, which is now providing electricity for west of half Changyang County. Taoshan transformer substation is a formal transformer substation; however, with its outdated facilities and simple wiring, it is hard to meet the increasingly developing power demand of industrial and agricultural development as well as the main power development. In the Houhe area, there are only 3 transformer substations, the 110KV Gaojiayan transformer substation established in 2003, the Hejiaping transformer substation and Langping transformer substation established in early 1980s, which are all simple transformer substations with old facilities, inadequate transformer capacities and high facility maintenance rate. The Hejiaping transformer substation is established at the end of Gaojiu cable while the Langping transformer substation is established at the end of Taolang cable. The cable is long with small diameter. At the same time, there is no other connecting cable between the two transformer substations, thus there is no looped power network and the power supply stability is low. The Changyang power network has the following obvious problems: first, the structure of the power network is not reasonable since the 110K major network is fragile; second, the transform capacity of the existing power network can not satisfy the increasingly developed load; third, the transform capacity of the existing power network can not meet the requirements of main power development; fourth, the operation mode is not flexible and power failure in half county often occurs; fifth, the comprehensive automation of the transformer substation is low.

With start of three major projects including Lurong Highway (part in west Hubei), Yiwan Railway and Zhonghan Natural Gas Pipeline, the planned 110KV Hejiaping transformer substation and 110KV Langping transformer substation will be finished one after the other and put into operation.

3.3.2 Social and economic condition of project site

The location of Changyang hydropower station is governed by Langping Town, which is home to 11606 households of 88 villager groups in 12 villages. The total population is 41882, including agricultural population of 39650, countryside labor force of 21361 persons, with natural population increase rate of -0.52‰. The land area is 531.3km^2, among which the cultivated land area is 4817hm^2. The river basin mainly develops agriculture by growing multiple cash crops such as dry fruits, medical material and so on. The total food production is 15700t, the total agricultural output is RMB0.121billion, and the average net income of farmers per capita is RMB1662. The industries there include coal industry, hydropower industry and vintage industry with total industrial output of RMB 490 billion.

Langping Town is located in the western border area of Changyang County, like a western door of Yichang City. Changyang Tujia Autonomous County governed by Langping Town, is a poverty county with many old people and children, mountain areas, reservoirs and poor financial condition. It governs 11 towns of 154 villages, including 127483 households of 992 village groups. Among the total population of 410793, the agricultural population is 355133 and the countryside labor is 197303 persons with natural population increase rate of -0.71‰. The land area is 3430km^{2,} among which the cultivated land area is 32787hm^2. The total food production in Changyang is 151800t, the agricultural output is RMB0.871 billion and the net income of farmers per capita is RMB1809. The GDP of Changyang reaches RMB2.619 billion with average annual increase rate of 5%.

3.3.3 Population health and main diseases

There are town hospitals, county clinics and village clinics in the counties and towns that the reservoir area of Changyang hydropower station is situated. According to the information provided by health and epidemic prevention offices of Changyang Tujia Autonomous County, the infectious diseases and verminosis occurred in recent years are mainly hepatitis, diarrhea and phthisis, while influenza, leptospirosis and hemorrhagic fever occur sporadically

There is no natural epidemic focused disease near the construction site of Changyang hydropower project.

3.4 Exiting environment quality and assessment

3.4.1 Existing environmental air quality and assessment

(1) Layout of monitoring station

In order to get find out the existing environmental air quality of the project construction area, the environmental monitoring station of Changyang Tujia Autonomous County monitors the environmental air quality of the above area for 5 successive days from August 1st 2004 to August 5th, 2004.

Based on climate features, environmental sensitive site and valley strike, three monitoring sites are set up near the dam and the power house. See attached figure 8 for detailed location. See table 3-3 for names and functions of each site.

Table 3-3 Monitoring Station Layout

No.	Monitoring station location	Relative distance (m)	Location and function
1	Dam site	50	At dam site
2	Overflow gravity dam below cofferdam	400	North to dam site, wind direction monitoring point below dam site
3	Lengshuiqiao, close to 318 National Highway	100	South east to power house, background monitoring point at power house

(2) Items and measures of monitor

The monitoring factors of environmental air quality are sulfur dioxide, nitrogen dioxide and total suspension particles. The sampling and analyzing are done in a way required by the State Ministry of Environmental Protection. The sampling points and sampling height are chosen as required in accordance with the Technical Specification for Environmental Monitoring-Atmosphere. See table 3-4 for methods of sampling and analysis

Table 3-4 Sampling and Analyzing Methods for Environmental Air Pollutants

Pollutant	Monitoring period per day	Sampling measure	Sampling instrument	Analyzing measure	Analyzing instrument	Reference standard
TSP	≥12h	Membrane filter	Intelligent large capacity sampling instrument for	Gravity method	TG328A analysis	GB3095-1996 GB/T15432-95

		concentration	total suspension particles TH-1000C		scale	
SO_2	≥18h	Liquid absorption	Microcomputer sampling instrument for average daily air pollution concentration TH-3000A	Mercury salts tetrachloride-saniline hydrochloride spectropthotometric method	721(B) spectrophotometer	GB3095-1996 GB8970-88
NO_2	≥18h	Liquid absorption	Microcomputer sampling instrument for average daily air pollution concentration TH-3000A	Naphthyl ethylenediamine dihydrochloride colorimetry	721(B) spectrophotometer	GB/T15435-95

(3) Monitoring result and assessment

The environmental air quality monitoring obtains 45 effective daily averages, among which there are 15 data for SO_2, NO_2 and TSP. See table 3-5 for statistic analysis of monitored results in two points.

Table 3-5 Environmental air quality result

item		1# dam site	2# Overflow gravity dam below cofferdam	3#Lengshuiqiao near 318 National Highway
SO_2	Range of daily average (mg/m^3)	0.001-0.020	0.001-0.023	0.001-0.013
	Success rate (%)	100	100	100
	Max exceeded times (time)	0	0	0
NO_2	Range of daily average (mg/m^3)	0.001-0.012	0.001-0.010	0.001-0.013
	Success rate (%)	100	100	100
	Max exceeded times (time)	0	0	0
TSP	Range of daily average (mg/m^3)	0.028-0.032	0.030-0.034	0.028-0.038
	Success rate (%)	100	100	100
	Max exceeded times (time)	0	0	0

According the assessment on monitoring results, the monitoring range of SO_2 daily average is 0.001-0.020mg/m^3, 0.001-0.023mg/m^3, and 0.001-0.013mg/m^3 respectively at dam site, overflow gravity dam below cofferdam and Lengshuiqiao 318 National

Highway, all of which meet the daily average concentration limit of 0.15mg/m^3 in the Environmental Air Quality Standard level II; the monitoring range of NO_2 daily average is 0.001-0.012mg/m^3, 0.001-0.010mg/m^3mg/m^3, and 0.001-0.013mg/m^3 respectively at dam site, overflow gravity dam below cofferdam and Lengshuiqiao 318 National Highway, all of which meet the daily average concentration limit of 0.12mg/m^3 in the Environmental Air Quality Standard level II; the monitoring range of TSP daily average is 0.028-0.032mg/m^3, 0.030-0.034mg/m^3, and 0.028-0.038mg/m^3respectively at dam site, overflow gravity dam below cofferdam and Lengshuiqiao 318 National Highway, all of which is lower than the daily average concentration limit of 0.3mg/m^3 in the Environmental Air Quality Standard level II. In general, the environmental control quality at the dam and power house of the project site is quite good.

3.4.2 Existing surface aquatic environment quality monitoring and assessment

(1) Layout of monitoring face

In order to master the existing quality of pollutant taking water, the monitoring station at Changyang Tujia Autonomous County monitored the water quality in the reservoir river. Since there is no sewage drainage upstream and downstream of Changfeng Dam site, a monitoring face is set up on the upstream and downstream of planned dam site. Each monitoring face has a sampling point.

See attached figure 9 for specific locations of each faces and see table 3-6 for name and functions of each point

Table 3-6 Layout of water quality monitoring faces

No. of monitoring face	Face name	Relative distance	Face function
1#	Near the resident area to be moved	About 800m from upstream of dam site	Comparison face
2#	Overflow gravity dam below cofferdam	About 400m from downstream of dam site	Controlled face

(2) Monitoring items and analyzing methods

Based on the main pollutant in wastewater of project construction, the eight monitoring items for existing water quality are PH value, water temperature, SS, DO. permanganic acid index, BOD5, ammonia-nitrogen and total phosphor.

The item analysis is made according to the standard methods in Environmental Quality Standard for Surface Water (GB3838-2002)

(3) Time and frequency of monitoring

On July 28th, 2004, we sample once on two faces

(4) Monitoring result and assessment

Through the monitoring, we obtained 16 effective monitored data for 8 items. See table 3-7 for statistic result of monitoring.

From the statistic result of monitoring in table 3-7, we can see that 8 items (except that there is no standard for SS) monitored from two faces meet the water quality standard for surface water level III and the water quality of Ganhe creek in construction area is quite good.

Table 3-7 Statistic result for environmental quality monitoring of surface water

face	index	Pollutant concentration (mg/L, except for PH value)						
		PH value	SS	DO	NH_3-N	permanganic acid index	BOD_5	Total phosphor
Near 1# resident area to be moved	Value range	7.86-7.98	2.5 *	9.50-11.6	0.038-0.055	0.76-1.24	0.82-1.08	0.01 *
	Actual achievement	II	/	II	II	II	II	II
2#Overflow gravity dam below cofferdam	Value range	7.85-8.00	2.5 *	9.70-11.7	0.026-0.052	0.72-1.23	0.78-1.13	0.01 *
	实际达标 Actual achievement	II	/	II	II	II	II	II
Water quality standard level II GB3838-2002		6-9	/	≥6	≤0.5	≤4	≤3	0.1 (lake reservoir 0.025)

Note: temperature index is not included, * indicates the half of the detection limit.

3.4.3 Existing noise monitoring and assessment

(1) Monitoring introduction

In order to find out the existing noise environment in the area, our institute entrust Environmental Monitoring Station of Changyang Tujia Autonomous County to monitor the

regional noise environment in the dam site and power house area of the project on July 28th, 2004. Though there are resident houses near the power house, it keeps the original ecological environment in the dam site and power house area. Therefore only 2 representative monitoring points are set up in the above site respectively. One monitoring point at dam site is at 10m near the river while another monitoring point is at 50m near the river. One monitoring point at power house is in front of the Lengshuiqiao Restaurant on the east of planed power house while another point is near the 318 National Highway on the north of the planned power house.

(2) Monitoring period

Both daytime and nighttime noise environments are conducted. The daytime monitoring period is 8：00-20：00, while the nighttime monitoring period is from 23:00 to 6:00 in the next day.

(3) Monitoring result and assessment

4 data for equivalent noise monitoring are obtained through the monitoring. See table 3-8 for monitoring results.

Table 3-8 Monitoring results of noise environment

No. and name of monitoring point	Monitoring period	Equivalent sound level	Assessment standard level	Assessment standard value	Standard achieving or exceeding	Main effective factors
1＃ dam site, 10m from the river	Daytime	48.0	1	55	Achieve the standard	running water
	Nighttime	46.0		45	Not achieve the Standard	Running water
2# dam site, 50m from the river	Daytime	47.0	1	55	Achieve the standard	Background value
	Nighttime	42.0		45	Achieve the standard	Background value
3# powerhouse, Lengshuiqiao restaurant	Daytime	48.9	1	55	Achieve the standard	Background value
	Nighttime	42.5		45	Achieve the standard	Background value
4# powerhouse,	Daytime	56.8	4	70	Achieve the standard	Background value

near 318 National Highway	Nighttime	48.6		55	Achieve the standard	Background value

Based on the monitoring results in table 3-8, the assessment is made according to Standard of Environmental Noise of Urban Area (GB3096-93). Due to the running water, at the dam site 10m from the river, the background noise is high, which achieves the standard at daytime while the equivalent sound level at nighttime exceeds relative standard value limit. At the dam site 50m from the river, it is less effected by running water, where the equivalent sound levels of background noise at daytime and nighttime falls in 42-45dB(A), which meet the relative standard value limit of 55dB(A) and 45dB(A) for daytime and nighttime respectively. At the powerhouse near 318 National Highway, there is resident houses and resident activity area with small traffic flow, where the daytime and nighttime noise meets the standard value limit of 70dB (A) and 55dB (A) respectively.

The dam site situated in remote mountains or between valleys is less effected by the outside. Without considering the effective factors of running water, insects and twittering, the planed site has good acoustic environment; the powerhouse is not developed with rather small crowd and traffic flow and quite good regional acoustic environment.

3.4.4 Assessment on existing ecological environment quality

3.4.4.1 Complete background assessment on natural ecological system

(1) Background production capacity of natural system

The net primary productivity of natural vegetation reflects the production capacity of the plant community in natural environment, that is, the production capacity of the natural system without any external artificial disturbance. By Comparing with many ecological matrixes and referring to the eco-physiological features of plants and thermal water balance equation, the comprehensive net primary productivity matrix of natural vegetation is established based on the measured data. Compared to other matrixes, this matrix better reflects the primary productivity of natural vegetation. The calculation formula of the matrix is as follows:

$$NPP = RDI^2 \cdot \frac{r \cdot (1 + RDI + RDI^2)}{(1 + RDI) \cdot (1 + RDI)} \times Exp\left(-\sqrt{9.87 + 6.25RDI}\right)$$

$$RDI=(0.629+0.237PER - 0.00313PER^2)^2$$

$$PER=PET/r=BT\times 58.93/r$$

$$BT=\sum t/365 \text{ 或 } \sum T/12$$

In the formula: RDI-radiation dry index

r-annual rainfall, mm

NPP-natural veneration net primary productivity, t/(hm^2·a),

PER- possible evaporation rate

PET – annual possible evaporation rate, mm,

BT – average annual biological temperature, □,

t – Daily average between 0□ and 30□

T – Monthly average between 0□ and 30□

Based on the measured hydrological and weather information of Changyang County and the river basin, the average annual air temperature of the area is 16.6□, the average annual rainfall in the controlled area of Changfeng reservoir is 1425.3mm. After calculated and analyzed through the above matrix, the background net primary productivity of natural vegetation in the assessed area is 3.16g/m^2·d, which is quite high.

(2) Stability of the natural system background

According to the calculated results, the productivity of the assessed area is 3.23g/m^2·d (1178.95g/m^2·a). Through comparing and analyzing the research result of net productivity of ecological systems on the earth and plant biomass, the average net productivity of the area is close to the average net productivity of temperate zone broad leaf forest (1200g/m^2·a) with high vegetation productivity and strong restoration stability of the system. The background restoration stability of the assessed area is quite high.

3.4.4.2 Existing ecological integrality of natural system

(1) Existing productivity of natural system

According to the site investigation and the existing surface vegetation coverage of the assessed area, the vegetation in this area is categorized into woodland, shrubbery, farmland vegetation and river shoal. Calculated according to the investigation result, the average net productivity of the area is 1024.5g/m^2·a or so, which is lower than the background value of 1178.95g/m^2·a. This shows that the vegetation in the area is disturbed and damaged by

human activity; however, the productivity of the natural system in this area is higher than the global productivity（720g/m^2·a） in general.

The comprehensive analysis shows that human activities has certain disturbance on the productivity of natural system in this area, however, the character of natural grade has not changed fundamentally and the natural system still has quite strong restoring and adjusting ability.

(2) Landscape Stability

□ Impedance stability of landscape

Due to severe disturbance from human being, the biological component heterogeneity is lower than background value. However, we see from the map of existing usable land in the area that the woodland section has better connectivity among various sections of landscape in the assessed area and appears more frequently, which shows that the vegetation type in the area is mainly the woodland. Thus, the natural ecological system has strong impedance stability.

□ Biological restorability of landscape

Though the vegetation primary productivity in this area is lower than its background value, it still maintains as transition ecological system between northern coniferous forest and temperate zone broadleaf forest, which show that the natural system in the area has strong biological restoring ability.

3.5 Main environmental problems

In the area and basin that the project is situated, there is no industrial enterprise, small population, less cultivated land, good vegetation, less usage of pesticide and chemical fertilizer. Therefore, the impact of environmental pollution is quite small. The main environmental problems of the project area are listed as follows:

(1) Water and soil loss: generally speaking, the vegetation coverage in the river basin is quite good, though there is natural landslide, landslip and debris avalanche in some area. As a rainstorm area, it has 4-5 rainstorms annually on average. Usually, rainstorms and floods occur in summer and autumn. Continuous rainstorms will lead to mountain flood,

which will cause severe water and soil loss, and even jeopardize residents and their property. Heavy rains and rainstorms often cause landslide, and the collapse of fields, roads and houses will ever cause casualties.

(2) Traffic Restriction

The dam site and the power house of the project is not far from the main traffic line nearby, which is only 3kmm away. However the main transportation depends on low level road in villages or mountain areas. The less developed traffic condition seriously restricts the development of regional economy, which also has some impact on project construction.

4 Prediction and assessment on environmental impact

4.1 Hydrology and sediment

The construction actives in the construction period of the project and the water

retention and diversion occurred in project operation have changed the natural characters of the water, which brings changes to the water level, flow rate, flow velocity as well as sediment scouring and deposition at assessed reservoir zone, downstream of dam site and river mouth, which has direct or indirect impact on the environment.

4.1.1. Hydrology

The project plans to built diversion tunnel from the dam site to power house of Changfeng hydropower station, the water intake and diversion tunnel at power house is at the right bank of the dam, which is about 100m away from the dam and the main tunnel is 5319.4m long. There are 5 adits along the tunnel and all together 10 working surfaces including the intake and outlet, which can be used for tunnel boring the same time. It has axial flow blower for ventilating and smoke exhausting, smooth blasting by artificial trolley or tractor. Due to the spanning watersheds diversion, it will certainly, to some extent, have impact on the runoff and water level of downstream of the diversion river basin.

Ganhe creek basin is a mountain-area river, where the flood is influenced by rainstorm intensity and landform. It has heavy intensity rainstorm in the basin, steep river slope, short flow concentration period, rapid flow rate and flash flood. The catchment area at upstream of the dam site of Changfeng hydropower project is 55.8km^2. When the reservoir starts reserving water in operation, the runoff into reservoir is natural flow, while the discharge runoff is related to the reservoir operation. In general, the annual runoff into reservoir and discharge runoff are basically balanced.

After finishing building the reservoir, the flow rate and velocity of the river in the reservoir zone will changes greatly. Due to the dam retention, the reservoir capacity is much larger than the original natural watercourse, thus the flow rate of the reservoir reach will be slower while the flow velocity and flow rate is related to the flood scale at that time. The average annual flow rate at the dam site of Changfeng hydropower project is 0.99m^3/s, and the average annual runoff is 31.3699 million m^3. The preliminary design does not consider the perennial discharge flow. Since there is a 2km long watercourse from the dam site to the outlet, a minimum discharge flow should be maintained during dry period in order to ensure that the ecological environment of the lower reaches will not have sudden change. In this circumstance, the hydrological environment of the lower reaches will not

have change a lot.

4.1.2 Sediment

There is no measurement data of sediment in Ganhe creek. We adopt the sediment data of Zhailai river hydropower project at the lower reaches, whose average suspended load sediment transport modulus is 488t/km^2. The suspended and transport sediment capacity is 1.3t/m^3 and 1.5t/m^3. The sediment detention rate estimated according to the reservoir capacity coefficient is 80% and the average sediment into reservoir is 14600 m^3.

According to No.4.7.4 of Design Code for Small Hydropower Station (GB50071-2002), the sediment deposition limit of the project is 20 years with sediment into reservoir of 292500 m^3, deposition height before dam site is 1093.4mnm, and reservoir sediment ratio higher than 30. Therefore the deposition of sediment into reservoir during reservoir operation can be ignored.

4.2 Local climate

When the reservoir is built and starts to store water, the reservoir area is 0.185km^2 (276.76mu). Since the original land is turning into water surface, the evaporation rate of the reservoir zone will be larger than before and the vapor into the air will increase, thus the humidity and temperature near the reservoir zone and its nearby area will change, which will cause changes to the small local climate.

(1) Rainfall

According to relevant research results, the reservoir has no obvious change to the precipitation of the area. It only has little change to the rainfall distribution. The annual rainfall and summer rainfall in the reservoir central area is less than before, while the rainfall in nearby area will increase. Since the reservoir river is rainstorm river, where summer rainstorm is quite frequent, small changes in rainfall has weak impact to the whole reservoir zone.

(2) Air temperature

When the reservoir starts to store water, the underlying surface of the reservoir area turned from land into water, the physical property of the underlying surface changes a lot. The natural watercourse is turned into relatively still water surface with higher water level,

larger water surface and larger water depth. The thermal exchange between the water in reservoir zone and the air changes, which lead to air temperature rise after water storage in reservoir zone. In addition the air temperature change will become moderate after water storage, while the daily temperature range and annual temperature range becomes smaller, the max annual air temperature get lower and the minimum annual air temperature rises. The above air temperature change is rather tiny.

(3) Humidity

After water storage of the project, the evaporation rate of the water surface increases and the reservoir humidity will be different compared with the condition before reservoir construction with increased average annual relative humidity. As regard to season distribution, the summer time is getting longer and winter is getting shorter, while spring and autumn sees little change.

(4) Wind

The planned construction project is a typical watercourse reservoir, the prevailing wind after reservoir construction has no obvious change due to major climate and landform conditions. The reservoir zone belongs to the weak wind area. Due to the temperature difference between water surface and land surface, the frequency of prevailing wind increase while the frequency of static wind decreases; smooth ground replaces the original uneven land with less roughness, which increases the surface wind velocity in reservoir zone.

(5) Fog

When the project is finished, the temperature rise in daytime and summer in reservoir zone, as well as the temperature fall in nighttime and in winter will be slower than that in the air and land. The above cooling & heating source function helps to form steam fog in winter and radiating fog in summer. In the meantime, due to the temperature, humidity and wind effect of the reservoir, the air temperature rise in winter and falls in summer; the humidity decreases in winter and increases in summer; the wind velocity in the whole year increases. These changed factors have some impact on fog, while the major factor of fog forming is air circulation. It is estimated that the construction and operation of the planed project will not change the fog.

4.3 Environmental geology

4.3.2 Leakage analysis

(1) Reservoir leakage

a. Leakage on right bank

The rocks on the right bank of reservoir are thick. The nearest valley to the reservoir is Qingyan creek of 5km away. The elevation of Qingyan creek valley is 540m, which is lower than the normal pool level of reservoir of 500m. From the reservoir zone investigation, there are two exposed spring on the right bank Q_1 and Q_2, and water in the small branches is running into the reservoir. The rocks of reservoir bank do not develop karst. We conclude through analysis that the groundwater near the watershed on the right bank is running into the reservoir zone. Based on outlet ZK6, the elevation of groundwater is 1082.4m, which is a litter higher than the river water level. It is estimated that the there is no karst groundwater low land on the right bank of reservoir. Therefore, it is concluded that there is no reservoir leakage on the right bank.

b. Leakage of left bank

The rocks on the left bank of reservoir are relatively thin. The nearest valley is only 2km away from the river valley of the branch of the main ditch in Xiufengqiao village. Since the reservoir bank stratum is limestone –shale of upper Shipai formation and limestone-shale of Shilongdong formation as well, which is aquiclude itself. From reservoir bank zone to the nearby valley, there is Dawan formation, which is better aquiclude. The strike of the stratum parallels with the reservoir bank, thus it is impossible for the left bank to leak into the near valley.

From the investigation result of land surface, there is a k_{W1}underground river doing into the reservoir. Other part of the reservoir has dry rocks and karst is not developed. No karst pipeline is found that connects the internal and external reservoir. The drilled hole exposes no strong karst area; the groundwater level in the drilled hole is much higher than the river water level. It is concluded that the left bank has no leakage either.

c. Leakage of reservoir bed

The reservoir bed is not wide, where the stratum is mostly limestone and shale of

upper Shibei formation of lower Cambrian system, as well as dolomitic limestone, limestone and shale of Shilongdong formation near dam site. There is a strong karst belt near two river mouths and some small karst caves in other parts. The geological and hydrological environment of the reservoir decides that the reservoir bed has no leakage problem.

d. Penetrability of dam monolith stratum

The rock mass of the dam monolith is complete. There is no strong karst in the land surface or any possibility for leakage along the karst pipeline to external reservoir. The shallow rock mass has developed joint fissure. The rock mass has weak to moderate penetrability and curtain grouting should be made to prevent leakage.

4.3.2. Stability analysis

The slope height of both valley banks is 300~600m with slope angle of 40~80° and rock stratum dip angle of 31~45°. There is no large scale unstable part and the general reservoir bank is quite stable. However the right bank slope near the dam monolith is not stable. It is made of rock fall karst deposition, which is loose and not bonded with thickness of 5-10m. With reservoir water storage, there is possibility of landslide near the immersion line. Though it has small impact on the reservoir, the swell due to landslide into reservoir has concern impact on the dam, which should be placed much attention.

(2) Karst

The stratum lithology of banks of reservoir zone, the Cambrian system on periphery and the Ordovician systemn which are mainly carbonates. These rocks develop karst. Relatively, the karst development in Honghuayuan formation and Najinguan formation of lower Ordovician system are strong while the karst development of Shibei and Shilongdong formation inside the reservoir basin are weak. The karst scale are different and has various shapes such as discharge tunnel, underground driver, blind valley, karst cave, karst hole, karst fissures, etc.

According to the survey, most visible surface karst caves are located above the reservoir water level and are dry caves. The biggest kasrt cave is Huangyangping karst cave, with 1430m cave entrance elevation, 30 wide, 12m high, 15m deep. In the cave, there is water year around and sandy loam. Near Huangyangping, there are many water

discharge caves and groundwater is deeply laid hidden in earth. These water discharge caves have elevation of about 1380~1450m. There is no big exposed spring on the northern (right) bank of reservoir, while there is a big exposed spring in Lengshuiqiao, with estimated flow rate of 90L/S, which has some hydraulic connection with ground water in Huangyangping. During level period, Huangyangping area will be dried up to be a blind valley.

Karst caves in the reservoir basin are small, from tens of centimeters to 1.5m, which are blind caves filled with clay and less connected to the nearby area. At the two river mouths, there is a 20m-wide-120m-long strong karst belt and karst fissures are developing along the stratum surface, or small karst caves are developed along vertical fissures with size of 5~15cm. The karst belt mainly has shallow development, which is less extended to nearby area and less connected to other karst caves. In summary, the stratum karst in the reservoir basin is not developed.

(3) Rock fall

The slope toe of the banks in dam zone has lot of colluvial deposits, which is several-meter-thick to over ten-meter-thick with small excavation volume. The natural slope angle is stable at present. With a free face formed after excavating dam foundation and the impact of previous blasting, there may has new unstable rock mass.

(4) Dam body stability analysis

The max dam height of the project is 58.8m, the designed upstream dam slope is 1：1.4while the downstream dam slope is 1：1.4. The deck rockfill dam is located at downstream water load. The whole rock-fill body and water gravity is resisting dam slide because the horizontal thrust of water load is about 1/8 of the rock-fill body while the water weight and the resultant forces of water load on dam axis is transmitting to the groundwork, which is good for stabilizing the dam slope. By using steel bar concrete leakage proof deck, the rock-fill body is hardly affected by penetrability. If there is any leakage in the deck, the leakage can be discharged out of the dam since the rock-fill body has good penetrabitliy, which will not affect the stability of the dam. The 1:1.4 dam slope is equivalent to slope angle of 35°32′, which is smaller than the natural repose angle (about 37°) of loose fill and

much smaller than the internal friction angle of roller compacted rock-fill body. Therefore, the deck rock-fill dam has good integral stability.

(5) Reservoir induced earthquake

The total reservoir capacity of the project is 4.001million m^3, which is a small reservoir. The reservoir is situated at stable-structure area without large fault or active fault going through the reservoir zone. The water storage in the reservoir will not lead to structure induced earthquake. However, due to regional karst developed in carbonate terrane in the reservoir zone, the reservoir water infiltration may result in deep circulation of groundwater. This may induce earthquake with weak intensity.

4.4 Estimation (analysis) and assessment on aquatic environmental impact

4.4.1 Pollutant analysis

(1) Agricultural pollutant

According to the survey, there are Wenjiaping village, Xiufengqiao village and Bajiaomiao village near the reservoir zone with total cultivated land area of 18616mu in 2003 while the 5500mu land area is involved in the reservoir project. The chemical fertilizer amount applied per area differs little with average application volume of 30kg/mu or so. Restricted by the traffic condition and cultivation in the planed project area, the actual fertilizer application is lower than average. Based on the average volume, the fertilizer application in the reservoir zone should be 165t/a. It is calculated by the application proportion of nitrogenous fertilizer and phosphorous fertilizer, the nitrogenous fertilizer applied is about 100t/a while the phosphorous fertilizer is about 50t/a.

According to the statistics, the fertilized in Wenjiaping village, Xiufengqiao village and Bajiaomiao village in past five years changes little. The land area will not change much as well. Therefore, when the reservoir is built, it can be predicted that the chemical fertilizer application in 2010 can be decided based on the application volume in 2003. Meanwhile, the average total soil loss in the reservoir zone is 17800 m^3 according to the preliminary design report. In this assessment, the nitrogen loss and phosphor loss due to

soil loss is considered at 10%.

Method of estimation: it is calculated according to the estimation equation for soil nutrition loss provided by Code for Environmental Impact Assessment of Water Conservancy and Hydropower Project (On trial) (SDJ88 - 2003), namely:

$$E = aS_{Np}+bcdF_{Np}$$

In the equation:

E – Estimated total soil nitrogen and phosphor loss into the reservoir, t/a

S_{NP} - total nitrogen and phosphor into water and soil, total soil into reservoir multiply total nitrogen and total phosphor;

a - Longitudinal consumption coefficient of nitrogen and phosphor, Nitrogen70%, phosphor 95%, the nitrogen into water is 30%, while the phosphor into water is 5%;

F_{NP} - Fertilizer application

b - average nitrogen and phosphor amount in chemical fertilizer, standard average nitrogen amount in fertilizer is 23% and standard average phosphor amount is 15%;

c - fertilizer utilization rate of crops, nitrogen 30% and phosphor 15%, the 70% nitrogen and 85% phosphor are discharged into water

d - fertilizer loss rate after discharged into soil and water, nitrogen 30%, phosphor 5%.

Based above calculation, total nitrogen and phosphor brought into to the reservoir through farming in 2010 is 10.97t/a and 3.55t/a respectively.

The farmland runoff pollution load is not only affected by rainfall, landform, soil and other natural factors but also the number and transferring process of land surface pollutant. Through comparison with the research result of farmland runoff pollution in the three-gorge area, it is preliminarily estimated that the discharge of runoff pollutant COD and BOD_5 in farmland surface of Ganhe creek reservoir zone in 2010 is about 187.8t/a and 76.2t/a respectively.

(2) Domestic pollution source

According to the survey, it is sparsely populated in the reservoir zone. The back water zone and upper reaches of reservoir involves Maping village, Zilangping village and Sheping village. There is no enterprise of industrial pollution in the villages. The total resident population of the villages is 9909 persons in 3023 households, among whom about 1980 persons in 600 households are draining their domestic sewerage into Ganhe creek. The drained domestic sewerage is the main domestic pollutant in reservoir zone. The estimated drained domestic sewerage is calculated by following equation:

$$X_t = L_t Y_0 (1+\mu)^{t-t_0}$$

In the equation: X_2—estimated sewerage drainage in level year (t/a);

L_t – sewerage drainage per capita (t/a);

Y_0 – population in benchmark year

μ- population growth rate (‰).

Referring to the design code for outdoor drainage, the domestic sewerage per capita is calculated as 150L/d per capita, the main pollutants COD, BOD_5, T-P and T-N are calculated according to the regular drainage concentration of domestic sewerage of 400mg/L, 200mg/L、 2.0mg/L and 25mg/L respectively. It is estimated that the domestic sewerage drainage in 2010 is about 108400 t/a and the drainage of main pollutants COD, BOD_5, T-P and T-N is 43.36t/a, 21.68t/a, 0.22t/a and 2.71t/a respectively.

4.4.2 Estimation and assessment of reservoir water quality

4.4.2.1. General water quality of reservoir

(1) Preliminary stage of water storage

During the preliminary stage of water storage in reservoir, various organics are released from inundated land and vegetation. The dripped and decomposed organics will cause some adverse impact on the reservoir water quality. The monitored data from reservoirs at home and abroad shows that the dissolved oxygen, mineralization, nutrition and plant growth in the water are related to the water-retaining-level of the reservoir. Changfeng hydropower project has 0.163km^2 reservoir area with smaller inundation area. Meanwhile, sanitary cleaning is made in the reservoir bed before water storage, which reduces the quantity of organics in the reservoir. The impact from various dripped and

decomposed organics in the inundated land after reservoir water storage is also reduced and the impact on the reservoir water quality is small.

(2) Normal reservoir operation period

During the normal operation period of Changfeng hydropower project, the main pollutants in the reservoir consists of background values of upstream river, domestic sewerage from upstream villages and farmland runoff near the reservoir zone. The general water quality during reservoir operation period is estimated by zero- dimension-matrix.

The matrix of estimation:

$$C_{(t)} = \frac{W_0}{K_h V} + \left(C_h - \frac{W_0}{K_h V} \right) \exp(-K_h t)$$

$$K_h = \frac{Q}{V} + K$$

In the equation: C(t) - pollutant concentration in calculating period, mg/L;

W_0 - rate of pollutant into reservoir, g/s;

K_h - intermediate variable, s^{-1};

V - reservoir capacity, m^3

Q - reservoir discharge rate, m^3/s;

K - comprehensive pollutant decontamination factor, s^{-1};

C_0 - Existing reservoir pollutant concentration, mg/L.

Taking BOD_5 as estimation factor and other item are used in qualitative analysis. The estimated average BOD_5 concentration after water storage in 2010 is listed in table 4-1.

Table 4-1 Estimated average concentration of main pollutant BOD_5 in Changfeng hydropower project in 2010

Calculation period	Calculation period t (s)		
	1	1000	3600
Result of estimation	0.018	0.018	0.016

From the estimated result, the average concentration of BOD_5 in reservoir zone in the level year of 2010 meets the level II water standard in Environmental Quality Standard for

Surface Water (GB3838-2002) .

It can be concluded that the hydrological change caused by water storage during reservoir operation of Changfeng hydropower project will not lead to any obvious adverse impact on the general reservoir water quality. The reservoir water will maintain its original quality in general.

(3) Estimation and assessment on reservoir eutrophication

The Dillon Matrix

$$[P]=\frac{L(1-R)}{H\rho_{\omega}}$$

In the equation: P—nitrogen and phosphor concentration of reservoir, mg/l ;

L—nitrogen and phosphor load into reservoir, g/m^2·a;

H—average water depth of reservoir, m.

$$\rho_{\omega}=\frac{Q}{V}$$

In the equation:

Q—annual flow into reservoir, m^3/a;

V—reservoir capacity, m^3;

R = 0.246exp(-0.271Qi)+0.574exp(-0.00949Qi)

In the equation: Qi—hydraulic load , Qi = Q/A , m/a ;

A —reservoir water area, m^2.

We work out that the nitrogen and phosphor load (L) after reservoir construction is 67.3g/m^2·a and 21.8g/m^2·a respectively. The above result does not take into account the water and soil loss due to land inundation or reduced artificial control as well as fertilizer application. The nitrogen and phosphor into reservoir are calculated based on present data of the nitrogen and phosphor into river. The calculation results of estimated parameters are listed in table 4-2.

Table 4-2 Estimated parameters of reservoir eutrophication of Changfeng hydropower project

Item	Q (m^3/a)	V (m^3)	A (m^2)	H (m)	ρ_{ω}	Qi (m/a)	R

Reference value	0.3122×10^8	0.04001×10^8	0.185×10^6	34	7.8	168.8	0.1157

The estimation level year is 2010. From the above matrix and parameters, we work out the total nitrogen concentration and total phosphor concentration of reservoir water is 0.0254mg/l and 0.0078mg/l respectively.

In the eutrophication of lakes and reservoirs, the eutrophic elements are the main control factors. According the AGP measurement in Lake Eutrophication Investigation Standard (2nd version), it is found that most lakes are phosphor restricting while some are nitrogen restricted lakes. There is no domestic standard for lake eutrophication. In this assessment, the eutrophication after reservoir construction of Changyang hydropower project is assessed by referring to some domestic standard for lake eutrophication. See table 4-3 for detailed standard.

Table 4-3 Domestic standard for reservoir eutrophication unit: mg/L

Type of nutrition	Main water quality index		Index of Tahu Lake		Index of Lake Eutrophication Investigation Standard	
	Total nitrogen	Total phosphor	Total nitrogen	Total phosphor	Total nitrogen	Total phosphor
oligotrophic					< 0.25	< 0.02
Oligotrophic-mesotrophic	0.2~0.4	0.005~0.01	0.16	0.01	0.16	0.01
Mesotrophic	0.3~0.65	0.01~0.03	0.31	0.023	0.310	0.023
Mesotrophic -eutrophic	0.5~1.5	0.03~0.10	0.65	0.050	0.650	0.05
Eutrophic	> 1.5	>0.10	1.20	0.110	1.20	0.11

According to the assessment result of the report, the quality index of water upstream the dam site meets Environmental Quality Standard for Surface Water (GB3838-2002) level II.

It can be concluded from table 4-3 that the reservoir water quality after construction of Changfeng hydropower project is oligotrophic. From the dam site to reservoir zone, the area along the river is sparsely populated, the existing upstream pollutant load is limited and water exchange is frequent, thus the eutrophication is less possible though the water depth is increased and the flow rate is lowered. It is concluded that under the existing trophic condition, the general water qualify of Changfeng hydropower project will not developing into eutrophication.

(4) Water quality analysis and assessment on downstream face of dam

The landform and geomorphy of upper reaches from dam site of Changfeng hydropower project to river mouth is similar to that of the upstream of dam, which is sparsely populated with no domestic drinking water intake or sewerage drainage outlet. The runoff regulation on the lower reaches of dam through reservoir operation and the water quality of discharge water are the main factors that effects the water quality of lower reaches of dam.

 Analysis on water quality change in flood season

For the flood protection requirement of Changfeng hydropower project, its task is to ensure the safety of the dam and the normal operation of power house. The limiting level during flood season is the normal pool level of reservoir. If the flood retarding exceeds the pool level, all gates will be opened for flood discharge. The impact on hydrological condition of lower reaches of the dam is small as compared with the original condition of natural watercourse. With reservoir sediment, the quality of discharged water is better than natural water condition, which helps to improve the water qualify of lower reaches of the dam. According to the analysis on the operation of other reservoirs, the reservoir operation in flood season only has small impact the water quality of downstream of the dam.

 Analysis on water quality change in non-flood season

By referring to the average annual flow in other hydropower projects, the water discharge of reservoir regulating operation is compared with natural water inflow. The reservoir starts retaining water after flood season. The water discharge is less than natural water inflow and the water discharge in dry season does not exceed the natural water inflow.

The reservoir water storage after flood season, the dam water discharge is less than the natural water discharge. Analyzing from the capacity of aquatic environment, it is larger when the flow is large. Since the flow after flood season is smaller than the natural water flow, which has some impact on the aquatic environment of the lower reaches of the dam. However the flow after flood season will not be smaller than the capacity of aquatic environment in dry season. Therefore, there is no obvious impact on the water quality of this reaches.

4.4.3 Reservoir water temperature estimation

Reservoir temperature is a major index of aquatic environment. The fishes in the country are mainly warm-water fishes. The appropriate water temperature for warm-water fish growth and breeding is 15 - 30□. The water temperature change in downstream reservoir will have certain impact on the aquatic organism in downstream of dam. The water temperature is closely related to water quality, which has obvious influence on indexes such as DO, BOD_5, COD and fecal coliform. Water temperature is also the necessary data of researching and monitoring the water leakage and permeating in concrete dam. Therefore, researching and analyzing the reservoir water temperature important for the comprehensive utilization of water, water quality protection and fully displaying the reservoir benefit.

(1) Structure of reservoir water temperature

When the reservoir starts water storage in operation, the water temperature will change as a hydrological factor showing thermal condition. The distribution of reservoir water temperature is influenced by many factors including solar radiation, reservoir capacity, reservoir water inflow and outflow, water temperature, shape of reservoir, sediment, reservoir regulating methods and so on.

To see if the reservoir water temperature is stratified due to water retarding, two methods can be applied: judge from the number of reservoir water exchange α and the ratio between one flood discharge and actual reservoir capacity β; or judge by Ford density index Fd. , At the preliminary stage Three-gorges project constriction, Changjiang Water Resources Protection Institute(CWRPI) has researched on this. The institute has conducted complete research on reservoir water temperature effect in its national major scientific task of Water Temperature Estimation of Three-Gorges Hydropower Project. The water temperature in the reservoir changes with water depth. Usually reservoirs are divided into thermal mixed, thermal stratified and thermal transition. See table 4-4.

Table 4-4 Judgment of reservoir water temperature α

α value	Type of reservoir water temperature
< 10	thermal stratified reservoir
> 20	Thermal mixed reservoir

10~20	Thermal transition reservoir

- Thermal mixed reservoir: the water temperature is distributed evenly in the reservoir at any time with small gradient.
- Thermal stratified reservoir: in temperature rising period, the water temperature of reservoir surface is obviously higher than that of middle and lower level of reservoir water temperature with gradient above 1.5□/m. The annual difference of water temperature in reservoir bed is within 15□。
- Thermal transition reservoir: the water temperature in this reservoir features both the thermal mixture reservoir and thermal stratified reservoir.

(2) Type and impact of reservoir water temperature

This assessment adopts factorαto assess the structure of reservoir water temperature of Changfeng hydropower project. The factor αis quite simple, which is checked by reservoirs with measured water temperature data. The result of the above method is basically same as the actual data. Its equation is listed below:

α=average annual runoff/total reservoir capacity

The α value of Changfeng hydropower project is 7.8（<10）, which shows that the structure of reservoir water temperature is typically thermal stratified. Since there is obvious seasonal flow and flood flow in Ganhe creek, the flood in this river basin is mainly caused by heavy rain which usually occurs in May-August. The flood rise and fall violently in short period with large flow. After building the reservoir, the water is relatively static, thus its thermal storage is better than river, and its surface water temperature is higher than that of natural rivers. According to measured data from the branch reservoir in the Gezhouba Dam, the temperature of water inflow in temperature rise period will rise as well as the surface water temperature along the reservoir; the surface temperature of water inflow in reservoir tail is similar to that of natural rivers; the surface temperature of water inflow in reservoir and dam front in winter is similar to that of natural watercourse, while it is different in spring, summer and autumn; the surface temperature in general reservoir is about 2□ higher than that of natural watercourse, while the temperature of reservoir bed is similar to that of surface water temperature.

(3) Temperature analysis on reservoir water discharge

The temperature of reservoir water discharge is related to many factors such as the location of reservoir water outlet, reservoir water flow rate, inflow water temperature and local air temperature at that time. Based on the measured data of Xinanjiang reservoir and Danjiangkou reservoir in China, the watercourse temperature below the dam is well related to the reservoir water temperature in certain depth, which should be 15~20m in the reservoir. The water temperature difference in the reservoir of Changfeng hydropower project is small. Therefore, the outflow water temperature differs little with that of natural rives at the same time.

Based on the investigation, the water flow in the reaches is rapid with no large spawn area of commercial fishes and precious fishes, no demand for production water and domestic water, and no demand for irrigation as well. Therefore, it has no adverse impact on the fish growth and breeding, water quality and aquatic organism at downstream face of dam, and farmland irrigation.

4.5 Analysis and assessment on ecological environmental impact

The impact on ecological environment by hydropower project features obviously. During the construction period of the project, it mainly causes unfavorable impacts on the ecological environment, while during operation period; it has multiple impacts on the ecological environment. Its unfavorable impacts includes: possible reduction of biomass and bio-system change due to reservoir inundation. Its favorable impacts includes: developing small hydropower station can change villagers' bad habit of using firewood and lowers the possibility of reducing wildlife habitat due to villagers' wood cutting; improved regional climate in the reservoir zone will provide better condition for vegetation replacement near the reservoir zone; the construction of project may have effective control on artificial and original water & soil conservation, which reduces floods, landslides and mud-rock flow, thus improves ecological environment.

4.5.1 Assessment on the integrity of ecological environment

Changfeng hydropower project has impact on the integrity of natural system, which is due to reservoir inundation and project land use. Construction of Changfeng hydropower

project will inundate 276.76mu land, among which there are 22.65mu cultivated land, 121.5mu fuel forest, 30.3mu timber forest and 102.31mu barren mountains; the permanent land use of project is about 204mu and the temporary land use is 54.9mu. In the reservoir inundated area, there are 3 households and 120 m^2 housing to be moved. The reservoir inundation and project land use will reduce the regional green area and change the productivity and stability of natural system, which has certain impact on the integrity of regional landscape ecological system.

(1) Analysis on productivity change in regional natural system

The productivity of landscape ecological system is influenced by reservoir inundation and project land use, which changes the type and area of various sections of the landscape in the assessed area, and reduces the area of woodland and bushes with high higher productivity due to inundation and project land use. Due to reservoir water storage, the river and shoal with lower productivity will be changed from unstable stream river into stable reservoir, where the biomass in aquatic ecological system will be increased obviously and productivity will be improved greatly. In a short period, the general regional productivity is in falling trend.

(2) Analysis on change of landscape ecological system stability

The stability of landscape ecological system has two features: restorability and impedance. Restorability is the capability of restore to the original state when the system is change; impedance is the capability of resisting or preventing the environmental change or potential disturbance. When the regional land ecological system in project area is inundated, it is transiting to aquatic ecological environmental system. The productivity of each system will reach new balance after short fluctuation. Since the area influenced by inundation and permanent project land use cover less than 1% of the area, the impedance of natural system will not decline to lower level due to the small inundated woodland by reservoir water storage. The construction of hydropower station has little impact on the stability of landscape ecological system. Therefore, the impact on regional landscape from construction and operation of hydropower station is within the ecological load limit, which is endurable for the regional natural system.

(3) Comprehensive assessment on quality of landscape ecological system

After construction and operation of Changfeng hydropower project, the land use pattern in the region is changed. After project operation, the advantage of various land types will change, among which the aquatic section will have more advantage due to reservoir inundation, the advantage of bushes will decrease a little due to reservoir inundation and the advantage of woodland maintain the same. The total water surface area in reservoir zone is 0.185km^2, while the landscape ecological system in the zone is far larger than the changed area. Therefore, the woodland and grass land are still the mold land in the zone. This shows that the construction and operation of project has no major impact on the landscape quality of natural system in the assessed zone.

4.5.2 Analysis of impact on terrestrial plant

During the construction period of the project, there is certain impact on the vegetation due to excavation of quarry area and earth, changed traffic route, building of water diversion power system, residue yard and so on.

According to the on spot investigation, there are small paths in mountain area going to the construction site, which is being improved and updated. In the areas along the paths there are Chinese red pine forest and bushes. In the zone within the road excavation line, the vegetation will be destroyed and excavation free surface on the roadside, which will likely cause water and soil loss in stormy days. The temporary land use of the project is 54.9mu and the vegetation type is shrubberies and grasslands.

According to the on spot investigation, the plants impacted by inundation are mainly the widely distributed species in the reservoir zone and Hubei province. There is no special plant under national or regional special protection in within the inundation area. Thus the reservoir inundation will not cause extinction of regional species. Since the land use of project construction is small, which is limited within the project construction zone, it has no obvious impact on the forest coverage in the construction impacted area.

When the reservoir starts water storage, with more project investment and improved regional climate in reservoir zone, it will provide more favorable condition for vegetation alternation in reservoir zone and its nearby area, and also brings favorable impact on the growth and progressive succession of forest vegetation. Meanwhile, after project construction, the water area in the reservoir zone is increased, which helps to improve

regional climate and is good for plant growth in reservoir zone.

4.5.3 Analysis of impact on terrestrial animals

Project construction will have certain impact on the amphibian and reptilian in the construction zone, some of which may move out of the construction area and inundation area, where its existence will not be threatened. The construction will force the birds and animals on the temporary used zone to move out of original habitat. Birds, medium and large beasts living near the construction zone may be scared by the blasting and drilling in the construction period and move out of their original habitat. These unfavorable impact is only limited to the construction period. With the recovery of vegetation in temporary used zone of construction, the habitat will be restored. There will be more snakes in the construction area, among which the bamboo snake is highly poisonous, and precautions should be taken during the construction period.

When the reservoir is constructed, the reservoir inundation will reduce the distribution zone of the terrestrial animals as the vegetation and shrubbery ecological system on original watercourse and banks will be turned into reservoir ecological system. The animals living in original reservoir zone are not special local species which can move to the periphery of reservoir zone. The project construction will not cause severe threat to the existence of these species. Meanwhile, with risen water level and enlarged water area, it provides better living environment for lentic amphibian, which helps to increase its species numbers. It will attract water birds and secondary water birds and increases there species and numbers.

4.5.4 Analysis of impact on aquatic organism

(1) Analysis of impact on aquatic habitat

In natural condition, Ganhe creek is the habitat of rapid river valley with high flow rate, large flow, water level fluctuation, large flow fluctuation in flood season and dry season, river bottom of rocks, cobbles and sands, which is unfavorable for primary productivity growth in aquatic ecological environment. When the reservoir is built, the hydrological condition of the reaches in reservoir zone of Changfeng hydropower project is changed. The fluctuation of reservoir water level is smaller, and the original open rapid flow aquatic habitat is turned into tranquil flow aquatic habitat. The aquatic ecological

environment is changed from watercourse ecological environment to lake ecological environment. When the reservoir operation reaches normal pool level of 1125.0m, the reservoir area is 0.185km^2 which is larger than that of natural condition and pool level in dam front is 10-50m higher. With larger water area, water depth and water body, smaller flow rate and deposited sediment, the water transparency is increased. Due to inundation, the trophic salts in the reaches of the reservoir zone increase, which leads to improved primary productivity, improved bait condition, increased biomass for tranquil water environment and decreased biomass for rapid water environment.

(2) Impact on planktons

With reservoir water storage, the water flow is slower, which reduces the turbidity of reservoir water, increases transparency and promotes photosynthesis of phytoplanktons. Meanwhile the exudation of soluble substance in inundated area and the trophic substance in land surface runoff will stay longer in the reservoir zone, which provides rich material foundation for growth of planktons in reservoir water area. When compared with original ecological river, the species structure and species number of the phytoplankton in reservoir water area increases obviously. The distribution density and location of plankton are changed with more plankton biomass. Meanwhile, there will be copepoda and cladocera for tranquil or static water environment will appear in the reservoir zone, and the chironomus plumosus and big tubifex worm for deep water and anoxic environment will increase and become the dominant species in reservoir.

(3) Impact on benthic animals

With reservoir water storage, the pool level of dam front will be higher, which changed the water exchange capability of natural watercourse. The sediment deposition will change the bottom sediment and destroy the inhabiting environment of benthic animals. It is estimated that the when the project is finished, the community structure of benthic animals will be changed greatly, with less species that likes running water environment in original watercourse. The community structure in the shallow water area of reservoir will be mollusca, oligochaeta and chironomus plumosus.

(4) Impact on fishes

With reservoir operation, the aquatic ecological environment of original watercourse

changed a lot, which will directly influence the inhabiting, breeding and feeding condition of fishes in original watercourse. Fishes suitable for living environment of valleys, rapid water and shoals will move out. While the highly adaptable polyphagia fishes with high breeding rate will be the dominant species in the reservoir zone such as carps and crucian carps. The other fishes adaptable in both running water and tranquil water environment keep stay in the reservoir zone. In general the dominated species of fish community will be changed from flowing water habitat species to tranquil water or static water habitat species.

When the retention dam of Changfeng hydropower station is built, the original rapid water ecological system is being destroyed successively. Construction of the dam cut off the sailing upstream route of the fishes, which reduces the fishes resource in reservoir zone. The hydrological condition in reservoir zone is much better then original watercourse. With reservoir construction, the original open rapid water aquatic habitat is changing into tranquil water aquatic habitat. The primary productivity in water will increase which is good for the inhabiting and breeding of fishes in tranquil or static water.

4.5.5 Impact of tunnel construction on ecological environment

The diversion tunnel of the project is 5319.4m long, going downstream of Ganhe creek on its right bank, which is one of the major projects. During constriction, 5 adits will be built along the tunnel. There will be all together 10 working surface including the inlet and outlet, which can be used for tunnel boring the same time. It has axial flow blower for ventilating and smoke exhausting, smooth blasting and mucking by artificial trolley or tractor. The depth of diversion tunnel is from 50m to more than 100m, which will not cut off the migration route of animals. Thus the impact of tunnel construction on ecological environment mainly includes vegetation damage and water & soil loss due to the waste residue from tunnel excavation.

The over burden on the intake of hydropower water diversion tunnel is 3~5m thick. Its bed rock is dark grey dolomite limestone of Shilongdong formation of lower Cambrian system. Going through Changyang anticline in the tunnel to the outlet in Beiji, the stratums are limestone-shale of Shilongdong formation of lower Cambrian system, Kelly shale of Shibei formation, Calcareous siltstone and black slate; dolomite limestone of middle Tanjiamiao formation, dark grey thick stratum dolomite limestone and white dolomite of

upper Sanyoudong formation; grey thick stratum macrocrystal limestone-shale of Nanjinguan formation of lower Ordovician system; grey black thick stratum block macrocrystal limestone of Fenxiang formation and black shale; dark grey thick stratum macrocrystal limestone of Honghuayuan formation and nodular limestone and shale of Dawan formation.

Along the tunnel, there are a few secondary faults of small scale with main structure feature of joint, fissure and fault. The tunnel is going through the core area of Changyang anticline. Though there is obvious partial fault in land surface, it is possible that there is fault and close joint belt developed in the core according to the features of anticline structure. Its impact on the tunnel can be hardly predicted. General speaking, there is no large scaled adverse impact. The depth of the diversion tunnel in most areas is more than 200m. There is level II plantation surface above elevation with discharge tunnel developed in Huangyangping area. The groundwater is discharged toward the north or the west. The elevation of groundwater is higher than that of the tunnel crest. During construction, it can be found that the groundwater in some area is quite rich.

In the preliminary report of main project, the waste residue is to be placed in 6 places. The waste disposal area will have drainage ditches at three directions, lined with mortar laid stone. The drainage ditch will be connected to nearby river and a sediment deposit will be built at the outlet. Before placing waste residue, the surface mellow soil should be separated and piled in the corner of the waste disposal area. When the construction is finished and waste residue is disposed, the waste disposal area can be restored to farmland. The detailed measure is listed as follows: clean, level off and earth up (45cm thick) the waste disposal area before planting trees and grasses. Choose the 3-year-old-seeding of Japan cedar with seeding height ≥0.8m and stem base≥3.5cm (or cypress as the second choice) , 2-year-old seeding of bunge pine with seeding height ≥0.3m and stem base≥1.5cm (or Chinese red pine as second choice). Plant trees in band in proportion of 3:2, with band width of 6.0m, band space between of 1.0m and row spacing of 2.0m. The space between trees in Japan cedar bank is 2.0m while the space between trees in bunge pine band is 3.0m. Each band is optimized in square. Procumbent vine magnolia should be

planted under the trees (second choice kudzu vine), branches planted underground with row spacing of 2.0m×2.0m and optimized in square.

By conducting the above measure, the adverse impact of tunnel construction can be reduced.

4.6 Analysis and assessment on water & soil loss

This part is written according to the approved Report on Water and Soil Conservation Plan of Changfeng Hydropower Project in Changyang, Hubei.

4.6.1 Destroyed area of water and soil conservation faculties

The project land use include permanent land use, construction road, restoration road, borrow area, waste disposal area, construction road and restoration road, construction temporary land use. According to the draft design report and the exploration investigation, the construction land area is 38.42hm^2. See table 4-5.

In the construction land area, the construction excavation or waste residue burying will destroy to some extent the original geomorphy, surface rock structure and surface vegetation, thus the original water and soil conservation function will be reduced or lost, and accelerates water and soil loss. The damage caused by project construction will be counted in destroyed area of water and soil conservation facility, which is 16.82hm^2, see table 4-6.

Table 4-5 Statistics of Construction land use unit: hm^2

Item	Water intake works	Diversion tunnel	Penstock	Power house	Total
1.Project permanent land use	19.99	0.01	1.23	0.27	21.50
2.Construction traffic land use	2.00	2.00	8.00		12.00
3.Waste disposal area	1.94	0.57	1.09	0.72	4.32
4.Construction temporary land use	0.20	0.20	0.20		0.60
Total	24.13	2.78	10.52	0.99	38.42

Table 4-6 Statistics of destroyed area of water and soil conservation facilities

Unit: hm^2

Content	Water intake works	Diversion tunnel	Penstock	Power house	Total
1.Project permanent land use	0.19	0.01	1.23	0.27	1.70

2.Land use of construction road	2.00	2.00	8.00		12.00
3.Land use of waste disposal area	1.94	0.57	1.09	0.72	4.32
4.Construction temporary land use	0.20	0.20	0.20		0.60
Total	4.33	2.78	10.52	0.99	18.62

According to the water and soil loss before construction, the destroyed area of water and soil conservation facilities are sorted as new water and soil loss area (for land without water and soil loss before construction, including cultivated land, woodland, sparse woodland with good forest coverage) and added water and soil loss area (land with serious water and soil loss before construction). According to on spot investigation, the new water and soil loss area is 18.62hm^2, and the added water and soil loss area is 0.41hm^2, see table 4-7.

Table 4-7 Type of project land use and destroyed water & soil conversation facilities

Item	Type and quantity of land (hm^2)						Destroyed area of water and soil conservation facilities (hm^2)		
	Cultivated land	woodland	Sparse woodland	Barren land	shoal	Total	New water and soil loss area	Added water and soil loss area	Total
Project permanent land use	1.98	6.10	15.35		1.37	21.50	1.70	0.41	2.11
Land use of construction road	1.08		10.92			12.00	12.00		12.00
Land use of waste disposal area	1.94		1.66		0.72	4.32	4.32		4.32
Construction temporary land use				0.60		0.60	0.60		0.60
Total	5.00	6.10	27.93	0.60	2.09	38.42	18.62	0.41	19.03

4.6.2 Quantity of waste earth and disposal

The waste residue produced in the construction of Changfeng hydropower project mainly comes from the main project as well as the excavation, base cleaning and slope cutting of quarry area, borrow area, construction road.

From the draft design report, it is found that the waste residue from excavation, base cleaning and slope cutting of main project is about 10.06万m^3, among which waste rock

excavation is 84300m^3 of about 170300t, waste earth excavation is 33100 m^3 of about 56300t. The waste excavation from construction road, waste disposal area and temporary facilities is about 16800m^3 , among which the waste rock excavation is 6700m^3 of about 13400t and waste earth excavation is 10100m^3 of about 17200t. The total waste residue is 117400m^3 of about 226600t.

See table 4-8 for total waste residue of the project

Table 4-8 Total waste residue of project

Item	Waste earth excavation		Waste earth excavation		Total waste excavation		Piling area
	10000m^3	10000t	10000m^3	10000t	10000m^3	10000t	
Water intake works	0.83	1.41	3.35	6.70	4.18	8.11	4#waste disposal area
tunnel			1．81	3．62	1．81	3．62	3#、4#waste disposal area
Penstock	1．01	1．72	2．31	4．62	3．32	6．34	1#、2#、3# waste disposal area
powerhouse	0.46	0.78	0.29	0.75	0.58	1.36	1# waste disposal area
Constructio n road	1.01	1.72	0.67	1.34	1.68	3.06	Measures are taken as to local condition
Total	3.31	5.63	8.43	17.03	11.74	22.49	

4.6.3 Prediction of new water and soil loss

4.6.3.1 Prediction of possible water and soil loss

Erosion mainly refers to the various destroying, moving and piling of soil and its parent material occurred by external force (including natural and artificial forces). For this project, it mainly refers to waste residue of construction excavation, geomorphic state, soil structure and accelerated erosion with destroyed surface vegetation.

(1) Prediction of waste residue loss

The waste earth excavation, waste rock excavation and waste residue during construction are the major reason for water and soil loss. However, not all waste residues will cause water and soil loss. It cannot be considered as water and soil loss until it is effectively transferred to rivers. It is calculated by following equation:

$$W_{S2}=\Sigma D_{ei} W_i$$

In the equation: W_{S2} - water and soil loss caused by waste residue discharge（t）;

D_{ei} - waste residue storage of each waste disposal area（t）;

W_i - water and soil loss coefficient of each waste disposal area

There are many factors that affect the coefficient of waste residue loss, which is mainly related to the location, rainstorm runoff and other dynamic conditions of waste disposal area, as well as the composition of waste residue and precautions. According to on spot investigation, the waste residue of the project is earth-rock mixture (which mainly consists of earth excavation), stored in mountain. By considering the rainfall intensity in the construction zone, the waste residue loss coefficient is 0.75t. The waste residue stored in the waste disposal area of the construction is 117400m^3 of about 224900t。It is calculated that water and soil loss caused by waste residue is 88100m^3 of about 170000t。 It can be concluded that if the massive waste earth disposal, waste rock disposal of the construction are loosely piled without disposal, it will cause large scaled loss.

(2) Prediction of new loss on destroyed land surface

New erosion is calculated by following equation:

$$W_s = \sum_{i=1}^{n} (M'_{S_i} - M_{S_i}) \cdot F_i$$

In the equation：Ws—annual new erosion (t)；

F_i—area of new erosion（km^2）;

M_{si}—Erosion modulus of original land（$t/km^2 \cdot a$）;

M'_{si}—erosion modulus after construction disturbance（$t/km^2 \cdot a$）。

•Determination of erosion modulus of original land

It is estimated by the documents of Changyang County. The total annual soil erosion in Changyang County is 8600000t and its total county land area is 3420km^2, thus average soil erosion modulus is 2515$t/km^2 \cdot a$ by taking into account the sand retention effect of

woodlandη=85%. Since the construction area is in river valley, the average erosion modulus of original land surface in added loss area is 2584t/km^2·a, the erosion modulus of original land surface in new loss area is Ms=(1-η)×2584=258t/km^2·a.

- Determination of erosion modulus after project construction

The erosion modulus in construction period is determined according to the erosion modulus of exposed land. During the impact period, we adopt the average of exposed land and barren slope erosion modulus. During the impact period after project construction, we adopt the average of erosion modulus before construction and erosion modulus in construction period. Therefore, the erosion modulus during construction impact period is Ms′=2713t/km^2·a.

- Calculation result of new erosion

According to the area of new erosion and land erosion modulus before and after construction disturbance, the new erosion caused by project construction is calculated on the basis of construction period (1.5 years) and impact period (3.5 years)

It is calculated that the average annual new erosion is 48.0t/a in construction period and the average annual new erosion is 24.0t/a in impact period (excluding the building land use). The new erosion in construction period is 720000t while the new erosion in construction impact period is 820000t, the total new erosion in construction period is 1560000t, and average annual new erosion is 312000t.

(3) Estimated total erosion

The total erosion in project construction consists of added erosion caused by waste excavation and new erosion caused by destroyed land surface. The total added erosion in construction is 1730000t，and the average annual new erosion is 346000t.

4.6.3.2 Estimated of possible harm caused by water and soil loss

During project construction, the land surface within project land use area will be destroyed in different extent and partial geomorphic state will change greatly. If no measures are taken for water and soil conservation, then new water and soil loss in project zone will reach 1730000t, which has different impact on regional productivity, regional ecological environment and scouring change in watercourse of Ganhe creek.

(1) Impact on land productivity

The storage and burying of much waste earth, rock and disposal produced in project construction as well as excavation all disturbs land surface vegetation, which destroys original geomorphic state, soil composition and land surface vegetation. The farming soil formed through years of fertilizer application or natural curing and the vegetation cover are severely destroyed or disappear. There is water loss, soil loss and fertilizer loss in the farmland and fertilizer effect is reduced. The local agricultural developed is impacted.

(2) Impact on project itself

Water and soil loss will impact the construction and operation of the project. If the waste earth produced in project construction area is not disposed effectively and timely, the lost water and soil may get to the construction zone, which will hinders the construction schedule, effects safety operation in production period, and threats the personal safety of staff.

(3) Impact on watercourse

With sediment inflow, there will be certain deposition in downstream watercourse. The harmful substance in the soil loss will pollute the water of downstream watercourse, and impact the production and living environment of residents at the river banks.

(4) Impact on ecological environment: water and soil loss not only cause direct economic loss of the land, but also impact the whole environment due to pollution of sediments and other reasons.

According to the water and soil conservation plan, the main project measure for water and soil conservation is to dispose the waste residue of project. Thus, there is a drainage measure for the temporary aggregate storage area in the construction zone, and constructive suggestions are forwarded for building of construction road. According to the waste residue of the project, we designed plant measures for the waste disposal area produced in project construction. It is suggest that Japan cedars, procumbent magnolia, bunge pine should be planted in the above area with wood-grass mixture. With these green measures, it can best control the impact of water and soil loss on environment.

4.7 Analysis on environmental impact of reservoir inundation and

immigration settlement

4.7.1 Index of reservoir inundated items

According to the draft design report of the project, the reservoir inundation of Changfeng hydropower project has impact four villages of Langping Town in Changyang Tujia Autonomous County, which are Xiufengqiao villege and Wenjiaping village at upstream of dam site, Bajiaomiao village at downstream of dam site, and Xiaosheping village at powerhouse area. The total immigration is 12 persons in 3 households, who are all residents of Xiufengqiao village. See table 2-1 for index of items within inundated area.

4.7.2 Analysis on immigration environmental capacity and impact

Population environmental capacity is the population limit of the land with certain production standard, living standard and environmental quality. Once the population exceeds the limit, the ecological environment in this area will deteriorate, the living standard will fall, and the regional economic developed will be hindered. The index that is most close to population environmental capacity is land load capacity, which refers to the impact of quantity and quality of cultivated land and output of agricultural production in a region on the living standard of supported residents. Usually, land resource, especially the cultivated land resource is important for immigration settlement in countryside.

(1) Analysis on land load capacity

The land load capacity depends on the quantity of land resource and agricultural production. See table 4-9 for land load capacity in villages impacted before reservoir inundation

Table 4-9 Existing land load capacity before inundation

Item	Cultivated land area	Land per capita	Food production	Food per capita	Income per capita
Before inundation	23137mu	1.83mu per capita	4267.625t	337.5kg per capita	RMB1911.5

According to table 4-9, the existing living standard in reservoir zone is anti-poverty by referring to the living standard made by World Bank: subsistence (300kg per capita), anti-poverty (400kg per capita), adequate (500kg per capita) and prosperous (600kg per

capita). With reservoir construction, the part of the inundated 276.76mu land will be compensated by restoring the waste disposal area to farmland which is built by the reservoir road. The average food per capita for immigration population will be lowered. But with other compensation and increased regional water area, there will be better condition for development of aquaculture in reservoir zone, which is to improve the land use structure adjustment and land productivity in immigration area.

(2) Impact on natural resource

Ganhe creek banks of Langping river basin are slopes with less cultivated land, good forest coverage on upper reaches, and natural vegetation mainly consists of shrubbery. The riverbed in reservoir zone is deep with less human activities and higher vegetation coverage.

The wildlife in reservoir zone is mainly small animals with no animal under national or provincial special protection. Only villagers in one small zone in a village are involved in immigration. The area of impact is rather small. The aquatic organisms in Ganhe creek are small carps and black carps. With less fishes, it has small commercial value.

In addition, the immigrant may be settled in the area behind the original area or moved to the town. The population density of the settlement area does not change much. New production and living will inevitably utilize some barren mountains, grasslands and woodlands, which will also reduce the living area for small animals in bushes in this area and changes their living environment and condition. However, the effected shrubbery is quite limited. It has no obvious impact on the vegetation distribution. It is estimated that the reservoir inundation will not greatly destroy the natural resource in reservoir zone.

(3) Impact on water and soil loss

Generally speaking, the immigrant development of Changyang hydropower project has impacts on local water and soil loss in two sides. The adverse impact is that if immigrant adopts positive slope cultivation instead of contour tillage, the newly cultivated farming slope may produce severe water and soil loss. The favorable impact is that immigrants change the slopes into terrace and dry land into water when developing the original and new cultivated barren slope, which not only improves the quality and production of cultivated land but also reduces water and soil loss. Therefore, during the

settlement and production of immigrants, existing water and soil loss should be controlled in order to prevent new water and soil loss, improve water and soil conservation and ecological environment, and effectively control the water and soil loss in reservoir zone.

During the project construction and immigration settlement, road construction, house building and construction of other infrastructures will also cause one-time water and soil loss in short period. Though its impact is limited, the water and soil conservation should be emphasized. During project construction and immigrant settlement, grass land and wood land should be restored in time and no long-term soil exposure should be found near construction area in order to prevent water and soil loss.

(4) Impact on regional economy and living standard

The reservoir inundation and immigrant settlement will bring new opportunity to regional economic development. The immigrants may get to know new concepts and new ideas, replacing some of the old, outdated living customs, get to change living environment and adjust production structure. Therefore, the reservoir construction many greatly promote the development of regional economy and society.

In addition, with the construction of Changfeng hydropower project, the hydropower cascade development in river valley is to finish. The power supply system in the valley will be more complete, which will provide sufficient energy for the economic development of Changyang County. With construction of hydropower station, the regional transportation, communication, medical treatment and environmental protection will be improved increasingly. The project provides better condition for local residents to live and work in peace and contentment.

4.8 Analysis on impact of population health

(1) Analysis of construction period

The present medical treatment in construction zone is less developed. There are only village clinics with simple medical treatment facilities. In peak period of construction, there will be about 367 persons in the construction area, producing 39.2m^3/d domestic sewerage and 0.37t/d domestic waste.

The highly intense field physical work will impact the immunity of construction staff.

If the domestic sewerage, production wastewater and domestic waste are not effectively disposed, it will be the medium for growing and breeding of mosquitoes and flies, which may cause insect borne infectious diseases and water borne diseases. Therefore, the sanitary quarantine and health inspection of staff should be stressed, the water source control as well as control and inspection of external staff should be emphasized, and the medical treatment condition in construction zone should be improved. In addition, the sanitary control of foods should be stressed so as to prevent group food poisoning accident.

(2) Analysis of operation period

During the reservoir inundation and water storage, wastes, excrements, pathogenic germs and other pollutants in the inundated barren mountains will flow into to the water and increase the organic pollutants in water, which will deteriorate its sanitary condition. When the reservoir is built, the water area is larger, the flow rate is slower, and the regional climate change is more favorable for growing and breeding of bacteria, virus and insect worms. If the reservoir bed is not cleared thoroughly before reservoir water storage, the water at the preliminary stage of reservoir water storage will be contaminated, which may cause the burst and widespread of bowel diseases in the nearby of reservoir zone.

According to the investigation, there are no natural focus diseases near the reservoir. During the water storage and reservoir inundation, mice will move to higher location due to the increase of water level, which will increase the possibility of the crowd infected by mouse-spread-diseases within and near the reservoir zone. The reservoir construction changes regional climate condition and aquatic environment, which is more suitable for growing and breeding of mosquitoes. The increased water area and slower flow rate will provide more breeding area for mosquitoes, which will increase mosquito density and increase the possibility of occurring and prevailing of infectious diseases spread by mosquitoes. In order to prevent the increase of mosquitoes in reservoir zone, weed and shrubbery in reservoir drawdown zone should be thoroughly cleaned before reservoir water storage so that there will be no more environment for growing and breeding of mosquitoes and flies.

4.9 Analysis of impact on social economy

Changfeng hydropower project is situated in an area with less developed economy in Hubei province with weak industrial and agricultural foundation. Ever since the reform and opening up policy, the domestic economic power is increased gradually with improved transportation. However, limited by its natural condition, its economic development is rather slow compared to other parts of Hubei province with domestic economic index falls far behind.

The construction of Changfeng hydropower project is to develop and utilize the rich hydropower resource in the county and promote the regional economic development. When the project is put to operation, the annual network power output of the station is 32982400kw•h, multiplied by unit price of RMB 0.30/kw•h, the annual sales income reaches RMB 9.5965million. Meanwhile, large project investment will be the driven force for economic development in Changyang Tujia Autonomous County; the project will recruit some local labor force and solve some employment problems. With many construction staff moved in, the local consumption will be increased. When the project is finished, the residents in reservoir zone can fully utilize the tourism resource of Changfeng hydropower project to develop local tourism industry and improve employment. In general, Changfeng hydropower project will promote the development of local society and economy in many aspects.

4.10 Analysis and assessment on impact of project construction

4.10.1 Analysis of impact on wastewater in construction period

The impact on water quality by project construction mainly comes from wastewater discharge in project construction and domestic sewerage discharge in living area. The construction wastewater mainly consists of washing wastewater from sand filling system, water discharge of pit excavation, washing wastewater of construction machinery maintenance and wastewater from concrete mixing. The main pollutants are suspension substance, alkaline water and petroleum. The domestic sewerage mainly consists of daily discharge of domestic water by construction organization and production staff, in which the main pollutants are BOD_5, COD and NH_3-N.

(1) Estimation matrix and its coefficients

It is to adopt impact estimated by one-dimensional matrix, the one-dimensional matrix for water quality:

$$Cx = C_0 \exp(-k\frac{x}{u})$$

$$C_0 = (C_p Q_p + C_h Q)/(Q_p + Q)$$

In the equation: C_x—pollutant concentration flowed in distance X , mg/L ; C_0—pollutant concentration at preliminary fault , mg/L ; k - pollutant degradation (settlement) coefficient , 1/d ; u - average flow rate , m/s ; C_p - pollutant discharge concentration , mg/L ; Q_p - wastewater discharge , m^3/s ; C_h - background concentration of river pollutant , mg/L ; Q - river flow rate , m^3/s。

See table 4-9 main parameters of dry period in lower reaches of dam site of Changfeng hydropower project

Table 4-9 Parameter for estimation of water quality in construction area of Changfeng hydropower project

Item	Flow velocity u (m/s)	Water depth H (m)	Flow rate Q (m^3/s)	Reducing coefficient K (1/d)	
				Oxide Consumption coefficient	Settlement coefficient
value	2.0	0.5	0.22	0.25	value

(2) Wastewater of aggregate processing system

The processing procedures of aggregate consist of screening and grading. During screening, water should be added to reduce dust, most of which is discharge as wastewater expect that some water is consumed in production. When aggregate is washed in processing system, the mortar in the raw material and sand smaller than 0.15mm will be carried by water flow, therefore, the SS concentration of washing waste water is high. In usual aggregate area, the sediment concentration of aggregate is between 2.26～13.6% while in this project the sediment concentration of aggregate is calculated as 8%. Usually, producing 1t aggregate needs 2.7t water, the SS concentration in washing wastewater of aggregate is 2.6×10^4mg/L based on material balance, which is much larger than the

allowable discharge of suspension substance in Integrated Wastewater Discharge Standard (GB8978-1996). Based on construction analysis, the estimated wastewater discharge from aggregate processing system is about 110m^3/h. See table 4-10 for estimated impact of wastewater discharge on water quality of Changfeng hydropower project.

Table 4-10 Estimated result of suspension substance in wastewater discharge from aggregate processing in construction area

Unit: mg/L

Distance (m)	50	100	200	300	400	500	800	1000	1300
Concentration(mg/L)	832.8	684.8	616.2	557.6	480.9	436.3	222.8	86.6	32.2

From the table, we can see that the when the wastewater from aggregate processing system of Changfeng hydropower project is discharged, the concentration of suspension substance in river will be lowered quickly after settlement. After full mixing, the concentration will be retrieved to natural state on the lower reaches of 1300m away.

(3) Pit drainage

The pit drainage consists of preliminary drainage and regular drainage. The wastewater drainage consists of rainfall, water leakage and construction used water. Due to the pit excavation and concrete placing and curing, the suspension concentration and PH value of pit water is quite high. According to measured data from other hydropower projects, the suspension concentration of pit drainage is about 2000mg/L, which will retrieve to about 100mg/L after settlement. The PH value of concrete curing water is 11 ~ 12, which has certain impact on water quality of regional lower reaches.

(4) Washing wastewater of concrete mixing system

Wastewater of mixing system is produced by washing roller and material tank. The suspension concentration in wastewater is about 5000mg/L with pH value of 12. The concrete washing water is discharged intermittently. The little wastewater has no big impact on water quality.

(5) Oily wastewater

There is a facility station on the south bank of construction zone, whose task is to provide regular maintenance and replacement of simple components for transportation

vehicles and construction machines. The oily wastewater comes from the wastewater drained from mechanical maintenance workroom and washing wastewater of vehicles, whose main pollutants are oil and suspension substance. If the oily wastewater is not disposed, the oil film formed on the surface when it is drained into water will prevent the oxygen restoration of water, which leads to adverse impact on water quality.

(6) Domestic sewerage in office and resident area

It mainly consists of the domestic sewerage of construction staff. The max staff number during peak period in project construction is 367 persons per day, the average staff number per day is 245 persons. Based on the regular domestic water consumption of construction staff for hydropower projects, the average water consumption per day of construction staff is about 200L and the total water consumption is about 26460m^3 during the whole construction period, and 80% of which will be discharged as sewage. The sewage discharge standard is 160L/d, and the max domestic sewage discharge per day is 58.7m^3, the average domestic sewage discharge per day is 39.2m^3, the total domestic sewage discharged during construction period is 21168m^3. Its main pollutants are COD, BOD_5, SS, NH_3-N.

The construction site is located in barren mountains, which is far always from villages and cities. By considering the general condition of construction site and existing regional environment, temporary toilets and simple constructed septic tank built near the construction site will fit the existing objective and technical condition. The purification efficiency of average cesspool is 50% - 90%. The purification efficiency of COD and BOD_5 is 60% while the purification of SS is 70%. The drainage concentration of COD and BOD_5 after in the purified wastewater is hard to reach discharge standard level I. Since the project scale is small with scattered buildings and small wastewater discharge in each construction, the impact of the above measures is not large. However, the peak period of construction is in winter when the river flow is small. If the wastewater is discharged without disposal, it will cause staged regional impact on water quality of the pollutant taking water.

4.10.2 Environmental air quality

Due to the preliminary excavation, backfill of earth-rock excavation, aggregate screening and processing and material loading of the main project during construction period, it produces powder and flying dust. Due to the operation of construction machines, internal and external transportation, it produces flying dust and vehicle tail gas. Due to operation of excavating machines, explosives blasting, and domestic coal burning in living area, it produces waste air. All of the above will impact the ambient air. The main pollutants in the waste air are TSP, SO_2, NOx, CO, hydrocarbon and lead compound.

Based on construction analysis and compared with other hydropower project, the discharge of main pollutant of CO and NO_2 during construction reaches 8850.6t and 5381.1t respectively.

(1) Mode of estimation

The existing canyon mode is categorized into experiential mode, box mode and Gauss mode. In K theory mode, the canyon size is small, and the critical condition and flow field is too complicated. It is seldom used for vehicle tail air diffusion in canyon. The pollutant concentration monitored in canyon has two parts: C=Cb+□C , among which Cb is the environmental background concentration, □C is the concentration of tail air discharged vehicles in the street, which can be estimated by canyon mode.

The project construction area has obvious features of a canyon with prevailing wind direction paralleling the canyon. We use Gauss mode to simulate vehicle tail air diffusion in a large sized canyon. Since the prevailing wind direction in canyon bottom is paralleling with the driving road, and the canyon is much wider than the driving road, thus the Gauss mode with paralleled wind and infinite linear source is adopted to simulate the vehicle tail air diffusion in canyon.

Mode of estimation： $$\Delta C = \frac{Q_L}{(2\pi)^{1/2} u \sigma_z(r)}$$

r=（x^2+z^2）$^{1/2}$，σ_z（r）is 0.48r。

In the equation：σ_z is vertical air diffusion parameter；r=（x^2+z^2）$^{1/2}$，σ_z（r）is 0.48r.

(2) Result of estimation and impact analysis

In normal operation, the max hourly NO_2 concentration in windy or small windy times usually appears at 80km from the both sides of the canyon central line, the concentration is 0.500mg/m^3 in windy time, which is 1.08 times higher than the standard limit level II of about 0.24mg/m^3, and the concentration is 0.342mg/m^3in small windy time, which is 0.425 times higher than the standard limit level II. The area with excessive concentration is within 200m from the central line of road. The max daily concentration is 0.180mg/m^3, which is 0.5 times higher than the standard limit level II of 0.12mg/m^3, which is also at the area 80m from the road, within 220m from the central line of the road. From the plan layout and background of air environment in construction area, the area with excessive concentration is within the regional construction area while its impact on external environment is within the standard level II of Ambient Air Quality Standard (GB3838-2002)

4.10.3 Noise environment

4.9.3.1 Mode of estimation

(1) Static noise source

The large static noise source in construction mainly comes from aggregate processing system, pit excavation, concrete mixing building and comprehensive processing. According to the Technical Guidelines for Environment Impact Assessment-Noise Environment (HJ/T2.4-1995), the following equation of estimation is applied:

Equation of static point noise source: $L_{A(r)} = L_{wA} - 20\lg r - 8$

In the equation, $L_{A(r)}$—noise level A r（m）from noise source, dB；

L_{wA} - noise power rate A, dB；

r - distance between testing point and noise source，m。

The noise level of estimation point if calculated by superimposing sound energy:

$$L_{总} = 10\lg(\sum_{i=1}^{n} 10^{0.1Li})$$

In the equation; $L_{总}$—estimated noise level，dB；

L_i —each superimposed noise level，dB；

n—noise pressure level n。

(2) Moving noise source

The noise produced by transportation of various heavy load vehicles and bulldozers can be seen as moving noise source. Its noise is related to quantity, size and speed of vehicle and road condition. It attenuation rate is calculated by following matrix:

Estimation mode for moving noise source

$$Lm = 10\lg(N/r)+30\lg(v/50)+64$$

In equation: Lm - noise pressure level r（m）from the noise source, dB；

N - vehicle flow，unit/h；

v - vehicle speed，km/h；

r - distance from testing point to noise source，m。

4.9.3.2 Impact analysis

(1) Static and successive point source noise

Considering the most unfavorable condition, we use the max source intensity, the source intensity of aggregate processing, concrete mixing system, steel and wood processing factory, pit excavating are 110dB, 88dB, 105dB and 112dB respectively. See table 4-11 for its range of impact.

Table 4-11 Estimated noise source of static successive noise in construction area of Changfeng hydropower project

Noise source	Source intensity (dB)	Estimated noise at different distance from noise source (dB)							
		10m	20m	30m	40m	50m	80m	100m	120m
Aggregate processing	110	82.0	76.0	72.5	70.0	68.0	63.9	62.0	60.4
Steel & wood processing factory	77.0	71.0	67.5	65.0	63.0	58.9	57.0	55.4	77.0

Concrete mixing system	88	60.0	54.0	50.5	48.0	46.0	41.9	40.0	38.4
Pit	112	84.0	78.0	74.5	72.0	70.0	65.9	64.0	62.4

The noise intensity of pit excavating and artificial aggregate processing system in dam site is large, which has negative impact on construction staff nearby.

There is no resident near the construction area, and noise mainly impacts the construction staff in the construction living area. According to the impact of various noise sources and background of noise environment, the comprehensive impact of noises on construction staff in construction living area is estimated. See table 4-12 for the result.

Table 4-12 Impact on sensitive points by construction of Changfeng hydropower project

Sensitive point		Min distance from the noise source(m)		Noise impact(dB)
Location	name	Aggregate processing system	Concrete processing system	
Left bank of dam site	Living area in construction zone	60	600	65.6

The noise pollution impacts the construction staff in living area in construction, with noise value exceeding the Standard of Environmental Noise in Urban Area level I (GB3096-93). The actual noise environment is lower than the estimated value due to mountain separation.

(2) Moving noise

The daytime vehicle flow in main transportation route during project construction is 80units/h at speed of 35km/h; its nighttime vehicle flow is 40units.h at speed at 15km/h. See table 4-13 for impact area of transportation noise

Table 4-13 Estimated impact area on both sides of main transportation route in construction

Noise time	Estimated noise at different distance from noise source (dB)								standard distance (m)
	5m	10m	20m	30m	40m	50m	60m	70m	
daytime	71.4	68.4	65.4	63.6	62.4	61.4	60.6	59.9	10
Nighttime	57.3	54.3	51.3	49.6	48.3	47.3	46.6	45.9	10

At 10m from the road, its noise in daytime or nighttime in construction meets the standard. Since the construction living area is beside the entrance on the road, it is greatly

impacted by noise.

(3) Noise of blasting

The noise of blasting last short period and occurs at fixed time in fixed place. Its noise intensity may reach 130～140dB(A). The major blasting points of the project are left of main dam, right bank of dam abutment, dam power house and block quarry area. Blasting has certain impact on construction staff.

4.10.4 Solid waste

Solid wastes mainly consist of waste earth and waste residue of construction, and domestic waste of construction staff.

(1) Waste earth and waste residue of construction

The waste residue produced in project construction are waste earth excavation and waste rock exaction from foundation excavation of main project, base cleaning, slope cutting and surface cleaning of quarry area and borrow area. See table 2-2 for calculation of balanced earth-rock filling and excavating. The total waste residue from leveling off of main project and construction area is 100600m^3, which is piled to the planed large pit waste disposal area. If the waste residue in construction is not transferred to specific area to for treatment, it will impact ambient environment by unplanned piling, which will cause water and soil loss. The large pit waste disposal area utilizes the karst depression with enough piling area, which is barren land and no nearby natural landscape will be destroyed.

(2) Domestic waste of construction staff

Lots of construction staffs are gathering in the construction area during project construction. The number of construction staff reaches 376 persons in peak time. Suppose the daily domestic waste discharge per capita is 1kg, the daily domestic waste discharge in peak time is about 0. 367t. If the domestic waste are not disposed as requested by environmental sanitary standard, it not only impacts landscape and pollutes the air, but also cause growing and breeding of mosquitoes, flies, and mice in certain climate. It is possible cause and spread or even epidemic of insect borne diseases, which will impact the health of construction staff. Meanwhile, when various pollutants and germina in the domestic waste get into Loushui River with rainfall and runoff, it will also pollute the river water.

4.11 Analysis of impact on Geheyan hydropower project of Changfeng hydropower project construction

Geheyan project is situated in Changyang County Hubei province, which is the secondary hydropower project in Qingjiang river valley. It is jointly invested and built by the state government and Hubei provincial government. Based on power generation, it also functions in flood protection and shipping. It began constructing in January 1987 and the 4 units began power generation on December 4th 1994. The dam is 151m high, which is a gravity dam with dam crest of 653.5 long. The steel concrete in main project is 2120000 m^3, with reservoir capacity of 3.4 billion m^3 , available storage of 2.2 billion m^3 and flood control storage of 0.87 billion m^3. It builds a diversion power house on the right bank with installed capacity of 1212millionW, 103.0m design head and annual power output of 3.04 billion kw·h, which is a major peak regulation and frequency regulation power house in the power network in central China. There is 300t vertical ship lift with one-way navigation capacity of 3,000,000 ton/year.

Qingjiang river is the first branch of Yangze River to the right bank when it flows out of Nanjinguan, which originates in the crossing area of west south Hubei province and Sichuan Province. It is 423km long with water basin area of 170,000 km^2, which goes through 10 counties and cities in Hubei (within the territory of Hubei province) with overall basin drop of 1480m, average annual rainfall of 1400mm, average annual flow rate of 423m^3/s, average annual runoff of 12.3 billion m^3/a. Langping river is the primary branch of Qingjiang river, with basin catchment area of 318.4km^2. The average annual flow rate at the hydropower station is only 0.99m^3/s , which is tens of kilometers from the dam site of Geheyan project. Therefore, it has no impact on the normal operation of Geheyan project in its construction or operation period.

5. Analysis of environmental risk

5.1 Risk identification

The environmental risk analysis of Changfeng hydropower project is to analyze the probability and possibility of future emergency disaster caused by construction and operation of project. The environmental risk of project construction is latent, which is not harmful until it bursts as emergency disaster.

According to the development task, scale, construction layout, design of main

buildings, reservoir operation mode of Changfeng hydropower project, and the geological environment, climate condition, landscape vegetation, hydrological and sediment condition, aquatic environment quality, aquatic organism of construction area, together with estimated assessment of environmental impacts on project construction and preliminary risk identification, the main environmental risk of Changfeng hydropower project is dam break and environmental geological risk.

5.2 Dam break risk

5.2.1 Risk identification

Once dam break occurs in Changfeng hydropower project, there will be severe power shortage in the region, which will waste the project investment and lead to unforeseeable casualty and bring immeasurable loss to the region. Reasons for reservoir dam break are: earthquake, extraordinary flood and bad reservoir operation management.

5.2.2 Risk analysis

(1) Earthquake

The neotectonic movement in west south Hubei succeeds the features of old tectonic both in intensity and rising extent. Ever since late Cenozoic, it mainly has large area intermittent uplift and differential re-active of some faults. Since Quaternary period, the crust rising is intensified with annual uplift rate of 2.9～9.5mm (cited from the Report of Investigation and Research on Mountain Stability and Rock Fall Landslide in Western Hubei (Yichang Area) Made by Hubei Hydrological Team). The uplift and differential movement results in late Cenozoic geomorphic state such as deep riverbed, multi-denudated plantation area and river terrace. The main active faults are at both sides of Xiannu mountain and Tianyangping Fault, which usually is the turning point of regional uplift and sedimentation. These faults belong to Neocathaysian tectonic system, which are also main active seismogenic fault.

Based on the achievements of seismic and geological research and the historical seismic documents for nearby areas (Yuan'an, Dangyang, Yichang and Changyang), the measured area in located at historical weak earthquake area with earthquake intensity

below level IV and some area is at level V. During 1905 to 1947, 7 earthquakes occurred with intensity of 4-5, some particular earthquakes occurred in areas near NNW Tongyu river fault, EW striking Tianyangping fault and its crossing area can reach earthquake intensity of 6-7. The total reservoir capacity of the project is 4.001million m^3, which is a small reservoir. The reservoir is situated at stable-structure area without large fault or active fault going through the reservoir zone. The water storage in the reservoir will not lead to structure induced earthquake. However, due to regional karst developed in carbonate terrane in the reservoir zone, the reservoir water infiltration may result in deep circulation of groundwater. This may induce earthquake with weak intensity, which will not threat the project safety.

According to Seismic Ground Motion Parameter Zoning Map of China scaled (GB18306~2001), the peak acceleration of seismic ground motion in this area is 0.05g, and the characteristic period of the seismic response spectrum is 0.35s, which is equivalent to basic earthquake intensity of level VI. However, with Xiannu mountain and Tianyangping fault nearby, it is suggested that the project design should take into account the anti-seismic construction.

(2) Extraordinary flood

Since floods in the river basin are caused by rainstorms, the flood seasons are closely related to rainstorms. The rainfall in a year mainly happens in April to October and the max flood peak flow usually shows in May to August with high frequency. Since the basin has high mountains, steep slopes, deep valleys and narrow river-course, the flood concentrates quickly with rapid water rise and fall, which features the mountain river flood. The flood mainly has single peak with multi-peak at some time. With flood storage of karst cave, underground river and open pit, as well as the long and narrow river basin, the flood peak modulus are smaller than the nearby river basin.

The designed flood standard of Changfeng hydropower project is that: the design standard for water retaining structure and water release structure is 50-year-return-period with relative peak flow of 377m^3/s; since the construction zone is sparsely populated in a remote mountain area, the water retaining structure and water release structure are made of concrete with check flood standard of 200-year-return-period. And related peak flow of

526m^3/s. Based on Standard for Classification and Flood Control of Water Resources and Hydroelectric Project (SL252-2000) , Design Specification for River-Bank Spillway (SL253-2000) and Design Specification for Concrete Gravity Dams (DL5108-1999), and the fact that the ski-jump energy dissipation zone is close to the dam, the design flood standard for energy dissipation facilities at lower reaches of the dam is 30-year-return-period flood with relative peak flow of 374m^3/s, and the check flood standard is 50-year-return-period flood with relative peak flow of 407m^3/s. For flood with return period longer than 50 years, it should be forecasted so that the reservoir storage can be discharged in advance in order to protect the dam. Thus it is less possible for the reservoir dam to lose stability due to extraordinary flood.

(3) Reservoir operation management

- Reservoir operation in flood season

During reservoir operation in flood season, especially when there is extraordinary flood, if flood is not discharged timely due to reservoir operation mistake, it will threat the dam, which may cause dam overtopping. Then the dam will lose stability and results in disaster. There are previous cases at home and abroad. Nowadays, with better weather forecast and hydrological forecast, the forecast period is longer and it is more accurate, which wins more time for reservoir operation, thus effectively protect the dam.

•Reservoir daily management

During reservoir daily management, improper maintenance may destroy the dam and threaten the safety of the dam. At present, the safeguard of reservoir structure is technically guaranteed and it is less probable to see dam break due to neglect in management and maintenance.

5.2.3 Risk alleviation

Improving reservoir management is the effective method to alleviate the risk of dam break of Chanfeng hydropower project. The management staff of reservoir operation should operate in strict accordance with the scientific regulation plan. The staff should pay close attention to regional weather forecast and river basin hydrological forecast, and make reasonable analysis. Improve daily safeguard of dam structure and deal with the problems and hidden troubles immediately as discovered. The guidelines for management and

operation should be carried out strictly, and supervision should be emphasized. Measure and emergency plans of dam break should be made in order to reduce or prevent environmental loss.

5.3 Environmental geological risk

The environmental geological risk mainly lies in the slopes in reservoir zone and its stability.

The rocks on the right bank of reservoir are thick. The nearest valley to the reservoir is Qingyan creek of 5km away. The elevation of Qingyan creek valley is 540m, which is lower than the normal pool level of reservoir of 500m. From the reservoir zone investigation, there are two exposed spring on the right bank Q_1 and Q_2, and water in the small branches is running into the reservoir. The rocks of reservoir bank do not develop karst. We conclude through analysis that the groundwater near the watershed on the right bank is running into the reservoir zone. It is estimated that the there is no karst groundwater low land on the right bank of reservoir. Therefore, it is concluded that there is no reservoir leakage on the right bank. The rocks on the left bank of reservoir are relatively thin. The nearest valley is only 2km away from the branch of the main ditch in Xiufengqiao village. Since the reservoir bank stratum is limestone–shale and siltstone of upper Shipai formation and limestone-shale of Shilongdong formation as well, which is aquiclude itself. From reservoir bank zone to the nearby valley, there is Dawan formation, which is better aquiclude. The strike of the stratum parallels with the reservoir bank, thus it is impossible for the left bank to leak into the near valley. The reservoir bed is not wide, where the stratum is mostly limestone and shale of upper Shibei formation of lower Cambrian system, as well as dolomitic limestone, limestone and shale of Shilongdong formation near dam site. There is a strong karst belt near two river mouths and some small karst caves in other parts. The geological and hydrological environment of the reservoir decides that the reservoir bed has no leakage problem.

No regional fault is found going through the reservoir zone. The region is relatively stable. However, as it is impacted by Neocathaysian tectonic movement, there are some small faults and fissures in the reservoir zone. The faults in reservoir zone are mainly

feather fault of north-east strike. In general, the reservoir zone is stable with few bad geological structures. But for some part in the left bank of reservoir zone, its rock dip is same with the strike with dip angle smaller than the slope angle, which may lead to collapse and landslide.

More monitors and observations should be made in order to get the stable condition of reservoir area. Emergency plans and measures should be made so that if there is any collapse or landslide, it can be disposed according to the emergency plan.

6. Measures and recommendations for environmental protection

6.1 Measures and recommendations for aquatic environmental protection

6.1.1 Control measures and recommendations in construction period

(1) Washing wastewater of aggregates

□ Disposal speed

The disposal speed for washing wastewater of aggregates is 110m^3/h.

□ Disposal procedures

The washing wastewater of aggregates can be disposed through natural deposition, flocculation deposition and mechanical accelerated purification. By considering management and operation cost, the natural deposition method is better while the flocculation deposition and mechanical accelerated purification are better in disposal effects and land coverage. The flocculation uses less dose but it have higher requirement in design, construction and management. Since the suspension substance are mostly inorganic particles that deposits quickly, we recommend flocculation deposition for wastewater disposal of aggregate processing system.

By referring to the water supply design of project during construction period, the wastewater disposal procedures for aggregate processing system is shown in figure 6-1.

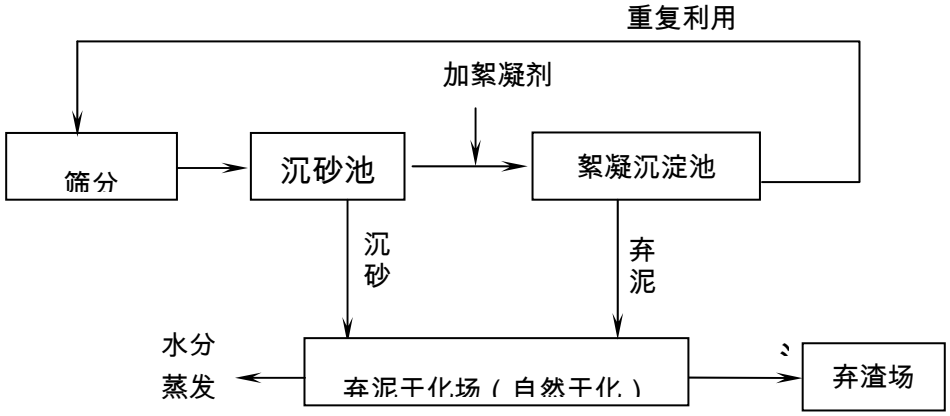

图 6-1　　砂石料加工系统污水处理工艺流程

Figure 6-1 wastewater disposal procedures for aggregate processing system

重复利用 reutilization

加絮凝剂 add flocculation dose

筛分 screening

沉砂池 sedimentation basin

絮凝沉淀池 flocculation deposit basin

沉砂 sediment

弃泥 waste silt

水分蒸发 water evaporation

弃泥干化场（自然干化） waste silt drying area (natural drying)

弃渣场 waste disposal area

The washing wastewater from screening and aggregate processing workroom flows into sedimentation basin, and will be reutilized after it is disposed by the flocculation deposit basin. Usually the water will reused for screening and aggregate washing in aggregate processing workroom. The waste silt from sedimentation basin and flocculation deposit basin is sent to the drying area and then delivered to waste disposal area after it is dried. According to the features of Changfeng hydropower project and construction layout, the waste silt is disposed through natural drying before transported to the large pit waste disposal area.

□ Plan design

Size of the planned sedimentation basin and deposit basin are: sedimentation basin area is 16m^2, size 8m（L）×2m（W）×3m（H）; flocculation deposit basin area is 144m^2, size 24m（L）×6m（W）×4m（H）. Use polyacrylamide (PAM) as flocculation dose and the flocculation basin is not necessary.

The sedimentation basin and deposit basin are built near the aggregate processing system at downstream direction of the aggregate processing system. The drying area is designed near the sewerage disposal basin which can be laid flexibly according to the silt volume and existing landform.

(2) Pit wastewater disposal

The suspension concentration of regular pit dewatering is about 2000mg/L, the pH value of concrete curing is 11-12. The rock-earth-powders and cement mortar in regular pit dewatering is easier to deposit. Referring to the monitored result of other hydropower

project constructed or under construction, the suspension concentration can reach the discharge standard when the regular pit water is allowed to stand in pit for about 2 hours. During standing, it should be neutralized by acid, which can effectively lower the alkalinity of dam concrete curing water. Therefore, the disposal plan for pit wastewater of the project is to allow the water to stand for over 2 hours after neutralized by acid, which should not be discharged until it meets the requirement. The pit wastewater is can tested by the acid-base indicator.

(3) Washing wastewater of concrete mixing system

Wastewater of mixing system produced by washing roller and material tank is discharged together intermittently. The suspension concentration in the wastewater is about 5000mg/L with pH value of 12. Since there is only little amount wastewater, a wastewater deposit basin is planed to be built beside the mixing system covering an area of $2m^2$ with capacity of about $2m^3$. After deposition, the supernatant liquor can be reused and the sediment should be disposed regularly and transported to the drying area.

(4) Disposal of oily wastewater

The mechanical maintenance factory of the project is close to the aggregate processing system in construction zone. In the wastewater of mechanical vehicle maintaining and washing, the concentration of petroleum and suspension is quite high.

- Wastewater disposal plan

The oily wastewater can be gathered and disposed by oil-water separator and adding flocculating agent regularly. The oil-water separator can clearly separates oil and water, but it requires more investment with higher maintenance requirement. The method of adding flocculating agent regularly is simple with low cost and easy management. Since the volume of water used in mechanical maintenance is small with little wastewater discharge, the method of adding flocculating agent regularly is recommended.

- Plan designed

There should be mortar lined stone drainage ditch around the mechanical maintenance area. Wastewater in the area is collected to the rectangular mortar lined disposal basin, which is close to the living area covering land area of $6m^2$ with size of 3m（L）×2m（W）

×1.5m（H）.When the oily sewerage collected to the disposal basin, flocculating agent should be put into the basin at night and the wastewater should be discharged the next day after flocculation and deposition for the whole night.

- Operation management and maintenance

Due to small amount of sewerage, the disposal basin is built in simple structure without machines and maintenance, which only requites regular flocculation cleaning during operation.

(5) Domestic sewerage disposal

- Sewerage amount

Domestic sewerage mainly comes from domestic water used by construction staff and excrement discharge. There is one office-living area in the construction zone. The domestic sewerage discharge in peak period is 58.7m^{3m}/d. The main pollutant in wastewater is SS, BOD_5, COD and NH_3-N.

- Disposal plan

The domestic sewage can be disposed by buried disposal facilities, cesspool, micropower sewage and methane tank. The disposal plan of buried unpowered disposal facility or septic tank has its own advantage. But the disposed sewage can not reach the discharge standard. As for the methane tank disposal, the capacities of the methane tank is too large which can be hardly built in the construction area.

The construction site is located in barren mountains, which is far always from villages and cities. By considering the general condition of construction site and existing regional environment, temporary toilets and simple constructed septic tank built near the construction site will match the existing objective and technical condition. The purification efficiency of average septic tank is 50% - 90%. The purification efficiency of COD and BOD_5 is 60% while the purification efficiency of SS is 70%. The drainage concentration of COD and BOD_5 in the purified wastewater is hard to reach discharge standard level I. According to the project analysis and environmental impact assessment analysis, its impact is limited, which interim and local.

Based on environmental protection requirements, dry toilets are recommended to fully

reduce the pollution caused by domestic sewage and its impact. The disposed domestic sewage can be regularly used in fertilizing farmland by nearby farmers.

6.1.2 Protection measures and recommendations during operation period

(1) Clean the reservoir bed. Before the reservoir storage, the project construction organization should thoroughly clean the aquatic pollution sources in the inundation area as required by the cleaning standard for reservoir bed, which is to prevent water quality deterioration during the preliminary stage of reservoir storage. At the same time, regular cleaning should be done to planktons and floating substances.

(2) Surface pollution control in reservoir zone. In order to reduce the impact of surface pollution load on reservoir water quality, the water and soil conservation near the reservoir zone and the upper reaches of the reservoir should be carried out quickly by local authorities of water conservancy, agriculture and forestry. The farmland should be turned into horizontal terrace. Cultivated land on inclining slope with slope angle over 25°should be restored to forest. The project construction organization should take greening measures to make forest coverage rate of impacted reservoir zone reaching 40% or above. Use of pesticide and chemical fertilizer in reservoir zone should be controlled. Fertilizers should be applied effectively in a scientific way according to different soil types, crops and seasons in order to prevent and reduce water quality pollution caused by loss of pesticide and chemical fertilizer.

(3) Domestic sewage disposal. When the project is put to operation, its main sewage produced mainly comes from domestic sewage of staffs. Though pollutant discharge is of small amount, it does not reach the discharge stand unless it is disposed. It is required that domestic sewage disposal facilities should be constructed during project construction, which can be small micro-power domestic sewage disposal device, so that the sewage can meet the discharge standard.

(4) Since the reservoir capacity is small, it is not suitable for fishery breeding, or it can easily cause eutrophication of the water.

(5) Do not built wastewater discharge outlet on upper reaches and in reservoir.

(6) Regular monitoring forecast should be done on reservoir water quality, which provides scientific basis for aquatic environmental management of the reservoir.

6.2 Precautions and suggestions for air pollution

(1) Reduction and control of fuel waste gas

With stressed management of large construction machines and vehicles, the project construction subcontractor should equip the mechanical facilities with relevant smoke and dust control facilities. Regular examination and maintenance should be made so as to ensure that the environmental protection indexes of construction machines and vehicles meet the discharge standard for tail gas.

(2) Dust reduction and control in construction

The aggregate processing, the wet crushing procedures with low dust should be applied in priority, which reduces dusts. For drilling and blasting, wet working is preferred. In dam zone, quarry zone and other construction zones with more excavations and blasting, watering measures can be used to reduce dust and pollution area. For underground excavation, water spraying and additional ventilation facilities are needed to reduce pollutant diffusion and dust concentration in operation zone.

(3) Dust reduction and control in transportation

The surface of permanent roads in construction zone is made of concrete or cement solidification, which reduces the dusts produced by transportation on earth and gravel roads. Regular curing, maintenance and cleaning should be applied to roads in order to maintain normal use of roads. Dusty materials should be wetted or covered with canvas before loading. The storage tank on vehicles for bulk cement delivery should keep in airtight state, and that delivers bag packed cement should be covered closely. The delivery vehicles should be cleaned frequently. In sunny and windy days, the construction area should be watered for 2-3 times a day.

(4) Health protection

The construction staff with much pollution impact should use individual protection measures such as wearing dust preventing respirator. Planting on the both sides of roads and office-living area reduces dust and helps water and soil conservation. Speed limit of 15km/h should be applied to vehicles going through the office-living area.

6.3 Noise control

In order to control the noise source in construction zone, regular maintenance should be applied the construction machines and low noise production machines and facilities should be used. For equipments with much vibration, buffering seat can be used. Planting on the both sides of main transportation roads and construction area reduces noise pollution. Operation of high-noise equipments should avoid the resting period of people. Labor protection of construction staffs should be applied. For construction staff working in high noise environment, the working time should not exceed 6h per day and noise proof products for labor protection should be provided to them.

6.4 Disposal of solid waste

(1) Disposal of waste residue

The construction waste residue of the project should be piled to planed area and control measures should be made to prevent water and soil loss. See the chapter of water and soil conservation for detail.

(2) Disposal of domestic waste

The working staff in peak period of the project construction is 376 persons, whose average domestic waste per day in peak period amounts to 0.367t. Sanitary facilities should be set up in construction area with garbage bins in fixed places for collecting domestic wastes in construction area and the layout of garbage bins are basically same as toilets. The garbage bins should be cleaned disinfected frequently to prevent growing and breeding of mosquitoes, flies or other pests. The project construction organization should send persons or entrust the local organization of environmental sanitation to clean the construction zone every day by disposing domestic wastes and improve the environmental sanitary condition in the construction zone.

6.5 Ecological environmental protection

6.5.1 Terrestrial animals

(1) Vegetation protection in construction zone

During earth and rock excavation in construction, forest vegetation destroy in construction zone should be reduced. Surface soil should be kept for re-cultivating and vegetation recovery. For construction zone, powerhouse and dam site, environmental planning and design should be carried out, where planting should be made to beautify the new landscape environment

(2) Vegetation restoration around the reservoir and in reservoir zone

With reservoir water storage of Changfeng hydropower project, the inundated land is 276.76mu, among which cultivated land is 22.65mu, fuel land is 121.5mu, timber land 30.3mu, barren hills 102.31mu; permanent land use of construction is about 204mu, and temporary land use is 54.9mu. In the reservoir inundation area, there are 3 households to move and 120m^2 housing to be moved. The inundated woodland should recover vegetation by planting at other places. The local forestry authority should plan the vegetation recovery site and woodland type based on actual site conditions. Based on its altitude, the forest belts in reservoir zone should be built from top to down by stages in sequence of watershed forest, water and soil conservation forest and bank protection forest, the ecological protection forests further enlarges the forest coverage rate, protecting and improving the landscape ecological environment in reservoir zone. New landscape ecological system in reservoir zone can be built through ecological projects such as slope-developed-into-terrace, biological fence and planted forests.

(3) To close hillsides for afforestation, prohibit destructive lumbering of forest, and restore cultivated land with slope angle over 25° to forest, the original ecological system can be recovered naturally. Better habitat environment for terrestrial animals helps the growing and inhabiting of terrestrial animals and plants, which prevents new water and soil loss.

(4) Prohibit destructive lumbering of forests in reservoir zone and protect the inhabiting environment of wildlife. Widely propaganda and strictly carry out the wildlife protection law and emphasize the protection for rare and precious endangered wildlife, especially the wildlife under special national or provincial protection, so as to maintain the stable variety of regional organism.

6.5.2 Aquatic organism

(1) Natural growth based with cage culture prohibited

With natural reservoir operation for some time, the fish species structure in the reservoir can reach new equilibrium. Since the reservoir capacity is small, cage culturing of fishes should be prohibited so as to prevent pollution of reservoir water quality.

(2) Stresses aquatic organism monitoring

After reservoir construction, monitor and investigation on bait organism, aquatic environment and structural change of fish species should be conducted. Find out the developing trend of fish resources in the reservoir zone based on the monitoring and investigation result in order to adjust relevant protection measures.

6.5.3 Other recommendations for ecological protection

(1) To ensure the production and domestic security under the dam site, the water storage in the first reservoir can not be used as production or domestic water, and relevant measures should be taken to propaganda and monitor this.

(2) To ensure the existing ecological environment of the downstream watercourse of the dam is not destroyed, certain amount of water discharge should be maintained according to actual situation and seasons.

6.6 Measures for water and soil conservation

The project construction organization entrusted Yichang Qingjiang Design and Investigation Institute of Hydropower to finish the report for the project, predicting the water and soil loss caused by the project and forwarding control plans of water and soil loss. This report cites the main content in it.

6.6.1 Responsibility of water and soil loss control

The responsibility of water and soil loss mainly consists of project construction area and direct impact area. The project construction area refers to the land use area controlled by zoning of occupied or rented land by the construction organization. Based on the principal of “developer responsible for protection and control” and Technical Regulation on Water and Soil Conservation Plan of Development and Construction Projects (SL204-98), the project construction area includes main project land area, waste disposal area, construction area, construction shortcut, etc. based on the construction zone boundary,

the project construction land use is 38.42hm^2, among which the permanent land use is 21.5hm^2 and temporary land use is 16.92hm^2(including construction road area of 12.0hm^2, temporary construction land use of 0.6hm^2 and waste disposal area of 4.32hm^2). The land use of project construction area is water intake works area of 19.99hm^2, water diversion structure area of 0.01hm^2, penstock of 1.23hm^2, power house of 0.27hm^2, construction road of 12.0hm^2, waste disposal area of 4.32 hm^2, temporary land use of 0.6 hm^2. The land use types are occupied cultivated land of 5.0hm^2, occupied timber land of 2.02hm^2, occupied fuel land of 21.72hm^2, occupied barren land of 7.67hm^2 and occupied shoal of 2.01hm^2。

The direct impact area refers to water and soil loss area and its direct impact area caused by project development and construction. The direct impact area of the project is zoned as 6-10m from impact area in lower reaches of the waste disposal area, while the impact area of the road construction is 1m from upper slope, 1.5m from lower slope, and 5m from the excavation zoning of buildings. The direct impact area of the project is 5.73hm^2.

6.6.2 Instructional recommendations

New water and soil loss is mainly the waste residue produced by project construction. Thus the major control area is the project construction area, waste residue transition area and waste disposal area.

Based on the estimation of water and soil loss intensity, construction measures should be taken to retain waste residue together planting. Drainage facilities should be built near the temporary waste disposal area in order to prevent waste residue being scoured by rain.

Based on estimation of water and soil loss intensity as well as total flow, the major monitoring period is the construction period and the major monitoring area is the temporary waste residue storage area and waste disposal area.

6.6.3 Control objectives of water and soil conservation

According to the Technical Regulation on Water and Soil Conservation Plan of Development and Construction Projects (SL204-98), the general control objective of water and soil conservation is to prevent and control the water and soil loss in area of responsibility, to protect project production security and the ecological environment

construction in project area, which is stated specifically as follows:

(1) For cultivated land, woodland or other facilities for water and soil conservation that is destroyed by the impact of project construction, should be restored and rebuilt as possible in order to protect ecological environment and reduce water and soil loss. The training rate of disturbed land should be over 60%.

(2) For land that has lost water and soil conservation function which is caused by the excavation, filling and occupying in project construction, construction and plant measures should be taken to restore or improve its water and soil function. The training rate of water and soil loss should be over 85%. New water and soil loss should be controlled, and the control rate of water and soil loss should be over 80%.

(3) The construction waste residue should be stored together. For loose deposit of waste residue, construction and plant measures should be taken to effectively control the loss of waster residue, and its protection rate should be over 90%.

(4) For permanent and temporary project land use, greening measures such as re-cultivating, trees planting and planting should be taken when the projected is constructed or under construction. The vegetation coverage rate should be over 80%, and the wood and grass coverage rate should be over 60% in the control area of responsibility. Improve the ecological environment in the project zone to effectively prevent and control the original and new water and soil loss.

6.6.4 General layout of water and soil conservation measures

Based on the landform, geology, soil condition and regional water and soil loss, as well as the construction characteristics, construction layout, short term and long term development plan, the impact of water and soil loss and its training objective, different training measures should to taken according to the specific features of different training areas of water and soil loss

6.6.4.1 Dam area

(1) All waste residues produced in project construction should be transported to 4# waste disposal area in the riverside 2.5km from the downstream face of dam site. 4# waste disposal area covers area of 1.94hm^2. As a temporary used area, it can storage 50000 m^3 waste residue. The major construction measure for the waste residue is building residue

retaining walls, which can be restored to farmland when project is finished.

(2) For aggregate excavation area of project, it should be leveled off after exploration and make green by planting trees.

(3) For permanent project land use, precautions should be taken by forwarding requirement for construction excavation.

(4) Construction requirements should be made for road construction. Drainage measures and roadside trees should be included in the design,

(5) Since the construction temporary land use is situated below the normal storage pool level, drainage facility is only needed in the aggregate storage area and cleaned when construction is finished.

6.64.2. Tunnel area

(1) The waste disposal areas should be laid out together. The waste residue of tunnel intake should be stored at 4# waste disposal area, the waste residue of tunnel outlet should be stored at 3# waste disposal area at the right of tunnel outlet and the waste residue in middle part of tunnel should be transported together to the 5# waste disposal area at the inclined shaft outlet.

(2) The aggregate used in the construction area comes from tunnel excavation, for which no aggregate area is designed.

(3) The temporary construction land use covers an area of about 0.2hm^2, which should be leveled off after construction is finished and make green by planting trees.

6.6.4.3 Penstock area

(1) All waste residue produced in project construction should be transported to 1#, 2# and 3# waste disposal area for storage together with relevant construction measures. Plant measures should be taken after construction is finished.

(2) The 0.2hm^2 construction temporary land use should be leveled off and make green by planting tree after construction is finished.

(3) The aggregates used in penstock construction come from the tunnel excavation, and no aggregate excavation area is needed.

6.6.4.4 Power house

(1) All waste residue produced by project construction should be transported to 1#

waste disposal area for storage together with relevant construction measures. Plant measures should be taken after construction is finished.

(2) The construction temporary land use should be leveled off and make green by planting tree after construction is finished.

(3) The aggregates used in power house construction come from excavation in the powerhouse area and the remaining part is purchased from Qingyan creek special aggregate area. No other aggregate excavation area is needed.

6.6.5 Main training plans

The hydropower project construction has its own characteristics. The training plan is stated as follows based on local geological, geomorphic and construction features.

6.6.5.1 Dam area

(1) Disposal of waste residue

Total earth-rock excavation of dam area and tunnel intake is 46500 m^3. In the training plan, all excavation are transported to 4# waste disposal area for storage together which is 2.5km of the lower reaches of dam site. The total capacity of 4# waste disposal area is about 50000m^3. The construction measures taken before waste disposal piled is: first, the 0.6m thick cultivating soil should be excavated and transported to the out of waste disposal area for storage and used for farmland restoration after the construction is finished. Second, build a waste retaining wall.

(2) Project permanent land use

Most land area of water intake works are inundated in water and covered by buildings. The water conservation measure is to taken precautions to the excavated slope during construction period.

(3) Construction temporary land use

As for the construction temporary occupied land at dam site, only the temporary occupied land of work shed for construction facilities and material storage area are designed, covering an area of 0.2hm^2. It is recommended that the permanent occupied land should be used as possible.

6.6.5.2 Tunnel area

(1) Training of waste residue

The waste residue in the area is 17400 m^3, among which the 4700 m^3 waste residue at tunnel intake is arranged to be stored at 4# waste disposal area, the 4700 m^3 waste residue at tunnel outlet is planed to be stored at the low lying land 350m from the right of tunnel outlet. A 15m long and 2m high waste residue retaining wall should be built and 0.3m×0.3m drainage ditches of 398m long should be built at both side of the waste residue of mountainside. The water from slope should be transferred to the sediment basin at ditch tail, the rest 8000m^3 waste residue is transported from the middle inclined shaft to 5# waste disposal area for storage. When the construction is finished, the waste residue should be leveled off for planting. The total planting area is 0.82hm^2 with 2100 trees planted.

(2) Project permanent land use

The surface area of tunnel construction occupied land is small and precautions are mainly adopted.

(3) Construction temporary land use

The construction temporary land use is 0.2hm^2, which should be cleaned after construction is finished and made green by planting trees. The total planting area is 0.2hm^2 and 500 trees can be planted there.

6.6.5.3 Penstock area

(1) Training of waste residue

The total waste residue in the area is 33200m^3, among which the 12300 m^3 waste earth excavation between 1-3# anchanchor block should be transported together for storage at 3# waste disposal area on the right of tunnel outlet, 8200 m^3 waste excavation below 10 anchanchor blocks are transported together for storage at 1# waste disposal area at the power house area, the remaining 12700 m^3 waste residue are stored at 2# waste disposal area nearby on the left of penstock. When the project is finished, the area should be leveled off for planting. The total planting area is 0.65hm^2 with 1600 trees planted.

(2) Project permanent land use

As for the project permanent occupied land for penstock area, some of which is sheltered by buildings and other excavation disturbed surfaces are designed to be concrete sprayed in the construction design. The water and soil conservation measures are mainly precautions.

(3) Project temporary land use

Clean the field after construction is finished for planting. The planting area is 0.2hm^2 with 500 trees to be planted.

6.6.5.4 Power house area

(1) Training of disposal residue

The area has 7000 m^3 waste residue, all of which is to be transported to store at the shoal 0.2km from the lower reaches of power house. The plan is designed to built 320m long, 2m high residue retaining wall made of M_5 mortar lined block stone at the water facing side of the waste residue. Since the shoal is flat, no drainage ditch is needed. When the project is finished, soils are covered at the top of waste residue and level off for planting. The total planting area of 0.70hm^2, with 1800 trees and 5.4kg grasses planted.

(2) Project permanent land use

Most project permanent occupied land is sheltered by building, and concrete is backfilled to the nearby area of the buildings. Thus the water and soil conservation measures are mainly precautions. In order to beautify the environment, some decorative flowers and nursery stocks can be planted nearby the permanent buildings.

(3) Project temporary land use

There is little project temporary land use in powerhouse area. When the construction is finished, the area is to be cleaned for planting.

6.7 Protection on public health

6.7.1 Clean the reservoir bed

Sanitary cleaning should be made in construction area to lower the density of various pathogeny microbes and insect borne animals so that the epidemic of infectious diseases can be prevented and controlled in the construction area.

(1) Area disinfection

Cleaning and disinfection should be done in construction camp, activity places of construction staffs, original toilets, cesspools, barns, waste storage area and tombs. When construction is finished, the temporary living area, temporary toilets and waste storage area can be moved. Disinfection can be done by sprayer with carbolic acid medicines according

to Technical Standard for Disinfection. And clean the waste at the same time.

(2) Disinfestation

In the construction period, regular disinfectation should be done in the living area in Spring and Autumn annually, which mainly kills mice, mosquitoes and flies in order to control the infection source of various infectious diseases and cut off the spread route. Use mouse trap or poisonous bait to kill mouse and use pesticide named Miehailing to kill mosquitoes and flies. With guidance from sanitary and anti-epidemic staff, the medicines and tools are given out to the construction staff to put to use.

6.7.2 Sanitary and anti-epidemic plan

(1) Sanitary quarantine

The construction staff should be sanitary quarantined before entering into the construction area which is to find and control germ carriers and new diseases into the construction area. Thus the inter-infection and epidemic between the construction staff and local residents can be prevented. The random quarantine should be done according to investigation results, which includes vital hepatitis, hemorrhagic fever, malaria, etc. The quarantine frequency: construction staff and management staff must be quarantined before entering the area. After that the 20% of construction staffs should be quarantined twice during construction period. The health examination of construction staff and epidemic situation should be filed regularly during construction period.

(2) Health examination

When the project began construction, the environmental medicine situation in construction zone is gradually changed. The construction staff with large labor intensity and various physical conditions, new infectious diseases may occur. The construction staffs should be observed and examined during construction period in order to know labor health conditions in various construction periods, so as to prevent and control the occurring and spreading of various diseases in time and ensure normal construction operation. The physical examination should be decided by actual situations. The catering staff in construction area, construction staff in dusty or noisy environment and construction staff

engaged in works harmful to health, should be examined once a year and their examination result should be filed.

(3) Precaution and immunity

Since the construction area is densely populated. The construction work is of large intensity. In order to improve the diseases immunity of construction staff in construction period and prevent the inter-infection or epidemic of typhoid fever, hemorrhagic fever, malaria and other infectious diseases, the construction staff should be planed for immunity. Based on the epidemic features of disease and the epidemic rules of diseases in hydropower project, precaution medicines or inoculation can be applied. In addition, the medical unit in construction area should store enough tetanus immunity preparations and medicines for poisonous snakes in order to make emergency rescue for tetanus infected staff or viper bite staff.

(4) Health propaganda and management

The construction and construction organization should decide person in charge of sanitary quarantine, who is responsible for managing the staff health propaganda and management, setting up and completing the epidemic report network and reporting to higher authority once epidemic is discovered. Regular sanitary inspection should be done on foods in construction zone and the health certificate of catering staff in construction zone should also be examined. The drinking water in the construction zone should be disinfected and monitored.

6.7.3 Public hygienic facility

The layout of public health facility in construction zone should be decided based on the general construction layout. The temporary toilets should be built according to the management situation and distribution of construction staff. Requirement for location of temporary toilets: it should be at least 30m from the canteen and its convenience should also be taken into account; the squatting position should be designed according to the Hygienic Standards for the Design of Industrial Enterprises (TJ35-79) by National Ministry of Health and National Labour Office; The number of toilets and squatting positions in each toilets should ne decided by the population density nearby.

According to the distribution of construction staff and layout of living area, garbage bins should be placed in construction living area and domestic wastes should be cleaned and transported timely. Do not dump waste into the river or drainage ditch or it will pollute the water.

7. Environmental monitoring and management

7.1 Plan for environmental monitoring

7.1.1. Purpose and requirement of monitoring

The Environmental change and impact during construction and operation period of Changfeng hydropower project should be monitored, in order to master the change of environmental factors and effective result of environmental protection in the project impact area, which is to find out environmental problems and forward related measures and reducing negative project impact. The monitoring result is to provide scientific basis for environmental management and project completing inspection.

The ecological and environment monitoring of the project should utilize the existing monitoring section (point) of local environmental monitoring station, sanitary epidemic preventing station, bureau of aquatic products and forestry bureau. The environmental monitoring is planed to be entrusted to competent organization to finish.

7.1.2 Environmental monitoring in construction period

7.1.2.1 Water quality

(1) Monitoring of river water quality

Section setting: there should be one monitoring section at the end of resersvoir back water zone, 200m at upstream face of the dam and 500m at downstream face of the dam respectively, among which the sections in front of the dam and at downstream face of the dam are also used as water quality section. There are 3 sections in construction.

Monitoring items: 11 items including water temperature, pH value, suspension substance, dissolved oxygen, BOD5, permanganate index, petroleum, total phosphor, total nitrogen, NH_3-N and fecal coli-form.

Monitoring method: monitoring conducted as required by the Specifications Requirements for Monitoring of Surface Water and Waste Water (HJ/T91-2002).

Monitoring period and frequency: monitor the river water quality for 1 year before water storage and the monitoring period of sections in construction area is 20 months of construction period. The monitoring frequency is three times per year at flood period, level

period and dry period respectively.

(2) Monitoring at sewage drainage outlet

Monitoring point setting: there is one monitoring point at aggregate processing system, parking lot of mechanical maintenance area, wastewater drainage outlet of concrete mixing station and domestic sewage drainage outlet.

The monitoring item: the monitoring of production wastewater is pH value, suspension substance, etc. Other monitoring items can also be added in if necessary. The monitoring item of domestic sewage is chemical oxygen demand, 5-day biochemical oxygen demand, suspension substance, total phosphor, total nitrogen, petroleum and fecal coli-form.

Monitoring method: monitoring conducted as required by the Specifications Requirements for Monitoring of Surface Water and Waste Water (HJ/T91-2002).

Monitoring period and frequency: conducted at synchronously with water quality monitoring in construction period.

7.1.2.2 Atmosphere monitoring

Monitoring point setting: a monitoring point should be set up in construction zone of dam site, construction zone of power house and living area.

Monitoring items: nitrogen dioxide, sulfur dioxide, PM_{10} (or TSP).

Monitoring method: monitoring conducted as required by the Ambient Air Quality Standard.

Monitoring period and frequency: monitoring should be conduct once every year for 5 successive days. The monitoring period is construction period.

7.1.2.3 Noise monitoring

(1) Monitoring of regional environmental noise

Monitoring point setting: there should be one monitoring point at construction zone of dam, construction zone of powerhouse, aggregate area, and concrete mixing building respectively and one monitoring point set near the road entering the living area of construction staff and aggregate processing system. There are altogether 5 monitoring points.

Monitoring frequency: monitoring should be conducted once in a year in construction period. Each monitoring is conducted for 24h. The monitoring is limited to the construction period.

(2) Monitoring of road traffic noise

Monitoring point setting; one monitoring point is set up beside the main road. The specific monitoring point should meet the requirement of The Technical Specification for Environmental Monitoring.

Monitoring frequency: the monitoring is conducted once in a year and records the flow of transit vehicle.

7.1.2.4 Monitoring of aquatic organism

Monitoring section: a monitoring section should be set up at the tail of reservoir back water zone, 200m at upstream face of the dam and 500m at downstream face of the dam respectively.

Monitoring content: including planktons, benthos, advanced aquatic plants and fishes.

Monitoring period and frequency: monitoring is conducted in the year before reservoir water storage in April.

7.1.2.5 Public health

Monitoring content: the regular monitoring of public health is conducted by medical networks of three levels by monitoring the epidemic change in construction zone. It is to know the relation between pollution caused by construction activities and public health. The infectious diseases should be monitored such as natural focus disease, water borne infection disease, insecte born infection disease and endemy. In epidemic seasons and regions of infectious disease, random examination and immunization should be done to susceptible crowds. Establish the epidemic report system, report, investigate and dispose epidemic as soon as discovered. Practical protection should be done to health of construction staffs.

Monitoring objective: staffs in construction zone.

Monitoring period: one monitoring is conducted in peak period of construction and period before the end of construction respectively. The monitoring is to be conducted by local sanitary quarantine authority as required by the sanitation authority.

7.1.2.6 Water and soil loss

Monitoring factor: rainfall, wind, slope angle, slope length and land composition in construction zone, intensity, features and hazards of water and soil loss in construction, plant growth, vegetation and its coverage rata, soil loss rate, soil nutrition, quantity and quality change of water and soil conservation facilities.

Monitoring content: includes water and soil loss, hazard of water and soil loss, benefit of water and soil conservation project.

Monitoring methods: includes on spot investigation and monitoring at fixed point.

Monitoring point setting: one observation point is set up the waste disposal area and the borrow area respectively. Two monitoring sections are set up at the typical parts of construction road. 1-2 monitoring points are set up in each monitoring section.

Monitoring period and frequency: to be conducted once in construction period.

7.1.3 Environmental monitoring in operation period

(1) Water quality

Section setting: there should be one monitoring section at the end of reservoir back water zone, 200m at upstream face of the dam and 500m at downstream face of the dam respectively.

Monitoring items: 11 items including water temperature, pH value, suspension substance, dissolved oxygen, BOD5, permanganate index, petroleum, total phosphor, total nitrogen, NH_3-N and fecal coli-form.

Monitoring method: monitoring conducted as required by the Specifications Requirements for Monitoring of Surface Water and Waste Water (HJ/T91-2002).

Monitoring period and frequency: the monitoring frequency is three times per year at flood period, level period and dry period respectively for two successive years.

(2) Water temperature

Monitoring section setting: there should be one monitoring section at dam front, 300m at upstream face of the dam and river mouth at downstream face of the dam respectively.

Monitoring period and frequency: it is conducted for 3 successive years after reservoir water storage. The monitoring is conducted 5 times each year in February, April, July, August and December respectively.

(3) Aquatic organism

Monitoring section: a monitoring section should be set up at the tail of reservoir back water zone, 200m at upstream face of the dam and 500m at downstream face of the dam respectively.

Monitoring content: including planktons, benthos, advanced aquatic plants and fishes.

Monitoring period and frequency: after reservoir water storage.

(4) Water and soil loss

Monitoring factor: rainfall, wind, slope angle, slope length and land composition in construction zone, intensity, features and hazards of water and soil loss in construction, plant growth, vegetation and its coverage rata, soil loss rate, soil nutrition, quantity and quality change of water and soil conservation facilities.

Monitoring content: includes water and soil loss, hazard of water and soil loss, benefit of water and soil conservation project.

Monitoring methods: includes on spot investigation and monitoring at fixed point.

Monitoring point setting: one observation point is set up the waste disposal area and the borrow area respectively. Two monitoring sections are set up at the typical parts of construction road. 1-2 monitoring points are set up in each monitoring section.

Monitoring period and frequency: to be conducted in first 3 operation years of hydropower station. The monitoring is conducted before flood, after flood and in winter respectively.

7.2 Environmental management

Environmental management is a major part of construction management the of Changfeng hydropower project, which goes through the construction period and operation period of project.

7.2.1 Purpose and objective of environmental management

It is stated clearly in the Environmental Protection Law of China that the purpose of environmental management is protecting and improving people's environment and the ecological environment, preventing and controlling pollution and other public hazards, safeguarding human health and facilitating the development of socialist modernization.

The major part of environmental management of the project is ecological environmental management. The purpose of ecological environmental protection is protecting ecological environment, preventing and controlling ecological damage caused during construction and operation period of project, promoting sustainable development of society, economy and ecology. The major objective of project ecological management is:

(1) Preventing ecological environment damage caused during construction and operation period of project, protecting the general ecological environment in project impact area.

(2) Strengthening controlling of environmental pollution including water quality, atmosphere and noise of project construction, preventing reservoir eutrophication and degenerating of water function of Changfeng hydropower project, and protecting public health.

(3) Water and soil conservation of project construction.

(4) Protecting the biological variety in assessment area.

(5) Conducting environmental protection measures of project and fully carrying out the policy of "developers responsible for protection, destroyers responsible for restoration and users responsible fore compensation"

7.2.2 Tasks of environmental management

(1) Carrying out state laws, regulations of environmental protection and related management system of local environmental protection authority, establishing rules and regulations for environmental protection of the project, clarifying the responsibility, rewards and punishments for environmental protection.

(2) Organizing and coordinating all tasks forwarded by the report and approval advices, fixing in advance the cost and expenses for ecological environmental compensation and pollution training.

(3) Responsible for dealing with the ecological environment polluting and damaging accident.

(4) Preparing and carrying out the ecological environmental monitoring plan.

(5) Carrying out supervision.

(6) Establishing complete information archives of project environment management.

(7) Organizing professional trainings for environmental management and monitoring staffs of the project.

(8) Improving contacts with local environmental protection authority for instructions an helps.

7.2.3 Environmental management organization

The environmental protection management should be conducted by professional organizations. According to state regulations on environmental protection, Changfeng hydropower project should set up an environmental management office in the construction management department, which is to be instructed by local environmental protection authority in professional field. Its main responsibility includes daily environmental management, coordinating and dealing with environmental disputes and accidents, carrying out the environmental monitoring and supervising plan as well s the environmental protection measures in different stages and being monitored and inspected by relevant authorities of water conservancy, environmental protection and sanitary quarantine.

The environmental management office needs one staff and the recruited staff should master professional techniques of environmental protection.

7.3 Environmental supervision

Environmental supervision is a major part of project supervision, which should go through the whole construction period. Entrusted by the environmental management office, the environmental supervising engineer is to supervise and check the environmental protection tasks conducted by professional organizations and project subcontractors during construction period.

7.3.1. Tasks of environmental supervision

(1) Randomly checking and supervising environmental protection of professional organizations conducting environmental protection tasks and project subcontractors, based on relevant laws, rules, regulations and agreement of environmental protection, and requiring the deadline of fulfilling environment protection tasks.

(2) Assisting environmental protection management office and relevant authorities in dealing with environmental pollution accidents and disputes in project impact area.

(3) Preparing monthly report and half-yearly report of environmental supervision, submitting report to environmental management office, concluding environmental supervision, Bring up major environmental problems and suggested solutions, indicating environmental supervision arrangement and focus in the future.

7.3.2 Monitoring method

Monitor through inspection and instructional documents.

7.3.3 Supervision personnel

Based on the environmental supervision work (excluding supervision on water and soil conservancy) of Changfeng hydropower project, 1 environmental supervisor is needed.

8. Analysis on environmental protection investment and its profit and loss

8.1 Investment estimation of environmental protection

Based on environmental economics, environmental laws and regulations, and basic ecological environmental principle of "the destroyer responsible for training", prediction on possible ecological impact and estimation of precaution investment are made in order to avoid major environmental damage of project construction, to avoid ecological deterioration, to promote good economic and ecological circulation and to realize sustainable development. It is necessary to lower environmental risks to minimum.

8.1.1 Investment principles

The following investment principles are determined based on applicable state laws, regulations and policies and referring to the actual situation of project.

(1) The principle of "pollution makers responsible fore controlling and developers responsible for protection: the investment project of environment protection is determined by the above principles, which is also used in investment apportionment when necessary.

(2) The principle of "functional protection": pollution control is aimed at protecting project functions.

(3) The principle of "function recovery": the investment scale should be adequate for protecting or recovering the ecological environmental function before project construction.

(4) The principle of "one time compensation"; ecological environmental losses caused by project is to be compensated by one-time compensation.

8.1.2 Estimation basis

(1) Design Methods and Calculating Criteria of Hydropower Projects (State Department of Economy and Trade, No.78 in 2002)

(2) Notice for regulating charges of environment impact consultant by National department of planning and developing, National Administration of Environmental Protection, (JJG No. [2002]125)

(3) Design for environmental protection measures of Changfeng hydropower project

(4) Related material are calculated according to market price in the first half of 2004.

(5) Hubei provisional regulation for charging of environmental protection industry and the management measures for charging of environmental monitoring.

8.1.3 Classification of investment projects

Based on relevant regulations on environmental protection of construction projects; all devices, equipments, monitoring instruments and project facilities for pollution control and environmental protection are environmental protection facilities.

All construction projects of environmental protection facilities should list estimated investment for environmental protection facilities.

The environmental protection projects that need special investment include environmental protection in construction area, environmental monitoring and management, protection of reservoir water quality, etc. For environmental investments from other sources such as reservoir bed cleaning, reservoir inundation and compensation, environmental protection faculties for construction are listed in construction investment, which are not calculated in special environmental investment.

8.1.4 Major environmental investments

Based on the environmental impact, environmental protection measures, basic unit price and comprehensive unit price of related measures of Changfeng hydropower project, the total investment of project environmental protection estimated according to the above principles are RMB2.16805 million, among which the investment on environmental protection facilities in main project zone is RMB 601150 covering 27.7% of total investment; independent expense is RMB290500 covering total static investment of 13.4%; total investment for water and soil protection is RMB1.2764 million, covering total static investment of 58.9%.

The environmental protection investments of the project are listed in table 8-1.

Table 8-1 Estimated Investment on Environmental Protection of Changfeng Hydropower Project

No.	Name of project or cost	unit	quantity	Unit (RMB)	Total (*RMB 10000)	Remarks
I. Environmental protection on hydropower project					60.115	

No.	Name of project or cost	unit	quantity	Unit (RMB)	Total (*RMB 10000)	Remarks
I	Disposal of sewage and wastewater				18.52	
1	Disposal of domestic sewage	m^3	39.2	1000	3.92	Micro-power domestic sewage disposal facilities, cesspool
2	Disposal of oily wastewater	Per location	1	20000	2.0	
3	Wastewater disposal of aggregate processing				12.0	Already listed in aggregate processing system
	□Construction cost	Per location	2	40000	8.0	Preliminary construction state
	□Operation cost	Per year	2	20000	4.0	Operation cost for washing wastewater disposal of aggregate processing system
4	Wastewater disposal of concrete production system	Per location	1	6000	0.6	Including operation cost in construction period
II	Ambient air quality protection				10.37	
	(1) Water spray	Per year	2	25000	5.0	Including wages and water cost
	(2)Bag dust collector for concrete mixing system	Per set	1	50000	5.0	
	(3) Dustproof respirator	Per set	367	10	0.37	
III	Noise training				0.37	
	Individual protection for high noise	Per set	367	10	0.37	
IV	Disposal of domestic waste				0.829	
	Garbage bin	Per pc	6	500	0.3	
	Disposal of domestic waste	t	132.3	40	0.529	
V	Public health protection				7.526	
1	Sanitary cleaning	m^2	20000	0.3	0.6	Conduct once before construction begins or after it finishes respectively
2	Sanitary quarantine	Per person	734	60.0	4.404	
3	Immunization	Per person	734	25	1.835	
4	Mouse and mosquito killing	/year/capita	2×367	5.0	0.367	Comprehensive unit price
5	Toilet	Per location	4	800.0	0.32	
VI	Aquatic organism protection	年 Per year	6	20000	12.0	
VII	Ecological and environmental monitoring				10.5	
1	Aquatic environment				3.0	
2	Ambient air quality				1.5	
3	Noise				0.4	
4	Aquatic organism				5.0	
5	Epidemic monitoring				0.6	

No.	Name of project or cost	unit	quantity	Unit (RMB)	Total (*RMB 10000)	Remarks
II. Independent cost					29.05	
I	Construction management cost				18.3	
1	Regular cost for environmental protection staff				1.80	3% of part I
2	Cost for research, survey and design				15.0	
3	Environmental protection propaganda and technical training				1.50	2.5% of part I
II	Environmental monitoring cost	/capita /year	1×2	50000	10.0	
III	Project quality Monitoring cost				0.75	0.25% of part I
Total static investment on environmental protection					89.165	
III.Total static investment on water and soil conservation					127.64	Based on plan of water and soil conservation
Total environmental protection investment					216.805	

8.2 Analysis on economic profit and loss of ecological impact

8.2.1 Economic benefit

Changfeng hydropower project mainly focuses on power generation, whose benefit mainly shows in the direct economic profit of power generation, and the social benefit produced by protecting and improving regional ambient environment.

The installed capacity of power station is 2×4000kW with average annual power output of 0.35 million kWh, annual utilized hour of 3453h and firm output of 1675kW。Though its installed capacity is not large, it can participate in system peak regulation and will be a regulating power source with free long regulation of Changyang County power system, which is to alleviate the conflict of power consumption and regulation in local power system, and helps the system to provide better power quality. The development of power industry will inevitably promote the development of regional economy, industrial and agricultural production.

When the project is completed, the financial internal rate of return of total investment is 10.68%, higher than the 10% financial standard rate of return. The investment payment period is 10.2 years (including construction period). The domestic economy investment and

profit adjustment is calculated with shadow prices on commercial electricity power (RMB0.30/kW.h). The domestic economic internal rate of return is 14.76%, which is higher than social discounting rate of 12%. Therefore, the project is feasible from the point of national economy.

Referring to the industrial and agricultural output value of power kWh in middle and east China, the industrial and agricultural output value of Changyang County can reach RMB0.13 billion.

8.2.2 Social Benefit

The project fully utilizes the local natural geographical condition and advantages by adopting trans-basin water diversion power generation, which is to bring considerable social benefit.

(1) When the project is completed, it will reduce damages to certain extent cause by flood, landslide and debris flow, which helps to create a safe production and living environment for nearby residents so that they can live and work in peace and content environment. With woods and grasses, the mountains become more beautiful, which also provide better working environment for power station employees.

(2) The planned project has real benefit of land resource protection and utilization. It improves flood storage capability of hydropower projects and its flood protection rate. With construction of diversion dam and diversion tunnel, local flood discharge capability is improved to some extent, which reduces the area and period of inundation.

(3) When the project is put to operation, it provides employment opportunities and employment environment for the society, improving local economic income and bringing better social benefit.

8.2.3 Ecological effect

During the project construction period, it has certain impact on ecological environment. When the project is completed, its impacts on ecological environment are mainly positive impacts. The project reduces the threats of downstream floods, enlarges land reclamation area, improves flood protection rate, avails hillsides closed for afforestation , controls water and soil loss, and improves ecological environment. The

general water quality of reservoir and downstream face of the dam will be improved. In summary, the project construction brings better ecological environmental benefit.

8.2.4 Environmental effect

Compared to other heat power project with similar output, it has better environmental benefit. Hydropower is renewable energy and clean energy. Compared with heat power station with same power energy output, take 480g/kW·h as the standard coal consumption of heat power station, then when it is replaced by hydropower station, the coal consumption reduced is 1.68×10^4t/a, reduced SO_2 discharge is 87.3t/a, and NO_2, CO_2, CO, smokes, dusts and other hazardous substances. The damage caused by hazardous substance from heat power station into air and water is also reduced. The hydropower station reduces waste disposal cost of RMB2.5×10^4/a annually. Since there is no fuel coal transportation, large transportation equipment investment and land use of special transportation line are reduced, which also reduces the damage to environment by project construction.

8.2.3 Comprehensive analysis on environmental economic profit and loss

From above analysis on environmental protection investment, environmental benefit, economic benefit and social benefit, we can see that the environmental loss is smaller than the environmental benefit, and the positive environmental impact is obviously more than negative impact. The social and economic benefits of the project are mainly in power generation and local economy promotion. Its environmental benefit is alleviating the regional ecological damage, while the losses are land inundation, water and soil loss, etc. the above losses can be reduced through relevant compensation and environmental protection measures. In summary, the environmental economic profit of the project is better.

9. Public participation

Public participation is a major part of environmental impact assessment. In order to make the public realize the construction, operation features and related problems of Changfeng hydropower project, to collect the public opinions and suggestions for the project, to avoid negative environmental impact as possible, to make more reasonable and complete planning and designing of project and to display comprehensive project benefit to maximum, the assessment organization launched various public participated activities in 2004 with support from relevant local authorities.

9.1 Scope, mode and content of public participation

9.1.1 Mode, object and scope of participation

By visiting and meeting at the reservoir zone and dam zone, we sent out public participation questionnaire to make a survey with residents in reservoir zone and inundating land as well as related persons with different occupation in the county

The objects of public participation are 50 persons from social groups, management organizations and residents in reservoir zone, who are project technicians, government officers, representatives of People's Congress Council (P.C.C), members of Chinese People's Political Consultative Conference (C.P.P.C.C.), common people and moving residents, most of whom are influenced persons in construction zone and reservoir zone. The survey result fairly reflects the desire of persons in construction zone the objectively

9.1.2 Content of questionnaire

See table 9-1 for content of form of the questionnaire.

Table 9-1 Questionnaire for public participation

- Basic information of the surveyed person

Name	gender	Age	Education	Occupation	Nationality
	☐ Male ☐ Female	-year-old	☐ college ☐ Middle	☐ cadre ☐ worker	

			school ☐ Primary school ☐ Below primary school	☐ farmer ☐ other	
company name					
Home address					
Telephone					

- survey content

1、Did you know about the project?

Yes □ no □

2、What is your attitude towards the project?

Agree □ disagree □

3、If you agree with project construction, when is the best time for construction in your opinion?

Immediately □ later in the future □

4、What impact may the project have on regional economy in your opinion?

Big promotion □ Small promotion □ no promotion □

5、What do you think of the existing ecological environment of the construction area?

Excellent □ average □ bad□

6、What impact the hydropower station will have in your opinion?

Important promotion of general development □
Promote the local economic development □
Improve regional environment □
Improve flood protection of dam downstream □
Improve regional ecological environment □
Improve people's living standard □
Increase employment opportunity □
Improve transportation condition □
Others: _____

7、What are the negative impacts of hydropower station construction in your opinion?

Immigration □
Land inundation □
Inundation of rare animals and plants □
More water and soil loss □

Others:_____

8、What your opinion on immigration and settlement?

Unwilling to move □ move by getting over difficulties □ willing to move □

9、What is your demand for immigration?

Move to nearby area □ move to other places □

10、What are the environmental problems in your place?

Inconvenient transportation □ water and soil loss □ natural calamity □

Others：_____

11、What are the rare animals and plant in your place?

（1）rare animals：_____

（2）rare plants（including medical medicines）：_____

Your suggestions in supplement is

_____

9.2 Statistic analysis on survey result

9.2.1 Basic information of the surveyed persons.

50 questionnaires are send out in this survey for public investigation with 50 questionnaires returned. The return rate is 100%. The distribution of the surveyed are listed in table 9-2

Table 9-2 Distribution of the surveyed persons

Surveyed person type		farmer	worker	cadre	Soldier	Other occupation	Total	
gender	male	12	9	6	2	8	37	50
	female	6	4	3	0	0	13	
	total	18	13	9	2	8	50	
Education	college	0	0	4	0	3	7	50
	Middle school	11	11	5	2	4	33	
	Primary school	7	2	0	0	1	10	

From the statistic result of the surveyed persons, we see that 36.0% of the surveyed are local farmers with largest proportion, among which 12 farmers are from inundated area and nearby area covering 24.0%, workers and cadres cover 26.0% and 18.0% respectively. Analyzing from genders, most of the surveyed are males, covering 74.0%. Analyzing from education background, most of the surveyed are of middle school education background covering 66.0% while the proportion of college and primary education background are similar.

Among all surveyed persons, there is one representative of People's Congress Council (P.C.C) of the County, and one members of Chinese People's Political Consultative Conference (C.P.P.C.C.) of Yichang City.

9.2.2 Statistic analysis on feedbacks

See table 9-3 for statistic results of questionnaire contents

Table 9-3 Statistics of Public opinions

NO.	Opinions		Number of persons	Classified number of persons	Percent
1	Did you know about the project?	yes	50	50	100%
		no		0	0
2	when is the best time for construction?	Immediately	50	45	90%
		Later in the future		5	10%
3	What impact may the project have on regional economy?	Big promotion	48	40	83.3%
		Small promotion		8	16.7%
		no promotion		0	0
4	What is the existing ecological environment of the construction area?	Excellent	50	43	86%
		average		7	14%
		bad		0	0
5	What are the environmental problems in your place?	Inconvenient transportation	44	26	52%
		water and soil loss		18	36%
		natural calamity		0	0

NO.	Opinions		Number of persons	Classified number of persons	Percent
6	What impact will the hydropower station have?	Important promotion of general development	50	50	100%
		Promote the local economic development		50	100%
		Improve regional environment		32	64%
		Improve flood protection of dam downstream		25	50%
		Improve regional ecological environment		12	24%
		Improve people's living standard		21	42%
		Increase employment opportunity		22	44%
		Improve transportation condition		45	90%
7	What are the negative impacts of hydropower station construction?	immigration	50	5	10%
		Land inundation		38	76%
		Inundation of rare animals and plants		0	0
		More water and soil loss		0	0
8	What your opinion on immigration and settlement?	Unwilling to move	3	0	0
		move by getting over difficulties		3	100%
		willing to move		0	0
9	What is your demand for immigration?	Move to nearby area	3	3	100%
		move to other places		0	0
10	What are the rare animals and plant in your place?	Rare animals: no	0	0	0
		Rare plants: no		0	0

(1) Among all surveyed persons, 50 persons know about the preparation of Changfeng hydropower project covering 100%. It means that most of the surveyed know about construction of the project, which is quite influential and common people concerns much about it.

(2) 45 persons require immediate construction covering 90% of the total surveyed

persons. 5 persons require starting the project later, covering 10%, whose main reason is worrying about the investment. It shows that common people are very active about economic activities in the zone and their desire for changing existing regional situation is strong.

(3) 86% of the surveyed consider that the existing ecological environment quality is excellent in the construction area, with green mountains and clean water, which is suitable for residents and tourism. 14% of the surveyed maintain that the existing ecological environment quality is average, whose main reasons are less controlled regional water and soil loss, frequent occurred geological disasters including landslide and the auxiliary facilities are not complete.

(4) For main problems at present in living, 52% common people chose inconvenient transportation which also impacts the development in other aspects; 36% chose water and soil loss.

(5) For positive effects of the hydropower project, most of the surveyed are quite affirmative about this with high expectations. 100% of the surveyed think it important to general regional development, 100% of the surveyed consider it will promote local economic development, 24% of the surveyed think it will improve regional environment, 42% of the surveyed think it will improve living standard of people, 90% of the surveyed maintain that it will improve transportation situation and 44% of the surveyed think it will increase employment opportunities.

(6) The possible negative impact of the project are classified as follows:

38 persons chose land inundation covering 76% of total.

No other problems are forwarded

(7) Immigration and settlement

In 3 representatives from all 3 households that are involved in immigration, 100% of them maintain that they will get over difficulties and move to nearby place. This shows that the public is especially concerned about immigration and places much importance on mountain lands.

(8) Regard to the question of rare animals and plants, more surveyed persons are familiar with animals than plants. No one answers the question of whether there are any

rare animals or plants.

9.2.3 Most Concerned problems of the public

By visiting villagers and hold discussions with persons from different occupation, we collect public opinions and the feedbacks of the questionnaire for public participation. The most concerned problems and opinions of the public are listed as follows.

(1) Concerned about reservoir zone land compensation. The villagers hope that local government and construction organization make compensation plans and relevant implementation measures according state policy. For land use compensation, reasonable land use price should be determined based on state policy and standard combining local actual situations. Fully understand the opinions and requirements of villagers and actually solve the problem without any possible problem left behind.

(2) Concerned about construction quality of project. The project quality is of vital and lasting importance. The public do not expect a “jerry-built project”.

(3) Concerned about further development and utilization when project is finished. The project should be utilized in long-term planning of local economic development. It is suggested by the public that government should make construction plans for infrastructures (including road, telecommunication, etc.) matched to the project and auxiliary welfare facilities. Speed up in making the plans of promoting local economic development and improving people’s living standard and collecting construction fund.

(4) Concerned about the timely flood discharge in operation, the flood protection, and water and soil loss after project is completed. The villagers hope that government could concern about these problems and examine careful of the technical measures and solutions for these problems in the project design report and environmental assessment report.

9.3 Conclusion and suggestion of public participation

From the above suggestions, it is reflected that most of the surveyed know about and agree with the project. Most of the surveyed agree that project construction can improve people’s living standard, promote local economic development and increase employment opportunities. The most concerned problems are land use compensation, environmental

pollution, ecological damage, etc.

According to the suggestions from public survey, it is advised that construction organization should strictly conduct all pollution control measures, alleviate the pollutions caused by ambient air, surface water, noise and solid waste, and reduce water and soil loss as well as damage to ecological environment.

10. Conclusions and suggestions

10.1 Assessment conclusion of major environmental factors

(1) Local climate

When the reservoir begins water storage, the original land is turned into water. With enlarged water surface, the evaporation rate in the reservoir zone will be higher than before. With more vapor into the air, the solar radiant heat is adjusted. The factors such as humidity and temperature of the reservoir zone its nearby area will change, which will cause changes in local climate. Reservoir water storage is to slow the temperature change with smaller daily difference and yearly difference of air temperature, lower max air temperature and higher min temperature in a year. Since the water surface is enlarged, the roughness of underlying surface of the reservoir is reduced and surface wind speed in the reservoir is increased. However the reservoir zone is not large and the impact area is limited within reservoir zone with small extent of change.

(2) Hydrology and sediments

Ganhe creek basin is a mountain-area river, where the flood is influenced by rainstorm intensity and landform. It has heavy intensity rainstorm in the basin, steep river slope, short

flow concentration period, rapid flow rate and flash flood. The catchment area at upstream of the dam site is 55.8km^2. The project changes the original condition of natural water course. With reservoir water storage, the sediment deposits in the reservoir year by year. The hydrological conditions of reservoir will see relative change in pool level, flow, flow rate, etc. With larger change in average annual reservoir pool level, the average flow rate is also slower than that of natural situation.

The water of Changfeng hydropower project is gathered to dam reservoir zone through karst caves, which has small amount of sediments and no deposition problems will be caused.

(3) Ambient geology

The rocks on the right bank of reservoir of Changfeng hydropower project are thick. From reservoir zone to nearby valley, there is Daye formation and Dalong formation with better aquiclude. In relevant part of the nearby valley, there is no obviously exposed spring or ground water pipe, thus reservoir water will not leak to the nearby valley. The stratum of the reservoir zone near the dam is made of limestone of Changxing formation with developed karst. The water pressure test in borehole shows that it is medium aquiclude, which should be treated with leakage proof measures together with dam site grouting. The mountain stratum of left reservoir bank is limestone-shale of lower Daye formation with certain aquiclude. The left reservoir bank will not leak to the nearby valley. With reservoir water storage, some part of the zone is possible to cause collapse or small landslide. There is no large landslide or any major security problems after reservoir water storage. There are no minable minerals and cultural relics in the inundation area with no land immersion problems. The regional geologic structure is stable, which is weak seismic zone, it is almost impossible to see strong earthquake induced by the project, however anti-seismic capability should be taken into account in project design.

(4) Water quality and temperature

When reservoir of Changfeng hydropower project starts water storage, the change in hydrological situation will not lead to obvious negative impact on general reservoir quality. The reservoir water quality can maintain its original state in general. Small amount of domestic sewage drainage from upstream reservoir will not impact the general reservoir

water quality. When Changfeng hydropower project is completed, the reservoir is oligotrophic.

Based on analysis, the reservoir of Changfeng hydropower project is thermal stratified. The reservoir water exchanges frequently with no large spawn area of commercial fishes and precious fishes. There is no demand for production water and domestic water, and no demand for irrigation of Changfeng hydropower project. Thus the low-temperature reservoir water in summer of Changfeng hydropower project has little impact on downstream rivers.

(5) Terrestrial ecological environment

When the hydropower station is put to operation, some woodland with high productivity is inundated and the use of land is changed relevantly, which lowers the productivity of the natural system in area. But it is still of high productivity. The project construction has small impact on ecological environment of landscape in the area.

Project construction and reservoir inundation will have negative impact on vegetation. Main vegetation in inundated area is shrubbery. There is no original vegetation, large-area-commercial-forest or rare plants in reservoir inundation area. The project has small impact on wildlife, which will not cause any obvious impact on biomass structures and variety of wildlife.

(6) Aquatic organism

With reservoir water storage, inundation cause the increase of trophic salts in the reaches in reservoir zone, leading to improved primary productivity and improved bait condition, which is good for growing and breeding of fishes suitable for tranquil water or static water.

With water storage of Changfeng hydropower project, the dam cut off the continuity of the original rapid water ecological system. Construction of the dam also cuts off the sailing upstream route of the fishes, which reduces the fish resource in reservoir zone.

Six waste disposal areas are setting up in the tunnel constriction zone and dam site construction zone, which are situated at the main dam site and near each adits. The waste disposal area will have drainage ditches at three directions, lined with mortar laid stone. The drainage ditch will be connected to nearby river and a sediment deposit will be built at

the outlet. Before placing waste disposal, the surface mellow soil should be separated and piled in the corner of the waste disposal area. When the construction is finished and waste disposal is disposed, the waste disposal area can be restored to farmland. The above measures not only slow down its impact on the ecological environment but also reduce its impact.

(7) Impact on construction environment

The construction zone is in mountain area with good existing air environment and noise environment. Since the dusts produced in project construction, exhaust air from machines, tail gas of transportation vehicles and road flying dusts has no obvious impact on the ambient air quality in the region. For impact on construction staff on spot, more protections should be applied. The pollutants in construction that has impact on aquatic environment mainly comes from washing wastewater of aggregate processing system, water discharge of pit excavation, washing wastewater of construction machinery maintenance, wastewater from concrete mixing and domestic sewage from construction staff. The construction wastewater and domestic waste has impact on part of the water area in construction zone. Gathered construction staffs produce domestic wastes. The wastewater, exhaust air, noise and domestic waste of construction zone have certain impact on the environmental quality of construction zone. However this impact is small which will disappear when construction is completed.

(8) Water and soil loss

Due to road construction inside the zone, earth-rock excavation, exploration in quarry area and borrow area in construction, it produces waste residues and destroys surface vegetation. It no measures of water and soil conservation is adopted, the new water and soil loss in the project zone may reach 1.73 million t, which will have different levels of impact on land productivity, watercourse deposition and change in regional ecological environment.

(9) Public health.

Construction staffs are engaged in high intensity physical labor in the field, which will lower their immunity. If the domestic sewage and production wastewater are not effectively disposed, they will become medium for growing and breeding of mosquitoes

and flies, thus lead to epidemic of some insect borne or water borne infectious diseases. At the preliminary stage of reservoir water storage, there may be higher morbidity of water borne diseases and natural focus disease. Thus precautions should be taken. Project construction has no impact on endemy.

10.2 Measures and conclusion of environmental protection

(1) Measures of environmental protection in construction area

The main aquatic environmental pollutant in construction mainly comes from wastewater of aggregate processing and domestic sewage. Wastewater of aggregate processing is to be disposed by sedimentation basin while the domestic sewage is to be disposed by dry toilet together with cesspool. For air pollutions such as dusts, flying dust in road and noise pollution in project construction, the suggested measures are providing individual protection for construction staff, water spraying on roads and vehicle speed limit. With above measures, the impact on ambient air quality and noise environment of project construction will be reduced.

(2) Ecological environment

For possible negative impact on aquatic organism by Changfeng hydropower project, the following suggestions are put forward: fish tagging propagation, aquatic organism monitoring and guaranteeing water use of downstream ecology of the dam during reservoir operation. For impact on terrestrial ecological environment by reservoir inundation and project construction, suggestions such as vegetation restoration, strengthened propaganda and management are put forward. In order to ensure that the existing ecological environment of downstream watercourse will not be damaged after dam construction, it is suggested that certain amount of ecological water discharge of the dam should be guaranteed. When calculated by existing minimum flow in dry season, the water flow should not be less than $0.22m^3/s$.

(3) Water and soil conservation

For new water and soil loss in project development zone (construction zone), plant measures and construction measures for water and soil conservation plan are brought forward based on various areas including project construction area, transportation area,

waste disposal area, quarry area, borrow area and powerhouse area.

(4) Public health

Since the project involves no settlement of immigrants, protection object of public health is construction staff. Main protection measures for public health in construction area are sanitary cleaning, vector control, sanitary examination of infectious diseases and vaccination, and sanitary and health propaganda.

(5) Ecological and environmental monitoring

In order to master environment change during project construction, knowing the changes of environmental factors such as water, air, noise and aquatic organism as well as effective results of environmental measures in the impact area, the ecological and environmental monitoring plan for Changyang hydropower project is put forward.

10.3 General assessment and conclusion

The project can meet the power supply demand of the power network in Changyang Tujia Autonomous Country, alleviating regional power shortage problems, and having positive impact on promoting local economic development. Meanwhile, the profit of power output can bring more direct economic income like taxes to Changyang County. The large investment will be the driven force for the local economic development. The project construction with many construction staff moved in will greatly increase local consumption.

Main negative impacts of the projects are: inundation of terrestrial vegetation by reservoir storage, potential negative impact on downstream ecological environment of the dam by reservoir operation, exhaust air, wastewater and waste residue produced in construction, water and soil loss in construction, etc. The negative impacts caused by construction can be alleviated or reduced by measures.

To sum up, the environmental impacts of Changfeng hydropower project are on both sides. The construction of hydropower station lowers the natural environmental quality in part of construction zone. From integrated and long-term view, the project has large economic profit, environmental benefit, social benefit and small change in general environment quality in project zone. Therefore, Changfeng hydropower project of Yichang

Changfeng Hydropower Development Co., Ltd. is feasible from the point of environmental analysis.

10.4 Suggestions

In order to reduce the negative impact of project to minimum and fully display the social benefit, economic benefit and environmental benefit, the followings are suggested:

(1) To strengthen environmental management and improve environmental protection in construction zone.

(2) To improve water and soil conservation in construction area by conducting water and soil conservation plans

(3) To set up environmental management organization to establish relevant environmental management system and bring it into effect.

(4) To fix in advance the environmental protection investment, establish relevant monitoring system and ensure that the special investment is used for environmental protection with its specified purpose only.