SFG2563 REV

China: Hubei Inland Waterway Improvement Project-
Yakou Navigation Complex

ENVIRONMENTAL ASSESSMENT

Executive Summary

JULY 2017

TABLE OF CONTENTS

1. INTRODUCTION

This document summarizes the social and environmental impact assessment (ESIA) process of the Hubei Inland Waterway Improvement Project (hereafter, the Project). The Project includes a major infrastructure component, i.e. Yakou Navigation Complex which is located in the middle reach of the Han River in Yicheng, Xiangyang (formerly Xiangfan) Municipality in Hubei Province.

The project proponent, Hubei Provincial Transport Department (HPTD), has retained Zhongnan Engineering Corporation Limited (an independent EIA consultant with Class A EA license in China) for the preparation of environmental impact assessment. Meanwhile, as supporting studies for EIA preparation, HPTD also engaged independent and licensed institutes which have developed a series of supporting documents, including *Water and Soil Conservation Plan*, *Special Study on Survey and Assessment of Aquatic Life for Yakou Navigation Complex project, Joint Ecological-flow Operation Plan of Complexes below Danjiangkou Dam Along Han River, Physical Cultural Resources Protection Plan,* as well as design documents for fish passage and fish breeding and release station of Yakou Complex. Based on these studies, an EIA report for Yakou Navigation Complex was prepared in November 2015, and reviewed and approved by Ministry of Environmental Protection on February 17, 2016.

In February 2016, the World Bank conducted the project identification mission. Based on the World Bank's safeguards policy requirements, a Supplementary EIA was prepared to further improve the scope and depth of environmental and social impact assessment. These improvements mainly include:

- Assessment scope: broadened the scope to cover the upstream dike improvement and power transmission line;
- Alternative analysis: conducted more systematic analysis considering technical, economic, financial and environmental perspectives for alternatives of dam sites, water level, fish passage design etc.;
- Natural habitat: developed detailed ecological flow operation plan, and formulated work plan for assessment and improvement of fish passages at different complexes of the Han River basin;
- Wanyangzhou Wetland Park: provided additional information on the adjusted wetland park plan to clarify potential project impacts on the park;
- Physical cultural resources: developed a Physical Cultural Resource Management Plan as part of ESMP;
- Social impacts: provided supplementary social impact analysis based on findings of Social Assessment;
- Cumulative Impacts Assessment (CIA): conducted a systematic cumulative impact assessment for the middle and lower reaches of Han River basin considering cascade dam construction, and developed environmental mitigation measures and work plan for next step studies;
- Public consultation and information disclosure: conducted additional rounds of consultation for the preparation of supplementary EIA and CIA, and disclosed the full reports to the public.

Based on safeguards screening, the following World Bank safeguards policies are triggered: 1) *OP4.01 Environmental Assessment*; 2) *OP4.04 Natural Habitats;* 3) *OP4.11 Physical Cultural resources;* 4) *OP4.12 Involuntary Resettlement;* 5) *OP4.37 Dam Safety*. The safeguards documents prepared include: a full EIA report (the supplementary EIA updated based on domestic EIA); a technical report on cumulative impact assessment; an ESMP for Yakou Navigation Complex; an ESMP for associated dike improvement project; a Social Assessment Report and a Resettlement Action Plan. This Executive Summary is based on these reports, as well as feasibility studies, design and relevant surveys carried out for the project. The compliance with World Bank's policies is summarized in the following Table 1.

Table 1 Compliance With World Bank's Safeguards Policies

Safeguard Policy	Compliance
Environmental Assessment (OP / BP4.01)	• Category A. Environmental and social impact assessment has been carried out; • EIA documents include: 1) the previous domestic EIA Report; 2) supplemental EIA report; 3) the ESMP of the complex and other auxiliary works; 4) the ESMP for upstream dyke improvement of reservoir area; 5) EIA executive summary; • Multiple rounds of public consultation have been carried out according to OP4.01 and the full text of EIA Reports has been disclosed.
Natural Habitats (OP/BP4.04)	• Survey on aquatic and terrestrial ecosystem has been implemented and potentially affected natural habitats and targets of ecological protection have been identified; • Potential impacts of the project on natural habitats and ecological sensitive areas and fish have been assessed; • Protective measures on the habitats have been proposed, including protection of fish habitats, fish passages, ecological operation of cascade reservoirs and so on; • The project will not cause significant degradation or conversion of any key habitats.
Physical Cultural Resources (OP/BP4.11)	• Survey on cultural relics has been done and several ancient tombs were identified in the project affected area. These ancient tombs will not be affected by the project construction but be subject to the inundation or erosion due to impoundment of reservoir; • Physical cultural resources protection plan has been formulated • "Chance-find" measures have been included into the ESMP
Dam Safety (OP/BP4.37)	• Dam safety plan has been prepared
Involuntary Resettlement (OP/BP4.12)	• Resettlement Action Plan has been prepared.

In summary, the EIA has thoroughly assessed potential environmental and social impacts related to navigation complex construction and operation, as well as associated projects of upstream dike improvement and power transmission line. It concluded that the project: (i) will have adverse environmental impacts on aquatic ecology (e.g. segregation of fish habitats, impacts on spawning sites, and adverse impacts on certain fish species), especially considering the cumulative impacts of the 7 cascade dams in the middle and lower reaches, for which a set of mitigation measures have been developed in the ESMP to minimize, mitigate or offset the impacts; (ii) will not adversely affect or convert critical natural habitats; (iii) will not adversely affect resources of high cultural value and has developed a management plan for cultural resources; (iv) will not adversely

affect ethnic minorities; (iv) will have minimized the need for resettlement and will provide adequate and just compensation and income restoration for affected peoples; and (v) has developed comprehensive management plans for addressing environmental and social issues during construction and operation of the project.

2. PROJECT DESCRIPTION

2.1 Background

2.1.1 Han River Basin

Han River is the largest tributary of Yangtze River in the middle reach of Yangtze River, originates from Qinling Mountains of Shaanxi Province and runs through Shaanxi and Hubei Provinces before flowing into Yangtze River in Wuhan. The total length is 1,567km, the drop height is 1,964m and the basin area is 159,000km^2.Han River basin is located between E106°12' to 114°14' and N30°08' to 34°11'.

Generally, the whole Han River Basin has a higher elevation in northwestern part and lower in the southeast. The terrain of upper reach is alternating hilly land, mountainous areas, valley and plain and the terrain of middle and lower reach is mainly plain protected by dikes. The whole Han River basin is divided into three typical sections: (1) section above Danjiangkou is upper reach, with length of 918km and controlled basin area of 95,200km^2, and a topography dominated by middle and low mountains and hills; (2) middle reach (section from Danjiangkou to Zhongxiang) with length of 270km and controlled basin area of 46,800km^2, and a topography dominated by low hills and plains; (3) lower reach (from Zhongxiang to Wuhan) with length of 379km and catchment area of 17,000km^2, and a topography of plains.

2.1.2 Han River Basin Development Plans

In order to reasonably develop the water energy resources of Han River, Yangtze River Water Resources Commission and other relevant departments have developed a number of plans for flood control, water supply, water resources, ecological and environmental protection, power generation, navigation planning and water & soil conservation since 1950s.

In June 2009, Yangtze River Water Resources Commission has developed a *Comprehensive Plan for Han River Trunk Stream* which has passed the evaluation of Water Conservancy and Hydropower Planning and Design Institute of the Ministry of Water Resources in December 2010. The plan was latterly revised and submitted to the State Council for approval in May 2011. The revised plan recommended a cascade of 15 hydro dams in trunk of Han River, i.e. Huangjinxia, Shiquan, Xihe, Ankang, Xunyang, Shuhe, Baihe, Gushan, Danjiangkou, Wangfuzhou, Xinji, Cuijiaying, Yakou, Nianpanshan and Xinglong. Among them, eight hydro complexes are within Hubei province, i.e. Gushan (upstream), Danjiangkou, Wangfuzhou, Xinji, Cuijiaying, Nianpanshan (midstream) and Xinglong (downstream) complexes. The cascade hydro complex dams plan is illustrated in **Figure 1**.

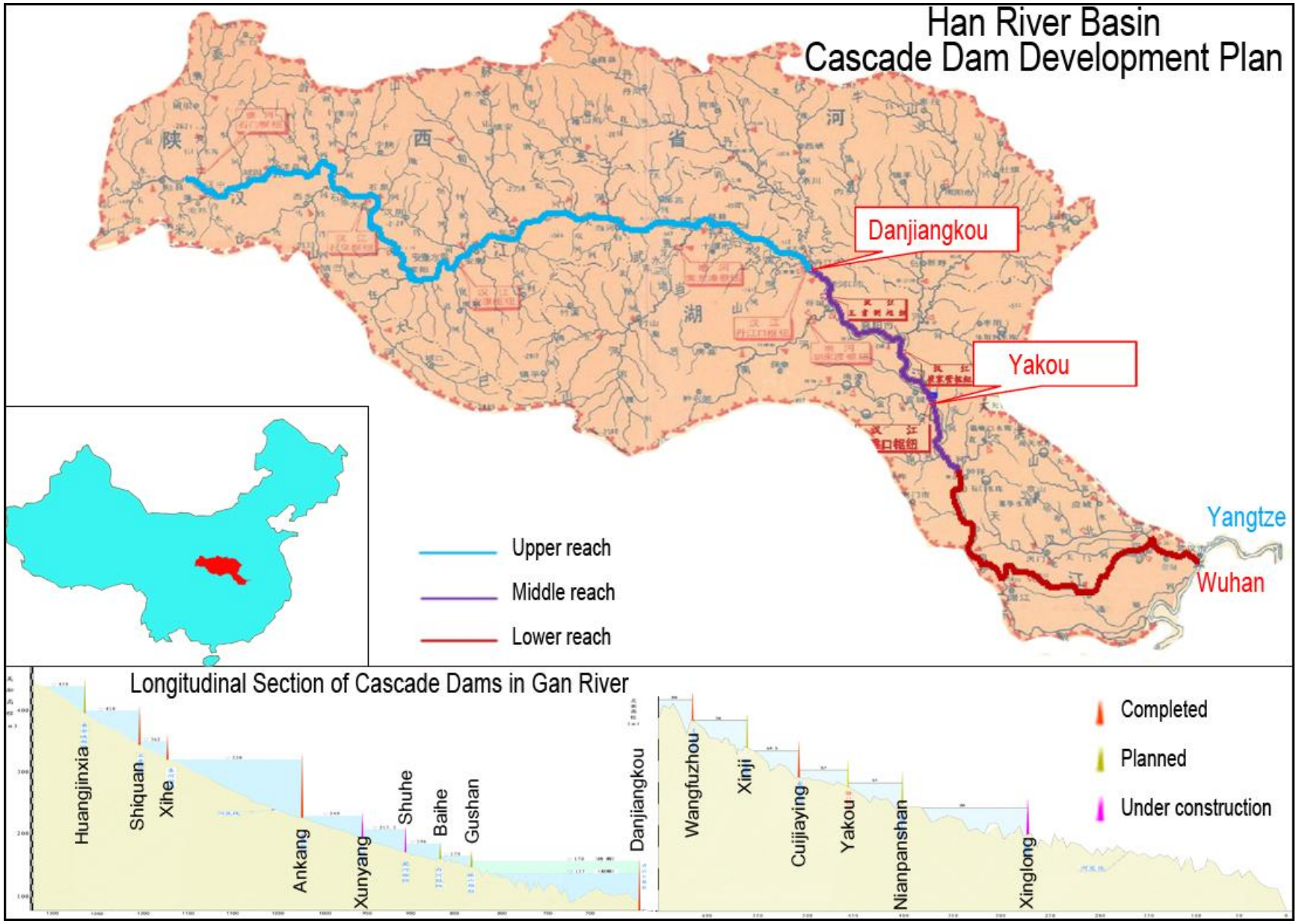


Figure 1 Cascade Dam Development Plan of Han River Basin

The transport authorities have been paying attention to the navigation development of Han River and have been developing and improving navigation plans of Han River basin since 1958. In September 2012, National Development and Reform Commission approved *Scheme for Construction of High Grade Waterway in Han River and Jianghan Canal (2011-2015)* submitted by Hubei Provincial Development and Reform Commission and Shaanxi Provincial Development and Reform Commission. In accordance with such navigation planning, channelization of complexes along Han River should be completed till 2020 and all waterways should meet the planned waterway standard. For the middle and lower reaches below Danjiangkou, the river channel is to meet Class III waterway standard, i.e. enabling 1000 Dead Weight Tonnage (DWT) vessels to navigate year-round to the Yangtze River from Xiangyang Municipality.

It should be noted that the transport authorities and the water resources authorities have the same plan for the eight hydro complexes development plan along trunk of Han River in Hubei Province.

Among the7 mid- and down-stream complexes, Danjiangkou reservoir has a designed capacity of 29.05 billion m^3, therefore has multi-year regulation capacity, while all the other six reservoirs in the downstream of Danjiangkou reservoir are run-off type of reservoirs with storage capacity only 0.51% to 3.02% of that of Danjiangkou reservoir and only have daily or no regulation capacity. Hence, the most important factor affecting the ecological environment in middle and lower reaches of Han River is mainly controlled by Danjiangkou reservoir and runoff of this section of Han River basin.

Currently, all the 8 complexes in the upper reaches have been constructed or are being constructed. Among the seven complexes in the middle and lower reaches, four dams have been completed (i.e. Danjiangkou in 1973, Wangfuzhou in 2000, Cuijiaying in 2010 and Xinglong in 2015). Three dams are to be built by 2020, including Xinji, Yakou and Nianpanshan.

2.2 Project Contents

The project has two components: (1) Construction of Yakou navigation and hydro complex; and (2) capacity building. The construction of Yakou complex is a single integrated infrastructure that will upgrade about 53 km waterways between Yakou and Cuijiaying to Class III standard, provide about 247 GWH of hydropower per year to local grid, increase over 5,300 ha of gravity irrigational farmlands, improve flooding resilience, and create better landscape for recreation.

The Yakou Complex component will consist of construction of Yakou navigation and hydro complex, land acquisition and resettlement, and associated projects of power transmission line and reservoir dike strengthening. The detailed activities are included in the **Table 2,** and shown in **Figure 2**.

Table 2 Project Activities

Project	Detailed Activities
1. Yakou complex	**Implementing agency: Port and Waterway Administration of HPTD**
Main work of the complex	●The total length of dam axis is 3179.9m and the maximum height is 14.0m. 44 sluice gates; ● Water diversion works during construction ● Waterway channel improvement works (limited to ship lock)
Material site	● 2 earth borrow areas; ● one gravel/sand borrow site;
Disposal site	There are two disposal sites and all spoils will be recycled to form the construction sites. Upon completion, these sites will be partially reused as office area and the rest will be reclaimed as farmland.
Access roads	●Newly built access road with total length of 1.3km on the left bank to connect with existing road network. ● Roads within construction sites at both left and right banks: 8 temporary construction roads with total length of 10.2km and a temporary road with length of 2.0km for other temporary works.
Construction camps	● The total number of workers in the peak period is 2,100 and two construction camps occupying 0.83hm^2, including working camps and office building.
Fish protection facilities	● Total length of fish pass is 951.08m (including 560.58 m natural fish channel and 390.5m engineered channel). ● A new fish breeding and releasing station, with fish releasing capacity of 4 million/year.
2. Land acquisition and resettlement	**Implementing agency: Port and Waterway Administration of Hubei Provincial Department of Transportation and People's Government of Xiangyang City**
Reservoir bottom cleanup	● Clean the reservoir area, including the buildings, structures and vegetation and so on before the impoundment to ensure the navigation safety and water quality after impoundment.
Resettlement	● Altogether 35 households (91 people) are to be displaced.
Special facilities rehabilitation in the reservoir area	● Rehabilitation of farmland road of 7.5km, 3 cargo docks and 4 ferries; ● Rehabilitation of 3km telecommunication lines; ● Rehabilitation and improvement of drainage ditches, small sluice gates and pumping stations;
Cultivated land protection work	● Farmland lifting in the reservoir area and form 12 lifted land areas to protect cultivated land of 894ha.
3. Transmission line	**Implementing agency: Hubei Electric Power Company**
Supporting transmission lines	● A 12km 110KV transmission lines
4. Reservoir dike strengthening	**Implementing agency: Xiangyang Water Resources Bureau and Xiangyang Waterway Administration**
Dike strengthening in the reservoir area	● Dike strengthening for three sections, with total length of 86.7km.

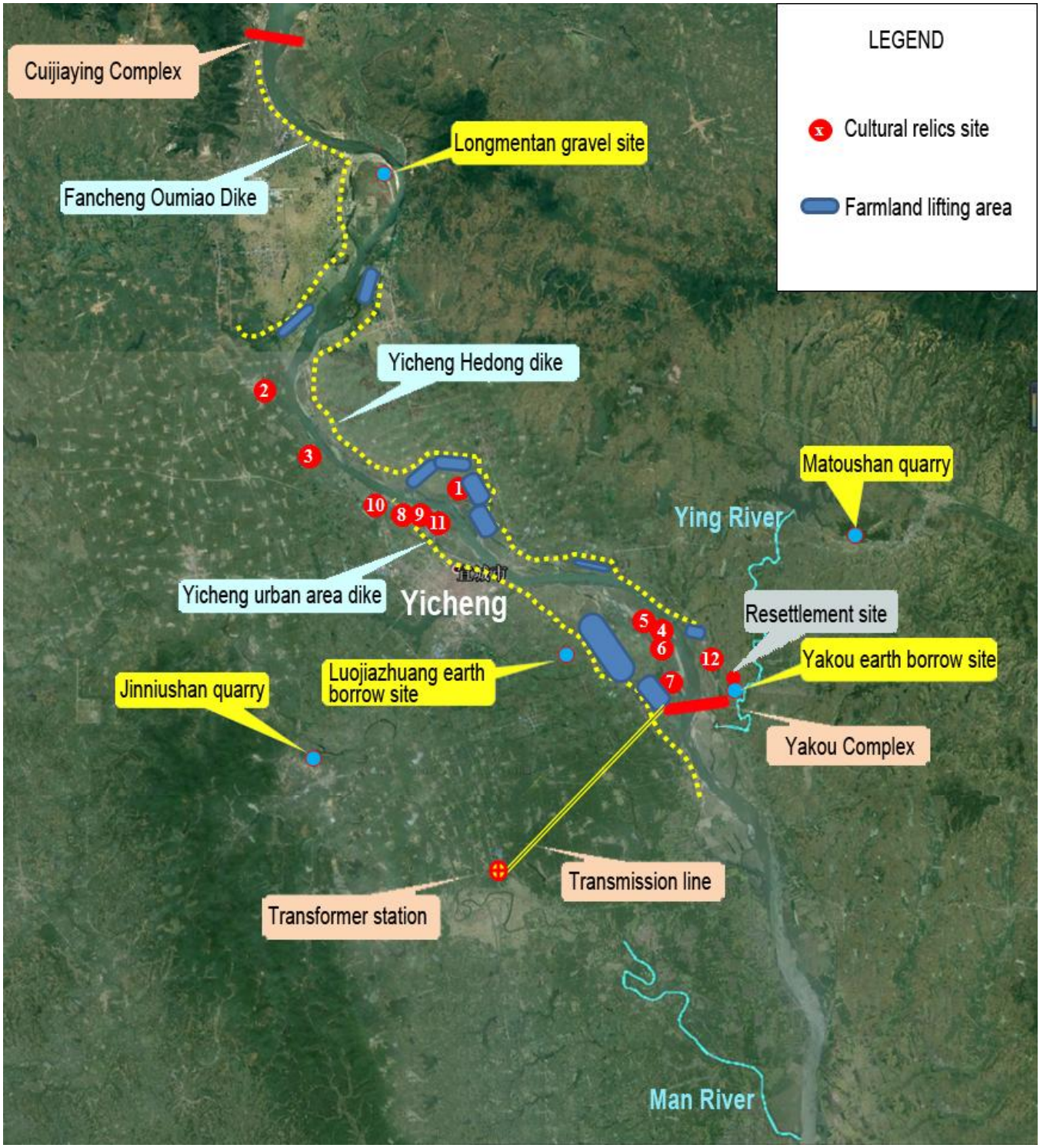


Figure 2 Project Contents

3. ENVIRONMENTAL AND SOCIAL BASELINES

3.1 Overview of Regional Environment

The Han River basin belongs to subtropical monsoon zone and the climate is mild and humid. The average annual temperature is 12 ℃ to 16 ℃ and the average annual precipitation is 873mm. The precipitation gradually increases from upper reach down and the rainfall mainly occurs in May to October. The rainfall in this period accounts for 70% to 80% of the rainfall of the whole year. The runoff is mainly supplied by rainfall which is abundant. However, the runoff is unevenly distributed during the year and mainly distributed in May to October.

3.2 Ecological Environment

Terrestrial flora: According to the field survey in September 2013 and April 2014 and available literatures, the vegetation in the project assessment area includes six types, i.e. broadleaved deciduous forest, bamboo forest, bushes, shrub-grassland, economic forest and cropland vegetation. There is one big old tree (*Pistacia chinensis bunge*) identified in the assessment area, which is 550m away from the reservoir inundation boundary. Neither reservoir inundation nor land occupation will involve national and provincial key protected wild plant.

Terrestrial fauna: In the assessment area, there are 4 classes, 20 orders, 44 families and 81 species of terrestrial vertebrates. There is no Class I national level protected wild animal, and there are three species of Class II national level protected bird species. There are 26 provincial level protected species in the assessment area, including 5 species of amphibians, 2 species of reptiles, 18 species of birds and 1 species of mammals.

Aquatic ecosystem: According to the results of the survey carried out in April and July 2014 and with reference to historical survey data on the aquatic ecology of the survey river section, in the river section under assessment, there are 8 phylums, 65 genuses and 124 species of phytoplankton, 62 genuses and 110 species of zooplankton, 4 phylums, 30 genuses and 36 species of benthoic animals, 3 phylums, 25 genuses and 39 species of periphytic algae and 12 families, 26 genuses and 36 species of aquatic vascular plants.

Aquatic wildlife and fish: In the project river section, there is no national-level protected aquatic wild life or fish listed as endangered species in China, and there is also no specific endemic species in Yangtze River. There is only one migratory fish species in records (*Anguilla japonica*), however, was not found in the survey. The main fish species found in the survey is river and plain group of *cyprinide* fish (carps).

Fish habitats: According to the results of the survey on the spawning of fish spawning pelagic eggs in the middle reach of Han River carried out by Institute of Hydrology in 2004, there were five spawning grounds of four major Chinese carps in the middle reach of the main stream in Miaotan, Yicheng, Guanjiashan, Zhongxiang and Maliang. However, the

survey in 2014 only found two spawning grounds in Guanjiashan and Dengjiatai, both of which are below Yakou dam and 13.5km and 61.8km respectively away from Yakou dam site. There are spawning grounds found in the two tributaries (Ying River and Man River) downstream of the Yakou dam site.

3.3 Water Environment

Based on the *Functional Categories of Surface Water Environment in Hubei Province (2000)*, the river section where the project is located has a designated function of Class II [1]standard of *Environmental Quality Standard for Surface Water* (GB3838-2002). According to the monitoring data collected in August 2013, December 2014, and May and October 2015, all the indicators are conforming to Class-II standard, except for total nitrogen. Total nitrogen exceeds standard mainly because some domestic sewage from villages along the river is discharged into the river only after simple treatment.

There are five water intakes within the project-impacted area, while four are distributed in the reservoir section, i.e. 33km, 20km, 3.2km and 1.5km upstream away from the dam site. There is a water intake 8.0km downstream from the project dam site. There are four agricultural irrigation pumping stations in the reservoir area.

3.4 Socio-economic Status

Under the jurisdiction of Xiangyang Municipality, Yicheng is located in the northwestern part of Hubei and in the middle reach of Han River. Total population in Yicheng is about 0.57 million in 2012. The total GDP in 2012 is 20.19 billion yuan, with a per capita disposal income of urban resident of 15,366 yuan and 9,639 yuan for rural population.

Archaeological survey conducted for the project dam site and reservoir area by Hubei Provincial Institute of Cultural Relics and Archaeology identified 12 underground ancient tombs, of which one site is a designated county-level protected relics site, and others are unclassified.

3.5 Environmentally and Socially Sensitive Areas/Receptors

The environmental and social sensitive areas/receptors in the potential project-affected areas are identified based on field survey and historical data references, including historical survey data on aquatic ecosystem, baseline survey on terrestrial and aquatic ecosystem, survey on cultural relics, field survey and expert opinions as well as public consultation.

Spawning grounds for fish producing floating eggs: In accordance with the historical data, there are three large spawning grounds of fish producing floating eggs in upstream and downstream of Yakou complex, i.e. Yicheng spawning ground in 14.5km upstream,

[1] Class II refers to the surface water quality meets "Class I surface drinking water source area, habitat for rare aquatic lifes, spawning ground for fish and shrimp, feeding ground for fry."

Guanjiashan spawning ground in 13.5km downstream, and Dengjiatai spawning ground (i.e. Zhongxiang spawning ground) in 61.8km downstream of Yakou dam site. Yicheng spawning ground still existed during the aquatic ecosystem survey in 2004, however, was not found in 2014 survey. The two spawning grounds in downstream of Yakou dam site are far away from Yakou complex and construction and operation of the complex will have little impact on them.

Ecological sensitive areas: There are two wetland parks in the vicinity of Yakou reservoir area, i.e. Cuijiaying Provincial Wetland Park at Cuijiaying reservoir site and proposed Wanyangzhou National Wetland Park. This project will have little impact on Cuijiaying Wetland Park, and will have potential impacts on the Wanyangzhou Wetland Park.

Drinking water source protection zone: Yicheng drinking water protection zone is located in river section of Yakou Navigation Complex reservoir area and water intake of Yicheng Water Plant is located on the right bank and 20.0km in upstream of Yakou dam site. The water in section from 1000m upstream of the water intake to 100m downstream of the water intake is Class I protection zone and the water in section from 3000m upstream of the water intake to 300m downstream of the water intake is Class II protection zone. Construction of the project will have little impact on the drinking water protection zones and the assessment will focus on the impact on water quality upon formation of the reservoir area.

Cultural relics and historical sites: Through the survey on cultural heritage, 12 underground tomb sites are found in the reservoir area. Among them, Wangjiagang tomb is classified as county-level Cultural Relics Protection Unit, and the other 11 are not classified as protected sites. Among the 12 sites, three (Haogouquan cemetery, Wangjiagang tomb and Tongmei cemetery) are influenced by erosion and others are affected by inundation.

Animals and plants under protection: In accordance with historical data on ecology survey, there are national and provincial level protected animals in the project region, including three class II national protection species and 26 provincial protection species. The EIA report focuses on the assessment on their current conditions and the potential impacts of this project. There is one old *pistacia chinensis* tree found, which is 550 away from the reservoir flooded boundary. No national or provincial protected wild plants was found in the area of influence.

Sensitive social receptors: Communities along both banks of Han River at the project section, including Yakou village, Maocao Village and Heluo Village.

4. ANALYSIS OF ALTERNATIVES

4.1 With/Without Project

Without the Yakou project, other measures would be needed in order to achieve the objectives of the Han River waterway plan, including:

- Navigation: significant amount of dredging for the section between Cuijiaying and Yakou is needed to achieve 1000 t-class waterway standard which will have significant environmental imapcts;
- Power generation: power shortage in the project area will have to be supplemented from other source which will be coal-fired power plant;
- Irrigation: significant amount of water intake and transmission/distribution pipelines is needed for meeting demands during dry season;

In contrast, with project scenario will generate significant social and economic benefits for the project region, including:

- Navigation: upgraded waterway will facilitate freight transportation, alleviate road traffic pressure, reduce energy and vehicle emission which otherwise will be generated from road traffic;
- Clean electricity: the project will provide 252GWH clean electricity to alleviate the power shortage in the project region and reduce the demand for coal-fired power plants;
- Irrigation: the increased water level in the reservoir will provide gravity irrigation of 5,333ha farmland, and improve the efficiency of other pumping stations;
- Tourism: the project will form a reservoir with 12,700ha water surface which provides a sound opportunity for tourism development, and beneficial for improving the landscape, enhancing city image and improving investment environment of Yicheng city;
- GHG and air pollution emission reduction: the clean power generated from the project would substitute 142,244t coal, and reduce emission of 5,584t SO_2 and 20,000t dust;
- The increased water surface will increase the humidity in the project areas and be beneficial to crops production.

The project will generate significant positive benefits to the social, economic as well as environmental situation in the project area. With effective implementation of mitigation measures developed in the ESMPs, the adverse environmental and social impacts can be avoided, minimized, mitigated or otherwise compensated to an acceptable level.

4.2 Alternatives of Dam Location

Under the strategic plan of the overall river basin dam development plan, three dam location options (Nanzhou, Lijiashan and Yakou sites, as illustrated in **Figure 3**) were proposed within 15km river section near Yicheng, and compared with comprehensive environmental, social, economic and technical considerations.

Yakou option is finally selected due to less civil works amount, flood releasing condition, good navigation condition, better power generation capacity, less impact on river water level, less residential communities around to be affected, less land surface disturbance, and better navigation safety condition.

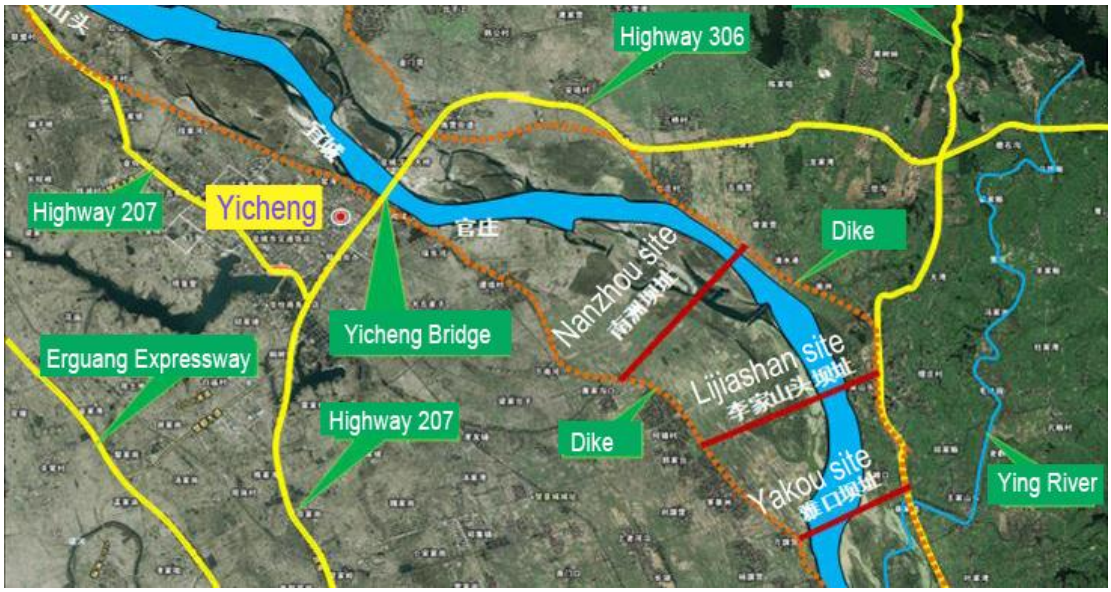


Figure 3 Alternative Dam Locations

4.3 Alternatives of Water Level

Three reservoir water levels were considered, i.e. 54.72m, 55.22m and 55.72m. In general, these three normal water level options do not differ significantly in terms of hydrology, water temperature, water quality, flooding, resettlement and fish impacts. Higher water level will have better benefits in terms of navigation, power generation and irrigation, but also have higher cost and larger environmental impacts. A lower water level will have less environmental and social impacts, and less land acquisition and inundation. However, since the Project does not affect sensitive receptors such as natural preserves, important cultural heritage sites or protected drinking water sources, the differences in environmental impacts are not notable , and will not be the limiting factor in determining the normal water level.

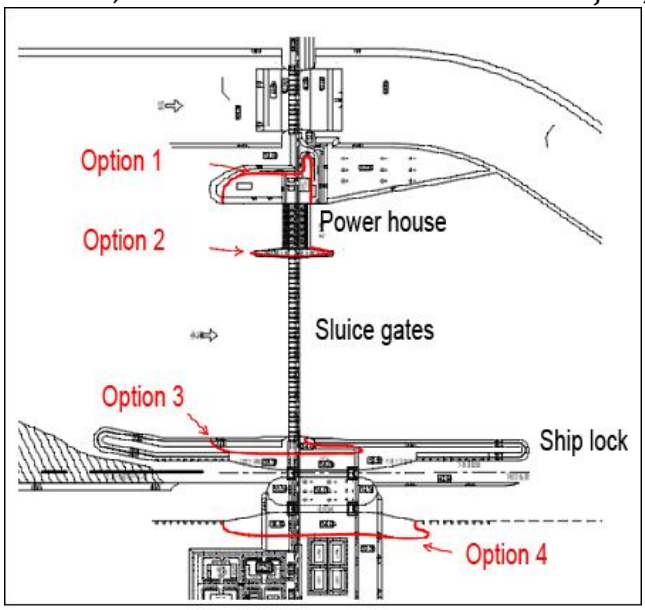
Therefore, considering the need to reduce flooding and expenditure, 55.22m is a reasonable recommendation that satisfies the demands of the waterway and power generation.

4.4 Alternatives of Fish Passage Design

Fish passage is designed together with the complex to facilitate the restoration of fish migration over the dam. Several options were considered, including (1) fish channel or fish ladder; (2) nature-imitating manmade fish channel; (3) fish lift or fish elevator; (4) fish lock which is similar to ship lock; (5) downstream catch and upstream release facilities.

Generally, fish lift, catch and release and fish lock are more appropriate for moderate and high dams. Since the Yakou dam only has maximum water head around 10m, these three options are not suitable due to issues such as non-continuous passage, instability, difficulty in operation, and high costs. While, fish ladder and nature-imitating manmade fish channel can provide the water flow pattern suitable for fish, and are both feasible for this Project, therefore, are chosen in the final design for the complex. The final design for fish passage is a 951.08m passage with combination of 560.58 m fish ladder and 390.5m engineered nature-imitating manmade fish channel.

Besides options of fish passages, the location of fish passage is also carefully considered with four options (illustrated in **Figure 4**). Among these options, the Option 1 has the advantages of frequent water release and close to in-river island that are favorable for fish migration, therefore, is chosen as recommended scheme.



Figrure 4 Alternatives of Fish Channel Locations

5. PROJECT IMPACTS ASSESSMENT AND MITIGATION MEASURES

5.1 Ecological Impact

5.1.1 Terrestrial Ecology

Surface Vegetation

The project construction area covers a total area of 377.08 hm^2, accounting for 0.25% of the total assessment area. The lands occupied mainly include farmland, woodland, as well as land for water area and water conservancy facilities and waste lands. The permanently and temporarily occupied forest lands are little. The plant species are mainly planted trees, secondary shrub and bushes. Therefore, the impact on the surface vegetation of the project area is slight. The reservoir will increase an inundated area of 78.68 km^2, and the inundated area is mainly covered by arable crops, followed by poplar-occupied woodland, as well as grass land with vegetation such as paper mulberry, *hemarthria compressa* and horseweed. The plants affected by the inundation are common local species widely distributed around the reservoir area. Therefore, there is no possibility that the inundation will cause the disappearance or extinction of plant population. There is no national-level key protected wild plant in the assessment area, so the terrestrial ecological impact is low. There is only one ancient tree (*Pistacia chinensis*) identified during the field survey which is located in Luojiahe and situated 500m from the reservoir flooded line, so it will not be affected by the project.

Main mitigation measures developed in the ESMP include: implement ecological restoration measures in combination of soil and water conservation measures; maintain and restore the original ecosystem of low hills areas in the process of restoration, and develop terrestrial ecosystem with main features of deciduous broad-leaved forests, scrubs, and shrub herbosa; reclaim the earth borrow site and farmland temporarily occupied by the project, etc.

Terrestrial Fauna

In terms of terrestrial animals, three types of Class II national protected bird species have been found in the project area (buteo buteo, milvus migrans and falco tinnunculus). These three species are raptors, with strong flying ability. They generally fly over woodland and the open ground near woodland. The main habitat of these species have not been inundated or occupied by the project. Only human activities and the noise produced by construction affect these species as the areas where they fly and look for food are disrupted. In conclusion, the project has a small impact on these species. The 26 provincial protected species include amphibians, reptiles and beast. As their habitats are widely distributed, and the project will just narrow small amount of their habitats, therefore there's insignificant impact on them. The bird species are good at flying and migration, and are able to avoid construction interference, the construction and operation have little impact on them.

Main mitigation measures are developed in ESMP, including: conduct search and rescue measures for wildlife before impoundment, especially for the wildlife species under protection; timely report the find of protected animals; timely rescue and treat the injured animals; strengthen wildlife protection campaign and education; enforce hunting ban measures, etc.

Wanyangzhou Wetland Parks

The Yicheng City has planned to establish a Wanyangzhou wetland park in the center of the city. The main body of Wanyangzhou wetland park consists of the Han River mainstem segment and riparian wetlands, which is located within the Yakou reservoir flooded area. The wetland park was proposed with an intention to protect the highly disturbed river segment and riparian wetlands from further degradation and to provide local communities with nature education and recreational opportunities. The wetland park proposal was approved by the National Forest Bureau in December 2013 but has not been implemented except some embankment rehabilitation and landscaping works near the urban center. A compliance review concluded that a wetland park is not considered a legally protected area (such as *Important International Wetland, Important National Wetland or Wetland Nature Reserve*) as defined by domestic regulations. Hence the Ministry of Environmental Protection (MEP) and the forestry agency approved the Yakou project. Baseline survey of the wetland park area indicates that the it doesn't show distinctive significance compared the other Han river sections from biodiversity perspective. Thus the wetland park is not considered critical natural habitat by definition of OP4.04. The current status of the wetland park area is shown in **Figure 5.**

The forthcoming Yakou reservoir will flood current riparian areas and shoals in the wetland park area. , rising of the water level in the reservoir will significantly increase the water surface of the park, and inundate woodland, grassland and river flat to a large extent. Main types of wetland in the park are permanent river wetland and flood plain. After rising of water level, part of the flood plain and manmade wetland will become permanent river wetland, and the area of permanent river wetland will increase while the area of flood plain will decrease. The natural wetland will still be the dominant land type within the park. Rising of the water level will change the water contents and salinity of the soil and then change the material cycle and energy flow on such basis. These changes will affect the distribution of hygrophytes and hygrocoles within the park and the biodiversity and wetland ecosystem within the region.
Based on analysis of water environmental impact, the water quality at the preliminary stage of water storage will decrease, but the decrease only lasts for a short time. On the whole, water quality of the reservoir area after completion of the project will remain basically unchanged.

Upon rising of the water level, xerophyte on the mud flat will decay and die due to lack of oxygen caused by inundation, however, it is good for growth of wetland plants. The increase in water area and decrease in mud flat will narrow down the habitats of part of amphibian and reptile animals and small mammals (such as rodents) and force them to move to the

riverside. It will also cause decrease of activity space and habitats of wading birds and increase of activity space and habitats of natatorial birds. The habitats of part of wetland plants and wetland animals will be inundated after completion of the project, but rising of the water level will not significantly change the diversity of wetland plants and wetland animals. In addition, rising of the water level of the reservoir area will provide broader space for activity and inhabiting of natatorial birds and aquatic plants.

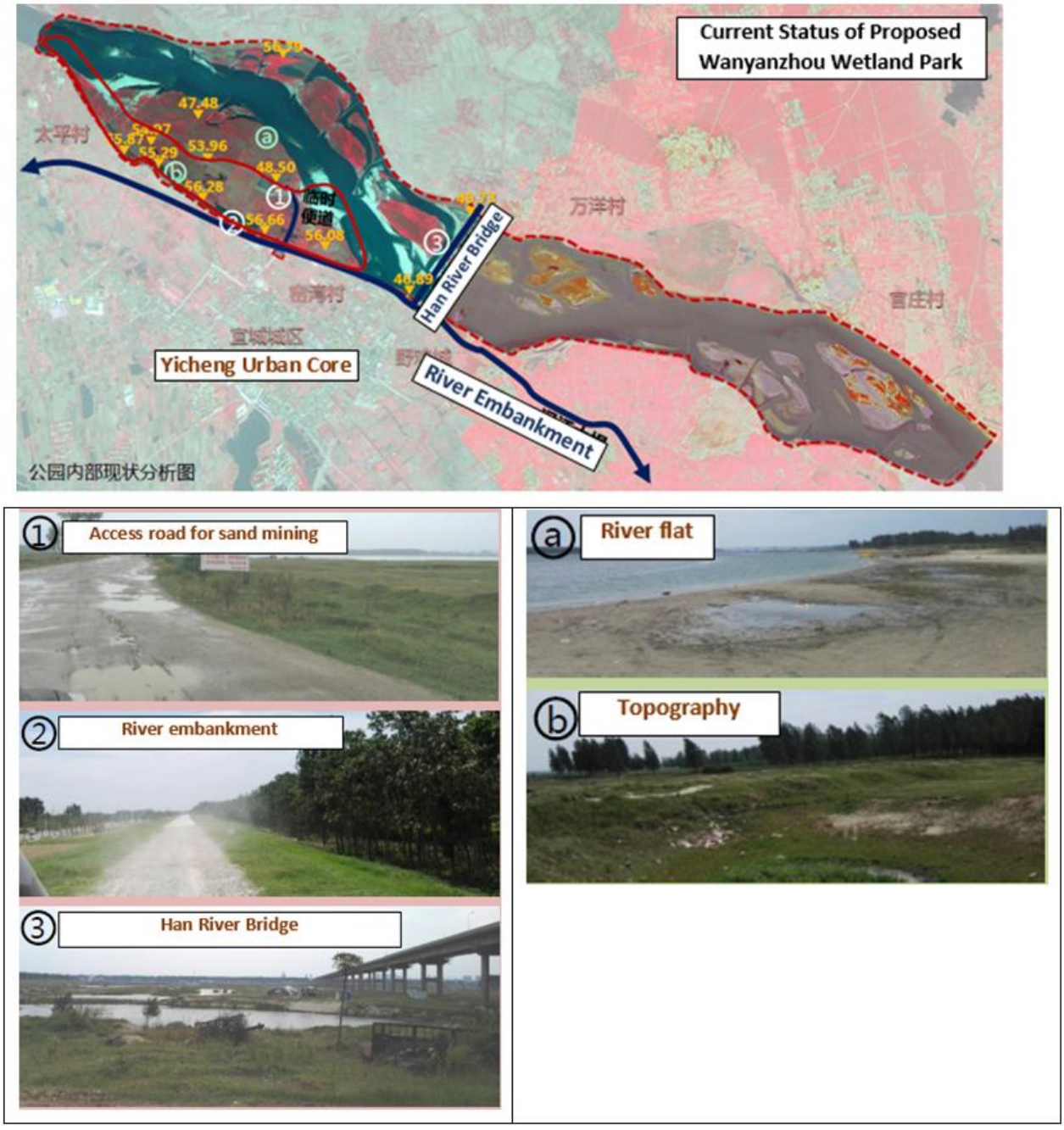


Figure 5 Current Status of Proposed Wanyangzhou Wetland Park

An optimal mitigation strategy to manage the impacts on the wetland park resulting from reservoir impoundment would be a well-conceived plan to fully take into account the impacts and incorporate ecosystem restoration efforts into the plan. During the project preparation, the Yakou project proponent agreed with the wetland park management committee to develop a detailed planning. Hubei Provincial Forestry Survey and Design Institute was commissioned to prepare a Yicheng *Wangyangzhou National Wetland Park Core Area Constructive Detailed Planning*. According to the detailed planning (see **Figure 6**), the wetland park will have significant sections of riparian areas restoration and restricting development activities, in addition to a science education zone and a service zone. The wetland park will also provide broader habitats for swimming birds and aquatic plants. On the whole, rising of the water level within the Wetland Park and increase of the water area are beneficial for protection of the wetland resources. The Yicheng Municipal Government approved the detailed planning on October 26, 2016, and requested the municipal forestry bureau to implement the plan as soon as possible.

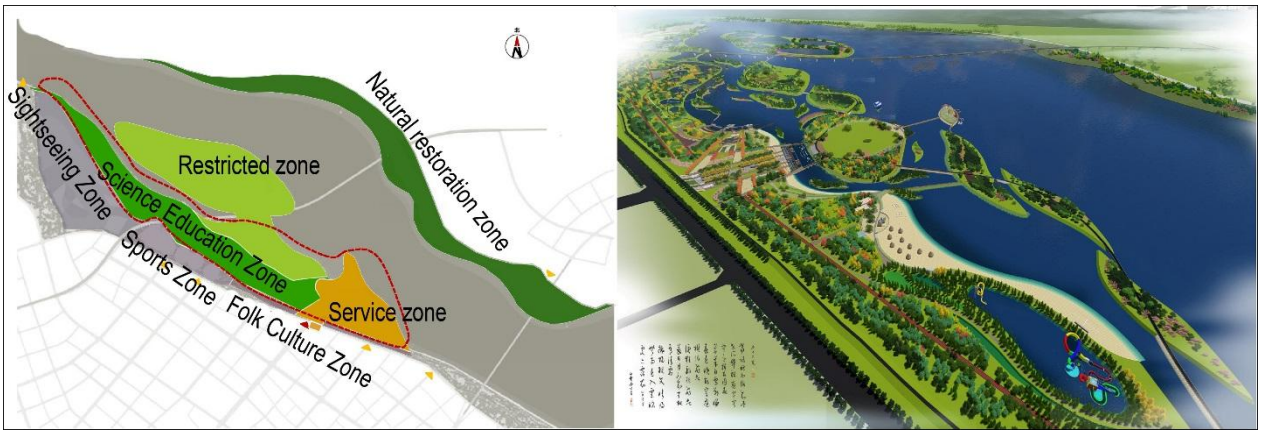


Figure 6 Wanyangzhou Wetland Park Zoning Plan and Rendering Effect

Other mitigation measures include: strengthening the restriction of sand and gravel exploitation in the project area and ban such activities inside the wetland; carry out dike strengthening works by taking into account the wetland park planning; strictly control construction scope and temporary sites; solicit opinions of park authority before construction; plant local wetland vegetation in areas along Han River and near the park, etc.

5.1.2 Aquatic Ecology

Fragmentation of Fish Habitats and Blockage of Migratory Channel

The upstream Danjiangkou dam was built in 1973, which blocked the gene exchange between upper and lower reaches of Han River. The latterly built Wangfuzhou (no fish passage), Cuijiaying at upstream and Xinglong at the downstream further fragmented the river habitat. Though fish passages are constructed in newly built dams, the migration channel is greatly blocked. After the construction of Yakou Complex, river section and fish habitat in Han River mainstream below Cuijiaying will be further fragmented, which will

obstruct the migration and gene exchange of fishes. Damage to continuity of river will strongly cut off activities of both migratory fishes and non-migratory fishes.

According to historical data, there is only one major river-ocean migratory fish species (*anguilla japonica*) in Han River. Its migration has been affected by the cascade dams, and can be hardly found in recent years. River and lake migratory fishes such as four major Chinese carps are affected by the dam too, and are not able to complete living activities such as reproduction, feeding and overwintering through migration, so their population will decrease significantly. Although fish passage construction can effectively reduce the upstream migratory impact on fish, it can't effectively reduce the downstream migratory impact on fish.

Impact on Fish Species Composition

According to the EIA report, after the construction and operation of the Yakou complex, the change of water regime will change the composition of fish species in Yakou reservoir area from "fluvial facies" to "lake facies". Fishes which are adapted to slow or still water environment will become the dominant species, due to the slowed flow velocity and increased food organisms. On the other hand, the fishes which are adapted to the rapid habitat will gradually shift to the tail of the reservoir and the downstream area of Cuijiaying Dam, due to changes in feeding and reproduction conditions. Therefore, their number will decrease.

For fishes spawning floating eggs (such as the four major Chinese carps), since the spawning areas are inundated, there are no conditions for breeding in general. Only when the complex discharges water in flood season, and the river returns to the natural state, will there be satisfactory conditions for breeding of such fishes. However, there is little possibility for occurrence of open discharge flow upon operation of South-to-North Water Transfer Project[2], so it is also difficult for such species to be maintained.

Spawning Grounds

In accordance with investigation on spawning sites of fishes producing floating eggs in middle reaches of Han River in 2004, there are three spawning grounds in Yakou assessment area, i.e. Yicheng, Guanjiashan and Zhongxiang spawning grounds.

According to the investigation in 2014, no spawning grounds for four major Chinese carps were found in Yakou reservoir area, i.e. the Yicheng ground was not found. However, even it still exists, the formation of Yakou reservoir will inundate it. The Guanjiashan and Zhongxiang spawning grounds were found in sections from Xinglong reservoir end to waters under Yakou dam. Both Guanjiashan and Zhongxiang spawning grounds are located under the dam, about 13.5km and 61.8km downstream of Yakou Complex respectively.

[2] The South-North Water Transfer Project is a major national project that transfers 9.5billion m^3/y water from Danjiangkou reservoir to the northern part of China. The project was put into operation in 2014, with only partial 1/5 designed capacity transferred so far.

During spawning season, Yakou Complex basically does not regulate the runoff and the conditions of Guanjiashan and Zhongxiang spawning grounds will remain unchanged. But under the circumstance of low-flow flood peak, flattening of Yakou reservoir will make flood peak of the spawning ground be unobvious, thus affecting reproduction of fishes.

Impact on Aquatic Germplasm Resources Conservation Zone

A germplasm resource conservation zone in Zhongxiang section in the lower reach of Han River was established in 2008 by Ministry of Agriculture, with protection objectives of conservation of *elopichthys bambus, ochetobius elongates* and *luciobrama microcephalus* species. Since Yakou Dam Site is far away from the conservation zone, i.e. 31.4km upstream of its upper boundary, it will not exert direct impact on the habitat and biological structure of the conservation zone. The main possible influential factor is changes of hydrological regime due to scheduling of Yakou Complex. This zone is mainly a spawning site for these species which produce floating eggs during flood season. Since Yakou Complex only has daily regulation capacity, which has weak flattening and limited effect on flood peak, it will not affect the hydrological and hydraulic conditions necessary for spawning of these fishes in the conservation zone.

To address the potential impacts mentioned above, a series of **mitigation plans** have been developed in the ESMP, including:

- **Habitat protection:**
  - Habitat protection in the trunk of Han River: Designate river section between Cuijiaying dam and end of backwater of Yakou reservoir (ca. 5km) and section between Yakou dam to the end of backwater of downstream Nianpanshan reservoir (ca. 7km) as fishing ban zone during flood season. Enforce ban for fishing, sand excavation and other construction activities during fish reproduction season (Mar-Aug).
  - Environmental flow: Ensure ecological flow released from Yakou dam (450m3/s) and establish on-line monitoring equipment. Environmental flows shall be properly increased during the fish breeding seasons in order to ensure the ecosystem quality of the aforesaid areas for fish spawning and inhabiting.
  - Habitat protection in tributaries: Designate a section of Ying River, a tributary in downstream of Yakou dam, as protected habitat (ca. 18km long), with habitat enhancement measures of: manmade gravel spawning grounds; fishing ban during fish reproduction season; long-term fish species and aquatic life monitoring program; strengthen enforcement capacity.
- **Construction of fish passage**: Build a 951m long fish channel, with 560.58m nature-imitating channel and 390.5m engineered channel.
- **Breeding and releasing station**: Build a fish fry breeding and releasing station as an integral part of the Yakou complex, with initial planned releasing capacity of 4 million fish fry per year. The plan is developed for 20 years, and is subject to adjustment afterwards. Conduct scientific researches on fish breeding and releasing.

- **Joint ecological flow regulation**: During the spawning period of "four major Chinese carps" in Han river every year, conduct at least twice joint open discharges through ensuring certain ecological flow from Danjiangkou and joint operation of cascade dams downstream in order to ensure the smooth spawning of existing spawning grounds, drifting hatching of fertilized eggs and fertilized fish migration channels to finish the reproduction. The first one has been scheduled in 2017.
- **Strengthen fishing regulation**: Strengthen capacity building of fishing management authorities; strictly enforce fishing ban regulations; strengthen fishing industry regulation through banning illegal fishing activities; enforce fishing permit system and regulate the total harvest cap system, etc.
- **Scientific research**: Conduct researches on (1) Habitat conservation and restoration; (2) Joint ecological flow operation plan and trial scheme; (3) Succession of aquatic organisms in the middle and lower reaches of Han River after formation of reservoir area; (4) Effect evaluation of fish channel; (5) Evaluation of effects of artificial breeding and releasing technology.

5.2 Physical Cultural Resources

HPTD commissioned Hubei Provincial Institute of Cultural Relics and Archaeology (HPICRA) to conduct a field survey for the Yakou project in July 2012. The survey identified 12 underground cultural relics sites (**Table 3 and Figure 2**), of which one is designated as a county-level protected site (Wangjiagang Cemetery) and others are unclassified. Among these 12 sites, three sites are subject to erosion impact, and the rest will be inundated.

Table 3 List of Cultural Relics Sites Identified

No.	Cultural Relics Site	Elevation (m)	History Period	Protection level	Preservation status	Relation with project route
1	Han dynasty Cemetery in Guanzhuang Village	53.5	Eastern Han Dynasty, Six Dynasties and Ming Dynasty	Unclassified	Average	Inundation
2	Haogouquan Cemetery Complex	68	Han Dynasty	Unclassified	Average	Erosion
3	Wangjiagang Cemetery	71	Han Dynasty	County level	Relatively good	Erosion
4	Tongmei cemetery complex	57	Wei and Jin Dynasties to Sui Dynasty	Unclassified	Average	Erosion
5	Six Dynasties Cemetery in Group 3, Tongmei Village	53	Six Dynasties	Unclassified	Average	Inundation
6	Six Dynasties Cemetery in Heluo Village	52	Six Dynasties	Unclassified	Average	Inundation
7	Six Dynasties Cemetery in Maocao Group 3	53.5	Six Dynasties	Unclassified	Average	Inundation
8	Cemetery at Taishanmiao	55	Ming and Qing Dynasties	Unclassified	Relatively poor	Inundation
9	Ming and Qing Dynasties cemetery in Tannao Group 3	53.5	Ming and Qing Dynasties	Unclassified	Relatively poor	Inundation
10	Han dynasty cemetery at Shuita in Tannao Group 3	53	Han Dynasty to Six Dynasties	Unclassified	Average	Inundation
11	Miaotai cemetery in Nanhe Village	54	Ming and Qing Dynasties	Unclassified	Relatively poor	Inundation
12	Yakou Village Cemetery	54	Six Dynasties and Ming Dynasty	Unclassified	Average	Inundation

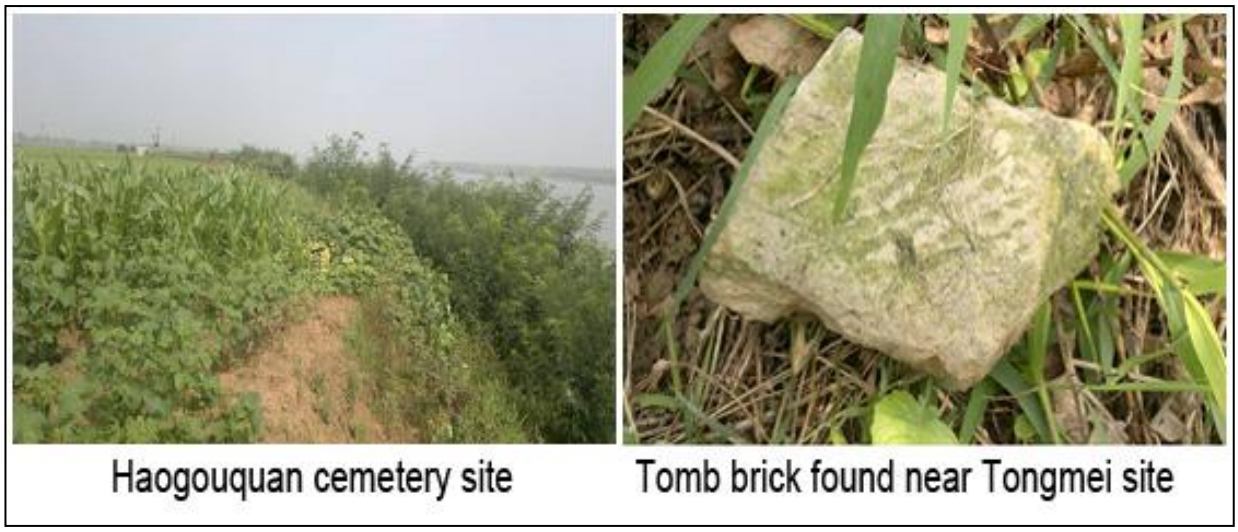


Figure 7 Typical Situation of Cultural Relics Sites Identified

Based on the initial findings, HPTD commissioned HPICRA to further complete the following works prior to the impoundment of reservoir, including: further archaeological investigation, avoidance suggestions, archaeological exploration, archaeological excavations, data compilation & preparation of reports, and heritage preservation & exhibition.

Currently, HPICRA has developed a next step cultural relics sites exploration and protection plan (included in the ESMP). This plan classified the 12 sites into three categories: (1) For category A sites which have high cultural deposit and value and provide substantial references for study of ancient culture, large-scale and careful excavation need to be carried out; (2) For category B sites which have relatively high cultural deposit and value and provide references for study of ancient culture, general excavation work needs to be carried out; (3) For category C sites which have little cultural deposit and value and provide few references for study of ancient culture, general excavation and archaeological survey need to be carried out. According to this plan, one site (Wangjiagang cemetery site) is classified as category A, 4 sites are category B and 7 sites are category C. These sites will be explored according to the plan prior to the impoundment of the reservoir. The total budget for cultural relics site exploration and protection is 2.325 million yuan.

Besides these 12 ancient relics sites identified, the project will also need to relocate 467 local rural family graves. The procedures and budget for this relocation have been incorporated into the Resettlement Action Plan.

During construction stage, chance-find procedures included the ESMP will be followed.

5.3 Water Environment

5.3.1 Hydrology

The construction of Yakou complex will change the river hydrology of the Han River. After formation of the reservoir, there will be increase of water surface area, volume of the water, water depth and river width in the reservoir area. The water surface area will increase from 35.5km^2 to 111.75km^2. The average flow velocity is reduced from 0.8m/s to 0.11m/s, and river flow pattern will change from swift current to slow current.

To meet the navigation requirement of this river section that the minimum water depth should be 2.0m, Yakou complex will have a guaranteed flow of 450m^3/s during its impoundment and operation period (accounting for 40.91% of the average annual flow of the dam site). Based on ecological flow calculation method (Tennant method) as specified in *Technical Guidelines for Environmental Impacts Assessment of Ecological Water for Waterway, Low-temperature Water and Fish Pass in Hydropower and Water Conservancy Construction*, the minimum ecological flow of Yakou Navigation Complex dam site is 110m^3/s. The currently designed 450m^3/s is adequate ensure ecological function of the downstream section of the dam.

5.3.2 Water Quality

Construction activities will have temporary adverse impact on water quality. The main pollution comes from wastewater of the aggregate processing system, concrete system, and domestic sewage of construction labors.

Influenced by inundation, water intake pump station of Yicheng City Water Plant will be renovated by lifting to guarantee water-taking after formation of the reservoir. The inundation will not affect the sewage discharge outlet.

During operation, it is predicted that that concentration of COD and ammonia nitrogen in the reservoir area will be 5.85mg/l to 8.91mg/l and 0.12mg/l to 0.16mg/l respectively; concentration of COD and ammonia nitrogen of Yicheng Water Plant will be 8.02mg/l and 0.15mg/l respectively, all meeting Class II standards of *Environmental Quality Standards for Surface Water (GB3838-2002)*. Concentration of total nitrogen and total phosphorus will be increased and the reservoir area will show status of mild eutrophication. Due to the frequent water exchange, the possibility of overall eutrophication is small.

To mitigate potential adverse impacts on water quality, measures have been developed in the ESMP, including: Reuse wastewater at construction sites; use integrated wastewater treatment facility to treat domestic sewage from camps; implement land clearing before impoundment; install wastewater treatment facility for management buildings and hydro station during operation, and reuse treated water for green belt and dust control; enforce the requirement of wastewater storage/treatment facilities for ships; control non-point source of pollution in watershed of reservoir and protect water quality of tributaries, etc.

5.3.3 Water Temperature

Yakou reservoir is typical mixing reservoir, and has relatively small storage capacity, poor regulating capacity and large runoff, therefore the water temperature structure of the reservoir is basically the same as that of the river before formation of the reservoir. No obvious impact is envisaged.

5.3.4 Groundwater

The rising water level during operation stage will increase the groundwater level on both sides of Han River, which may affect the living environment and the growing of farmland crops. Based on modelling calculation, the total affected area will be 27km^2.

To mitigate such impacts, a series of engineering measures have been developed, including deploy a number of pressure release wells and drainage ditches along the dikes at the affected areas to drain the excessive groundwater seepage. And farmland lifting measures (926.19ha in total, compensating 93.94% of farmland to be inundated by Yakou Reservoir).

5.4 Ambient Air Quality

Air pollution during the construction is mainly caused by construction dusts and waste gas emission from construction equipment. The dusts mainly come from soil excavation, spoil dumps, transportation, construction site, temporary storage site and earth filling. Such impact is temporary, and can be readily mitigated with good construction management practice. During the operation of ship locks, main air pollution comes from waste gases from ships, include SO_2 and NO_2 and particulate matters. Given the limited ship traffic amount and short time for ships to pass the ship locks, the impact of air pollution is basically limited within the waterway area and has little impact on the surrounding sensitive receptors.

The protective measures for ambient air quality developed in the ESMP mainly include: Implement water spraying to suppress dust on construction sites and material transportation access roads; use covered trucks to transport materials; timely clean the access roads; strengthen vehicle inspection and maintenance; enforce the installation of exhaust treatment facility for ships using internal combustion engine and car engine; etc.

5.5 Noise Impact

Noises during construction mainly come from machine operation, vehicle transportation and blasting. The noises from machine operation and vehicle transportation exceed the limits for daylight and nights of Maocao Village and Yakou Village. The blasting has only a short term of impacts on surrounding sensitive receptors due to short duration. The following noise control measures will be taken during construction: strictly control the schedule of material/waste transportation; control vehicle speed; enforce horn ban; properly maintain access roads and vehicles; install soundproof walls along the red line marked for the requisitioned land near the residential areas of Maocao Village and Yakou Village, etc.

During operation, noise made by ships passing through the dam generally will not disturb local residents, but the number of ships passing through the dam will be regulated, and continuous whistling from ships will be prevented. A large number of ships traveling and whistling at night will be banned in the waterway segments along which a large number of residents live. The speed of ships traveling at night will be controlled.

5.6 Impacts of Ancillary Works

5.6.1 Access Roads

Due to the large amount of earthwork volume and high construction intensity, road transportation is needed. On the left and right bank of the dam's downstream/upstream section, roads leading to the working face of construction are arranged. The road is 13.50km long in the construction site, including 1.3km access road (permanent road). The land occupied includes dry farmland, woodland, road, inland mud flat, and waste land. There is no sensitive environmental or social site being affected. Except for the access road which will be reserved as permanent access road, the cultivated land & woodland occupied by temporary construction roads will all be reclaimed by measures such as topsoil stripping and backfilling, land rehabilitation and vegetation restoration. In addition, according to the requirements of farmland-lifting area and farming, rehabilitation measures will be taken for 7.5km farmland road which is inundated by the reservoir.

5.6.2 Material Borrowing Sites

The project requires a total of 583,600 m^3 stone material, which will be used as backfill materials of main works, gabion materials, and interception materials for cofferdam. According to project design, this material will be purchased from two outside commercial suppliers, i.e. Matoushan quarry and Jinniushan quarry sites (see **Figure 2**), to avoid ecological impact and soil erosion by opening new quarry sites. These two sites are legal quarry sites with environmental license.

The sand and gravel of the project will be obtained from Longmentan sand and gravel site. This site is an existing sand and gravel material site being excavated for construction material. Excavation will be conducted strictly following the design to minimize environmental impact.

The project will need 191,200 m^3 of soil to be borrowed from two sites, i.e. Yakou borrow site and Luojiazhuang borrow site (see **Figure 2**). Current land use of these two sites is farmland. Top soil will be reserved aside, and the sites will be reclaimed upon completion of earth borrowing.

5.6.3 Spoil Disposal Sites

Two spoil disposal sites are selected near the complex, with total dump capacity of 4.71 million m^3. The current land use at these two sites is farmland and river flood land. The dumped spoil material in these two sites will be used to create two pieces of lifted land, which is partially used as construction ground (latterly turned into part of the dam management area) and the rest will be reclaimed as farmland.

5.6.4 Construction Camps

The project construction will last 58 months, with total labor during peak time of construction of about 2,100. The area for construction camps, office buildings and ancillary facilities will be about 12,600 m^2. Two construction camps and office buildings will be arranged, one on each side of the river. Drinking water will be supplied from Han River, and electricity will be supplied by two existing substations nearby. The dense population of construction staff will demand large-scale logistics service, which will provide employment opportunities for local residents. However, influx of labors may also have impacts on social life of nearby communities in terms of cultural conflicts, social safety, public health etc. Measures are developed in the ESMP to address such impacts, including, e.g. provide education to labors; implement health examination to labors; strengthen camp and behavior management; etc.

5.7 Land Acquisition and Resettlement

After taking the protective measures, the inundation will affect land and houses in 34 villages. 18 households with population of 91 (13,238.47m^2 private houses) will be resettled. The total inundation area will be 6,633ha, including 5,194ha water area and 1,839ha land area. Total population affected is 660 by land acquisition. Other facilities affected include 7.5km farmland road, 4 ferries, 3 freight docks, 3km power transmission line, 10 pumping stations and 12 drainage sluice gates.

To address land acquisition and resettlement impact, a Resettlement Action Plan (RAP) has been developed in accordance with national laws/regulations and the requirements of the World Bank's OP4.12. (see details in RAP)

5.8 Social Impacts

As part of social safeguards efforts, HPTD has commissioned Wuhan University to conduct a dedicated social assessment in 2016, of which the findings and mitigation measures have been incorporated into the ESMP.

The potential adverse impacts mainly include project construction disturbance, reservoir inundation, land occupation and resettlement, fishermen's livelihoods, vulnerable groups, women, local residents and traditional cultures.

- Fisherman's livelihood: there are 17 registered fishing families. Field survey indicates that currently only two persons are engaging ferry boats, all the rest labors are seeking jobs in other cities.

- Vulnerable people: the project will affect 5 vulnerable households which are all subject to resettlement.
- Women: land acquisition will affect women engaged in agricultural activity; business activities affected by the project will impact the job employment of women.
- Construction disturbance: traffic disturbance of material transportation vehicles, road safety concern, and nuisance of dust and noise.
- Community safety and health: influx of labors may pose public health risk of infectious diseases such as typhoid, dysentery, hepatitis, STDs and AIDS. Meanwhile, with the increase of temporary residents, public security & social order may also become a concern.

To address such potential impacts, a series of mitigation measures have been developed in the ESMP including, e.g. design of fish passage; fish fry breeding and release program; encourage cage aquaculture industry in reservoir; hire local labor for project construction jobs with preference to vulnerable households and women; purchase local products; provide employment training to vulnerable families; improve public infrastructure; provide training to women; schedule construction works to minimize traffic disturbance; install traffic safety signage; spray water on access roads; enforce labor behavior management; implement periodic health examination for labors; labor education; establish grievance mechanism etc.

5.9 Impacts of Associated Works

5.9.1 Dike Strengthening Works

The Han River dike in Xiangyang section has a total length of 210.74km. It has been heightened and thickened a number of times through floods. Currently, the dike has potential safety risks due to insufficient height, inadequate thickness, hidden dangers body and foundation, frequent seepage during flood season etc. In February of 2005, the Ministry of Water Resources and Hubei Provincial Government issued the *Master Plan of Pilot Modernized Hydraulic Complexes at Middle and Lower Reaches of Han River in Hubei Province* (SGJ [2005] No.85). The *Construction Plan of Pilot Modernized Hydraulic Complexes in the Han River Basin in Hubei Province* was completed and approved in 2012. According to this plan, dike strengthening is planned for 9 sections with total length of 142.747km.

According to the *Dike Strengthening Plan for Reservoir Backwater of Yakou Navigation Complex* developed by the project in 2014, the areas affected by the backwater of Yakou navigation complex involves three sections (out the total 9 sections mentioned above), i.e. Oumiao dike, Yicheng urban area dike and Hedong dike (see locations shown in **Figure 2**), with total length of 86.739km. To prevent the impact of backwater, the water resources departments will implement the dike strengthening work while the Yakou Navigation Complex project is being implemented.

As the dike strengthening work is to be conducted by local water resources authority, rather than the HPTD, a due diligence review on the implementation of dike strengthening

was conducted to review the legal compliance and performance of works that have already been done (i.e. Yicheng urban area dike). This review was conducted through documents review, consultation with relevant stakeholders and field investigation. The key findings of due diligence review include:

- There is well-established management structure for the dike strengthening project, i.e. Xiangyang Dike Construction Commend Office for overall leadership, guidance and supervision; Xiangyang River Channel Management Department for implementation of project, including environmental management; contractors for implementation mitigation measures; and supervision companies for supervision of contractors' environmental performance;
- Xiangyang Water Resrouce Bureau has engaged Xiangyang Academy of Environment to prepare an EIA report for the dike strengthening project in 2015, which confirmed the environmental compliance of the project and has developed a set of mitigation measures with adequate budget to minimize adverse impacts;
- Field investigation on completed dike section confirmed the overall environmental compliance, and there was no environmental complaints received. The roads and flood control facilities along the Han River banks within the completed dike section have been greatly improved. Vegetation restoration measures have been implemented in accordance with the project design. Vegetation has been growing well. The vicinity of the completed dike section has been frequented by local residents for relaxation. Moreover, the construction of the river dike landscape belt has driven development along the Han River banks, improving the local residents' living conditions and generally realizing the social and environmental benefits as expected.

Based on this due diligence review, it can be concluded that the preparation and implementation of Xiangyang Dike Strengthening Project complies with the national and local laws and regulations on environmental protection, and conforms to the requirements of the World Bank's safeguards policies. Further an ESMP for the dike strengthening was developed and will be implemented during the project implementation.

5.9.2 Power Transmission Line

The project will need to build a 12km transmission line to connect the Yakou Complex with the nearby transformer substation (as shown in **Figure 2**). The power transmission lines will be carried out in the later stage of the project, and implemented by local power authority. Initial environmental screening and assessment were conducted at this stage to provide an overview of potential environmental issues and references for the later EIA preparation by local power authority.

Based on field survey, the area between the Yakou complex and the Zhengji power substation is all farmland, the alignment does not involve any residential houses. There is no environmentally and socially sensitive receptor in the vicinity of the alignment corridor.

The potential adverse impacts will include limited land acquisition, soil erosion, noise and dust and safety during construction stage, and electro-magnetic frequency, landscape and

safety concerns during operation. These impacts are common and well known to such projects, and can be readily addressed with mitigation measures of design and good construction management practice.

There are well established legal framework, technical guidelines, institutional procedures and environmental management system for EIA preparation and implementation for power transmission line projects in China. Based on initial screening and assessment, there will not be any significant environmental and social impact envisaged for this transmission line.

6. CUMULATIVE EFFECTS

According to the *Comprehensive Plan for the Trunk Han River* (2012), in total there are 15 dams planned along the Han River. The upper reach of Han River, namely upstream of Danjiangkou there are 8 dams, of which 4 have been built and the remaining 4 are under construction. The mid to lower reaches, starting from Danjiangkou there are 7 dams(see **Figure 1**), namely the Danjiangkou (built in 1973) – Wangfuzhou (built in 2000) – Xinji (planned) – Cuijiaying (built in 2010) – Yakou (planned) – Nianpanshan (planned) – Xinglong (built in 2014).

According to national and Hubei provincial inland waterway plans, the middle to low reaches of the Han River (650 km) will be upgraded to a Grade III navigation channel (allowing for year-round navigation of 1,000 dwt vessels) mainly through cascade development. It is planned that by 2020, the remaining three complexes, namely Xinji, Yakou and Nianpanshan are expected be built by 2020 to achieve the planned navigation objective. It is apparent that construction of the multiple dams on the Han River will bring about significant cumulative impacts. A special cumulative impact assessment report has been developed during preparation of the project EA.

In terms of a single dam, construction of navigation complex is a short-term action with relatively small impact; but with construction of multiple dams on the same river, there will be significant cumulative effects. Since the cumulative environmental impact of construction of navigation complexes is of great importance for the analysis of environmental impact of Yakou Complex, a special report has been prepared for cumulative impact assessment during the preparation of EIA. The key findings and recommendations of this cumulative assessment are summarized below:

6.1 Assessment Scope

The Danjiangkou reservoir was built in 1973 as the first dam on the Han River. Danjiangkou reservoir has a designed capacity of 29 billion m3, while the remaining 6 complexes downstream of Danjiangkou are all of run-off type and with storage capacity only 0.5-3% of that of Danjiangkou reservoir. Therefore, Danjiangkou reservoir/dam plays a control role in terms of hydrological regime (hence the aquatic ecological environment) in the mid to low reaches of Han River. Namely, the mid to low reaches of Han River forms a relatively self-standing unit

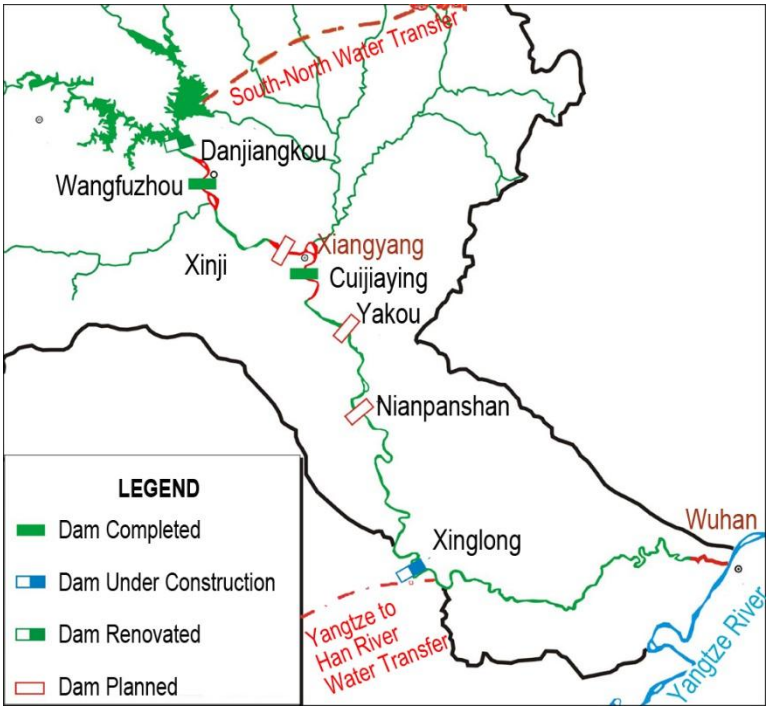


Figure 8 Cumulative Impact Assessment Scope

for impact assessment. Further, considering the need to develop practical mitigation plans and establish effective institutional coordination, it is prudent to focus the cumulative impact assessment to the mid to low reaches of Han River, covering the dams of Danjiangkou - Wangfuzhou - Xinji – Cuijiaying - Yakou - Nianpanshan – Xinglong (See **Figure 8**).

6.2 Screening of VECs and Cumulative Impact Issues

Of the 7 dam/reservoirs along the length of middle and lower Han River mainstem, four have been built and operational (i.e., Stage 1 Danjiangkou, Stage 2 Wangfuzhou, Stage 4 Cuijiaying and Stage 7 Xinglong); the remaining three stages (i.e., Stage 3 Xinji, Stage 5 Yakou and Stage 6 Nianpanshan) are expected to be completed in coming 3 years. Several valued environmental components (VECs) were identified through comprehensive desk review and public consultations with pertinent agencies, technical experts and other stakeholders; hydrologic regime, water quality, fish and riparian areas were considered of high priority among those identified VECs.

6.3 Affected Environment

Review of the historical conditions, trends and inter-dependency of the VECs leads to the following findings, a) Hydrologic regimes: flow measurement results at each fixed cross-section on the middle and lower Han River mainstem since 1956 suggest that annual average runoff ranged from 1,100-1,500 m3/s. The Danjiangkou reservoir (built in 1973) and increased human uses reduced the overall flow rate moderately compared to the natural conditions. Combined with subsequent dam/reservoirs, the spatial and temporal distribution of the runoff varied markedly as demonstrated by reduced annual variations, elevated levels, expanded areas, reduced flow velocity and decreased solid contents; b) Water quality in the mainstem and major tributaries in the past 15 years has seen continuous improvement. In recent years the designated Class II standard have been fully attained in the mainstem, while the tributaries' water quality ranged from clean to polluted status; 3) The fishery resources present a declining trend over the past 4 decades, as evidenced by the facts that the abundance and diversity of traditionally dominant fish species with floating eggs (represented by the *Four Domesticated Fish*, namely *black, grass, bighead and silver carps*) and their spawning grounds reduced markedly; fish species favoring stagnant waters such as common and crucian carps became dominant; the sizes of individual fishes decreased. Overfishing, water pollution, dam/reservoir development and other activities such as in-stream sand mining cumulatively contributed to the changes. Meanwhile, the government has made extensive protection and restoration efforts, such as water pollution control and no-fishing regulation that have helped mitigated the negative effects, as exemplified by the improved water quality; and 4) Riparian habitats and wildlife. Terrestrial ecology was examined routinely in traditional Han River EA studies. Drawing on international advancements in research and EA practices, this CEA study specially examined the riparian areas, which are transitional between terrestrial and aquatic ecosystems, presenting distinguished ecological functions and higher relevance to the proposed developments than the general terrestrial ecosystem. Apparently, many riparian areas along the Han River have been lost due to intensified human activities (e.g. farming and urban development) and inundation resulting from reservoirs formation. Currently the

riparian corridor is dominated by secondary vegetation (such as poplar and willow), shrubs, grass and crops. Wetland and adjacent emergent/submerged plants provide habitats for fish, birds and other wildlife. 44 waterfowls (13 swimming birds and 31 wading birds) were recorded, including two national Class I protected wading bird species, namely Oriental White Stork (*Ciconia boyciana*) and Black Stork (*Ciconia nigra*); and four national class II protected waterfowls. Following the formation of Wangfuzhou and Cuijiaying reservoirs, local governments established a wetland nature reserve and a wetland park in each reservoir area; two other wetland parks have been proposed. These actions result in ecological and recreational benefits as well.

6.4 Cumulative Effects and Mitigation

Based on the deepened understanding of past activities and their cumulative effects on the key VECs, major future development activities were identified: a) Completion of the 7-stage cascade development on the middle and lower Han River in coming 3-5 years is a high likely condition; b) the South-to-North Water Diversion (SN Diversion) project that was put into operation in Dec 2014 and transfers water from Danjaingkou reservoir to north China. Other present and future activities that may have cumulative effects on the VECs were also considered though quantitative evaluation were impossible. Specifically, cumulative effects and mitigation measures include the following.

a) Hydrologic regimes. The SN Diversion currently transfers 2-3 billion m3/year water from Danjiangkou reservoir annually, compared to the 40 billion m3/year annual inflow into the reservoir. Flow reduction in the middle and lower Han River is moderate. In future, combined with the full cascade development, the cumulative effects on flow rate and flow velocity will be significant. The formation of reservoirs in the middle and lower Han River will to certain extent compensate for the river width and depth reduction resulting from the flow reduction but will turn the river into connected lakes. To mitigate the cumulative effects, a regulation has been enacted to ensure that the minimum releases from each dam must meet downstream environmental flow, navigation and water supply needs.
b) Water quality. Initial mathematically modelling suggests that cumulatively the SN Diversion and full cascade development may result in significant loss of water environmental carrying capacity and non-compliance with the designated Class II surface water standards. More aggressive domestic/industrial wastewater pollution and agricultural non-point source pollution control plans, and more stringent pollution discharge standards are being implemented to mitigate the impacts;
c) Fish. Changes of flow regimes and fragmentation caused by the dams have and will further negatively impact on fish species with floating eggs such as the *four domesticated fish* through disturbing their breeding and hatching life stages and spawning grounds, while fish species favoring lake-like conditions will become more dominant. Mitigation measures include fish breeding facilities and fish reproduction programs that are implemented and financed by each dam operator; fish passages in the 5 dams downstream of Wangfuzhou (Stage 2), coordinated dam operation (i.e., ecological scheduling) to provide needed water rise, flow velocity and floating distance for the successful reproduction of fish species with floating eggs; fish habitat protection and restoration in the mainstem tail waters and

tributaries; fishery administrative measures such as no-fishing zone and season, and educational activities.

d) Riparian areas. Riparian/floodplain areas along the middle and lower Han River will be further impacted due to the changes of hydrologic regimes (e.g. changes of seasonal flooding process) and inundation. Since riparian ecology is a relatively new area of study internationally and in China, a general mitigation strategy was proposed, including expanding the existing ecological scheduling program and create flooding process that is essential to riparian wetland (current ecological scheduling is designed for fish needs primarily), riparian vegetation restoration and other good management practices addressing over-farming, grazing and other development activities. The proposed Wangyangzhou wetland park (linked to Yakou project) has the potential to demonstrate riparian ecosystem restoration as well.

6.5 Inter-agency Coordination Mechanism

The CEA also carefully examined inter-agency coordination mechanism that is essential to address cumulative effects. Existing coordination mechanism as exemplified by the coordinated dam operation program (i.e. ecological scheduling) is overseen by the provincial government and involves pertinent provincial departments, dam operators. Proposed habitat restoration, fishery administration (e.g. no-fishing zone), and wetland park development will require close engagement with local governments, agriculture and fishery departments. In addition, the uncertainty associated with future actions require an adaptive monitoring and management approach to incorporate those scientific, technical, institutional uncertainties into the implementation and further development of cumulative effects action plans. To this end, a more detailed cumulative effect assessment will be carried out during the Yakou project implementation building on the preliminary CEA prepared during the project preparation. The primary objectives of the detailed CEA include: a) expanding the VECs and deepening understanding of the cumulative effects; 2) maintain and enhance the inter-agency coordination mechanism; and 3) develop a long-term adaptive monitoring and management plan.

7. PUBLIC CONSULTATION AND DISCLOSURE

During the preparation of domestic EIA report, public consultations were conducted by the EA consultant during the period from August of 2012 to December of 2015 through interview, questionnaire survey and public meetings in the area directly affected by the project, including Oumiao Town in Xiangcheng District, Dongjin Town in New Dongjin District, and six villages and towns in Yicheng (Liushui, Nanying, Wangji, Zhengji, Yancheng, and Xiaohe). According to the results of the questionnaire survey, 88.4% of the respondents are supportive of the project while 11.0% of the respondents take neutral stance. According to the survey, the primary concern of the public with regard to the implementation of the project is economic benefits, followed by resettlement compensation and the impact of construction and inundation to the ecosystem. These concerns were taken into account in the preparation of EIA report.

Information disclosure was conducted through two rounds website disclosure of EIA information: (1) disclosure of project information, public consultation methods in August 2012 in website of Yicheng City Government; (2) disclosure of key findings of EIA reports and mitigation measures in August 2014 and January 2015 on the websites of HPTD, Yicheng News and Xiangyang EPB. Full EIA was disclosed on January 26 2016.

In order to meet the World Bank's requirements, during the preparation of the supplementary EIA, additional public consultations were conducted in four stages, with participation of project affected people, NGO and local government departments. The four stages consultation is summarized in **Table 4**.

Table 4 Public Consultations for Supplementary EIA

Method	Participant	Date	Location	Main Concerns
Stage I: field visit and information collection	Xiangyang Center for Disease Control and Prevention	2016.3.15	Xiangyang Center for Disease Control and Prevention	Impact on the quality of water from the Han River water sources; impact on water intake facilities
	NGO, Green Han River	2016.3.15	Green Han River office	Han River pollution; impact of main works and environmental measures
	Xiangyang Bureau of Aquatic Products	2016.3.16	Bureau of Aquatic Products	Impact of the project to fish species; the feasibility and effectiveness of the measures of restoring fish species
	Yicheng Municipal Administration of Culture Property	2016.3.16	Yicheng Municipal Administration of Culture Property	Potential impact to the local cultural relics; procedures for relocating the cultural relics
	Yicheng Forestry Bureau	2016.3.17	Yicheng Forestry Bureau	Impact of the project to the national-level wetland park in Wanyangzhou
	Yakou Village head, villagers, and fishermen	2016.3.18	Yakou Village	Impact of the project to the local residents
	Villagers of other villages	2016.3.18	Maocao Village	Impacts of resettlement
Stage II: public meetings	Yicheng Municipal Government officials, the villagers of the affected villages	2016.4.28	Yicheng Municipal Government	Impacts on aquatic ecosystem, physical cultural resources, the resettlement and livelihood rehabilitation, etc.
Stage III: interviews	The PIUs of the hydropower and	2016.5.16	Yicheng	Cumulative impact of the hydropower and navigation

Method	Participant	Date	Location	Main Concerns
	navigation complexes in the Han River middle- and lower reaches, villagers along the Han River			complexes in the Han River middle and lower reaches; impact of the hydropower and navigation complexes to local production and the livelihoods of local residents
Stage IV: Consultation meetings for cumulative impact assessment	The PIUs of the hydropower and navigation complexes in the Han River middle- and lower reaches, local governments and departments	2016.6.21 -6.22	Xiangyang, Zhongxiang	Cumulative impact of the hydropower and navigation complexes in the Han River middle and lower reaches to the environment; the river basin management proposals

Strong support to the project has been expressed from the consulted stakeholders for timely implementation of the project. The main concerns include water quality, fish resources impact, cultural relics sites protection, land acquisition and resettlement compensation, land inundation and drainage etc. These concerns were responded during consultation, and taken into account in project design and development of ESMP.

Information disclosure during the preparation of supplementary EIA is summarized in **Table 5**.

Table 5 Information Disclosure of Supplementary EIA

No.	Content	Time	Website
1	Project description; channels for public consultation, grievance and complaint	2016.4	http://www.hbghj.gov.cn/
2	Domestic EIA summary	2016.5	http://www.yichengnews.com/ http://www.hbghj.gov.cn/
3	RAP draft, supplemental EIA, CEIA draft, Environmental & Social Management Report (all in Chinese)	2016.6.20	http://www.yichengnews.com/ http://www.xfhbj.gov.cn/
4	Notice on disclosing the complete information of RAP and EIA online	2016.6.20	http://xfrb.hj.cn/
5	Final RAP, final supplemental EIA, final CEIA and final ESMP (all in Chinese)	2016.6.25	http://www.yichengnews.com/ http://www.xfhbj.gov.cn/

8. ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

Two stand-alone Environmental and Social Management Plans (ESMPs) have been developed, one for Yakou Navigation Complex Project (including associated works) and one for Reservoir Dike Strengthening Works. The ESMPs include all measures to mitigate environmental impacts during the construction and operation, organizational structure, procedures, institutional responsibilities for implementation, and budget and source of financing for each activity. The ESMP also includes environmental monitoring and capacity building programs.

More specifically, besides a comprehensive set of generic mitigation measures, the Yakou Navigation Complex Project ESMP also include a number of annexes with detailed plans for specific environmental issues, including:

- Water Conservation and Erosion Control Plan;
- Reservoir Bottom Cleanup Plan;
- Construction Environmental Specifications for Contractors;
- Hazardous Material and Wastes Management Plan;
- Physical Cultural Resources Management Plan;
- TORs for Stage-II Cumulative Impact Assessment;
- TORs for Ecological Flow Regulation Study;
- Work Plan for Fish Passage Effects Evaluation

8.1 Environmental Management Organizations and Responsibilities

The Project Management Office (PMO) under the Yakou Navigation Complex Co. Ltd. (which is responsible in construction and operation phases) will be responsible for the overall environmental management during the project construction and operation. PMO will be responsible for tracking environmental issues in respect of Yakou Navigation Complex Project and communicating with other Chinese governmental authorities and Word Bank on all environmental and social issues. PMO will appoint full-time, trained and qualified environmental management staff to conduct environmental and social management works in construction and operation phases in order for effective development and implementation of mitigation measures set out in the ESMP.

Construction Supervision Company (CSC) will establish Environmental Management Unit to deal with all daily environmental issues related to project construction activities on site. Each environmental manager and his or her employees (environmental engineers and site inspectors) will be appointed by CSC. Each main construction contractor (CC) is required to establish its environmental department consisting of environmental coordinator, engineer and site inspector. Environmental personnel of CSC and contractors will be independent from construction personnel. Environmental personnel will closely work and cooperate with construction personnel.

Whether in construction or operation phase, independent consulting experts will be employed by PMO as part of technical support service, to provide necessary aids for the Project in the whole implementation process of the Project.

The environmental management structure of Yakou Navigation Complex is illustrated in Figure 9. The reservoir dike strengthening project has the same structure, with Xiangyang Water Resource Bureau (WRB) and Xiangyang Waterway Management Bureau as implementing agencies.

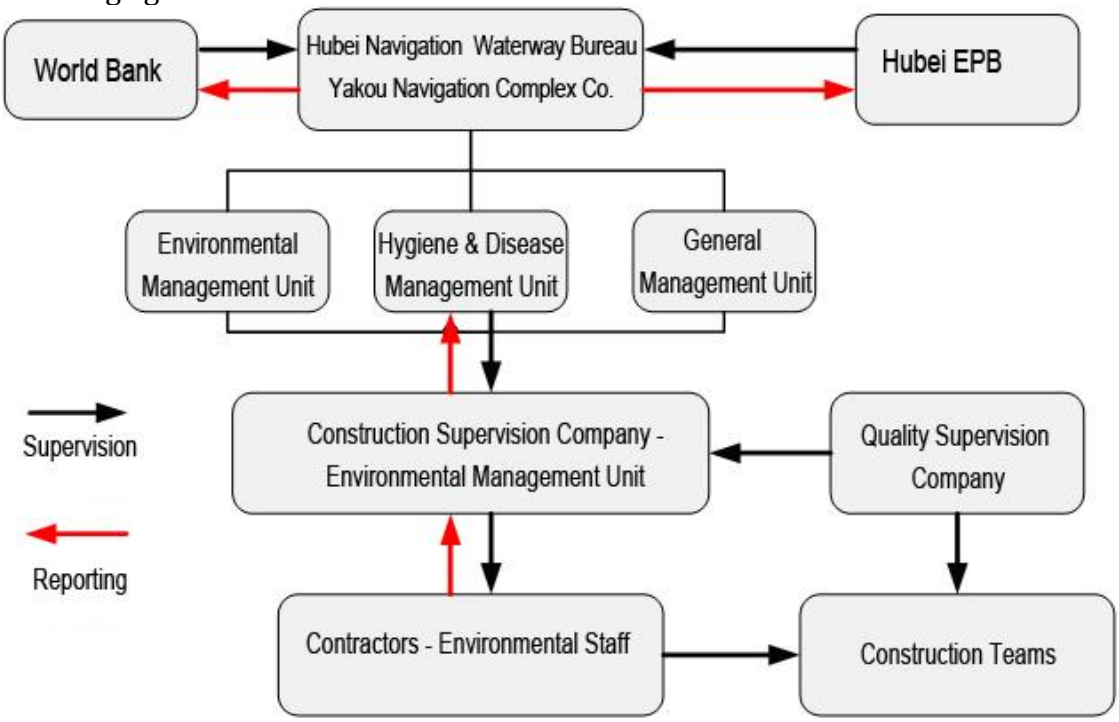


Figure 9 Environmental Management Structure for Yakou Complex Project

8.2 Mitigation Measures

The ESMPs include a comprehensive set of mitigation measures with explicit implementation timeline, budget and implementing and supervising agencies, as well as monitoring index and frequency for result monitoring of related measure implementation, so as to develop and take necessary actions in a timely manner to strengthen or adjust such measures and to ensure meeting the defined environmental and social objectives. Mitigation measures will be incorporated into detailed design, tender documents and project management manual, to be implemented by the design institutes, contractors and supervision engineers under the supervision of Project Management Office, local environmental protection authority and the environment expert of the expert team. The key mitigation measures for Yakou Navigation Complex Project are summarized in the following **Table 6**.

Similar sets of mitigation measures are also developed for inundation areas and resettlement areas, power transmission line construction, as well as the dike strengthening works respectively, and included in the two ESMPs.

Table 6 Environmental and Social Management Plan for Construction and Operation

Potential impacts/issues	Mitigation measures/action plan	Budge (CNY 10,000)	Implementing agency	Supervising agency	Monitoring index	Monitoring frequency
Construction period						
Land acquisition and resettlement	• Develop RAP with meaningful consultation; • Compensate affected people, with special assistance to women and vulnerable group; • Provide employment training, and provide non-professional jobs to resettlement people • Plan production development projects; • Establish grievance mechanism	Refer to the RAP.	PMO,CC, Yicheng Resettlement Office, Agricultural Bureau, Land and Resources Bureau, Forestry Bureau, villages and towns and village committee in the resettlement area as well as reservoir area	PMO, Yicheng land and resources bureau, external monitoring agency	Refer to the RAP.	Refer to the RAP.
Water and soil erosion at dam site, borrow pits and spoil disposal sites	• Engineering measures, vegetation measures and temporarily preventive measures developed in the *Control Plan for Water and Soil Loss* (Appendix 1 of ESMP)	8023.27	CC, CSC	PMO, Xiangyang EPB, Xiangyang WRB	Refer to monitoring requirements in the *Control Plan for Water and Soil Loss*	Refer to monitoring requirements in the *Control Plan for Water and Soil Loss*
Construction dust at the complex, borrow sites and disposal sites may affect nearby communities	• Use special blasting technology to minimize dust; • Use dust filter for mixing plants; • Install fence around construction site near villages (500m) • Halt soil excavation and backfilling in windy days (more details in ESMF Annex 3 Environmental Specifications for Contractors)	251.01	CC, CSC	PMO, Xiangyang EPB Protection Bureau	SO_2, NO_2, TSP	Three times per year
Exhaust emission from construction vehicles and equipment	• Restrict vehicle speed (max 30km/h) when passing Yakou Village, Luojiazhuang Village and Maocao Village. (more details in ESMF Annex 3 Environmental Specifications for Contractors)					
Noise from construction activities, and blasting and material transportation	• No high-noise construction activities during nighttime; • Install noise barrier at Yakou Village Maocao Village, and Heluo village; • No excavation on the side near the villages • Enforce horning ban (more details in ESMF Annex 3 Environmental Specifications for Contractors)	147.79	CC, CSC	PMO, Xiangyang EPB	Leq	Two times per year, two times per day, 24 hours per day
					Leq	3 times every year (4 years in total)

Potential impacts/issues	Mitigation measures/action plan	Budge (CNY 10,000)	Implementing agency	Supervising agency	Monitoring index	Monitoring frequency
Wastewater from aggregate washing, mixing plant, foundation excavation, vehicle/equipment maintenance station, and sewage from camps	• Install sedimentation tank system; • For mixing plants, add flocculants, periodically remove sediments. • Install oil separation tanks for maintenance stations .• Reuse treated water for dust control, greening and vehicle washing, without discharge to environment. • install integrated set of domestic sewage treatment system, used treated water for irrigation after disinfection	1035.1 (aggregate systems) 35.6 (mixing plants) included in the project investment 51.06 (maintenance stations) 364.63 (camp)	CC, CSC	PMO and EPB	Flow & SS: Water quality: pH, SS, DO, COD_{Mn}, BOD, COD_{Cr}, ammonia nitrogen and petroleum	4 times every year (concrete mixing system); water quality: twice every year (high- and low-flow periods)
					COD, BOD5, ammonia nitrogen, TP, TN for camps	4 times every year (4 years in total)
Solid wastes of spoil materials and garbage	• Two disposal sites designed with adequate protection measures and reclamation plan • Install garbage collection tanks on sites; • Use Yicheng city garbage collection and disposal service system.	Included in the costs of *Water and Soil Conservation Plan*	CC, CSC	PMO, EPB, WRB	/	/
		192.03 (garbage)	Yicheng Environmental Sanitation Administration	PMO, EPB, ESA	/	daily
Disturbance of surface vegetation.	• Proper design and plan the project construction to minimize land disturbance; • Pay adequate compensation fee for vegetation restoration; • Extensive greening plan after project completion, with consideration of avoiding single species and introduction of invasive species.	Included in RAP	PMO, CC, CSC and local forestry department	Local forestry department	Forest resources; distribution and changes of main vegetation types; agricultural ecosystem change, quality of regional landscape	once every year
Disturbance of wildlife habitats; Illegal hunting or poaching;	• Labor education; • Enforce code of conduct for labors • Control construction boundary • Properly schedule blasting; • Timely restore disturbed land • Develop brochures of protected animals for labors	14.25	CC and local department of wild animal conservation	Local department of wild animal conservation	Habitats, diversity and changes of terrestrial wildlife; regional wildlife composition, distribution; distribution of rare, endangered or endemic animals	once every year (2 years in total) (incl. 1 year of background monitoring before construction and construction period)
Construction disturbance of fish habitats; fish catching by labors	• Labor education • Ban fish catching from labors	10	CC and CSC	Local authorities of wild animal conservation	/	/
Physical cultural relics sites protection.	• Cultural relics sites exploration and protection plan dis developed, with budget and timeline (see ESMP Appendix 5). • Chance-find procedures in ESMP • Family graves relocation included in the RAP	232.5	PMO, CC and Yicheng Culture Property Bureau,	Xiangyang Bureau of Cultural Heritage Village committees	 Refer to RAP /	 Refer to RAP /
Hygien and health concerns at the construction area	• Clean and desterilize sites of camps; • Conduct periodic vector control measures in spring and autumn; • Disease prevention measures all labor prior to construction; 10% random application during construction;.	97.90	PMO, CC and CSC	Local department of hygiene and disease control	Species and density of rats and species and density of mosquitoes in the construction area	twice every year (from the preparation period to the completion of the Project)

Potential impacts/issues	Mitigation measures/action plan	Budge (CNY 10,000)	Implementing agency	Supervising agency	Monitoring index	Monitoring frequency
	• Provide vaccine for labors in epidemic period • Conduct annual/biannual health examination for labors • Ensure hygiene of drinking water and canteen areas, conduct quarterly inspection • install adequate toilet facilities, garbage tanks and timely disposal of wastes	42.75 28.50 28.50			Infectious dis eases of Categories A, B and C (e.g., entity, time and age of morbidity, gender and job)	When an infection case is found,
Safety risks of dangerous materials such as explosives	• See ESMP Appendix 4: Hazardous Materials and Wastes Management Plan	/	PMO, CC and CSC	Local department of hygiene and disease control	/	/
Traffic safety of communities near construction sites and access roads.	• Publish traffic disturbance notice and measures through media and posters • Provide education to drivers, properly maintain vehicles, restrict speed through villages, install signage, and assign parking areas • Provide notice to public warning traffic peak, and coordinate traffic police • Develop emergency response plan for traffic accidents.	included in the overhead cost of the Project	PMO, CC, CSC and local traffic police department	Local traffic police department	/	/
Vocational health and safety	• Contractor develops health and safety plan for approval of Construction Supervision Company; (more details in ESMF Annex 3 Environmental Specifications for Contractors)	included in the overhead cost of the Project	CC	PMO and CSC	/	/
Operating period						
Limited data and timeframe due to tight project schedule results in a limited cumulative impact assessment	• Conduct second stage cumulative impact assessment as a part of TA component of the project. TORs developed in ESMP Annex 6.	380	PMO	WB	/	/
Joint operation of cascade dams for to ecological flow to ensure the natural flow status of the river to provide the hydrological and hydraulic conditions necessary for reproduction of fishes laying drifting eggs	• Conduct joint operation for ecological flow regulation study. TORs has been developed as Annex 7 of ESMP.	460	PMO	WB	/	/
Effect of current fish passages in Cuijiaying and Xinglong is not ideal.	• Conduct monitoring and evaluation of actual effect of fish passage, and modify or improve the fish channel accordingly. Work plan developed an Annex 8of ESMP.	280				
Adaptive management for mitigation measures based on second stage cumulative impact assessment	• Adjust and improve mitigation measures for construction and operation based on latest assessment results	180	PMO, CC and CSC	EPB	/	/
Water quality may deteriorate due to release of	• Cleanup the bottom of reservoir before impoundment (see Annex 2 of ESMP).	117.8	The Project Operation Unit, CC and CSC	The Project Operation Unit	21 items, including water temperature, pH,	Twice every year (high- and low-

Potential impacts/issues	Mitigation measures/action plan	Budge (CNY 10,000)	Implementing agency	Supervising agency	Monitoring index	Monitoring frequency
nutrients from biomass and soil during initial impounding period.				and EPB	SS, DO, COD_{Mn}, COD, ammonia nitrogen, TN, TP, chlorophyll a, transparency, Hg, As, volatile phenol, fluoride, Cr^{6+}, Pb, petroleum and sediment content etc.	flow periods)
Incoming pollution from domestic sewage, agriculture and industries in the river basin near reservoir	• Implement wastewater pollution control program according to Han River basin pollution control plan • Strictly prohibit cage aquaculture in the reservoir. • Adjust agricultural structure to restrict consumption of fertilizers of nitrogen and phosphorus	included in the overhead cost of the Project	The Project Operation Unit and EPB	EPB		
Domestic sewage from management staff	• Install a biological purification tank (with the volume of about $40m^3$), and the treated water will be used for agricultural irrigation and not discharged	94.05	The Project Operation Unit	EPB		
Wastewater from power station may contain oil	• Strengthen operation management; • Install sump pump and oil separation treatment facility to recover the waste oil, and treated water used to water roads, flowers and trees	136.8	The Project Operation Unit and EPB			
Wastewater from ships (55.66t per year in 2020)	• Construct oil-containing wastewater collection and treatment system relying on the existing integrated port in Xiaohe harbor district of Xiangyang Port (about 23km upstream)	830	The Project Operation Unit and EPB			
Surface vegetation loss due to construction and inundation	• Timely restore vegetation after construction completion according to green plan • Properly schedule reservoir cleanup to avoid soil erosion • Strengthen greening plantation ar reservoir area. • Restore vegetation on the flood land	14.25	The Project Operation Unit, CC and CSC	WRB, EPB	See Appendix 1: Water and Soil Erosion Control Plan.	See Appendix 1: Monitoring Plan of Soil and Water Conservation Scheme.
Impacts on Wanyangzhou wetland park	• Strengthen management of sand excavation activities in the assessment area of the Project, ban sand excavation activities in the wetland park and its surrounding regions, • Solicit opinions from wetland park authority prior to construction for protection works and land elevation works • Plant wetland plants along Han River and near the park, with consideration of wetland park plan		the Project Operation Unit, wetland authority	Forestry Bureau, WRB		
Impact on habitats of terrestrial animals	• Provide training on labors on wildlife protection and rare, endangered animals • Drive wild animals away through whistling and drumming before bottom cleanup • Limit construction within boundary, prohibit fireworks and hunting activities.	14.25	The Project Operation Unit, CC and CSC	EPB	Habitats and diversity; wildlife composition and distribution; rare, endangered or endemic animals	1time/year, for 2 years (the 1^{st} year after impounding and the 5^{th} year thereafter)

Potential impacts/issues	Mitigation measures/action plan	Budge (CNY 10,000)	Implementing agency	Supervising agency	Monitoring index	Monitoring frequency
Impacts on fish spawning grounds and fish reproduction	• Conduct **joint operation for ecological flow regulation** among cascade dams at least twice a year to implement open discharge and achieve natural flow status for the river to the smoothing in spawning of existing spawning grounds, drifting hatching of fertilized eggs and fertilized fish migration channels to finish the reproduction. • To be implemented based on the regulation test	Included in the project operation costs	Provincial Department of Water Resources, Port and Waterway Administration and operation units of downstream complexes	Hubei Provincial EPB	Survey of fish spawning grounds:	2 times/year (April, August), altogether 6 years (1 year before impounding and the 1st, 2nd, 4th, 7th and 10th year after impounding)
Fragmentation of fish habitats and blockage of migration channel	• **Habitat Protection:** designate fishing ban zones for the river segments (from Cuijiaying dam to the tail of the Yakou reservoir and downstream of Yakou dam) with a flow rate of 0.2m/s; • Designate 18km section of Ying River, a tributary in the downstream of dam, as protected habitat. Create manmade fish habitats placing pebbles and gravels in an area and transplanting water plants to the area, and build manmade spawning grounds.	63	Project Operation Unit, Fishery Administration Station, Bureau of Animal Husbandry and Aquatic Products and Agricultural Bureau	Project Operation Unit and Fishery Administration Station	Fish habitat conditions	
	• **Artificial fish passage:** built fish channel as part of dam; • organize professional fishermen to catch fish in the downstream of dam, transport them upstream and put them in the reservoir so as to facilitate fish exchange in the upstream and downstream of dam.	30	Project Operation Unit, Fishery Administration Station, Bureau of Animal Husbandry and Aquatic Products and Agricultural Bureau	Project Operation Unit and Fishery Administration Station		
Impacts on fishes species composition	• Build fish breading and releasing station as part of dan operation, with planned capacity of 4 million fish release per year; • Conduct long-term monitoring and relevant scientific studies •Adjust release program after 20 years operation and monitoring	1494.71	Project Operation Unit, Fishery Administration Station, Bureau of Animal Husbandry and Aquatic Products and Agricultural Bureau	Project Operation Unit and Fishery Administration Station	Recapturing analysis and enhancement and releasing effect evaluation (fluorescence labeling method)	1 time/year in the 1st, 2nd, 4th, 7th and 10th year after impounding
	• Strengthen fishery management • Ban cage aquaculture and other activities that might pollute water environment in the reservoir area shall be forbidden; • Conduct research on fishery industry in Yakou Reservoir • Compensate affected people according to RAP • Strengthen capacity of local fishery administration authorities	150	Project Operation Unit, Fishery Administration Station, Bureau of Animal Husbandry and Aquatic Products and Agricultural Bureau	Project Operation Unit and Fishery Administration Station	Dynamic survey of fish gathering and population:	One year before reservoir impounding and in the 1st, 2nd, 4th, 7th and 10th year after impounding,
Livelihood of affected fishermen	• Provide compensation and employment program developed in RAP	60	Project Operation Unit, Fishery Administration Station, Bureau of Animal Husbandry and Aquatic Products and Agricultural Bureau	Project Operation Unit and Fishery Administration Station	Refer to the resettlement action plan and monitoring plan	Refer to the resettlement action plan and monitoring plan