Initial Environmental Examination (Draft)

Project number: 48274
July 2017

PRC: Shanxi Urban–Rural Water Source Protection and Environmental Demonstration Project

Prepared by the Zuoquan County Government for the Asian Development Bank

CURRENCY EQUIVALENTS

(as of 17 July 2017)

Currency unit	–	yuan (CNY)
CNY1.00	=	$0.1478
$1.00	=	CNY6.7637

ABBREVIATIONS

A2/O	Anaerobic, anoxic and oxic treatment
ADB	Asian Development Bank
BOD_5	5-day biochemical oxygen demand
BOT	Build-operate-transfer
CRVA	Climate risk vulnerability assessment
CNY	Chinese Yuan
COD_{CR}	Chemical oxygen demand
CSC	Construction supervision company
CSO	Combined sewage overflow
DEIA	Domestic environmental impact assessment
DO	Dissolved oxygen
EA	Executing agency
EAG	Environmental assessment guidelines
EHS	Environmental, health and safety
EIA	Environmental impact assessment
EIS	Environmental impact statement
EMP	Environmental management plan
EMS	Environment monitoring station
EPB	Environmental protection bureau
EPD	Environmental protection department
FSR	Feasibility study report
GDP	Gross domestic product
GHG	Greenhouse gas
GRM	Grievance redress mechanism
HDPE	High density polyethylene
IA	Implementing agency
IEE	Initial environmental examination
LID	Low impact design
LIEC	Loan implementation environment specialist
O&M	Operation and maintenance
OHS	Occupational Health and Safety
PE	Polyethylene
$PM_{2.5}$	Particulate matter with diameter<2.5μ
PM_{10}	Particulate matter with diameter<10μ
PME	Powered mechanical equipment
PLG	Project leading group
PMO	Project management office
PPE	Personal protection equipment
PRC	People's Republic of China
PPTA	Project preparatory technical assistance
RP	Resettlement plan
SBR	Sequencing batch reactor
SEPP	Soil erosion protection plan
SPS	Safeguard policy statement
SPG	Shanxi provincial government
SS	Suspended solids
SRMU	Shixia Reservoir Management Unit
TN	Total nitrogen
TP	Total phosphorus
TSP	Total suspended particulates
WDM	Water demand management
WRM	Water resources management
WTP	Water treatment plant
WTS	Water treatment station
WWTP	Wastewater treatment plant
ZCG	Zuoquan County Government

WEIGHTS AND MEASURES

°C	degree centigrade
dB	Decibel
ha	hectare (10,000 m^2)
kg	Kilogram
km	Kilometer
km^2	square kilometer
kW	Kilowatt
L	Liter
m	Meter
m^2	square meter
m^3	cubic meter
m^3/a	cubic meter per annum
m^3/d	cubic meter per day
mg/kg	milligram per kilogram
mg/l	milligram per liter
mg/m^3	milligram per cubic meter
mu	Chinese land unit (1 ha=15 mu)
MW	megawatt (1 million watts)
t	metric ton (1,000 kg)
t/a	ton per annum

NOTE

In the report, "$" refers to US dollars.

Contents

I. EXECUTIVE SUMMARY

A. Introduction

1. The Zuoquan County Government (ZCG) of Shanxi Province, People's Republic of China (PRC), has requested the Asian Development Bank (ADB) to provide investment and technical assistance support for the Shanxi Zuoquan Urban and Rural Water Conservation and Environmental Improvement Demonstration Project (the project). ZCG is the executing agency (EA) to plan and implement the project. Zuoquan County has set up a project leading group (PLG) and the project management office (PMO). The project will help the ZCG improve water and environmental management in the county, facilitate future sustainable development, and enhance climate resilience. The project has been developed based on the approved Zuoquan County City Master Plan (2010-2030) and Zuoquan County City Drainage Special Plan. Under ADB's Safeguard Policy Statement (SPS, 2009) the project is classified Category B for environment, requiring preparation of an initial environmental examination (IEE).

2. This IEE has been prepared in accordance with SPS requirements. It is based information from (i) two domestic environmental impact assessment (DEIA) reports prepared by the China Institute for Radiation Protection and Shanxi Qingyuan Environmental Consulting Co. Ltd.; (ii) a feasibility study report (FSR) prepared by Tongji University Architecture Design Institute; and (iii) environmental, social, and economic assessments and site visits conducted between September 2015 and May 2016 by a consultant team for the project preparatory technical assistance (PPTA), in cooperation with the provincial and local governments.

B. Background

3. Zuoquan County is part of Jinzhong Municipality and is located in the upper catchment of the West Qingzhang River, a main tributary of the Zhang River. The West Qingzhang River is a water source for 1.92 million people in six counties of Shanxi Province. The Shixia Reservoir is located close to the urban centre of Zuoquan County. It has a storage capacity of 50.99 million m^3 and is a critical potable water resource for the county.

4. Protection of the ecological and water environment of West Qingzhang River at Zuoquan is important to secure local and regional water supplies and conserve the Zhang River system and downstream waters. To address these issues and promote sustainable economic growth of the area, the SPG has formulated development strategies including the *Shanxi Province Water Source Management Regulations* and *Shanxi Province's Action Plans on Climate Change (2013-2020)* that incorporate elements of flood management, environmental and ecological protection goals. These efforts have not been sufficient to address water source protection, including: (i) safety — there has been no inspection of the Shixia Reservoir and dam since 2003, posing a severe risk to the people living downstream; (ii) flooding — due to poor reservoir maintenance and low capacity of downstream sections of the West Qingzhang River, there are continued flood risks to areas of Zuoquan County adjacent to the river. In August 1996, a flood caused over 30 deaths and 550 injuries; (iii) water quality — continued water quality deterioration due to non-point source pollution, soil erosion and a lack of investment in wastewater infrastructure poses a threat to public health of local residents, who rely on the West Qingzhang River for water supply and recreational use; (iv) water supply — Shixia Reservoir provides potable drinking water for the urban centre of Zuoquan, yet only 47% of the county population has access to tap water. Most rural areas have no supply of treated water. Areas along the West Qingzhang River between the reservoir and urban center of Zuoquan County are development regions (City West New District) with no water supply infrastructure; and, (v) ecological degradation — the degraded water environment has caused damage to the riparian and aquatic ecosystems of the West Qingzhang River.

5. These problems are not unique to Zuoquan County, but are widespread across Shanxi Province. In recognition of the local issues in ZCG and wider resource management issues in Shanxi Province, the ZCG requested ADB to provide lending support to implement flood and

environmental management in and around the Shixia Reservoir and West Qingzhang River consistent with higher-level and long-term city plans. The project will focus on four major outputs: (i) water source protection of the Qingzhang headwaters, (ii) Qingzhang river rehabilitation and integrated low impact facilities, (iii) inclusive water supply and wastewater collection services, and (iv) strengthened institutional capacity. In terms of flood protection, around 20,000 people and 148.75 ha farmland will be protected, including approximately 4,000 people in rural areas. The project will demonstrate that international best practices in sustainable water resources management (WRM) can be adopted in smaller cities counties in poverty areas, contributing to the development of livable cities and villages through integrated urban-rural land use planning and improvement.

C. Project Components

6. The project incorporates a number of special components including integrated urban-rural land use planning and protection, water demand management and Low Impact Design (LID). LID refers to a range of landscape treatments used to capture, clean and store urban stormwater for sustainable reuse and discharge, and is often referred to as 'sponge city concept' in the PRC. The expected project impact will be to improve water and ecological environment and the quality of life in Zuoquan County; and the adoption of integrated and climate-resilient flood and environmental management strategies. The expected project outcome is improved quality of water resources and environment of West Qingzhang River. The project has four outputs, described in the following sections. Project components and anticipated benefits are summarized in Table ES-1. Physical works under the project are limited to Outputs 1-3, with the location of these Outputs shown in Figure ES-1.

- **Output 1: Shixia Reservoir Operation and its Watershed Vegetation Improved.** Include (i) revegetation around the Shixia Reservoir and planting of forest belt along two headwaters; (ii) improving the reservoir spillway gate and construction of flood discharge tunnel; and (iii) construction of hydrological and water quality monitoring stations around the Shixia Reservoir and water supply configuration station.

- **Output 2: Qingzhang River and Binhe Road Rehabilitated.** Include (i) dredging selected sections of the river (totaling 11.9 km) which are heavily silted; (ii) river rehabilitation and construction of embankment, (iii) construction of wetland and river associated amenity facilities (hereafter referred to as wetland park); and (iv) LID (sponge city concept) for road improvement and stormwater drains installation.

- **Output 3: Inclusive Water Supply and Wastewater Collection Services Achieved.** Include (i) rural water supply system; and (ii) water pollution control.

- **Output 4: Institutional Capacity Strengthened.** Include (i) project management support and capacity strengthening; (ii) flood warning system; (iii) institutional and capacity strengthening for integrated urban-rural water supply; and (iv) institutional and capacity strengthening for LID (sponge city design) for city development.

Table ES-1: Project Summary

No.	Project Element	Project Description	Primary Benefits
Output 1—Shixia Reservoir Operation and its Watershed Vegetation Improved			
1.1	Revegetation around the Shixia Reservoir and planting of forest belt along two headwaters	Re-vegetation of a total area of 128.2 ha of forest belt in three locations with a planting density of 1,280 trees/ha.	(i) Reinforce river banks; (ii) reduce soil erosion; (iii) improve stormwater regulation; (iv) improve water and soil quality protection and flood control
1.2	Improving the reservoir spillway gate	Construction of a sluice with two gates in the spillway, and flood	Enhance the reservoir pre-discharge capacity and restore its flood

No.	Project Element	Project Description	Primary Benefits
	and construction of flood discharge tunnel	discharge tunnel.	regulation capacity.
1.3	Hydrological and water quality monitoring stations	Construction of five hydrology and water quality automatic monitoring stations with telecommunication system	Improved management of water resources, pollution control and flood mitigation.
Output 2—Qingzhang River and Binhe Road Rehabilitated			
2.1	Dredging selected sections of the river and tributaries which are heavily silted	Length: 11.6 km; Volume: 78,700 m^3	Improve flood standards of the West Qingzhang River in Zuoquan County (Shixia Reservoir down to Xihetou Village, and from Taizilianchi Road to the intersection of Ku River and West Qingzhang River) from less than 1-5 year to 1-20 year. Improve ecological, landscape and recreation/education opportunities along the lower West Qingzhang River.
2.2	River rehabilitation and construction of embankment	Improve embankments of about 8.9 km of river channel to enhance flood control and restore ecology.	
2.3	Construction of wetland and river associated amenity facilities (Wetland Park)	Enhancement of 41 ha land adjacent to lower West Qingzhang River for habitat enhancement, flood retention zone, landscape improvement and recreation/ education opportunities.	
2.4	Low impact design for road improvement and stormwater drains installation	Improvement of Binhe Avenue including LID elements and improved stormwater drainage to enhance stormwater flood control and water quality enhancement.	The sponge city elements aim to manage >70% of stormwater runoff from the road, and increase green space along the road to >20%.
Output 3—Inclusive Water Supply and Wastewater Collection Services Achieved			
3.1	Rural water supply system	Construction/ expansion of five pump stations, two water treatment stations, and 93.618 km water supply pipelines; and replacement of 36.5 km of existing water supply pipelines.	Improve water supply to 43 villages, with total service population of 32,134 by 2020 and 34,200 by 2030. Drinking water quality of City South and North Water Supply System will be improved to meet Standard for Drinking Water Quality (GB 5749-2006). Provide water supply to 13 industrial users in both City South Area and City North Area. Reduce leakage of both City South Water Supply System and City North Water Supply System to 10% (PRC standards require a 10~12% leakage rate for newly built networks)
3.2	Water Pollution Control	Upgrading of the Zuoquan County Waste Water Treatment Plant (WWTP), construction of 4.97 km trunk sewers, replacement of 12.9 km existing sewers; and upgrading of four overflow manholes.	Increase wastewater collection rate from 60% (in 2015) to 90% in 2020, preventing pollution to the West Qingzhang River. The interception ratio of the combined stormwater and wastewater from the built up area of county city will improved to 2. This is within the design standard (1~5), and appropriate considering the economic condition of Zuoquan

No.	Project Element	Project Description	Primary Benefits
			County.
Output 4—Institutional Capacity Strengthened			
4.1	Project management	(i) Consultancy service during initial stage (ii) Project implementation support consulting services (iii) Resettlement external monitoring (iv) Training for reservoir management and operating procedures; dam safety management including dam safety monitoring, compilation and implementation of reservoir operation and maintenance manual, and compilation of dam safety reports	
4.2	Flood warning system	To enhance the existing flood warning system of Zuoquan county by incorporating real-time information collected from the five hydrological stations to be built under Output 1 and provision of appropriate equipment and software.	
4.3	Institutional and capacity strengthening for integrated urban-rural water supply	(i) Integration of water supply services in urban and rural areas (ii) Strengthening the capacity of the newly established water company to meet the challenges of water sector reform (iii) Training for water demand management	
4.4	Institutional and Capacity Strengthening for Sponge City Design (Low Impact Design) for City Development	(i) Prepare a Sponge City Action Plan for new urban areas (ii) Prepare LID standards to be implemented in urban construction (iii) Develop training of trainers on the Sponge City Action Plan and LID Standards (iv) Prepare monitoring framework for Sponge City and LID implementation (pilot on Binhe Road)	

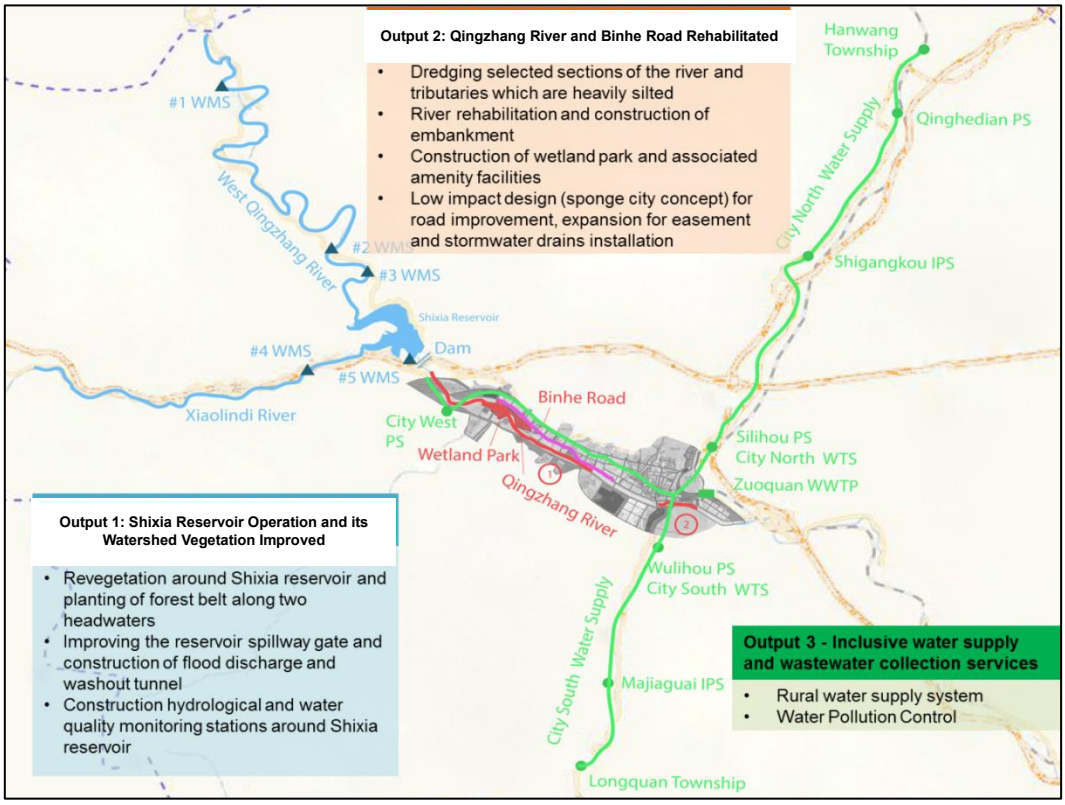

Figure ES-1: Project Location Map

D. Baseline Environment

7. Areas within and adjacent to physical works proposed under the project have been substantially modified by past human activities. Hillsides in the catchment of Shixia Reservoir

are dominated by low growing shrubland, having been largely cleared of vegetation in the past. They have only recently have been included in revegetation programmes, and plantations on the hillsides remain immature. Valleys within the reservoir catchment are used for agriculture and rural development. Land use in the areas downstream of Shixia Reservoir has been heavily modified by recent urban and industrial developments. No protected areas, rare, protected or threatened species, or physical cultural resources are known from the project sites.

8. Two tributaries drain into the Shixia Reservoir, the Xiaolingdi and West Qingzhang Rivers. The river channels support modified riverine vegetation and scrub. Water quality meets Class III requirements for most parameters. Downstream of the reservoir, habitat quality along the West Qingzhang River is relatively poor. Channel morphology has been modified by human activities, flow rates are low due to the regulatory effect of Shixia Reservoir (as water is abstracted for water supply), and water quality is poor with elevated Total Nitrogen, Ammonium Nitrogen, Chemical Oxygen Demand (COD_{cr}) and iron resulting from domestic wastewater, urban stormwater, and discharge from industrial and mining enterprises. Despite these pollution issues, sediment quality in the downstream river sections remains relatively good, meeting relevant national class II standards for all parameters except nickel. Groundwater in the project area complied with Category III Standards for most parameters.

E. Potential Environmental Impacts and Mitigation Measures

9. **Avoided impacts.** An integrated approach for project design and safeguards resulted in significant avoided impacts for the project: (i) the ZCG originally proposed a new 6.5 km road to divert traffic from the existing road running along the eastern bank of the Shixia Reservoir. The proposed road alignment would have passed through hilly terrain covered with maturing shrubland, causing ecological, spoil disposal and water quality impacts. Because of these environmental concerns, and cost considerations, the proposal was removed from the project scope; (ii) the original design included dredging an area of 48.51 ha to remove 639,200 m^3 of sediments from Shixia Reservoir. This activity would have created potential environmental impacts from water quality deterioration, sediment disposal and ecological disturbance. A review of storage capacity of the reservoir determined that dredging was not necessary to maintain reservoir functionality, so this element was removed from the project scope; and (iii) water supply, stormwater and wastewater pipeline routes have been selected along existing roadways and utility alignments to avoid and minimize potential adverse impacts to the environment and surrounding communities.

10. **Construction phase.** Key potential impacts are from the proposed dredging and construction of embankments of the lower West Qingzhang River, and noise disturbance during improvements to Binhe Avenue. Dredging works would affect 27 ha of riverbed, and embankment works will affect an 11.6 km stretch of the river. These works will physically alter in-channel and riparian morphology and habitats, may cause pollutants and odor to be released from the dredged sediments, cause temporary, elevated increases in sediment levels, and will result in loss of habitat for aquatic and riparian ecological communities. Inappropriate transport and disposal of dredged material may damage roads along transport routes and cause leakage at spoil sites. Construction works along the Binhe Avenue would affect existing sensitive receptors located adjacent to the road alignment, leading to high levels of construction noise. Other construction risks include air pollution (mainly fugitive dust), soil erosion from uncontrolled earthworks, uncontrolled solid waste disposal, interference with traffic and municipal services during pipeline construction across roads and bridges, permanent and temporary acquisition of land, involuntary resettlement, and occupational and community health and safety.

11. To minimize the impact of dredging and embankment construction to the West Qingzhang River, the following measures will be applied: (i) works will be limited to short (<200 m) sections of the river at any one time to minimize disturbance; (ii) works would be conducted

along one side of the river at a time, using temporary coffer dams to limited sediment release; and (iii) works will only be conducted in the dry season (October to May), the time of lowest water depth and slowest flow, to minimize impacts related to sediment transport and disposal, as well as potential impacts to breeding wildlife: (iv) dredged spoil will be dewatered in clearly demarcated areas close to the river channel, with sedimentation tanks deployed to minimize pollution risks to the river; and (v) the dewatered spoil will be re-used for embankment construction along the river.

12. The net impacts of dredging and embankment are concluded to be relatively low as: (i) the stretch of river affected by the works is degraded and modified by long-term human activity, has low water quality, and flow is highly regulated (meaning water levels are typically low, impacting wetland ecological resources) due to operation of the Shixia Reservoir; (ii) no rare or threatened fauna or flora, nor any protected areas or "critical habitat" as defined by the SPS would be directly affected; (iii) water quality and disturbance impacts would be temporary in nature; and (iv) effective measures can be implemented to minimize water quality impacts.

13. The construction schedule for Binhe Road has been decided to minimize noise impacts. Further measures, including the use of noise barriers and consultation with local residents, would be employed to minimize noise disturbance.

14. **Operation phase.** Operational phase impacts would be largely beneficial. In particular, water and habitat quality in the Shixia Catchment and lower West Qingzhang River will be enhanced through the revegetation programme, ecological embankment construction, wetland park construction, and improved wastewater management. Potential negative impacts are associated with using groundwater to improve rural water supply. However, the risk from this impact is minor, as the aquifer proposed as a water source has sufficient recharge to allow sustainable abstraction for water supply.

15. **Induced impacts.** The expansion of water supply to 43 rural villages will have the consequence of increasing wastewater generation in these communities. As the villages have no existing wastewater infrastructure, wastewater disposal could induce impacts on surface and groundwater resources, affecting water quality and aquatic ecological communities. To address this issue, a loan assurance has been agreed that adequate rural wastewater treatment systems (e.g., septic tanks) will be provided for all villages receiving improved water supply under project.

16. **Dam safety, operation, and maintenance.** An independent dam safety assessment report for Shixia Reservoir was commissioned and approved by Jinzhong City Water Resource Bureau in February 2015. The main issues identified in this report comprised: (i) water seepage on the left and right dam abutments; (ii) a temporary emergency gate constructed in 2013 is being used to access the dam for inspections; (iii) an existing rubber dam installed at the spillway has been in operation for 12 years and is close to the end of its design life; and (iv) water leakage has been observed between inlet and outlet pipes. Under the project, a technical review for structural and O&M improvements to the reservoir was conducted by the PPTA dam safety consultant. Recommendations were made on: (i) provision of dam safety monitoring automatic system; and (ii) capacity building on reservoir O&M. The project includes structural enhancement of the Shixia Reservoir flood discharge and regulation capacity, as well as training to improve management, operating and safety procedures. Both the independent review team and the PPTA consultant verified the feasibility and value of these proposed measures to improve dam safety, operation and maintenance. ADB's SPS (2009) requires that for projects involving structural elements of dams situated in high-risk locations (and where their failure or malfunction may threaten the safety of communities), the borrower/client should engage qualified and experienced safety experts, separate from those responsible for project design and construction, to review project design, construction, and commissioning. For the current project, structural works are relatively minor, comprise improvements to flood discharge and regulation capacity, and do not present risks to the integrity of the dam wall. An independent dam safety panel is not required for the project. Nonetheless, development of a dam emergency response plan is included in the project EMP.

F. Project Benefits

17. The project will result in multiple benefits to water and environmental management, including:

(i) **Improved flood control.** The project will improve flood standards of the West Qingzhang River in Zuoquan County (Shixia Reservoir down to Xihetou Village, and from Taizilianchi Road to the intersection of Ku River and West Qingzhang River) from less than 1-5 year to a 1-20 year flood interval. The pre-discharge capacity will be increased (the new sluice gate will allow for increased storage in the reservoir), and flood regulation capacity during the flood season and emergency response capacity of Shixia Reservoir will also be increased. These initiatives will reduce flood damage to properties, crops and livestock, and help prevent injury and loss of life among villagers living close to the river.

(ii) **Improved water supply management**. Drinking water quality and water security of 43 villages in the county with total population of 34,200 (in 2030) will be improved. The drinking water quality of City South and North Water Supply System will be improved to meet *Standard for Drinking Water Quality (GB 5749-2006)*. Water resource efficiency will be improved by supplying water of different quality to residents and industrial users. The leakage of both City South Water Supply System and City North Water Supply System will be reduced to 10%, in line with PRC standards for newly built networks

(iii) **Enhanced wastewater management.** Infrastructure will increase the wastewater collection rate of Zuoquan County from 60% in 2015 to 90% in 2020, preventing pollution to the surface waters in West Qingzhang River area as a consequence of future development. The interception ratio of the combined stormwater and wastewater from the built up area of county city will improved to two.

(iv) **Water quality improvement.** Water quality in the West Qingzhang River downstream of Shixia Reservoir will be improved through dredging of polluted sediments, improved wastewater sewerage infrastructure and upgrading of the Zuoquan WWTP.

(v) **Ecological enhancement.** Reforestation of 128.2 ha in the upper catchment of Shixia Reservoir, habitat enhancement in the lower West Qingzhang River and water quality improvement/ enhanced water flow will improve ecological conditions across the project area. The 41 ha wetland park constructed under the project will enhance landscape value and also provide socio-economic benefits for residents of Zuoquan County.

G. Public Consultation and Grievance Redress Mechanism

18. Two rounds of information dissemination and two rounds of public consultation were conducted for the project. Twenty-five government agencies and local resident groups were consulted. No major concerns were raised about the environmental aspects of the project. The Environmental Impact Assessment (EIA) Institute presented the planned mitigation measures to be adopted. All government agencies present expressed their support for the project and readiness to coordinate with the PMO. Other participants expressed support and there was no opposition.

19. A Grievance Redress Mechanism (GRM) has been developed to address environmental, health, safety, and social concerns associated with the project.

H. Climate Change

20. Observed results suggest that temperatures are increasing in Zuoquan, especially since the late 1980s, and temperatures and precipitation are projected to increase in the future, with these changes combined with large inter-annual variations. A climate risk vulnerability assessment (CRVA) was conducted for the project based on observed and projected climate

change assuming a project design life of 30-40 years. Many of the project components and outputs will have significant positive effects and contributions to the climate change resilience of the project area. Key adaptation measures in the project design include adopting a mix of native species for the revegetation and forest planting components, improvements to Shixia Reservoir management, enhanced hydrological and water quality monitoring, river and wetland habitat restoration, improved stormwater and wastewater management and enhanced wastewater management.

I. Environmental Management Plan

21. An EMP was developed that brings together all the mitigation measures for identified impacts as well as pre-construction requirements, and construction and operational management prescriptions. The EMP also includes the GRM and an environmental monitoring program, to monitor and report on the environmental performance of construction and operations. The EMP includes institutional responsibilities, training needs, reporting schedules, implementation costs, and future public consultation.

J. Risks and Assurances

22. The ZCG has no previous experience in ADB safeguard procedures and low institutional capacity for environmental management. To support effective implementation of the project EMP: (i) full-time environment officers will be appointed by the project management and implementation offices; (ii) a loan implementation environmental consultant will be recruited to support local agencies; (iii) pre-construction readiness procedures and defined roles and responsibilities of all relevant agencies have been included in the EMP; and (iv) staff will receive training in EMP implementation. Project-specific environmental assurances have been agreed and are included in the project agreement between the ZCG and ADB.

K. Conclusion

23. It is concluded that full and effective implementation of the project EMP, together with the training and project assurances, will minimize the environmental risks of the project and achieve compliance with the policy and regulatory standards applied in this IEE.

II. INTRODUCTION

24. Zuoquan County is part of the Jinzhong Municipality, and is located at the upstream of the West Qingzhang River, a main tributary of the Zhang River (Figure II-1). The West Qingzhang Riveris a strategic water source for 1.92 million people in six counties of Shanxi Province. Shixia Reservoir is located in the Haihe River Basin, with a total capacity of 50.99 million m^3.

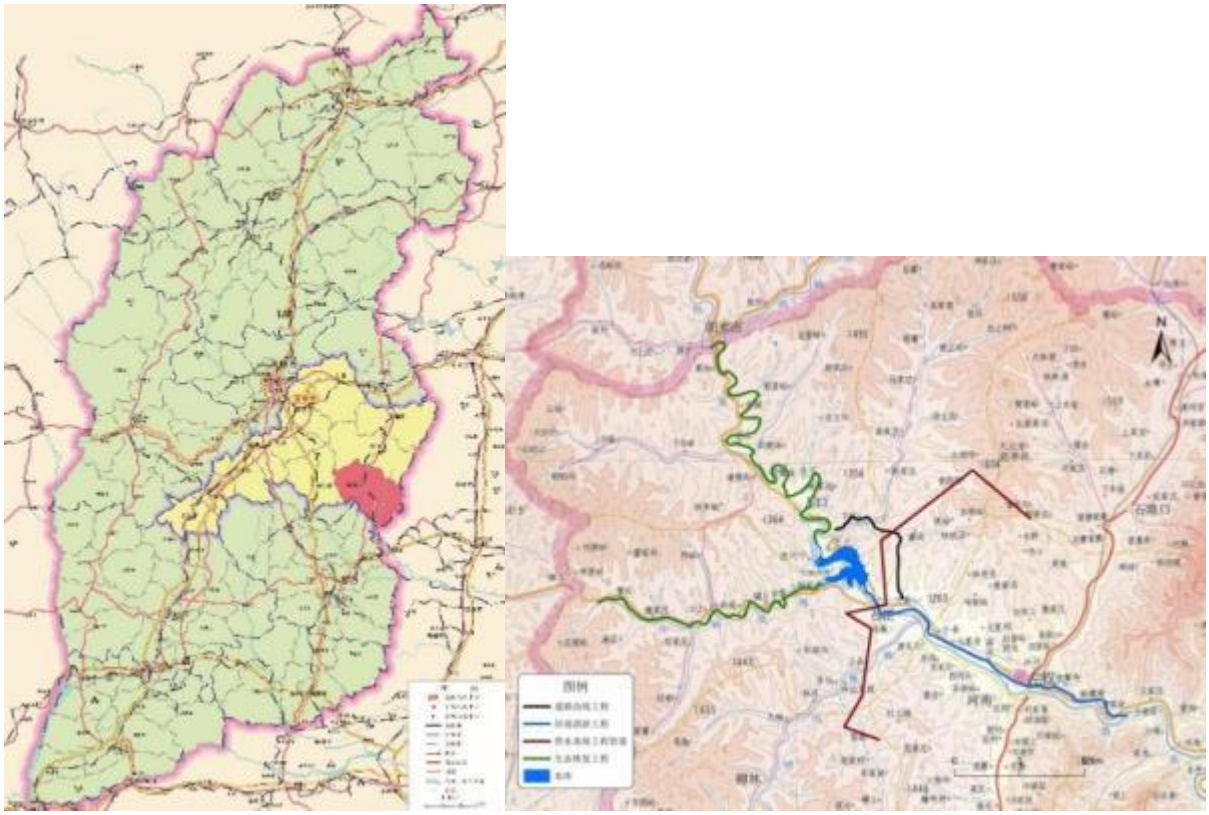

Figure II-1. Location of Zuoquan County and West Qingzhang River in Shanxi Province

25. As an important source of potable water, protection of the ecological and water environment of West Qingzhang River in Zuoquan County is important for the Zhang River system and downstream waters.

26. Under the Zuoquan County Master Planning (Figure II-2), areas along with West Qingzhang River downstream of Shixia Reservoir are the future development regions. It is necessary to conduct integrated management from flood control safety, water resources management (WRM), and ecosystem and environmental improvement with respect to the overall urban development needs.

Figure II-2. Zuoquan County Masterplan

27. The water supply components proposed in this project have been developed based on the draft Zuoquan County Water System Construction Plan being prepared by the Zuoquan Water Resource Bureau. The project wastewater and stormwater management components are based on the approved Zuoquan County City Master Plan (2010-2030) and Zuoquan County City Drainage Special Plan.

28. The Government of the People Republic of China (PRC) requested the ADB to assist ZCG in developing the Shanxi Urban-Rural Water Source Protection and Environmental Demonstration Project (the project). A PPTA was needed to ensure that the design and preparation of the proposed works by the ZCG could meet the loan processing requirements of the ADB, and be suitable for ADB lending support.

29. This Initial Environmental Examination (IEE) is based on: (i) information in the FSR prepared by Tongji University Architecture Design Institute and two DEIAs prepared by China Institute for Radiation Protection and Shanxi Qingyuan Environmental Consulting Co. Ltd; (ii) site visits conducted between August 2015 and March 2016 by a consultant team for the PPTA. PPTA fieldwork included inspection of most proposed sites for major construction, river embankment and dredging, sections of proposed alignments and easements, and the Zuoquan WWTP; and (iii) other sector studies by the PPTA team, including reforestation, water resources, social assessment, and climate change. The data presented in tables and figures in this IEE are from the FSR and DEIAs unless stated otherwise. The EMP (Attachment 1) is based on the findings and recommendations of the IEE and domestic studies, and will be the key guiding document for environmental-related issues in the construction and operation phases of the project.

III. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

A. Provincial Policy Framework

30. The *Shanxi Province Water Source Management Regulations (2008)* provides a framework for the development, utilization and protection of water resources, the prevention and control of water hazards, and conservation of vegetation, including tree and grass planting, for the prevention and control of water and soil losses.

31. The Shanxi Provincial Government (SPG) has declared Zuoquan County as part of the "ecological barrier" for Shanxi Province, prioritizing eco-environmental protection in the area. The Zuoquan County Government (ZCG) is committed to ecological civilization by prioritizing and integrating environmental and ecological protection goals in the county's overall development strategy. During 2012-2016, the ZCG invested Chinese Yuan (CNY) 597 million on greening 23,000 ha of degraded hills and slopes. To date, 11,000 ha of greening has been completed. The county government has also invested about CNY 400 million in rehabilitation of rivers (e.g., dredging, flood control works, water quality improvements).

32. The SPG released *Shanxi Province's Action Plans on Climate Change (2013-2020)* in 2014. The plan outlines the provincial objectives and tasks to address climate change before 2020. The SPG expects to complete 45% of its carbon dioxide emission targets by 2020. The measures include adjusting industrial structure, saving energy, increasing energy efficiency, optimizing energy structure, and controlling greenhouse gas (GHG) emissions from non-energy activities.

B. Legislative Framework for Environment Impact Assessment in the PRC

33. The two DEIA Reports upon which this IEE is largely based (one for Binhe Road improvements, one covering all other works) were prepared under the PRC's *EIA Law* (2003) and *Management Guideline on EIA Categories of construction Projects* (2008). The *Interim Guideline on Public Participation in EIA* (2006) also provides for opportunities to involve the public in the EIA process. This was strengthened by the *Requirements on Preparation of Environmental Impact Report Summary* (2012[51], MEP), which requires that the summary of DEIA reports are disclosed on local Environmental Protection Bureau (EPB) websites. Key national laws and regulations that guide the DEIAs for the project are listed in Tables III-1 and III-2.

Table III-1. Applicable Environmental Laws

Title of the Law	Year
Environmental Protection Law	2015
Environmental Impact Assessment Law	2003
Water Law	2002
Water Pollution Prevention and Control Law	2008
Air Pollution Prevention and Control Law	2000
Noise Pollution Control Law	1997
Solid Waste Pollution Prevention and Control Law	2005
Water and Soil Conservation Law	2011
Forest Law	1998
Wild Fauna Protection Law	2004
Cleaner Production Promotion Law	2002
Urban and Rural Planning Law	2008
Land Administration Law	2004
Circular Economy Promotion Law	2009
Fishery Law	2000
Flood Control Law	1998
Protection of Cultural Relics Law	2013

Table III-2. Applicable Administrative Regulations

Regulation	Year
National	
Regulation on EIA of Plans and Programs	2009
Regulation on Environmental Protection Management for Construction Projects	1998
Directive on Wetland Protection and Management	2013
Environmental Protection Supervision Rules for Construction Projects	1998
Regulation on Culture Heritage Protection	2003
Regulation on River Course Management	1988
Requirements for the EIA Summary of Construction Project	2010
Classification of Construction Project Environmental Protection Management (MEP)	2009
National Biodiversity Strategy and Action Plan (2011-2030)	2010
Requirement for Social Risk Assessment of Large Investment Projects	2012
National Biodiversity Strategy and Action Plan (2011-2030)	2010
National regulation for public disclosure of EIAs	2012
Regulations on Scenic and Historic Areas	2006
Regulation on Hazardous Chemicals Safety Management	2011
Regulation on Wild Flora Protection	1996
Regulation on Wild Fauna Protection	1992
Regulation on Aquatic Wildlife Protection	1993
Regulation on Urban Water Supply	1994
Management of National Wetland Park (trial)	2010
Local	
Shanxi Environmental Protection Ordinance	1997
Atmospheric Pollution Prevention Act of Shanxi Province	2014
Shanxi surface water environmental function zoning	2006
Shanxi Provincial People's Government to implement the State Council Opinions on Scientific Development and Strengthening Environmental Protection	2006
"Second Five Year Plan" Circular economy development in Shanxi Province	2012
Notice on the issuance of Interim Provisions of Shanxi strengthen environmental management of construction projects	2006
Shanxi Province People's Government decision on the implementation of the blue clean water project	2011

34. Implementation of environmental laws and regulations is supported by a series of associated management and technical guidelines (Table III-3).

Table III-3. Applicable Environmental Impact Assessment Guidelines

Guideline	Year/Code
Jurisdictional Division of Review and Approval of EIAs for Construction Projects	2009
Guideline on EIA Categories of Construction Projects	2008
Interim Guideline on Public Consultation for EIA	2006
Technical Guideline on EIA: Outline	HJ2.1-2011
Technical Guideline on EIA Regarding Surface Water	HJ/T 2.3-1993
Technical Guideline on EIA Regarding Atmospheric Environment	HJ 2.2-2008
Technical Guideline on EIA Regarding Acoustic Environment	HJ 2.4-2009
Technical Guideline on EIA Regarding Ecological Impact	HJ 19-2011
Technical Specification on Water and Soil Conservation Plan	GB50433-2008
Technical Guideline on Environmental Risk Assessment for Construction Project	HJ/T 169-2004
Industrial Restructuring Directory (2011)	Revised in 2013

35. The PRC environmental quality standard system that supports the implementation of the environmental laws and regulations is classified into two categories by function: pollutant emission/discharge standards; and ambient environmental standards (Table III-4).

Table III-4. Applicable Environmental Standards

Standard	Code
Surface Water Quality Standard	GB 3838-2002
Urban Ambient Acoustic Quality Standard	GB 3096-2008
Ambient Air Quality Standard	GB 3095-1996/2012
Integrated Emission Standard of Air Pollutants	GB 16297-1996
Integrated Wastewater Discharge Standard	GB 8978-1996
Underground Water Quality Standard	GB/T 14848-93
Domestic Drinking Water Quality Standard	GB 5749-2006
Emission Standards of Environment Noise for Boundary of Site Noise	GB 12523-2011
Noise Limit of Industrial Enterprises	GB 12348-2008
Standard for pollution control on hazardous waste storage	GB 18597-2001
Pollution control for storage and disposal site for industrial solid wastes	GB18599-2001
Emission Standards for Odor Pollutants	GB 14554-93

C. International Agreements

36. The PRC is a signatory to international agreements relevant to environment protection. Those relevant to the project, along with the date of signing by the PRC, include:

- *Paris United Nations Climate Change Conference,* 12 December 2015. The key result was an agreement to set a goal of limiting global warming to less than 2 degrees Celsius (°C) compared to pre-industrial levels. The agreement calls for zero net anthropogenic greenhouse gas emissions to be reached during the second half of the 21st century. In the adopted version of the Paris Agreement the parties will also "pursue efforts to" limit the temperature increase to 1.5 °C.
- *Kyoto Protocol to the United Nations Framework Convention on Climate Change*, 23 February 2005. To reduce greenhouse gas emissions by enhancing the national programs of developed countries aimed at this goal and by establishing percentage reduction targets for the developed countries;
- *Montreal Protocol on Substances That Deplete the Ozone Layer*, 1 January 1989. To protect the ozone layer by controlling emissions of substances that depletes it; and,
- *United Nations Framework Convention on Climate Change*, 21 March 1994. To stabilize greenhouse gas concentrations in the atmosphere at a low enough level to prevent dangerous anthropogenic interference with the climate system.

D. Applicable PRC and ADB Policies and Assessment Categories

37. **National policies.** The proposed project activities are classified as “Significant Impact” (requiring a Environmental Impact Statement; EIS). Based on the *PRC Management Guideline on EIA Categories of construction Projects (MEP, 2008)*, two EIS studies were required for the project (Table III-5). The EIS for LID for road improvement component was approved by Zuoquan County Environment Protection Bureau in 2014. The other project components were approved by the Jinzhong City Environment Protection Bureau.

Table III-5. Domestic EIA Institute for Each Component

No.	Component	EIA institute	Report
1	Water source protection of the West Qingzhang headwaters	China Institute for Radiation Protection	EIS
	West Qingzhang river rehabilitation		
	Inclusive water supply and wastewater collection services		
2	Low impact design (sponge city concept) for road improvement, expansion	Shanxi Qingyuan Environmental Consulting Co. Ltd	EIS

38. ADB's SPS provides the basis for this IEE. All projects funded by ADB must comply with the SPS. The purpose of the SPS is to establish an environmental review process to ensure that projects funded under ADB loans are environmentally sound, comply with domestic laws, and are not likely to cause significant environment, health, or safety hazards. The project is classified as Category B by ADB, requiring the preparation of an IEE and EMP.

E. Assessment Standards

39. The environmental standard system that supports the implementation of the environmental protection laws and regulations in the PRC can be classified by ambient environmental quality standards for different functions (i.e., different uses for water), and by pollutant emission and/or discharge standards. ADB's SPS requires projects to apply pollution prevention and control technologies and practices consistent with international good practices such as the World Bank Group's Environmental, Health and Safety (EHS) Guidelines[1]. For this assessment, where EHS standards exist for parameters and are relevant, they are used in parallel with PRC standards in this assessment.

1. Ambient Air Quality

40. The project area belongs to the second category of ambient air function area, therefore ambient air quality execution *Ambient Air Quality Standard (GB3095-2012)* and its amendments in the secondary standard limit requirements are relevant (Table III-6).

Table III-6. Ambient Air Quality Standards (Unit: μg /m^3)

Pollutants	Average time	Second Category Standard Concentration Limits
Sulfur dioxide (SO_2)	annual average	60
	24-hour average	150
	1 hour average	500
Nitrogen dioxide (NO_2)	annual average	40
	24-hour average	80
	1 hour average	200
Respirable particulate matter (PM10)	annual average	70
	24-hour average	150
Particulate Matter 2.5 (PM2.5)	annual average	35
	24-hour average	75

2. Acoustic Quality

41. The noise environment for project will be evaluated against Class II standards of the *Ambient Acoustic Quality Standard (GB3096-2008)* (Table III-7). The PRC standards are more stringent than those of EHS.

Table III-7. Ambient Acoustic Quality Standards (unit: dB (A))

Applicable Class	Standard Value	
	Day-Time	Night-Time
Class I (residential, hospital, education, research, administrative area)	55	45
Class II (residential, commercial and industrial mixed area)	60	50
Class 4a (along roads – within 35 m measured from the mid-line)	70	55
World Bank EHS	70	70

3. Surface Water

[1] World Bank Group. 2007. *Environmental, Health and Safety Guidelines General EHS Guidelines.* Washington.

42. According to *Shanxi Surface Water Environmental Function Zoning (DB14 67-2014)*, Shixia Reservoir outlet should meet "Surface Water Environmental Quality Standard" II class standards, and the reservoir/other areas of the upper West Qingzhang River should meet of III class standards. The values relating to these standards are described in Table III-8.

Table III-8. Surface Water Ambient Quality Standards (Unit: mg/L)

Standard	**pH**	**DO**	**Permanganate index**	**COD**	**BOD**	**Ammonia nitrogen**	**Total phosphorus**
Class II	6-9	6	4	15	3	0.5	0.1 (0.025 in lakes)
Class III	6-9	5	6	20	4	1.0	0.2 (0.025 in lakes)
Standard	**TN**	**Copper**	**Zinc**	**Fluoride**	**Selenium**	**Arsenic**	**Cadmium**
Class II	0.5	1.0	1.0	1.0	0.01	0.05	0.005
Class III	1.0	1.0	1.0	1.0	0.01	0.05	0.005
Standard	**Chromium (hexavalent)**	**Cyanide**	**Volatile phenol**	**Oil**	**Anionic surfactants**	**Sulfide**	**Fecal coliform (a/l)**
Class II	0.05	0.05	0.002	0.05	0.2	0.1	2000
Class III	0.05	0.2	0.005	0.05	0.2	0.2	10000

4. Groundwater

43. Zuoquan is situated in the catchment of the Niangziguan Spring Karst Water System. Groundwater in this area should comply with *Groundwater Quality Standards (GB / T14848-93)* Class III. These are summarized in Table III-9.

Table III-9. Class III Quality Standards for Groundwater

pH	**Total hardness**	**TDS**	**Volatile phenols**	**chloride**	**Permanganate index**	**HG**	**Copper**
6.5-8.5	≤450	≤1000	≤0.002	≤250	≤3.0	≤0.001	≤1.0
Zinc	**Sulfate**	**Nitrite**	**manganese**	**Nitrate**	**Anionic synthetic detergents**	**Iron**	**Fluoride**
≤1.0	≤250	≤0.02	≤0.1	≤20	≤0.3	≤0.3	≤1.0
Cyanide	**Ammonia**	**Arsenic**	**Selenium**	**Cadmium**	**Chromium (hexavalent)**	**Lead**	
≤0.05	≤0.2	≤0.05	≤0.01	≤0.01	≤0.05	≤0.05	

5. Soil

44. Soil quality in the PRC is divided into three classes according to the *Environmental Quality Standard for Soils (GB 15618-1995)*. Class I represents the best and Class III the worst. Class II is applicable for the proposed project area (Table III-10).

Table III-10. Environmental Quality Standard for Soils (Class II)

Parameter	**Maximum Allowable Concentration (mg/kg dry weight)**		
pH	<6.5	6.5-7.5	>7.5
Cadmium (Cd)	0.30	0.30	0.60
Mercury (Hg)	0.30	0.50	1.0
Arsenic (As) paddy / dry land	30 / 40	25 / 30	20 / 25
Copper (Cu) farmland / orchard	50 / 150	100 / 200	100 / 200
Lead (Pb)	250	300	350
Chromium (Cr) paddy / Dry land	250 / 150	300 / 200	350 / 250
Zinc (Zn)	200	250	300
Nickel (Ni)	40	50	60

F. Emission Standards for Construction and Operation Activities

1. Air Quality

45. Fugitive emission of particulate matter (such as dust from construction sites) is regulated under PRC's *Air Pollutant Integrated Emission Standard (GB 16297-1996)*, which sets 120 mg/m^3 as the maximum allowable emission concentration and ≤1.0 mg/m^3 as the concentration limit at the boundary of construction sites, with no specification on the particle diameter. Odor from the wastewater treatment stations and solid waste transfer stations should follow the *Malodorous Pollutant Emission Standard (GB 14554-93)*. The maximum allowable concentrations at the boundary of the sites for NH_3, H_2S and odor are 1.5 mg/m^3, 0.06 mg/m^3, and "20" (dimensionless) respectively.

2. Noise

46. Construction noise will be assessed against the *PRC Emission Standards of Ambient Noise for Boundary of Site Noise (GB 12523-2011)* and Class II of *Emission Standard for Industrial Enterprises Noise at Boundary (GB 12348-2008)* (Table III-11).

Table III-11. Construction Site Noise Limits. Unit: Leq [dB (A)]

Period	Major Noise Source	Noise Limit	
		Day	Night
Construction	Bulldozer, excavators, loader; pile driving machines; concrete mixer, vibrator and electric saw; hoist and lifter	70	55
Operation	Pumps	60	50

3. Vibration

47. Construction activities causing vibration impact should comply with the *Standard for Urban Area Environmental Vibration (GB10070-88)* (Table III-12).

Table III-12. Vertical Vibration Standard Value for Various Urban Areas (Unit: dB)

Scope of applicable area	Day	Night
Special residential area	65	65
Residential, cultural and educational area	70	67
Mixed area and commercial center	75	72
Industrial centralized area	75	72
Both sides of traffic trunk line	75	72
Both sides of railway main line	80	80

4. Wastewater

48. Discharge of wastewater from construction sites is regulated under PRC's *Integrated Wastewater Discharge Standard (GB 8978-1996)*. Class I standards apply to discharges into Category III water bodies, and Class II standards apply to discharges into Categories IV and V water bodies. Class III standards apply to discharges into municipal sewers linked to municipal WWTPs with secondary treatment. Wastewater generated during construction will be discharged into a Category II water body, therefore Class I of GB 8978-1996 applies for construction sites under this project (Table III-13).

Table III-13. Integrated Wastewater Discharge

Parameter	Class I	Class II	Class III
	For discharge into Category III water body	For discharge into Category IV and V waterbodies	For discharge into municipal sewer
pH	6–9	6–9	6–9
SS mg/L	70	150	400

BOD_5 mg/L	20	30	300
COD mg/L	100	150	500
TPH mg/L	5	10	20
Volatile phenol mg/L	0.5	0.5	2.0
NH_3-N mg/L	15	25	---
PO_4^{2-} (as P) mg/L	0.5	1.0	---
LAS (= anionic surfactant) mg/L	5.0	10	20

49. Proposed WWTPs in urban areas of townships are designed based on Class 1A/1B of *Urban Sewage Treatment Plant Pollutant Discharge Standards (GB18918-2002)*. A summary of required discharge standards is provided in Table III-14.

Table III-14. Discharge Standards for Urban WWTP

Parameter	Unit	Class 1A	Class 1B
COD	mg/L	50	60
BOD_5	mg/L	10	20
SS	mg/L	10	20
Ammonia	mg/L	5(8)	8
TN	mg/L	15	20
TP	mg/L	0.5	1.0

50. Operation of the Water Treatment Plants (WTP) and the quality of treated water to be supplied to residents must comply with the PRC *Drinking Water Quality Standard (GB5749-2006)*, which sets standards for 106 parameters (Tables III-15 and III-16).

Table III-15. Drinking Water Quality Standards (GB5749-2006)

No.	Parameter	Standard
	Routine Parameter of Drinking Water Quality	
	Microbiological parameter[2]	
1	Total coliform (MPN/100ml or CFU/100ml)	LD
2	Thermotoletant coliform (MPN/100ml or CFU/100ml)	LD
3	Escherichia Coli (MPN/100ml or CFU/100ml)	
4	Total plant count (CFU/ml)	100
	Toxicological parameter	
5	Arsenic (As, mg/L)	0.01
6	Cadmium (Cd, mg/L)	0.005
7	Chromium Hexavalent (Cr 6+, mg/L)	0.05
8	Lead (Pb, mg/L)	0.01
9	Mercury (Hg, mg/L)	0.001
10	Selenium (Se, mg/L)	0.01
11	Cyanide (CN-, mg/L)	0.05
12	Fluoride (mg/L)	1.0
13	Nitrate (mg/L)	10
14	Trichloromethane (mg/L)	0.06
15	Carbon tetrachloride (mg/L)	0.002
16	Bromate (when O3 is applied) (mg/L)	0.01
17	Formaldehyde (when O3 is applied) (mg/L)	0.9
18	Chlorite (when ClO2 is applied) (mg/L)	0.7
19	Chlorate (when compound chlorine dioxide is applied) (mg/L)	0.7
	Sensory Properties and General Chemical Parameter	
20	Chromaticity (Unit of platinum cobalt color)	15
21	Turbidity (diffusing turbidity unit) NTU	1
22	Odor and Taste	No odor, no taste
23	Appearance	None
24	pH	6.5≤X<8.5
25	Aluminum (Al, mg/L)	0.2
26	Iron (Fe, mg/L)	0.3

2 MPN= Most Probable Number; CFU: Colony Forming Unit.

No.	Parameter	Standard
27	Manganese (Mn, mg/L)	0.1
28	Copper (Cu, mg/L)	1.0
29	Zinc (Zn, mg/L)	1.0
30	Chloride (Cl-, mg/L)	250
31	Sulfate (SO4-mg/L)	250
32	TDS (mg/L)	1000
33	Total Hardness (CaCO3) (mg/L)	450
34	CODMn (mg/L)	3
35	Volatile phenols (phenol) (mg/L)	0.002
36	LAS (mg/L)	0.3
	Radioactivity Parameter3	
37	Total α radioactivity (Bq/L)	0.5
38	Total β radioactivity (Bq/L)	1
	Non-routine parameter – microbial indicators	
39	Giardia cysts (count/10L)	<1
40	Cryptosporidium oocysts (count/10L)	<1
	Non-routine parameter – toxicological parameter (mg/L)	
41	Antimony (Sb, mg/L)	0.005
42	Barium (Ba, mg/L	0.7
43	Beryllium (Be, mg/L)	0.002
44	Boron (B, mg/L)	0.5
45	Molybdenum (Mo, mg/L)	0.07
46	Nickel (Ni, mg/L)	0.02
47	Silver (Ag, mg/L)	0.05
48	Thallium (Ti, mg/L)	0.0001
49	Cyan chloride (CN- mg/L)	0.07
50	Chlorodibromomethane (mg/L)	0.1
51	Bromodichloromethane (mg/L)	0.06
52	Dichloroacetic acid (mg/L)	0.05
53	1,2-dichloroethane (mg/L)	0.03
54	Dichloromethane (mg/L)	0.02
55	THMs	1
56	1,1,1 - trichloroethane (mg/L)	2
57	Trichloroacetic acid (mg/L)	0.1
58	Trichloroaldehyde (mg/L)	0.01
59	2,4,6- trichlorophenol (mg/L)	0.2
60	Bromoform (mg/L)	0.1
61	Heptachlor (mg/L)	0.0004
62	Malathion (mg/L)	0.25
63	PCP (mg/L)	0.009
64	HCH (total amount, mg/L)	0.005
65	Hexachlorobenzene (mg/L)	0.001
66	Dimethoate (mg/L)	0.08
67	Parathion (mg/L)	0.003
68	Bentazone (mg/L)	0.3
69	Parathion-methyl (mg/L)	0.02
70	Chlorothalonil (mg/L)	0.01
71	Carbofuran (mg/L)	0.007
72	Lindane (mg/L)	0.002
73	Chlopyrifos (mg/L)	0.03

3 Radionuclide phase analysis is conducted if radioactivity value exceeds limits, to determine if the water is drinkable.

No.	Parameter	Standard
74	Glyphosate (mg/L)	0.7
75	DDVP (mg/L)	0.001
76	Arazine (mg/L)	0.002
77	Deltamethrin (mg/L)	0.02
78	2, 4 - dichlorobenzene oxygen ethanoic acid (mg/L)	0.03
79	Dichloro-diphenyl-dichlorothane (mg/L)	0.001
80	Ethylbenzene (mg/L)	0.3
81	Dimethylbenzene (mg/L)	0.5
82	1,1- dichloroethylene(mg/L)	0.03
83	1,2- dichloroethylene(mg/L)	0.05
84	1,2- dichlorobenzene(mg/L)	1
85	1,4- dichlorobenzene(mg/L)	0.3
86	Trichloroethylene(mg/L)	0.07
87	Trichlorobenzene(mg/L)	0.02
88	Hexachlorobutadiene(mg/L)	0.0006
89	Acrylamide (mg/L)	0.0005
90	Tetrachloroethylene (mg/L)	0.04
91	Toluene (mg/L)	0.7
92	DEHP (mg/L)	0.008
93	ECH (mg/L)	0.0004
94	Benzene (mg/L)	0.01
95	Styrene (mg/L)	0.02
96	Benzopyrene (mg/L)	0.00001
97	Chloroethylene(mg/L)	0.005
98	Chlorobenzene(mg/L)	0.3
99	Microcystin-LR(mg/L)	0.001
	Physical Properties and General Chemical parameters (mg/L)	
100	Ammonia Nitrogen(NH3-N, mg/L)	0.5
101	Sulfide (S, mg/L)	0.02
102	Sodium (Na, mg/L)	200

Table III-16. General Parameters and Requirements for Drinking Water Disinfectant

No.	Disinfectant	Exposure duration with Water	Limit in water supplied (mg/L)	Residue in water supplied (mg/L)	Residues in network end (mg/L)
103	Chlorine and free chlorine (mg/L)	≥30 min	4	≥0.3	≥0.05
104	Monochloramine (total chlorine, mg/L)	≥120 min	3	≥0.5	≥0.05
105	Ozone (O_3, mg/L)	≥12 min	0.3	-	0.02/ ≥0.05 if chlorine is added
106	Chlorine Dioxide (ClO_2, mg/L)	≥30 min	0.8	≥0.1	≥0.02

5. Sludge Disposal

51. The quality of sludge going to landfill for disposal should meet the *Standard for Pollution Control on the Landfill Site of Municipal Solid Waste (GB 16889-2008)*. This requires the water content of sludge not to exceed 60%, and meet standards for reuse including as soil conditioner (GB15618-1995), afforestation in gardens and windbreak plantation (GB23468-2009), fertilizer for agricultural use (GB4284-84), land improvement (CJ/T 291-2008), brick building (CJ/T 289-2008) and other land applications.

IV. DESCRIPTION OF THE PROJECT

A. Overview

52. Zuoquan is a county administrative region under Jinzhong Municipality, and is located in the upper reaches of the West Qingzhang River, a major tributary of the Zhang River (Figure IV-1). The West Qingzhang River is a strategic water source for 1.92 million people in six counties of Shanxi Province.

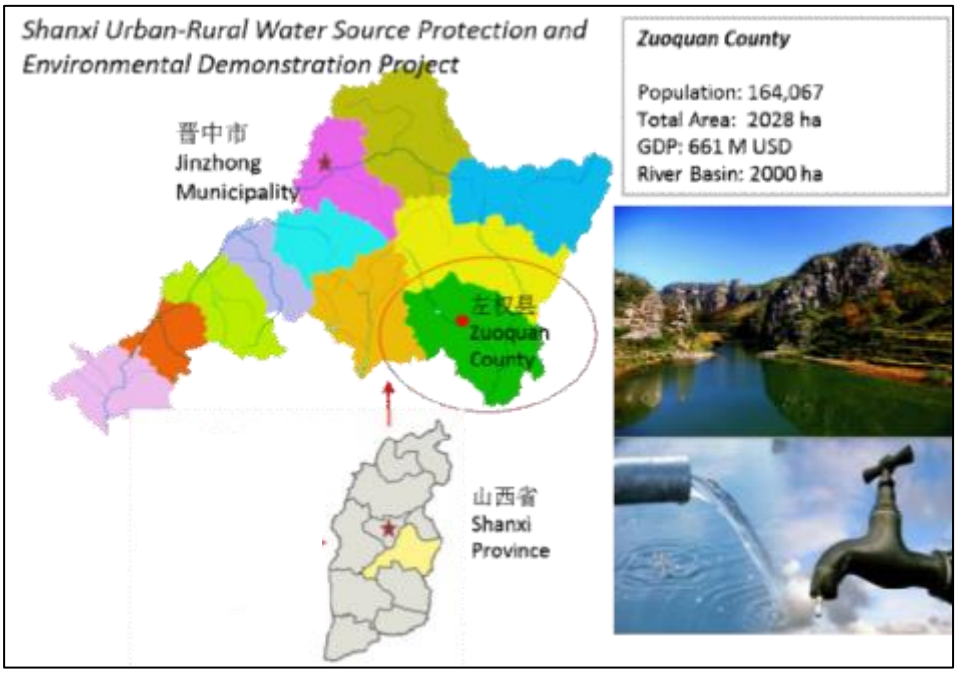

Figure IV-1. Location Map of Zuoquan County

53. The Shixia Reservoir is a medium-sized reservoir mainly for flood control, but also water supply and power generation. It is located in the upper catchment of Shixia County, 10 km upstream and northwest of Zuoquan urban centre (Figure IV-2). The catchment area of Shixia Reservoir is 754 km^2, including 137.8 km^2 of Huangtu plateau ravine area (18.28% of the catchment), and 616.18 km^2 of sand shale hills (81.72% of the catchment). The average yearly inflow to the Reservior is 54,550,000 m^3. An average low flow of 0.3 m^3/s (approximately 17% of total inflow) is discharged from the dam to maintain irrigation water supply downstream and also maintain ecological flow. Historically, soil erosion in the watershed has been severe. According to the records, an estimated 7.09 million m^3 of sediment was deposited in the reservoir from 1960 to 1993.

54. The construction of the reservoir started in November 1959, and it became operational in June 1960. The reservoir was abandoned in 1964, but reconstructed in 1966. In 1972, the reservoir was enlarged (the crest elevation was increased to 1153.3 m. The height of the dam is 33.3 m), increasing capacity to 50.39 million m^3. At that time, the designed flood control standard of the reservoir was 1/50 years, and checked for 1/100 years. From 2002 to 2003, the reservoir was further augmented, increasing the capacity to 50.99 million m3, with 1/100 years designed flood control standard, and checked for 1/1000 years. The flood control level of the reservoir is 1139.5 m; the normal water level is 1142.5 m; the designed flood level is 1149.36 m; and the checking flood level is 1152.56 m. The main dam is a homogeneous earth dam, the maximum dam height is 33.3 m, and the crest elevation is 1153.3 m. The crest length is 274 m, and the crest width is 7 m. A masonry wall with a height of 1.2 m was built in the crest. The upstream and downstream of the dam slope are 1:2.5, 1:3.75, 1:4,1:4.2, and 1:2, 1:2.5, 1:3 from top to bottom. The auxiliary dam is located in the ancient river channel to the

right end of the main dam. It is a homogeneous earth dam, filled in 1972. The crest elevation is 1154.5m, the crest width is 7.0 m and the height of the dam is 17 m. In the event of a 300 year + flood, it can double as an emergency spillway.

Figure IV-2. Location of Shixia Reservoir

55. As an important water source, protection of the ecological and water environment of West Qingzhang River at Zuoquan is important for the entire Zhang River system and its downstream receiving waters. There has been serious under-investment in water source protection in Zuoquan County, including upkeep and staff resourcing for Shixia Reservoir. This has depleted its water storage and flood control functions. Continuing deterioration of water quality due to non-point source pollution and soil erosion poses a threat to public health of local residents, who rely on the West Qingzhang River for water supply and recreational use. The degraded water environment has also impacted the riparian and aquatic ecosystems of West Qingzhang River. Key water and environmental management issues relating to management of the River are described in the following paragraphs.

56. **Flooding.** The Shixia Reservoir has not been properly operated and the dam structure and flood control facilities are aged, meaning the storage capacity of the reservoir cannot be fully utilized to control downstream flooding. Safety inspections of the reservoir have not been carried out since 2003, posing a severe risk to the people living downstream. For the West Qingzhang River, siltation has reduced the flood capacity. There have been four major flooding incidents recorded since 1920s, resulting in significant losses in lives and properties. As recently as August 1996, a flood event is estimated to have caused over 30 deaths and 550 injuries to people living alongside the river.

57. **Water supply.** Potable drinking water from Shixia Reservoir is provided for the existing urban centre of Zuoquan, and will also provide water for the planned City West New District. However, rural areas to the north and south of this area have either no potable water supply, or existing infrastructure is insufficient to meet current (and future) domestic and industrial

demand. Furthermore, there is no more water intake quota of Shixia Reservoir to extend supply from the reservoir to these rural areas. Industrial demand is mainly from scattered industrial facilities in rural areas, as well as the Longquan Industrial Innovation Demonstration Zone, an Industrial Park south of the Zuoquan urban area. At present, less than half (47%) of the county population have access to tap water, with most rural areas without supply of properly treated water. Inequitable and unsafe water supply is inconsistent with socially inclusive development in Zuoquan County, and hinders the government's goal of urban-rural integration. Furthermore, According to Zuoquan County Master Planning (Figure II-2), areas along the West Qingzhang River between the Shixia Reservoir and existing urban core of Zuoquan County are future development regions (City West New District). Thus, it is necessary to conduct integrated management from flood control safety, WRM, ecosystem environment improvement with respect to the overall urban development needs.

58. **Water quality and wastewater management.** Water quality in the West Qingzhang River adjacent to the urban core of Zuoquan County is poor, impacting ecological resources and affecting downstream uses of the river. Water quality issues are a consequence of various factors, including:

(i) The existing sewerage system is poorly maintained, has incomplete coverage, and is inadequate to meet future development plans of the City West New District.
(ii) The current Zuoquan WWTP is not well maintained, and has insufficient capacity to meet future wastewater generation.
(iii) The existing wastewater infrastructure in Zuoquan County relies on combined stormwater and sewage drains. As a consequence. Zuoquan WWTP normally halts operations during heavy rain events to avoid impacts to biological treatment processes. At these times, untreated sewage is discharged directly to the West Qingzhang River.

59. **Ecological degradation.** Various factors have impacted the aquatic and riparian habitats of the West Qingzhang River, including deforestation of the Shixia Reservoir catchment, water pollution, and flood-control engineering works along the river downstream of the Shixia Reservoir. A reforestation programme has been implemented in the Shixia Reservoir in recent years, but some has been affected by development and quarry activities. The revegetation areas under this project will not affect any existing farmland.

60. To address these issues and promote sustainable economic growth, the SPG has formulated development strategies incorporating flood management, environmental and ecological protection goals. Under the 3rd Plenum of the 18th Central Committee of the Chinese Communist Party (2013), a high priority has been given to integrated urban-rural development and eco-civilization, and is reflected in the 13th Five Year Plan. The ZCG has committed to prioritize and integrate environmental protection goals in the county's overall development strategy. This is consistent with ADB's PRC County Partnership Strategy. The Shanxi Urban-Rural Water Source Protection and Environmental Demonstration Project is an initiative to boost comprehensive improved water environment system and integrated urban-rural development. The project will act as a demonstration which can be replicated in other parts of Shanxi Province.

61. The project impact will improve water and ecological environment and the quality of life in Zuoquan County; and the adoption of integrated and climate-resilient flood and environmental management strategies. The outcome of the project is improved quality of water resources and environment of West Qingzhang River, to be achieved through the following four outputs:

62. **Output 1: Shixia Reservoir operation and its watershed vegetation improved** will include (i) revegetation around the Shixia Reservoir and planting of forest belt along two headwaters; (ii) improving the reservoir spillway gate and construction of flood discharge tunnel; and (iii) construction of hydrological and water quality monitoring stations around the

Shixia Reservoir.

63. **Output 2: Qingzhang River and Binhe Road rehabilitated** will include (i) dredging selected sections of the river (totaling 11.9km) which are heavily silted; (ii) river rehabilitation and construction of embankment, (iii) Construction of wetland park; and (iv) low impact design (LID; "sponge city concept"[4]) for road improvement and stormwater drains installation.

64. **Output 3: Inclusive water supply and wastewater collection services achieved** will include (i) rural water supply system; and (ii) water pollution control.

65. **Output 4: Institutional capacity strengthened** will include (i) project management support and capacity strengthening; (ii) flood warning system; (iii) institutional and capacity strengthening for integrated urban-rural water supply; and (iv) institutional and capacity strengthening for sponge city design (low impact design) for city development.

66. Construction works are summarized in Table IV-1 and described in Section B (project design). The location of different project elements is shown in Figure IV-3. An integrated-urban rural land use planning model has been adopted for the project, including:

(i) In rural areas of Shixia Reservoir, continue reforestation activities to preserve urban and rural drinking water sources and protect urban and rural areas from flooding;
(ii) In the rural area between Shixia Reservoir and Zuoquan urban area, improve flood mitigation by enhancing wetland areas;
(iii) In the urban area of Zuoquan County, manage run-off and wastewater from the urban area to minimize threat of contaminants entering the river and minimize risk of localized flooding and flooding in rural areas downstream of the urban section; and,
(iv) Improve water supply and wastewater management for urban and rural areas.

Table IV-1. Summary of Project Outputs and Components

No.	Output/Component	Contents/Purposes
Output 1—Shixia Reservoir Operation and its Watershed Vegetation Improved		
1.1	Revegetation around Shixia Reservoir and planting of forest belt along two headwaters	Planting forest belts in the following locations: (i) West Qingzhang River (upper stream of Shixia Reservoir) – 74.4 ha (ii) Xiaolindi River – 43.8ha (iii) Around Shixia Reservoir – 10 ha Total Area: 128.2 ha
1.2	Improving the reservoir spillway gate and construction of flood discharge tunnel	Construction of a sluice with two gates in the spillway, and a flood discharge tunnel
1.3	Construction hydrological and water quality monitoring stations around Shixia Reservoir	Construction of five hydrology and water quality automatic monitoring stations with telecommunication system. The stations will be operated automatically by the Zuoquan Shixia Reservoir Management Office (ZSRMO), who will share relevant information with the Zuoquan Water Resource Bureau (ZWRB) for the flood warning system.
Output 2—Qingzhang River and Binhe Road Rehabilitated		
2.1	Dredging selected sections of the river and tributaries which are heavily silted	Length: 11.6 km; Volume: 78,700m^3

[4] Sponge City refers to a range of measures that can be adopted to replicate the functions of a natural watershed in an urban setting. Central to these measures are landscape treatments such as bioswales, raingardens and wetlands that function to collect, clean and store urban stormwaters. These features are collectively refereed to as Low Impact Design (LID).

No.	Output/Component	Contents/Purposes
2.2	River rehabilitation and construction of embankment	Construction of river embankment of about 8.9km to enhance flood control and restore ecology along the river. (i) Shixia Reservoir to Xihetou Village: 7.1 km (ii) Taizilianchi Road to Kuhe River: 1.8 km
2.3	Construction of wetland and river amenity facilities	Habitat enhancement, wetland, flood retention zone, boardwalks, pedestrian footpaths, bridges, etc. of about 41 ha.
2.4	Low impact design (sponge city concept) for road improvement and stormwater drains installation	Improvement of Binhe Road of 4.925 km, including small 4 bridges (each approximately 16 m in length) and 13 km stormwater drains together with low impact facilities designed in accordance with the sponge city concept
Output 3—Inclusive Water Supply and Wastewater Collection Services Achieved[*a]		
3.1	Rural water supply system	Raw Water Transmission (i) City West raw water pumping station expansion (add capacity 28700 m3/d) (ii) Raw transmission pipelines (DN 280~450, 45.298 km) Rural Industrial Water Supply[b] (i) Wulihou Pumping Station expansion (add capacity 18200 m3/d) (ii) Silihou Pumping Station expansion (add capacity 10500 m3/d) (iii) Majiaguai Pumping Station expansion (add capacity 17000 m3/d) (iv) Shigangkou Pumping Station expansion (add capacity 9000 m3/d) (v) Water Distribution Pipelines (DN355~450, 48.32 km) Rural Domestic Water Supply Two (2) water treatment stations (WTS) for rural drinking water supply (1200 m3/d and 1500 m3/d); Replacement of existing water supply pipelines (36.5 km, DN63~250).
3.2	Water Pollution Control	(i) Zuoquan County WWTP expansion & upgrading (expand existing facilities from 10,000 m3/d to 15,000 m3/d; add advanced treatment system 15,000 m3/d; replacement of aging and fault equipment); (ii) Construction of 4.97 km trunk sewers (DN 400~500) and associated manholes (124 Nos.) in City West New District; (iii) replacement the existing DN 600 main sewer with DN 800 pipeline (12.9 km, with 25 Nos. of manholes); (iv) Reconstruction of four (4) overflow manholes.
Output 4—Institutional Capacity Strengthened		
4.1	Project management	(i) Consultancy service during initial stage (ii) Project implementation support consulting services (iii) Resettlement external monitoring

No.	Output/Component	Contents/Purposes
		(iv) Training for reservoir management and operating procedures; dam safety management including dam safety monitoring, compilation and implementation of reservoir operation and maintenance manual, and compilation of dam safety reports[c]
4.2	Flood warning system	To enhance the existing flood warning system operated by the Zuoquan Water Resource Bureau (ZWRB) by incorporating real-time information collected from the 5 hydrological stations to be built under Output 1 and provision of appropriate equipment and software. The improved flood warning system will also include: (i) Telemetry system for water and rain (ii) Video Surveillance System (iii) Flood Control Dispatch Simulation System (iv) Rural rescue emergency equipment and alarm equipment
4.3	Institutional and capacity strengthening for integrated urban-rural water supply	(i) Integration of water supply services in urban and rural areas (ii) Strengthening the capacity of the newly established water company to meet the challenges of water sector reform (iii) Training for water demand management
4.4	Institutional and Capacity Strengthening for Sponge City Design (Low Impact Technologies) for City Development	(i) Prepare a Sponge City Action Plan for new urban development areas (ii) Prepare Low Impact Development Standards to be implemented in new urban construction (iii) Develop training of trainers on the Sponge City Action Plan and LID Standards (iv) Prepare monitoring framework for Sponge City and LID implementation (pilot on Binhe Road)

[a] Zuoquan local government will ensure to complete the water and wastewater house connections.
[b] nd users will be responsible for industrial connections.
[c] The Zuoquan Shixia Reservoir Management Office will carry out periodic dam safety reports. Monitoring and the reports will be addressed to the Jinzhong Municipal Water Resources Bureau which is the administrative department in charge of water resources.

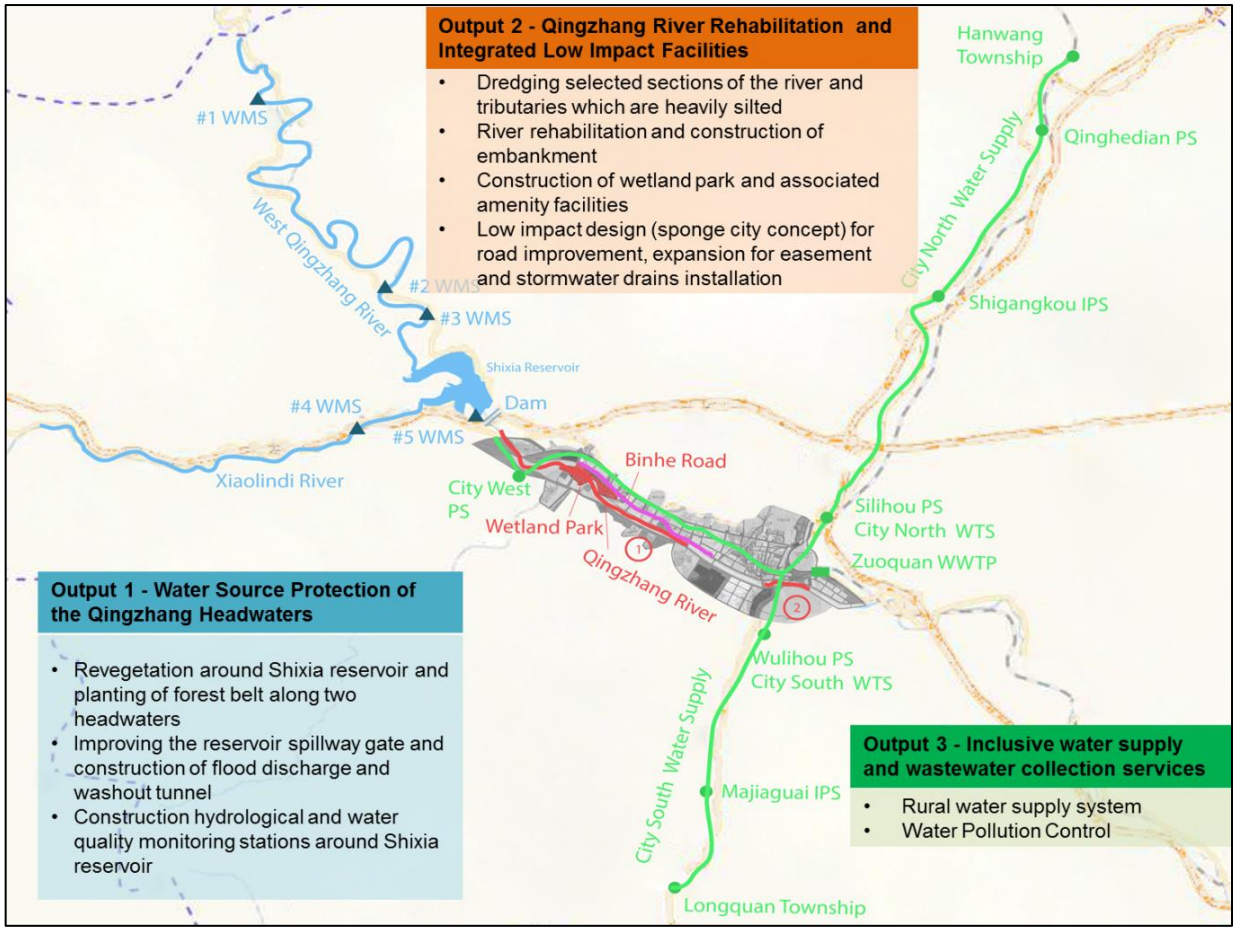

Figure IV-3. Project Location Map

B. Project Benefits

67. The project will result in multiple benefits to water and environmental management, including:

(i) **Improved flood control.** The project will improve flood standards of the West Qingzhang River in Zuoquan County (Shixia Reservoir down to Xihetou Village, and from Taizilianchi Road to the intersection of Ku River and West Qingzhang River) from less than 1-5 year to a 1-20 year flood interval. The pre-discharge capacity, flood regulation capacity during the flood season, and emergency response capacity of Shixia Reservoir will be increased through structural improvements and staff capacity building. These initiatives will reduce flood damage to properties, crops and livestock, and help prevent injury and loss of life among villagers living close to the river.

(ii) **Improved water supply management.** Drinking water quality and water security of 43 villages in the county with total population of 33,946 (in 2030) will be improved. The drinking water quality of City South and North Water Supply System will be improved to meet Standard for Drinking Water Quality (*GB 5749-2006*). Water resource efficiency will be improved by supplying water of different quality to residents and industrial users. For industrial users, since they either have their own in-plant treatment system to treat the raw water to required standards for production or they can use raw water directly for production, raw water is supplied directly without centralized treatment. For domestic water supply, the water will be treated to meet drinking water standards.The leakage of both City South Water Supply System and City North Water Supply System will be reduced to 10%.

(iii) **Enhanced wastewater management.** Infrastructure will increase the wastewater collection rate of Zuoquan County from 60% in the base year of 2015 to 90% in 2020, preventing pollution to the surface waters in West Qingzhang River area as a consequence of future development. The interception ratio of the combined stormwater and wastewater from the built up area of county city will improved to two.

(iv) **Water quality improvement.** Water quality in the West Qingzhang River downstream of Shixia Reservoir will be improved through dredging of polluted sediments, improved wastewater sewerage infrastructure and upgrading of the Zuoquan WWTP. This will contribute to improved regional water quality in the Zhang River system.

(v) **Ecological enhancement.** Reforestation of 128.2 ha in the upper catchment of Shixia Reservoir, habitat enhancement in the lower West Qingzhang River and water quality improvement/ enhanced water flow will improve ecological conditions across the project area. The 41 ha wetland park constructed under the project will enhance landscape value and also provide socio-economic benefits for residents of Zuoquan County.

C. Project Design

1. Output 1: Shixia Reservoir Operation and its Watershed Vegetation Improved

68. This output refers to Shixia Reservoir and two 12 km sections of its two main tributaries: the West Qingzhang River and Xiaolingdi River. The output contains three sub-projects; (i) revegetation around the Shixia Reservoir and planting of forest belt along two headwaters; (ii) improving the reservoir spillway gate and construction of flood discharge tunnel; and (iii) construction of hydrological monitoring stations around the Shixia Reservoir and water supply configuration station.

1.1 Revegetation around the Shixia Reservoir and Planting of Forest Belt along Two Headwaters

69. This revegetation sub-project is focused on tree planting to improve water management, and its main objective is to create a natural buffer zone along West Qingzhang River, some sections of Xiaolingdi River, and a small area around Shixia Reservoir itself (Figures IV-4 to IV-6). These areas have been selected as they have been excluded from previous reforestation programme implemented by Zuoquan Forestry Bureau. Revegetation will be within the reservoir and river protection zones, and have the following positive impacts: (i) reinforce river banks; (ii) reduce soil erosion; (iii) improve natural regulation of stormwater run-off volume and quality; (iv) Improve water and soil quality protection and flood control to provide socio-economic benefits to residents in the county; and (v) provide a buffer between nearby roads and the waterways.

70. The total area of the revegetation sub-project is about 1.282 km^2 (Table IV-2). This will focus on restoring the riparian forest belt along the two headwaters, by tree planting in gaps between existing riparian forest, with a planting density of 1,280 trees/ha. The main tree species to be planted will be *Populus simonii* and *Salix matsudana*. The average width of the riparian forest is set to be 5 m for the river sections close to roads and villages (due to space constraints) and 25 m for the other river sections. Other plant species to be included are: *Robinia pseudoacacia*, *Ulmus pumila*, *Hippophae rhamnoides*, *Ziziphus jujube*, *Medicago sativa*, *Ranunculus japonicus*, *Juncus effuses*, *Phragmites communis*.

71. Before planting, holes for trees (80 x 80 x 80 cm) and shrubs (40 x 40 x 40 cm) will be dug and prepared by adding top-soil to the base of the pit. Planting for trees can be scheduled at any time of the year, whereas planting of shrubs will be conducted in the spring and autumn seasons. Tree tubes/protectors will be provided for newly planted saplings. Mulch will be

provided to fertilize the newly planted saplings and help retain soil moisture. As vegetation matures, the requirements for limited selective thinning should be reviewed to maintain tree health.

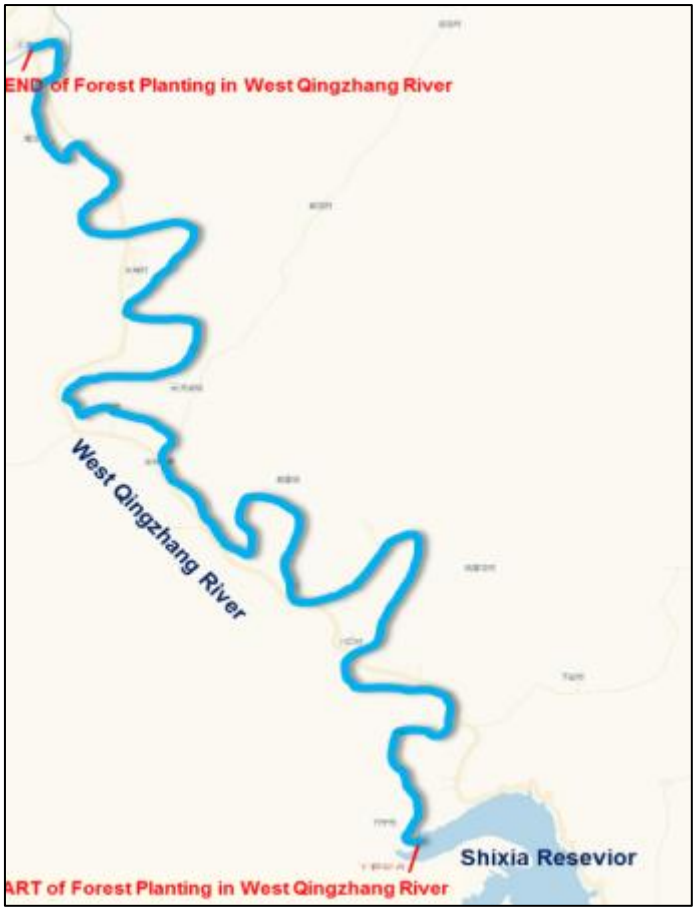

Figure IV-4. Revegetation Location along West Qingzhang River

Figure IV-5. Revegetation Location along Xiaolingdi River

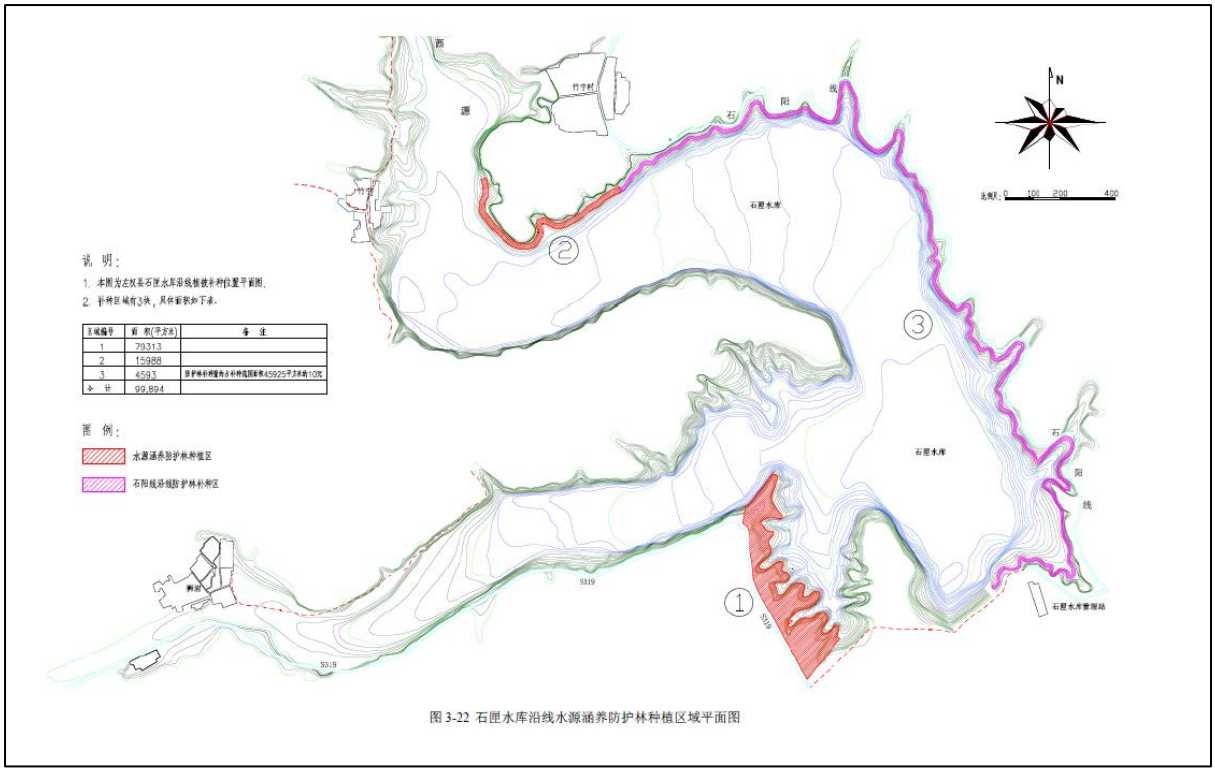

图 3-22 石匣水库沿线水源涵养防护林种植区域平面图

Figure IV-6. Revegetation Locations around Shixia Reservoir

Note: Areas shaded in red refer to reforestation for water protection. Areas shaded in purple refer to planting adjacent to Shiyang Road for water protection.

Table IV-2. Summary of Revegetation Planting Area

	West Qingzhang river	Xiaolingdi river	Shixia Reservoir
Length of the river	22.7 km	16.2 km	
Total area	74.4 ha	43.8 ha	10 ha
Number of tree planting	95,500	56,100	13,000

1.2 Improving the Reservoir Spillway Gate and Construction of Flood Discharge Tunnel

72. The Shixia Reservoir is located in the upper catchment of Shixia County, 10 km upstream and to the northwest of the Zuoquan County. Construction of the reservoir started in November 1959, it became operational in June 1960, was rehabilitated in 1966, and in 1972, the dam was enlarged (both in height and width) and the capacity increased to 50.39 million m^3. In 1972, the designed flood control standard of the reservoir was 1/50 years, and checked for 1/100 years. From 2002 to 2003, the reservoir was further augmented, increasing the capacity to 50.99 million m3, with 1/100 years designed flood control standard, and checked for 1/1000 years.

73. The current operation and maintenance of the dam has functional and safety issues, as identified under the PPTA: (i) the rubber dam on top of the spillway has no pre-overflow function and has been abandoned for years. It is no longer used to regulate the reservoir water level to provide flood storage; (ii) the last safety inspection of Shixia Reservoir was conducted in 2003, whereas national standards require an inspection every 6-10 years.; (iii) day-to-day operations at the dam are completed manually, which is time consuming and has low accuracy. There are few automated processes, demonstrating that operation and maintenance lags behind national standards; (iv) data collection and analysis of the reservoir monitoring data is poor and the information has not been utilized to improve system operation; (v) the existing reservoir dam safety regulations and rules adopted for Shixia Reservoir are insufficient. A proper operation and maintenance manual is not in place; and (vi) technical staff do not have

the knowledge or capacity to compile annual dam safety reports.

74. Upon the request of the PPTA dam expert, a new dam safety inspection was conducted in January 2016. The main conclusions of this inspection were: (i) the overall works are qualified; (ii) the operation and management is good; (iii) the flood control standards meet the specification requirements; (iv) through stability checking, the safety factors of the stability analysis for the main and auxiliary dam slope upstream and downstream meet the specification requirements, and seepage flow of the left and right abutment is about 1~2L/s and 0.1L/s, which will have little impact on the dam safety, so it does not need to be considered in the project; (v) the safety factors of the the stability analysis for the anti-sliding of the rubber dam of the spillway and the structure of discharging chute section meet the specification requirements; (vi) Permeability gradient of the main and auxiliary dam is less than the permissive permeability gradient, (vii) the percolation state of the dam is normal; and (viii) metal structures are basically intact and meet operation requirements. In summary, while there are problems with the dam operation and maintenance, the dam is safe, flood control capacity is reliable, and operations can continue.

75. The proposed spillway gate will be located at the connection of the reservoir and the original spillway, and would replace the existing (non-functional) rubber dam, and consist of two 8 m wide arc-shaped hydromatic gates. The proposed flood discharge tunnel will be constructed to help drain the reservoir to improve emergency response capacity. The tunnels consist of pressured culvert inlets, lock chamber of intake tower, non-pressure tunnel, and flip trajectory bucket sections at the tunnel exit. The tunnels will be 476 m long and have a maximum discharge rate of 214 m^3/s. The design of the spillway gate and flood discharge tunnel are shown in Figure IV-7 and Figure IV-8 respectively.

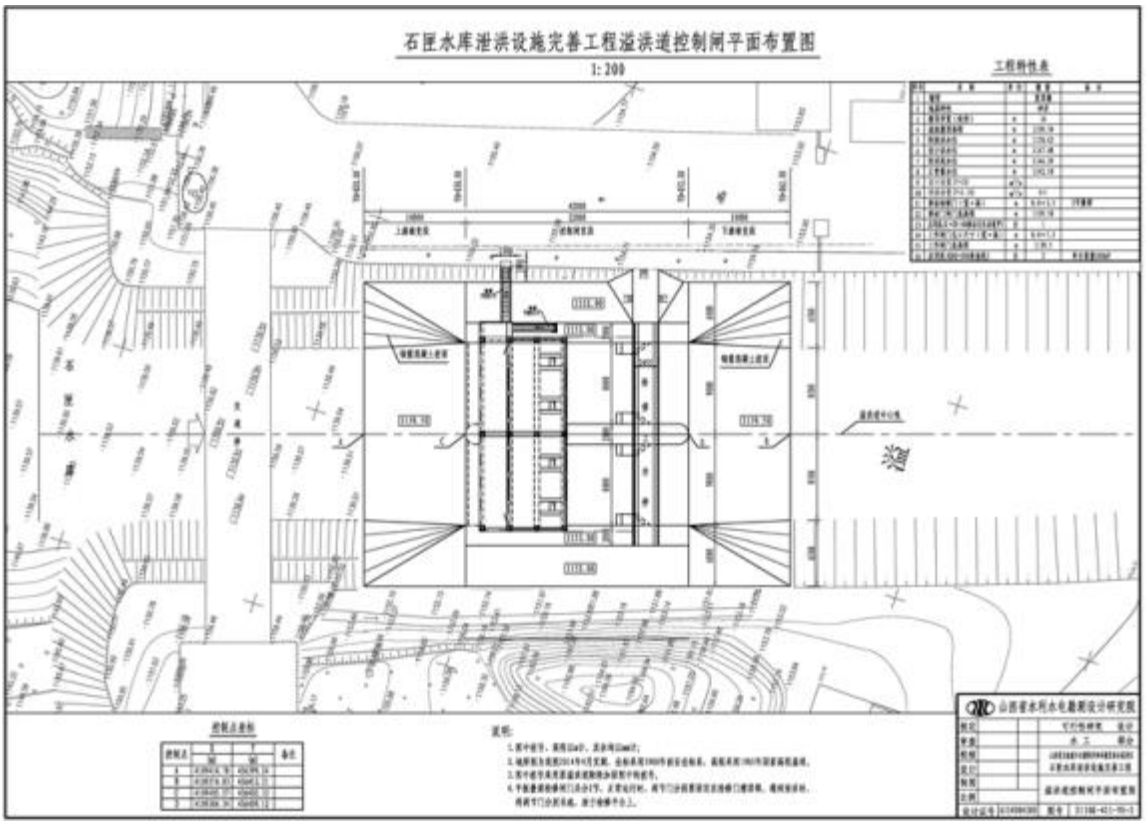

Figure IV-7. Design of Spillway Gate

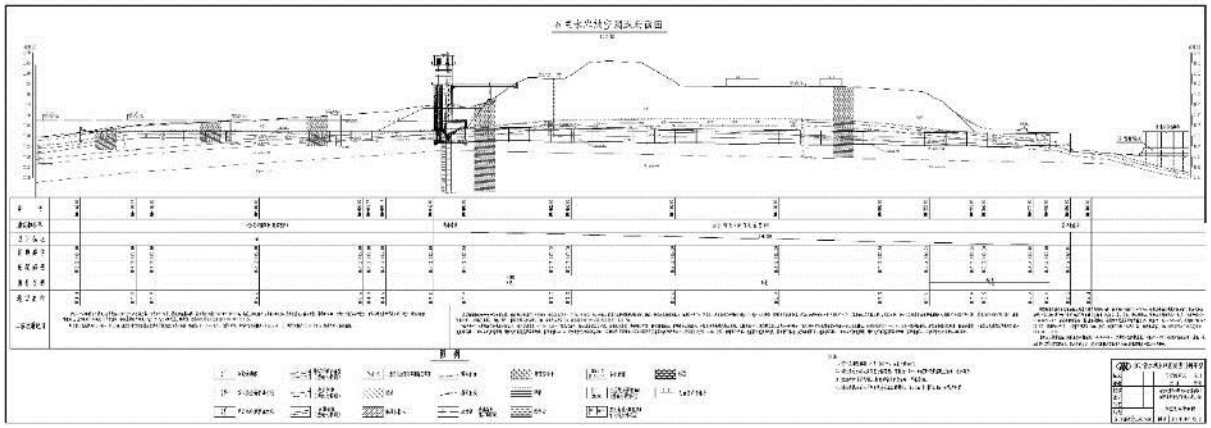

Figure IV-8. Design of Flood Discharge Tunnel

1.3 Construction of Water Monitoring Stations around Shixia Reservoir

76. Hydrological and water quality monitoring stations collect real-time data on flow rates and water quality. These data are essential for water resources assessment, flood risk management and regulatory and research activities. Currently, Zuoquan County has no monitoring stations. To address this shortfall, five small (each with an approximate footprint of 200 m^2) monitoring stations would be constructed in the villages of Songgou, Chuankou, Xiajiao and Shiyan, and near the water intake point of Shixia Reservoir (Figure IV-9). A central station is proposed in the management office of Shixia Reservoir, responsible for remote data acquisition, aggregation, analysis, and control from the five field stations. The stations will be operated automatically by the Zuoquan Shixia Reservoir Management Office (ZSRMO), who will share relevant information with the Zuoquan Water Resource Bureau (ZWRB) for the flood warning system. During IEE preparation, the exact location of the stations was being finalized, to avoid potential impacts to farmland. Available details of each station summarized in Table IV-3.

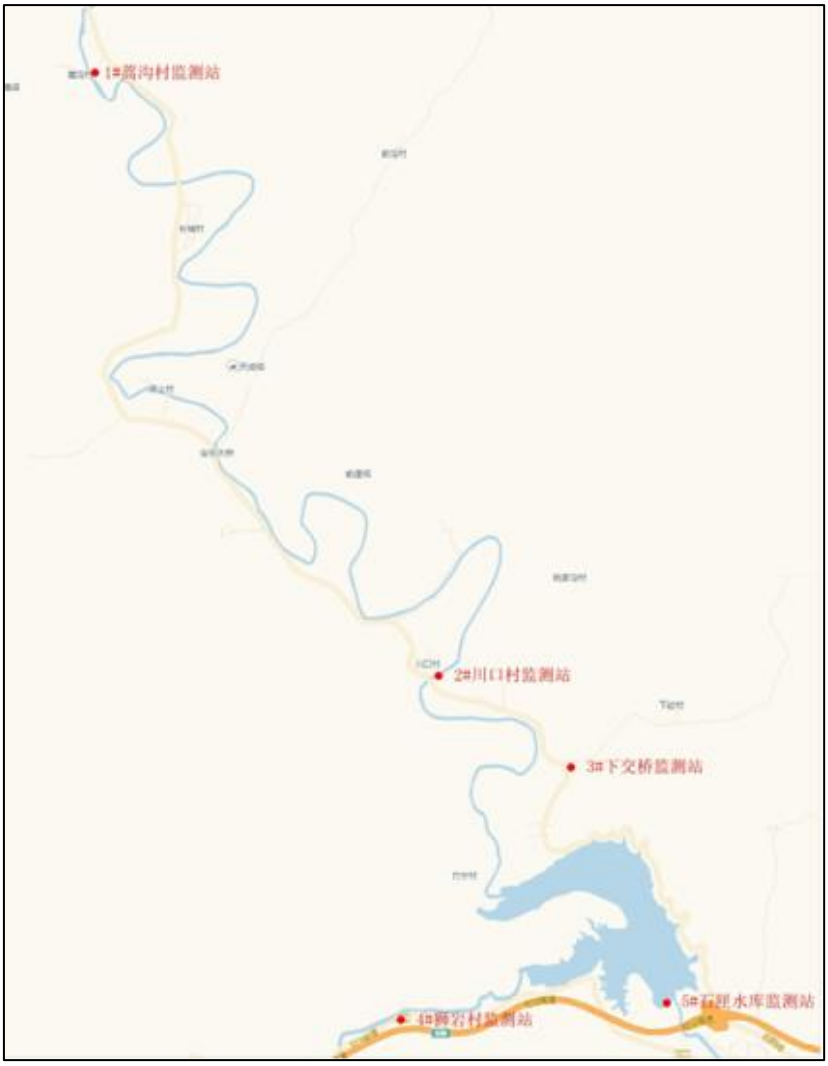

Figure IV-9. Location of Hydrological Monitoring Stations

Table IV-3. Summary of Proposed Hydrological Monitoring Station

Name	Location*	Monitoring Scope
Songgou Village Station	Opposite bank of Songgou village primary school	West Qingzhang River within Heshun County, with catchment of 440.1 km^2
Chuankou Village Station	South of Chuankou Village	West Qingzhang River sections from Songgou Village to Chuankou Village, with a catchment of 94.0 km^2.
Xiajiao Bridge Station	Under Xiajiao bridge, at the entrance to the village	Xiajiao River, with a catchment of 109.6km^2
Shiyan Village Station	420 m west of Shiyan Village	Xiaolingdi River area, with a catchment of 91.7 km^2
Reservoir Water Intake Monitoring station	Close to the water intake of Shixia Reservoir	Water quality of Shixia Reservoir.

*Exact locations to be confirmed during subsequent design stage.

2. Output 2: Qingzhang River and Binhe Road Rehabilitated

77. Key issues for the urban center along the West Qingzhang River include: (i) low (1-5 year) flood control standard; (ii) poor ecological condition along some sections; (iii) blocked flood discharge channels; (iv) existing hard embankments with low ecological and landscape value; and (v) weak capacity for river management. To address these issues, the following measures will be undertaken under output 2: (i) dredging selected sections of the river and tributaries; (ii) river rehabilitation and embankments; (iii) wetland park construction; and (iv)

LID for road improvement, expansion for easement and stormwater drains installation.

78. These works focus on the urban reaches of West Qingzhang River, from Shixia Reservoir to Ku River, a total length of 11.6 km. The length of river bank protection for flood control and ecological restoration (excluding the wetland park) is about 8.9 km. Dredging would be undertaken along the entire 11.6 km stretch. The proposed works are designed to improve flood management to accommodate 1-20 year flood events.

2.1 Dredging Silted Sections of the River and Tributaries

79. The river dredging scope is from West Qingzhang River downstream of Shixia Reservoir to the Ku River (Figure IV-10). Dredging is required to remove the accumulation of silt deposits in these areas that have formed as a consequence of wastewater discharges into the River, and the operation of two existing rubber dams in the mainstream. The dams are approximately 2 m high, and will be deflated during high flow-events to increase flood conveyance in the river. The average dredging depth will be 20-30 cm, covering an area of 27.5 ha; resulting in a total dredged volume of approximately 78,700 m^3 (Table IV-4).

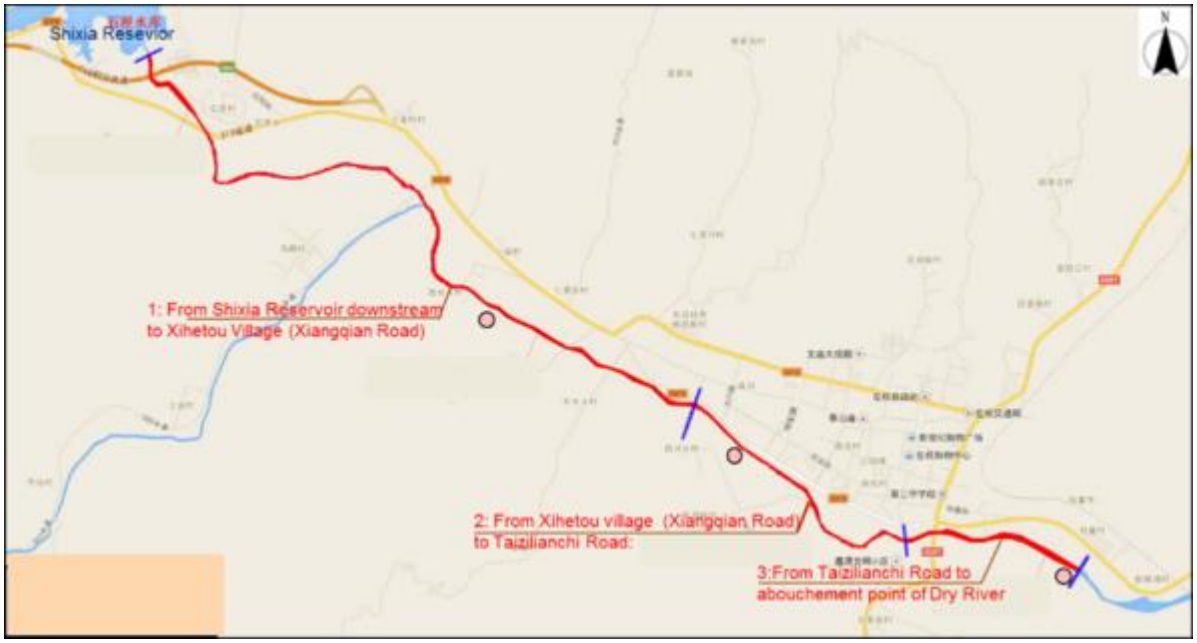

Figure IV-10. River Dredging Locations

Table IV-4. Summary of River Dredging

Location	River Length	Dredged Area	Average Dredging Depth	Dredged Volume
From Shixia Reservoir downstream to Xihetou Village (Xiangqian Road)	7.4 km	7.0 ha	0.2 m	14,000 m^3
From Xihetou village (Xiangqian Road) to Taizilianchi Road	2.4 km	17.3 ha	0.3 m	51,900 m^3
From Taizilianchi Road to Ku River	1.8 km	3.2 ha	0.4 m	12,800 m^3
Total	**11.6 km**	**27.5 ha**		**78.700 m^3**

80. The dredged material will be dewatered by natural drying, which will be accelerated by manual turning of the material by workers. The processed material will be used as fill for river embankment construction. The location of the temporary sludge treatment (Figure IV-11) is summarized as follows: (i) between Xichangyi and Jinggou Villages: 500 m from the west of Jinggou Village, covers an area of 5,000 m^2, and temporary land acquisition by renting; (ii) opposite bank of Binhe Park: to the south of an abandoned suspension bridge, covers an area of 8,000 m^2, and temporary land acquisition by renting; and (iii) confluence point of Ku River:

area of dry river bed where Ku River flows into West Qingzhang River, covers an area of 4,000 m^2, the site is dry all year except for the rainy season, wasteland at current status.

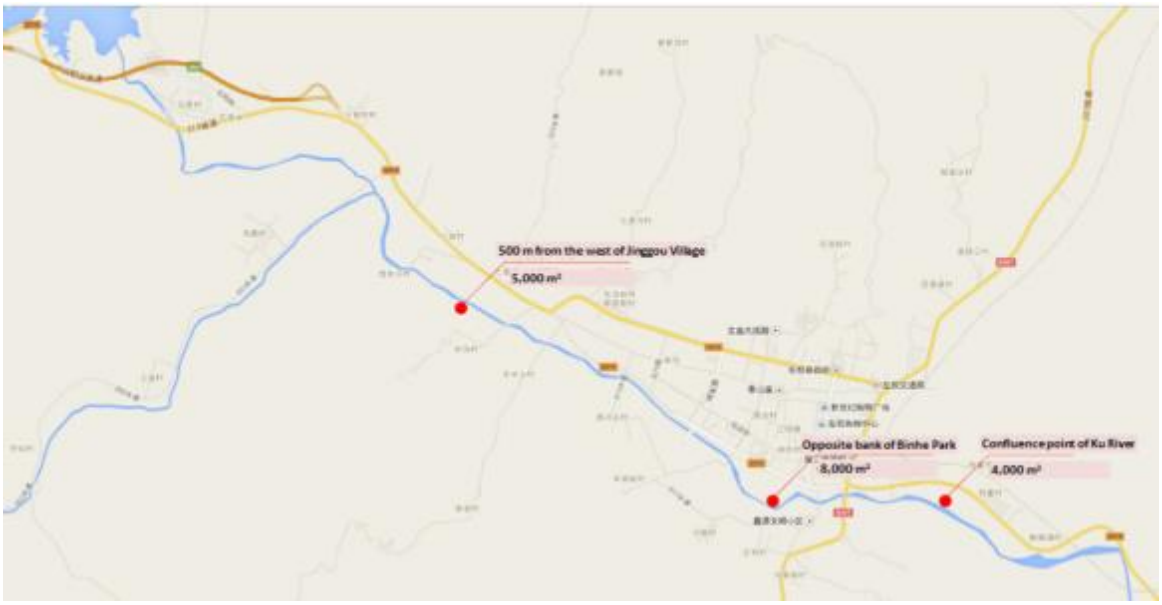

Figure V-11. Location of Temporary Dredged Sludge Treatment Areas

2.3 River Rehabilitation and Construction of Embankment

81. Embankment improvements would be conducted over two stretches of the urban West Qingzhang River: (i) Shixia Reservoir to Xihetou Village (7.1 km), (ii) Taizilianchi Road to Ku River (1.8 km) (Table IV-5). The total length is 8.9 km (Figure IV-12). The stretch of river between these two proposed works areas already has embankment improvements to address flood control.

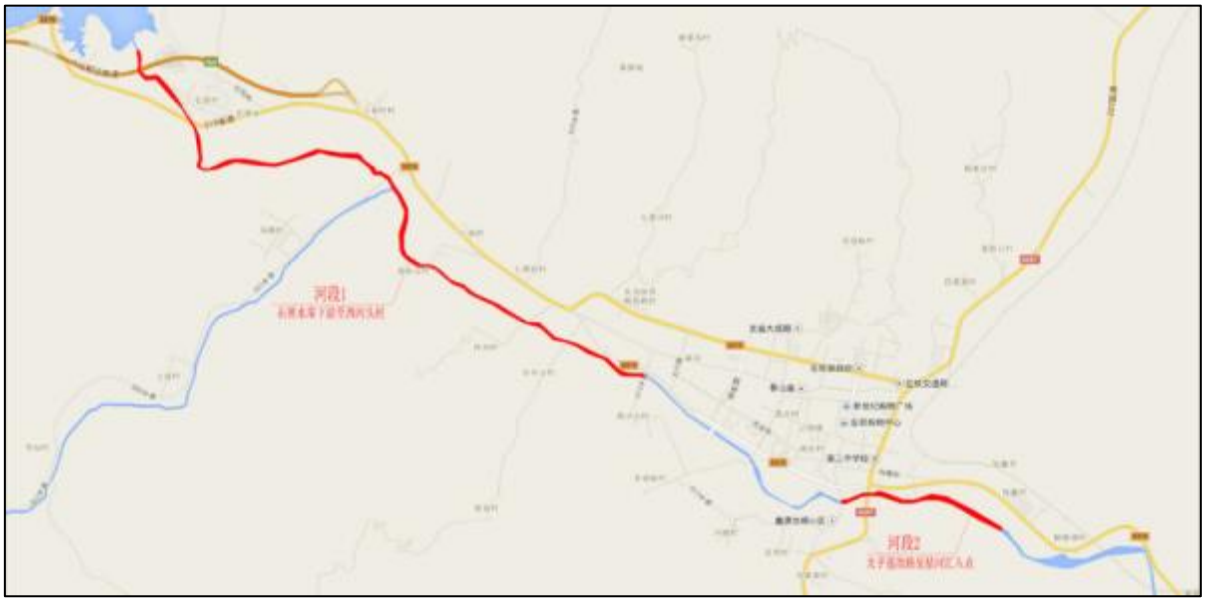

Figure IV-12. Location of River Embankment Improvement Works

Table IV-5. Summary of River Embankment Improvement Works

Location	River Length	Flood Control Standard
Shixia Reservoir to Xihetou Road	7.1 km	1 in 20 year
Taizilianchi Road to Ku River	1.8 km	
Total	**8.9 km**	

82. Embankment improvements will involve replacing existing earthen embankments with ecological enhanced engineered banks along both sides of the river. Embankment types have selected by the Design Institute to meet flood management/erosion control requirements while providing ecological enhancement. Typical sections of the new embankments are shown in Figure V-13. Embankment types of different river sections are listed in Table IV-6.

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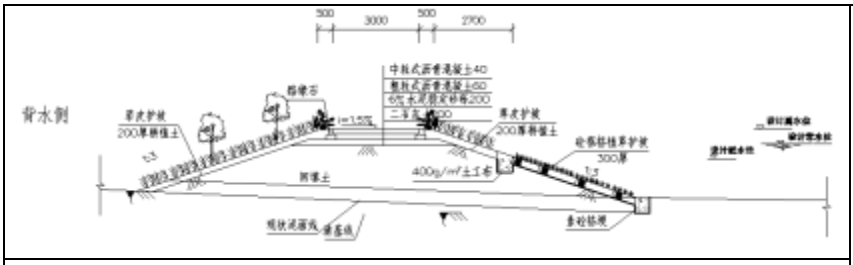
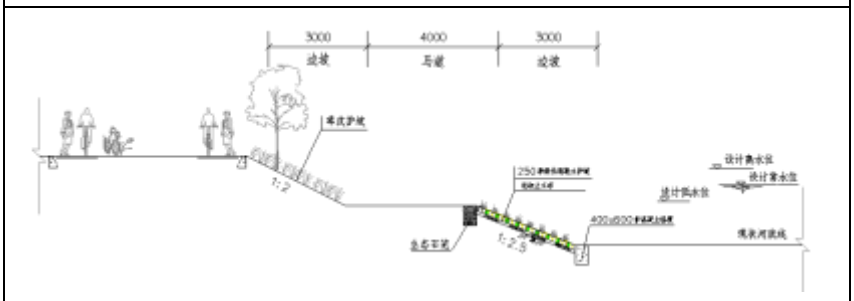
<td> 
 </td>
<td>Type A: Ecological Slope
Interlocking blocks or grasscrete are used below the designed high water level, and grass/shrub planting is provided from the average high water level to the top of the embankment. This revetment is suitable for the upstream near the reservoir section of this project. The embankment can be integrated with the existing plantation along the river by tree planting on the landward side of the structure.</td>
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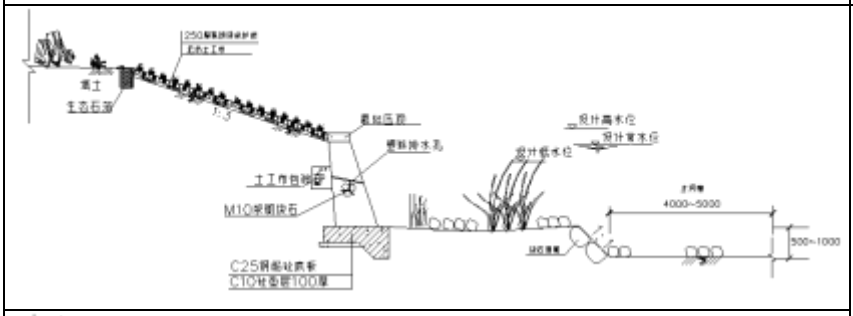
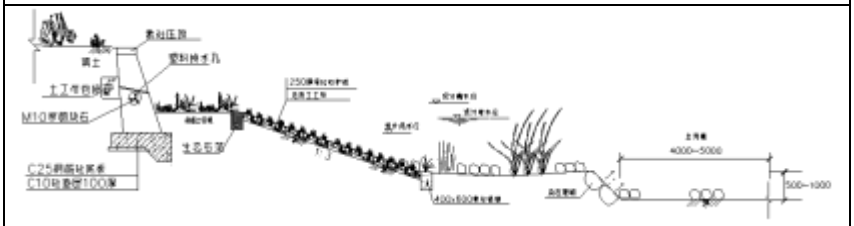
<td> 
 </td>
<td>Type B1: Ecological Retaining Wall
To reduce the width of the flood protection embankment, a retaining wall complex (retaining wall + slope) can be provided. This design will be adopted where existing constraints (e.g., roads, buildings, bridges) limit the space to adopt other embankment design.

Boulders will be used below the mean water level to provide scour protection. Above this, a platform for wetland planting will be provided. Above the mean water level, interlocking grasscrete blocks of 1:3 slope up to the flood protection elevation are used. These blocks can be planted with grasses and shrubs to improve appearance and provide some ecological value.</td>
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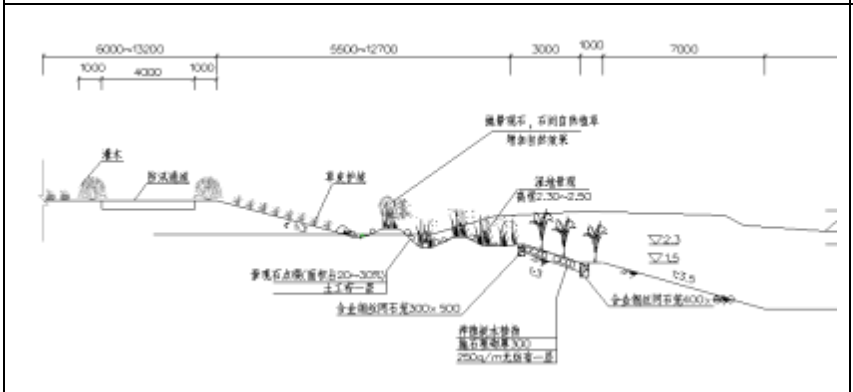
<td>  </td>
<td>Type C1: Ecological Plus Slope
The stretch of West Qingzhang River between the Shixia Reservoir and the Zuoquan County Urban Centre supports some riparian tree planting. To maintain ecological functioning in this area, a low grade embankment design will be adopted. From low water level to mean water level, a 300 mm thick riprap slope will be constructed to provide scour protection. Areas above this will be re-graded to a gentle slope, and</td>
</tr>
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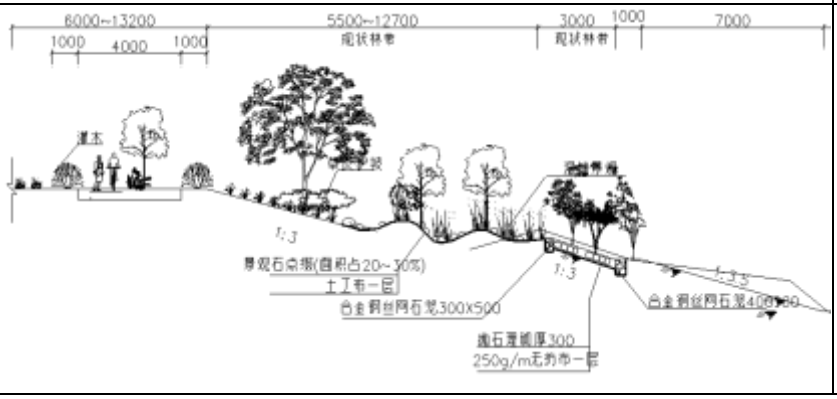
	planted with appropriate wetland and riparian vegetation.
	**Type C2: Ecological Plus Slope (use of existing woodland)** Both sides of the West Qingzhang River adjacent to the planned western urban district of Zuoquan have recently been planted with trees. A modified Ecological Plus Slope design will be adopted in these areas to retain as many existing trees as practicable.

Figure IV-13. River Embankment Types

Table IV-6. Distribution of Embankment Types along the West Qingzhang River

Embankment Name	Embankment No.	Length (m)	Location
Ecological Slope	A	7201.0	Z1+404.0 - Z5+288.5
			Y2+123.3 - Y5+139.7
			Y1+280.6 - Y1+580.7
Ecological Retaining Wall	B	7050.9	Z5+288.5 - Z7+094.1
			Y5+139.7 - Y7+207.6
			Z0+000.0 - Z1+674.0
			Y0+000.0 - Y1+280.6
			Y1+580.7 - Y1+803.5
Ecological Plus Slope	C	3527.3	Z0+000.0 - Z1+404.0
			Y0+000.0 - Y2+123.3

2.3 Construction of Wetland Park

83. The wetland park will be located 2.4 km downstream from Shixia Reservoir and extending down about 1.36 km, as per the existing Zuoquan County Masterplan (Figure IV-14). The facilities will comprise a county wetland park covering an area of approximately 41 ha, and provide multiple functions including flood storage, water supply conservation, residential recreation, and ecological enhancement.

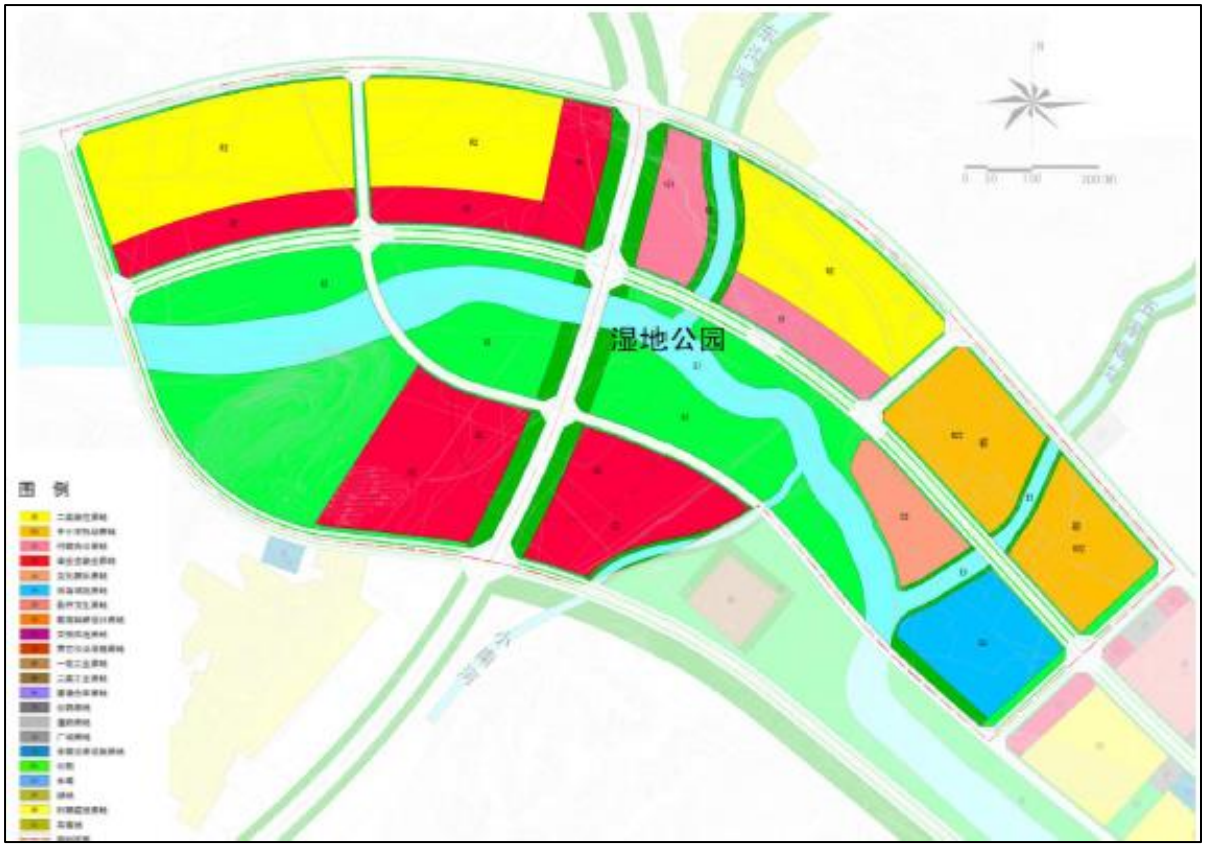


Figure IV-14. Land Utilization Plan of the Wetland Park

84. The wetland park will be divided into five broad zones by existing and planned roads (Figure IV-15). The area of each zone is provided in Table IV-7, and development programme for the entire area summarized in Table IV-8.

Figure IV-15. Wetland Park Area

Table IV-7. Zoning of the Wetland Park

Zone	Area (m^2)
1	19,614
2	113,823
3	43,091
4	169,587
5	65,542
Total	**411,657**

Table IV-8. Development Programme for the Wetland Park

Project	Area (m^2)	Notes
Water features and surface waterways (dry season)	60,300	Three water storage areas of and connecting channels
Local roads (including pedestrian trails)	20,000	-
Buildings	3,700	-
Other facilities	5,000	Plaza, parking, playgrounds etc.
Total	89,000	22.2% of the total area
Total Area of Wetland Park	**411,657**	

85. **Ecological water storage and flood detention.** The wetland park will have three water storage areas. In the dry season, water depth in these areas will be about 0.6 m, supplied by base flow from drainage channels discharging into the area. During the wet season, water levels will rise to a depth of 1.8 m, as the facilities receive runoff from local drainage and discharge from Shixia Reservoir. Areas in the flooded zone would be planted with wetland vegetation to mimic natural wetland floodplain habitats. The layout of water features in the wet and dry seasons is shown in Figure IV-16, and storage capacity summarized in Table IV-9.

Figure IV-16. Layout of the Wetland Park in the Wet (Left) and Dry (Right) seasons

Table IV-9. Wetland Park Water Surface Area and Water Retention Capacity

Water Storage Area	Area (m^2)		Storage Capacity (m^3)	
	Dry Season	Wet Season	Dry Season	Wet Season
1	8,203	14,970	4,922	26,946
2	11,989	24,872	7,193	44,770
3	20,133	35,164	12,080	63,295
Total	40,325	75,006	24,195	135,011

86. Native plant species proposed for landscaping and wetland habitat creation in the wetland park are summarized in Table IV-10 and Figure IV-17:

Table IV-10. Plant Species Proposed for Wetland Park

Wetland plants species	*Lythrum salicaria*, *Phragmites communis*, *Typha orientalis*, *Acorus calamus*, *Korsa kowii*, *Nelumbo nucifera*, *Scirpus validus*
Trees and shrubs	*Metasequoia glyptostroboides*, *Populus* sp, *Pinus* sp, *Salix matsudana*, *Euonymus fortunei*
Ground cover	*Viola philippica*

Figure IV-17. Plant Species Proposed for Wetland Park

2.4 Low-Impact Design for Road Improvement and Stormwater Drains Installation

87. There are three planned east-west arteries in the Zuoquan urban center. One of these is the already partially constructed Binhe Avenue, which starts from Yingbin Road in the west, and ends at Jiangjun Road in the east (Figure IV-18). Under the current project, the section from the start point to planned Fifth Road will be new construction; the rest will be expansion of existing Binhe Avenue. This section of Binhe Avenue, also named S319, will be expanded and upgraded to urban trunk road standards.

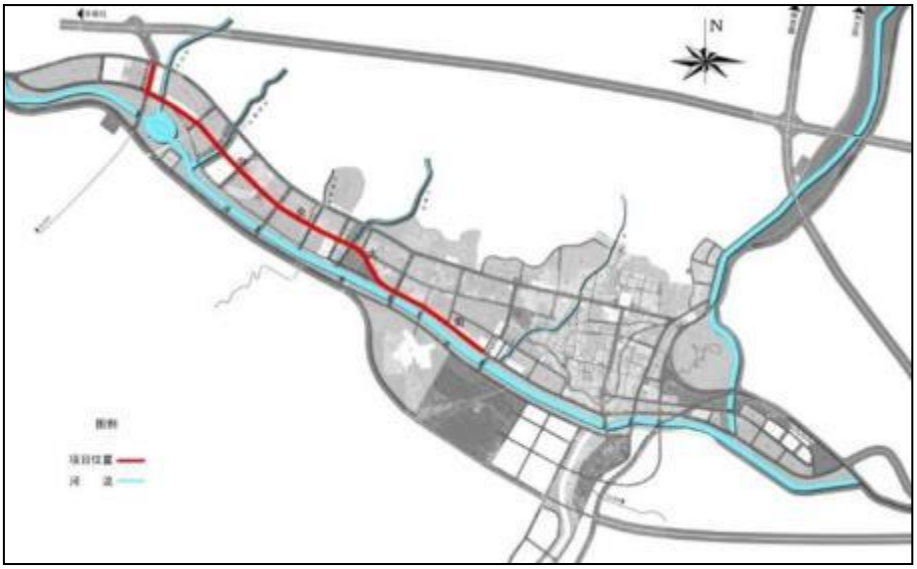


Figure IV-18. Location of Proposed Upgraded and Extended Binhe Road

88. The proposed expressway collector is a north-south trunk road that will carry traffic leaving/joining the expressway from/to Zuoquan County Urban Centre. It will start from the expressway exit and end at new S319. The section from Binhe Road connecting to the expressway exit is excluded from this ADB finance project.

89. Associated municipal infrastructure will include expansion for easement, LID, stormwater drainage, and traffic signals, signage and markings, lighting etc. The improvement works will also include reprovisioning of four bridges. Technical parameters of the road improvements are summarized in Table IV-11, and typical sections are in Figures IV-19 and IV-20. Design parameters have been selected in accordance with relevant national codes and design specifications, and are appropriate for an urban trunk road.

Table IV-11. Technical Parameters of the Proposed Road

No.	Parameter	Unit	Criteria
Road			
1	Urban classification		Grade III-Urban Trunk
2	Design speed	km/h	40
3	MV lane width	m	Dual 3×3.5
4	Design Load		BZZ-100
5	Seismic Intensity	Degree	6
6	Designed life	Year	15
Bridge/culvert			
7	Bridge/culvert load standard		Urban-A
8	Seismic Intensity	degree	6
9	Design flood return	Year	1/100
10	Design life	Year	100

90. The proposed Binhe Road will have a total right of way width of 40 m. Lane configuration is proposed as 2.5 m x 2 sidewalk, 2.5 m x 2 cycle lane, 2.5 m x 2 green belt, 11 m x 2 carriageway, and 1 x 3 m median.

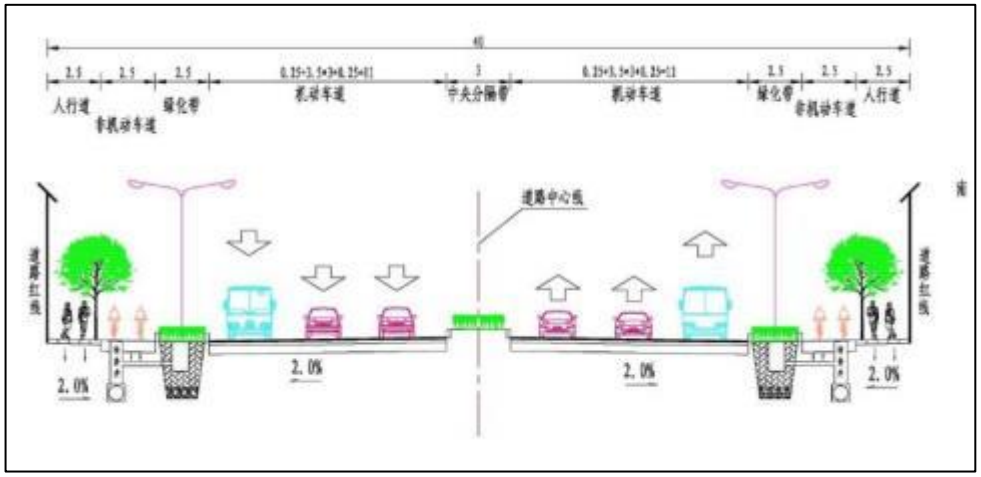


Figure IV-19. Cross Section of Binhe Road (Expressway Connector-North Avenue)

91. The section from North Street to Jiangjun West Road will an upgrade of the existing road. The total right of way is 40 m wide. Lane configuration is proposed as 3 m x 2 sidewalk, 3.5 m x 2 cycle lane, 2.5 m x 2 green belt, and 11 m x 2 carriageway.

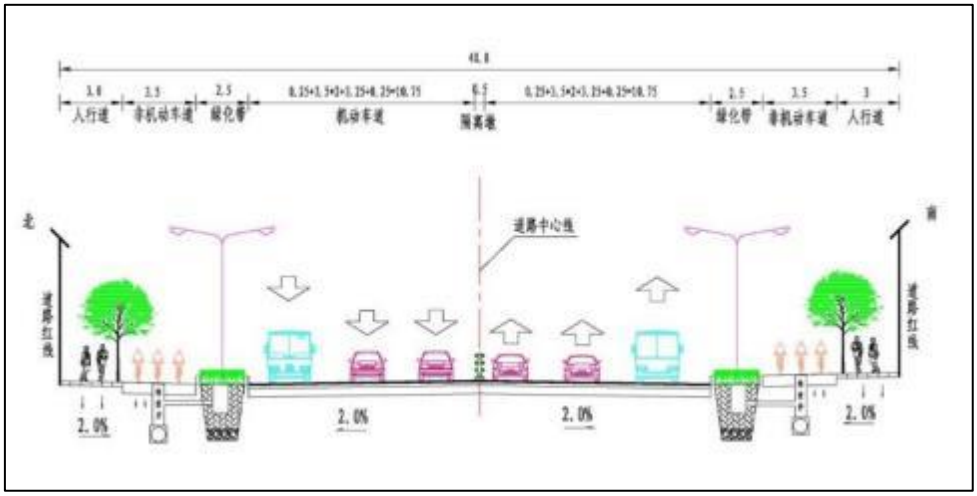


Figure IV-20. Cross Section of Binhe Road (North Avenue-Jiangjun West Road)

92. The proposed road will cross four rivers (Table IV-12). The bridge widths will be 40 m, comprising two bridge sections, each 17.5 m wide with 5 m median separator. The cross section is configured as 0.5 m side guardrail, 1.5 m sidewalk, 3 m cycle lane, 1.5 m utility viaduct, and 10.5 m carriageway.

Table IV-12. Summary on Proposed Bridge

Bridge	Span (m)	Type
Donghegou Bridge	3x16	Pre-stressed Concrete cored slab
Wujiayan Bridge	2x16	
Qilidian Bridge	2x16	
Qilihe bridge	2x16	

93. **Low-impact design.** LID techniques will be integrated in the road design, comprising permeable pavement, LID tree pits, and rain gardens (Figure IV-21). Rain gardens remove contaminants and sediment by collecting stormwater into the treatment area which consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch-layer, planting soil, and plants. Runoff passes first over or through a sand bed, which slows the runoff's velocity, distributes it evenly along the length of the ponding area. The ponding area is graded and

depressed at the center. Water is ponded to a depth of 15 cm and infiltrates the bioretention area or is evapotranspired. The bioretention area is graded to divert excess runoff away from itself (Figure IV-22). Raingardens will be located along the carriageway, with a width of 2.5 m.

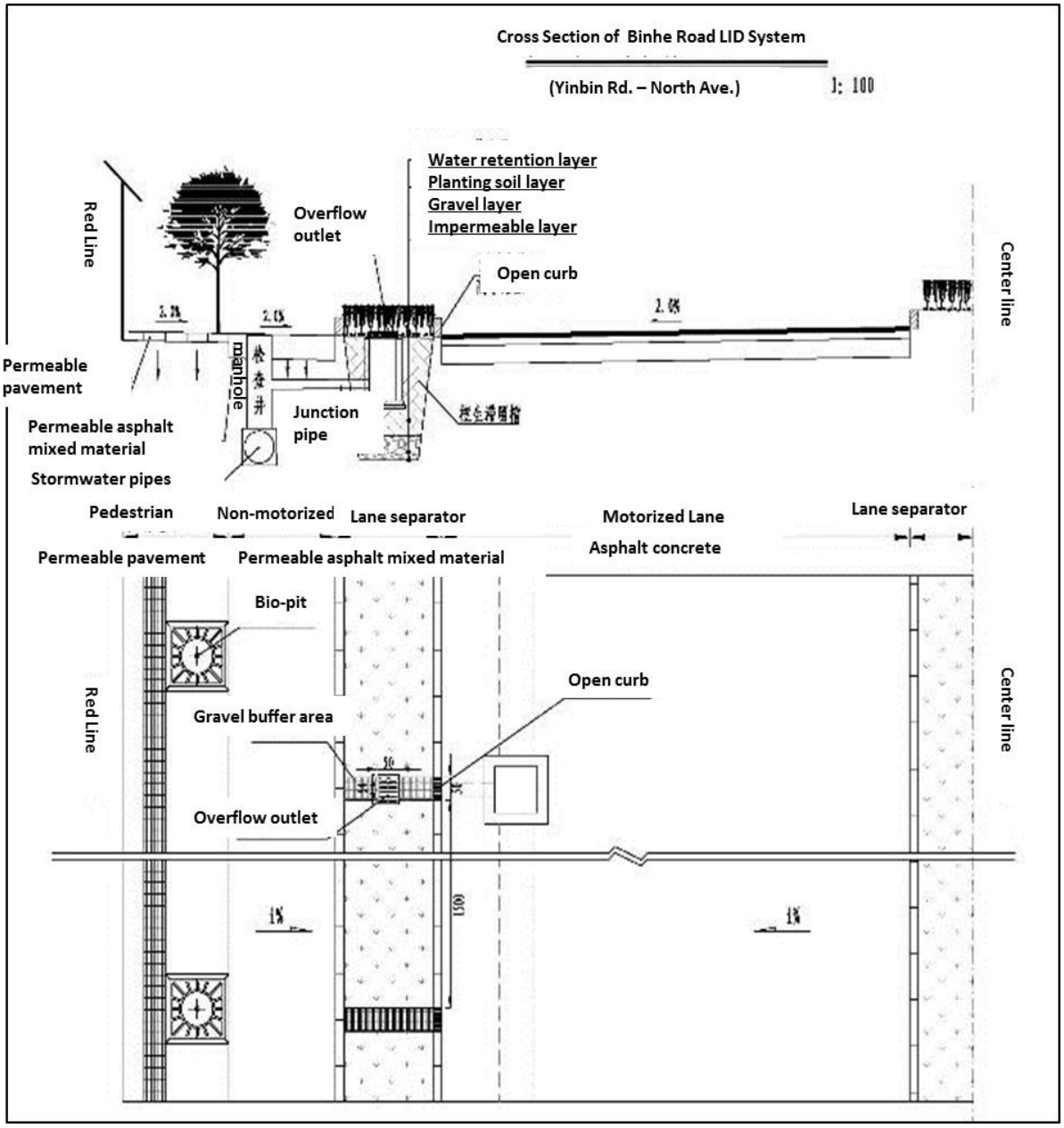


Figure IV-21. Concept Design of the Road LID System

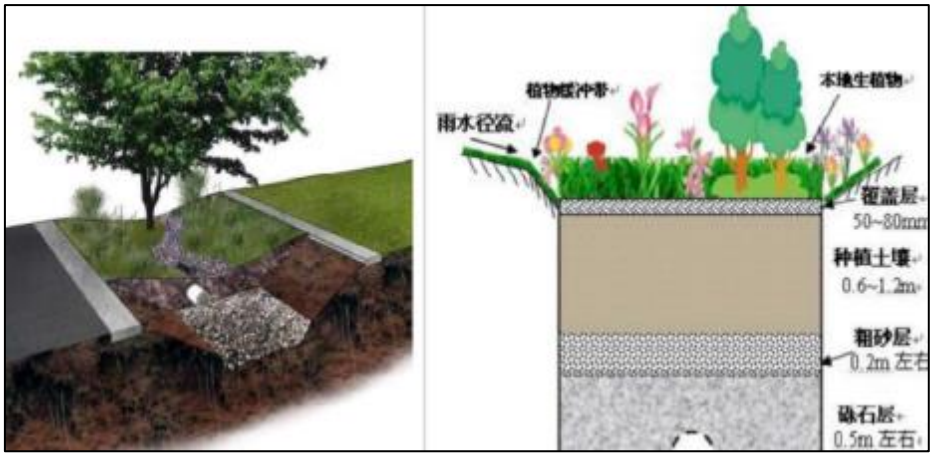


Figure IV-22. Example of Bioretention Green Belt Design

94. **Stormwater drainage.** Based on the receiving water bodies (Donggou River, Wujiayangou, Qilidian River, Qili River, and West Qingzhang River), the City West New District is divided into five drainage zones. Under this project, a main pipeline will be constructed along Binhe Road, with branch pipelines at intervals of 90-150 m. The main storm water pipeline will not be smaller than d600. The layout of proposed stormwater drainage is shown in Figure IV-23, and technical specifications summarized in Table IV-13.

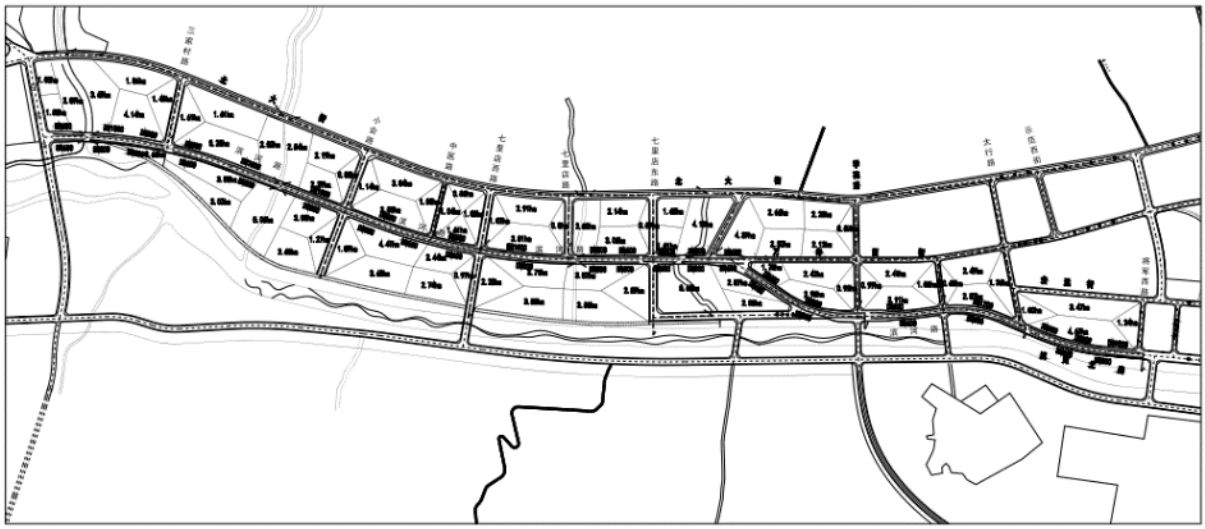


Figure IV-23. Stormwater Pipeline Layout

Table IV-13. Proposed Stormwater Pipelines

Binhe Road Section	Side	Diameter	Length (m)	Pipe Selection	Receiving Waterbody
Starting Point: Yingbin Road BHK0+041.85 – Donggou River BHK0+186.71	North	Φ600	150	HDPE double-walled pipe	Donggou River
	South	Φ600	150		
Donggou River BHK0+186.71 – Sanjiacun Road BHK0+542.11	North	Φ800 - Φ1000	360	HDPE double-walled pipe	Donggou River
	South	Φ600 – Φ800	360		
Sanjiacun Road BHK0+542.11 - Wujiayangou BHK1+055.39	North	Φ800 – Φ1000	650	HDPE double-walled pipe	Wujiayangou
	South	Φ600 – Φ800	650		

Binhe Road Section	Side	Diameter	Length (m)	Pipe Selection	Receiving Waterbody
Wujiayangou BHK1+055.39 – Zhongyi Road BHK1+758.48	North	Φ800 – Φ1000	700	HDPE double-walled pipe	Wujiayangou
	South	Φ600 – Φ1000	700		
Zhongyi Road BHK1+758.48 – Qilidiangou BHK2+389.8	North	Φ800 – Φ1000	650	HDPE double-walled pipe	Qilidiangou
	South	Φ600 – Φ800	650		
Qilidiangou BHK2+389.8 – East Qilidian Road BHK2+735.48	North	Φ600 – Φ800	350	HDPE double-walled pipe	Qilidiangou
	South	Φ600 – Φ800	350		
East Qilidian Road BHK2+735.48 – Qili River BHK2+926.28	North	Φ800	230	HDPE double-walled pipe	Qili River
	South	Φ800	230		
Qili River BHK2+926.28 – West Wanshou Street Project boundaries	North	Φ600 – Φ800	250	HDPE double-walled pipe	Qili River
	South	Φ600 – Φ800	250		
Binhe Road BHK3+150 – Xueyuan Road BHK3+686.11	North	Φ600 – Φ800	550	HDPE double-walled pipe	West Qingzhang River
	South	Φ600 – Φ800	550		
Xueyuan Road BHK3+686.11 – Taihang Road BHK4+410.12	North	Φ800 – Φ1200	750	HDPE double-walled pipe	West Qingzhang River
	South	Φ600 – Φ800	750		
Tanghang Road BHK4+410.12 – Ending Point: West Jiangjun Road BHK4+966.5	North	Φ600 - Φ1000	600	HDPE double-walled pipe	West Qingzhang River
	South	Φ600 – Φ800	600		

3. Output 3: Inclusive Water Supply and Wastewater Collection Services Achieved

95. Water supply and water pollution control components of the project aim to improve water supply for rural areas (including rural communities and industrial facilities), and water pollution control infrastructure to improve the efficiency of wastewater conveyance and treatment. Industrial demand is mainly from scattered facilities in rural areas, as well as the Longquan Industrial Innovation Demonstration Zone (Industrial Park).

3.1 Rural Water Supply System

96. The existing rural water supply in Zuoquan County is limited, and unless there are improvements, water demand is expected to exceed supply based on calculations made in the FSR (Table IV-14).

Table IV-14. Rural Water Demand Assessment

Location		Domestic Water Demand (highest day) (m^3/d)		Existing Water Supply Facilities (m^3/d)
		2020	**2030**	
City South	Domestic Water	964	1,112	2,500
	Industrial Water	16,005	36,642	
	Sub-total	**16,970**	**37,754**	

Location		Domestic Water Demand (highest day)（m^3/d）		Existing Water Supply Facilities (m^3/d)
		2020	2030	
City North	Domestic Water	1,263	1,456	1,500
	Industrial Water	8,915	37,964	
	Sub-total	**10,177**	**39,420**	

Note: 1. Domestic water demand include domestic water demand and public buildings water consumption; 2. Industrial water demand refers to demand from industrial users in the water supply service area (which is in rural area not in county city area) 3. Both domestic water and industrial water demand calculated in the table has factored in 10% leakage/unforeseeable water losses.

97. The service area for water supply infrastructure to be provided under the project is City South Area (22 Villages) and City North Area (21 Villages), with total service population of 32,134 by 2020 and 34,200 by 2030. The water supply component will also supply 13 industrial users in both City South Area and City North Area.

98. The water supply component will use water from different sources to service domestic and industrial users. Households and public buildings will be supplied with potable water, and industrial users will be supplied with raw water. The structure of the water supply system is shown in Figure IV-24.

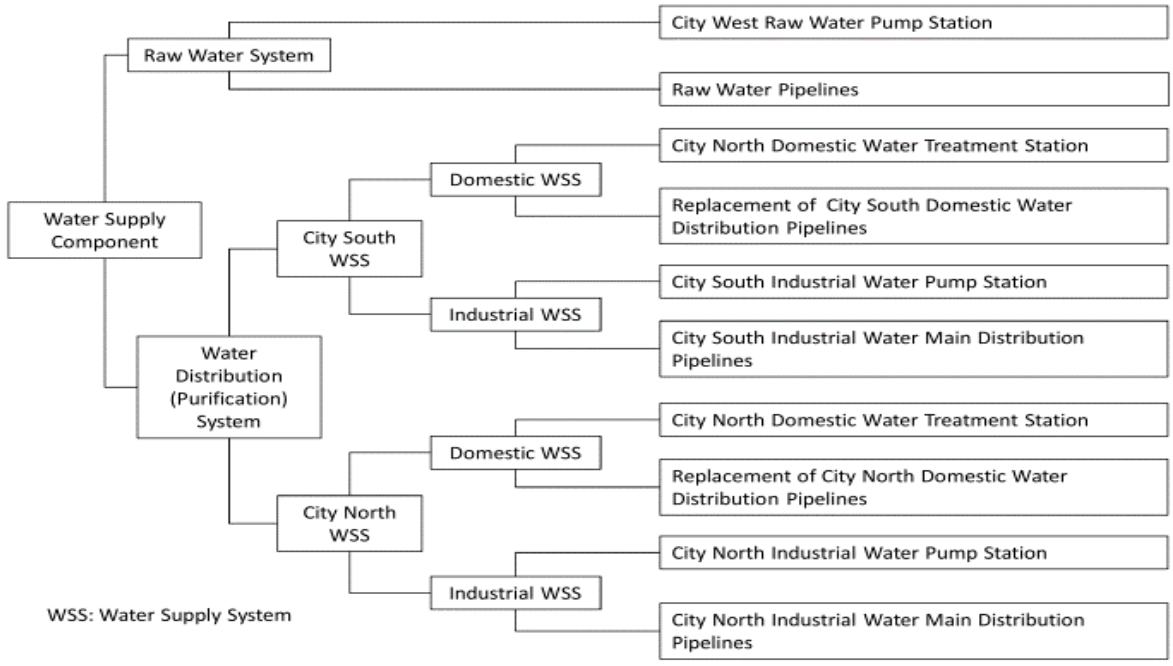


Figure IV-24. Water Supply Component Structure

99. **Water sources.** Water resource efficiency will be improved by supplying water of different quality to residents and industrial users. For industrial users, since they either have their own in-plant treatment system to treat the raw water to required standards for production or they can use raw water directly for production, raw water is supplied directly without centralized treatment. For domestic water supply, the water will be treated to meet drinking water standards. Water for industrial supply will be sourced from Shixia Reservoir, which has sufficient quota to meet this demand (total water demand of industrial users in service area with official water permits is 3,319,300 m^3/yr). Domestic water will be supplied by groundwater from the wells of City West Water Supply Station. The total water demand for domestic use in the service area is 774,100 m^3/yr by 2020 and 892,500 m^3/yr by 2030.

100. The capacity of the existing water transmission system will be upgraded. Twin

transmission pipelines (DN450) will be laid from the Agricultural Park Water Distribution Station to the existing City West Water Supply Station. Then, raw water will be pumped to City North Water Supply System and City South Water Supply System. City West Water Supply Station will be expanded with additional capacity of 28,700 m^3/d.

101. The capacity of the existing water supply pumping system is only sufficient for domestic use. Therefore, the existing system will still be used for supplying potable water. New automatic water treatment stations (WTS) (Silihou WTS-1500 m^3/d; Wulihou WTS-1200 m^3/d) will be built to treat the raw water to drinking water standards. The treatment process will be "filtration (activated carbon filter tank) + disinfection (sodium hypochlorite)" (Figure IV-25). All distribution pipes of the existing system will be replaced to reduce leakage. Blackwater will be treated at the WWTP.

102. A new pumping system will be built for suppling raw water to industries, including pumping stations and distribution pipelines.

103. The overall layout of the water supply system is shown in Figure IV-26. The facilities to be built and replaced are summarized in Table IV-15.

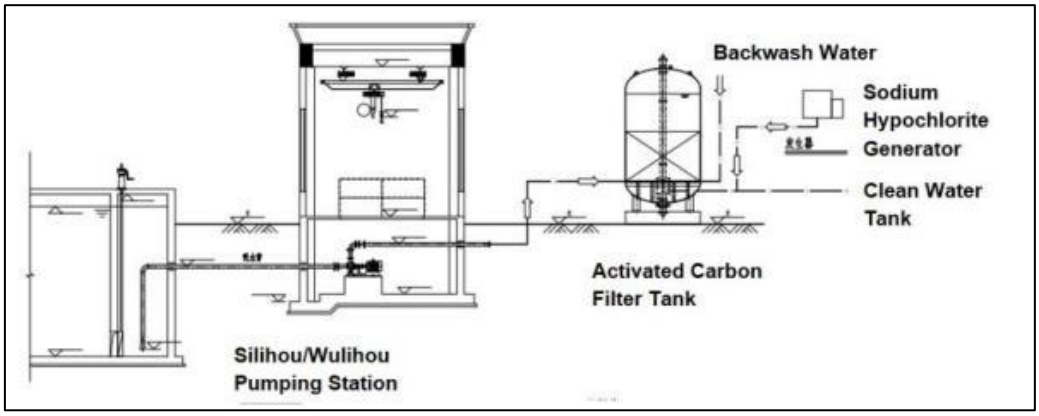


Figure IV-25. Arrangement of Water Treatment Stations

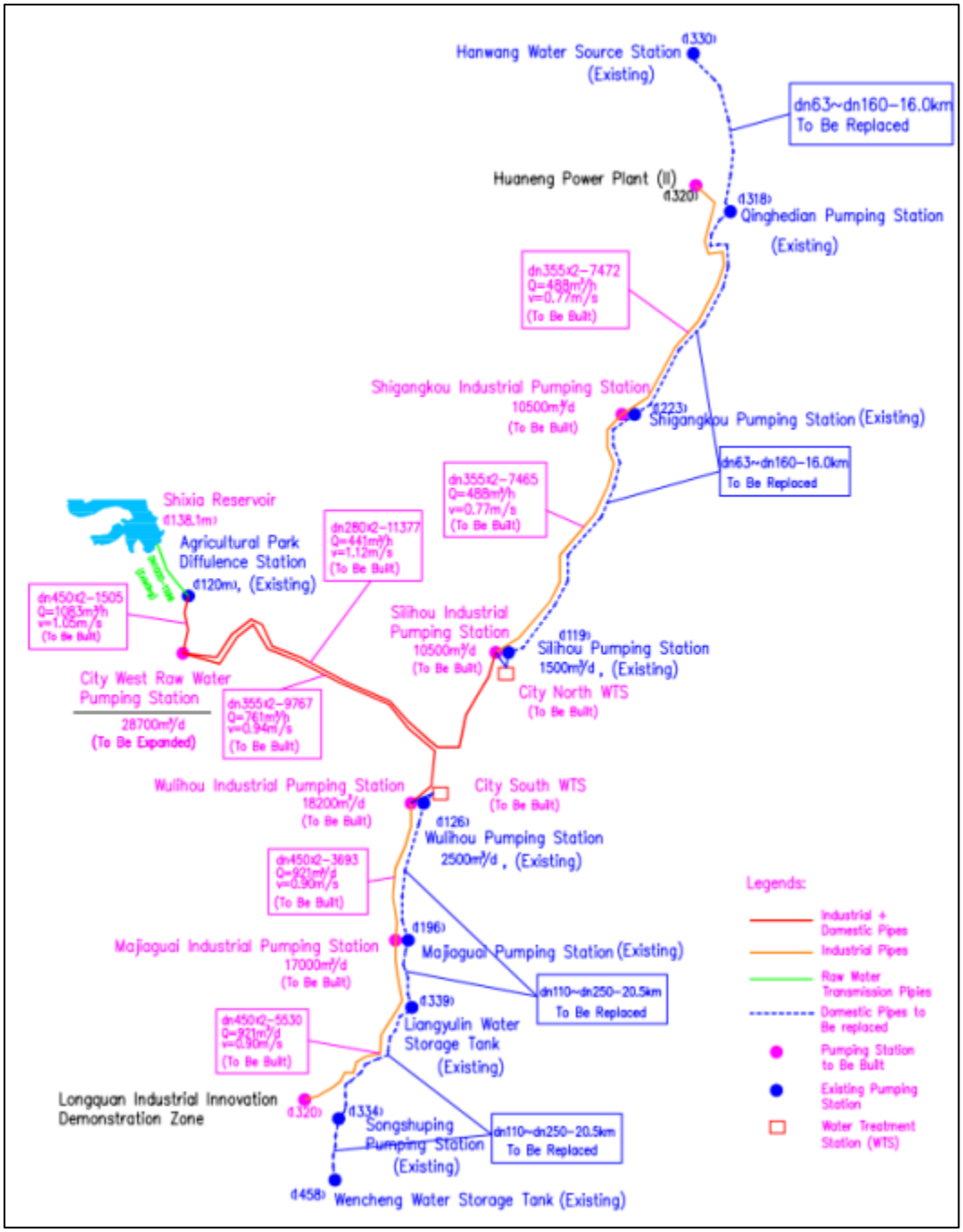


Figure IV-26. Layout of Water Supply System

Table IV-15. Proposed Water Supply Facilities

Name	Design Capacity	Remarks
Raw Water Transmission		
City West raw water pumping station expansion	Capacity 28,700 m^3/d • 441 m^3/d to Silihou Pumping Station (City North) • 761 m^3/h to Wulihou Pumping Station (City South)	Major civil structures include: pumping station building, equalization tank, substation building
Raw transmission pipelines	DN 280~450, 45.298 km • Agriculture Park Distribution Station - City West RW PS: Q=1,083m^3/h, DN450, 1,505 m*2	Steel Wire Reinforced PE pipe

Name	Design Capacity	Remarks
	• City West RW PS - Wulihou PS: Q=761 m^3/h, DN 400, 9,767 m*2 • City West RW PS - Silihou PS: Q=441 m^3/h, DN 280, 11,377 m*2	
Rural Industrial Water Supply		
Wulihou Pumping Station expansion	Add capacity 18200 m^3/d	Major civil structures include: pumping station building, equalization tank, substation building
Silihou Pumping Station Expansion	Add capacity 10500 m^3/d	
Majiaguai Pumping Station expansion	Add capacity 17000 m^3/d	
Shigangkou Pumping Station expansion	Add capacity 9000 m^3/d	
Water Distribution Pipelines	DN355~450, 48.32 km Silihou PS – Shigangkou PS: Q=488 m^3/h, DN 355, 7,465 m*2 Shigangkou PS – Huaneng Power Plant (II): Q=488 m^3/h, DN 355, 7,472 m*2 Wulihou PS – Majiaguai PS: Q=921 m^3/h, DN 450, 3,693 m*2 Majiaguai PS – Longquan Industrial Park: Q=921 m^3/h, DN 450, 5,530 m*2	Steel Wire Reinforced PE pipe Pipelines will be laid along No. 207 State Road
Rural Domestic Water Supply		
Two (2) Water Treatment Stations (WTS) for rural drinking water supply	City South Water Treatment Station (1200 m^3/d) City North Water Treatment Station (1500 m^3/d)	To be built in Wulihou Industrial Pumping Station building To be built in Silihou Industrial Pumping Station building
Replacement of existing water supply pipelines	36.5km, DN63~250. dn63, PN1.6MPa (2400 m) dn90, PN1.6MPa (800 m) dn110, PN1.6MPa (1800 m) dn125, PN1.6MPa (2000 m) dn160, PN1.6MPa (19800 m) dn200, PN1.6MPa (5000 m) dn250, PN1.6MPa (4700 m)	Steel Wire Reinforced PE pipe

3.2 Water Pollution Control

104. The project components for wastewater management will cover Zuoquan County Urban Area. Within this area, there are two wastewater drainage zones: Zone 1 - City West New District and Zone 2 – Zuoquan City Urban Area (Figure IV-27). Currently, only the Zuoquan City Urban Area is served with wastewater collection and treatment facilities.

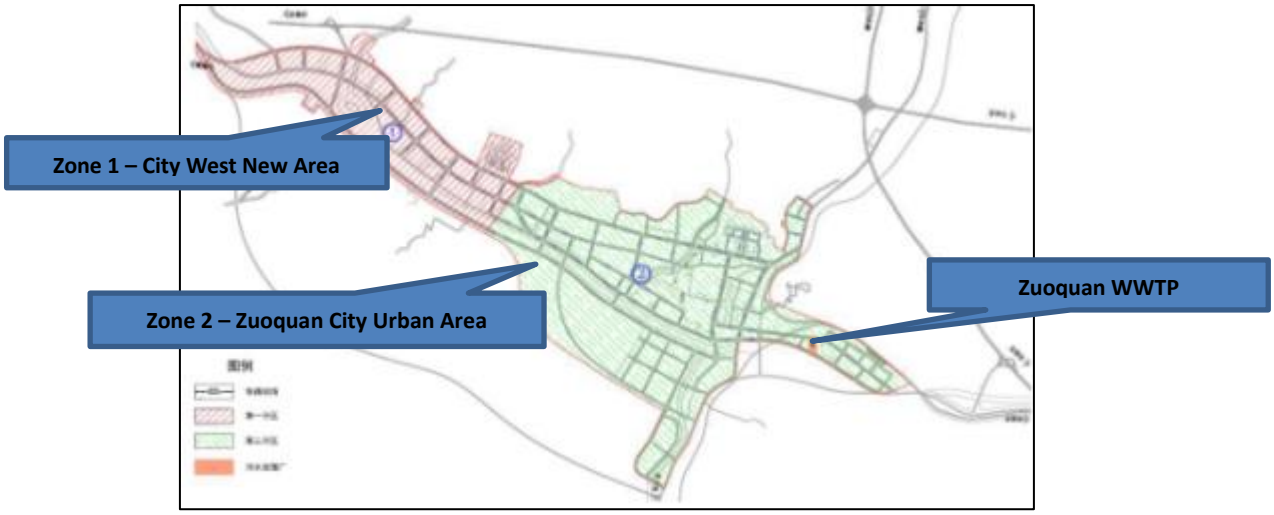


Figure IV-27. Zuoquan County City Wastewater Drainage Zone

105. There are 10 villages in Zone 1 which currently use basic pit latrines and non-flushing dry toilets (Figure IV-28). The wastewater generated from these villages is mainly grey water from showers, laundry, cooking, and dish washing and cleaning. The wastewater is collected through sanitary sewers and covered or open drains and discharged to nearby cannels or rivers. The exact volume of waste water discharge is unknown yet relatively small, but the channels are malodorous and severely polluted with waste water and garbage (Figure IV-29). These pollutants enter the West Qingzhang River and contribute to poor water quality.

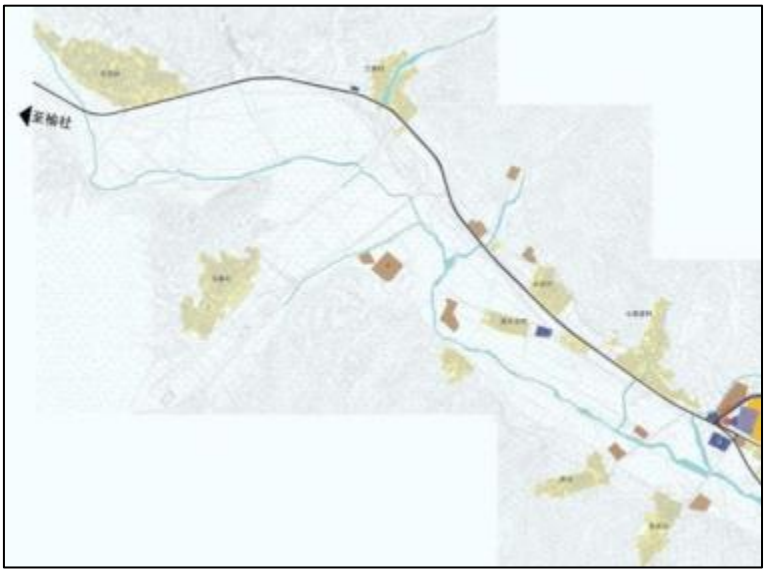


Figure IV-28. Current Land Use of Zone 1 – City West New District
Note – shaded areas are existing villages

Figure IV-29. Poor Wastewater Management in City West New District (Zone 1)

106. The Zuoquan City Urban Area (Zone 2) is still using a combined drainage system for waste water and stormwater. The sewerage coverage rate is above 90%. The combined sewage is collected by an interception trunk sewer (or covered box drains), laid along West Qingzhang River, and directed to Zuoquan WWTP for treatment. Combined Sewage Overflow (CSO) is discharged to West Qingzhang River during storm events. Site investigations undertaken as part of the PPTA found three downstream overflow manholes were discharging wastewater even during dry weather (Figure IV-30), emphasizing the urgent need for and improved wastewater management system.

Figure IV-30. Overflow from existing overflow manholes in dry weather

107. Located at the south east of County City (Figure IV-27), Zuoquan WWTP has a design capacity of 10,000 m^3/d and currently treats 6,400 m^3/d on average. It commenced operation in 2007, using Anaerobic, Anoxic and Oxic (A2/O) as biological treatment. Its effluent meets Class 1A standard of GB 18918-20025. The treatment process is shown in Figure IV-31. It has advanced treatment facilities allowing effluent to be reused in the nearby Huaneng Power Plant as cooling water, and it supplies 2,859 m^3/d reclaimed water to the power plant.

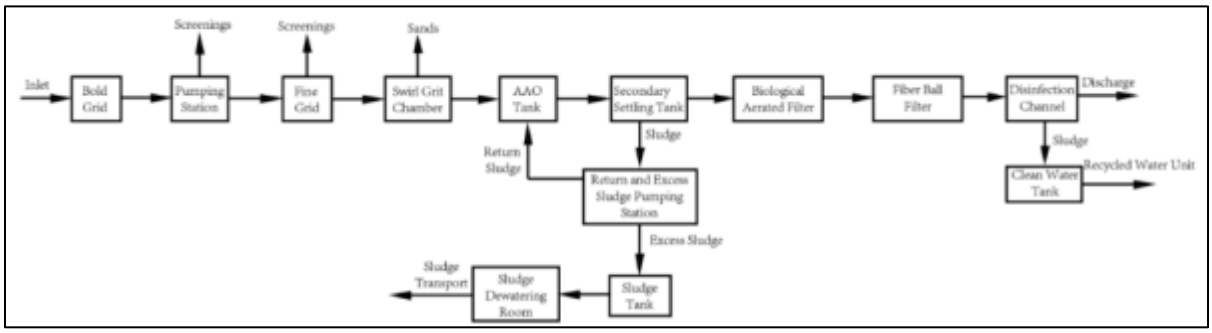


Figure IV-31. Process Diagram of the existing Zuoquan WWTP

108. Zuoquan WWTP was constructed under a Build-Operate-Transfer (BOT) contract, but was transferred to ZCG after one year operation due to poor performance. At present, there are numerous issues with the treatment equipment:

- Rotary coarse screen machines: Only one of the two machines has limited functionality (the other cannot be used at all).
- Wastewater lift pumps in influent pump station: Two of the five wastewater lift pumps are damaged.
- Fine screen machines: Both are out of order, and cannot be operated for more than two hours at a time.
- One of the two microporous aeration systems has poor performance, leading to low dissolved oxygen content in the west pool.
- Two root blowers of 55 kW cannot be used normally.
- Both reflux pumps for mixed liquor are poorly maintained and cannot be used normally
- Chlorine dioxide generator in disinfection canal is out of service.
- One sludge reflux pump is out of service.
- Belt filter press is out of order.
- Biological aerated filter: abnormal and asymmetrical aeration.

109. In addition to existing problems with operation of Zuoquan WWTP, projections of wastewater volume generated in the Zuoquan County City Wastewater Drainage Zone indicate the WWTP will be under capacity in the coming decade. By 2030, wastewater volume

[5] Zuoquan County WWTP was upgraded to meet the Class 1A discharge standard in November 2015.

is expected to be 14,774 m^3/d, while the design capacity of the WWTP is 10,000 m^3/d (Table IV-16).

Table IV-16. Wastewater Volume Forecast

Sewage Source	Sewage Quantity (m^3/d) in 2030
Domestic sewage (1)	11,832
Industrial wastewater (2)	1,599
Unforeseen sewage quantity (3)	1,343
Total	**14,774**

Note: (1) population is estimated at 87,000 by 2030; comprehensive water consumption indicator is taken as 160 L/cap.d; sewage discharge coefficient is taken as 0.85; (2) Planned industrial area = 35.54ha, water use index= 6000 m^3/km^2.d; industrial sewage discharge coefficient = 0.75; (3) assume 10% of total wastewater volume.

110. To summarise, current wastewater management issues in Zuoquan County City include:

- No wastewater collection/treatment facilities in City West New District (Zone 1)
- Zuoquan City Urban Area (Zone 2) still uses a combined drainage system for waste water and stormwater. During heavy rain, Zuoquan WWTP normally will stop operation to avoid impacts to biological treatment processes.
- Some overflow manholes are in poor condition, and wastewater overflows into West Qingzhang River even in dry weather.
- The Zuoquan WWTP is poorly maintained, with various pieces of equipment in poor repair.
- Zuoquan WWTP capacity cannot meet future development needs of City West New District (Zone 1).

111. **Zuoquan County wastewater treatment plant expansion and upgrading.** The Zuoquan WWTP will be expanded to 15,000 m^3/d to treat the wastewater generated across the City by 2030, and to meet the needs of the improved interception ratio. Some faulty and aged equipment will be replaced. The discharge standard of the upgraded WWTP will be Class 1A. Some of the effluent (around 4000 m^3/d) will be pumped to Huangneng Power Plant II to be reused as cooling water (the piping system for reclaimed water supply for power plant cooling will be funded and built by Huaneng Power Group and will not be included in this ADB project). The rest of the effluent will be discharged to West Qingzhang River.

112. The site of the expansion project is located next to the existing WWTP (Figure IV-32). The area of the existing plant is 19,098 m^2, and area for expansion 11,892 m^2. The total area of the Zuoquan WWTP will be 30,990 m^2 after expansion.

Figure IV-32. Satellite Photo of the Existing Zuoquan WWTP

113. **Treatment process.** The expanded Zuoquan WWTP will use modified A2/O as main biological process, similar to the existing WWTP. The advanced treatment process will adopt “Reaction Sedimentation Tank + Micro Rotary Filter + UV Disinfection Process”. The process flow diagram is illustrated in Figure IV-33.

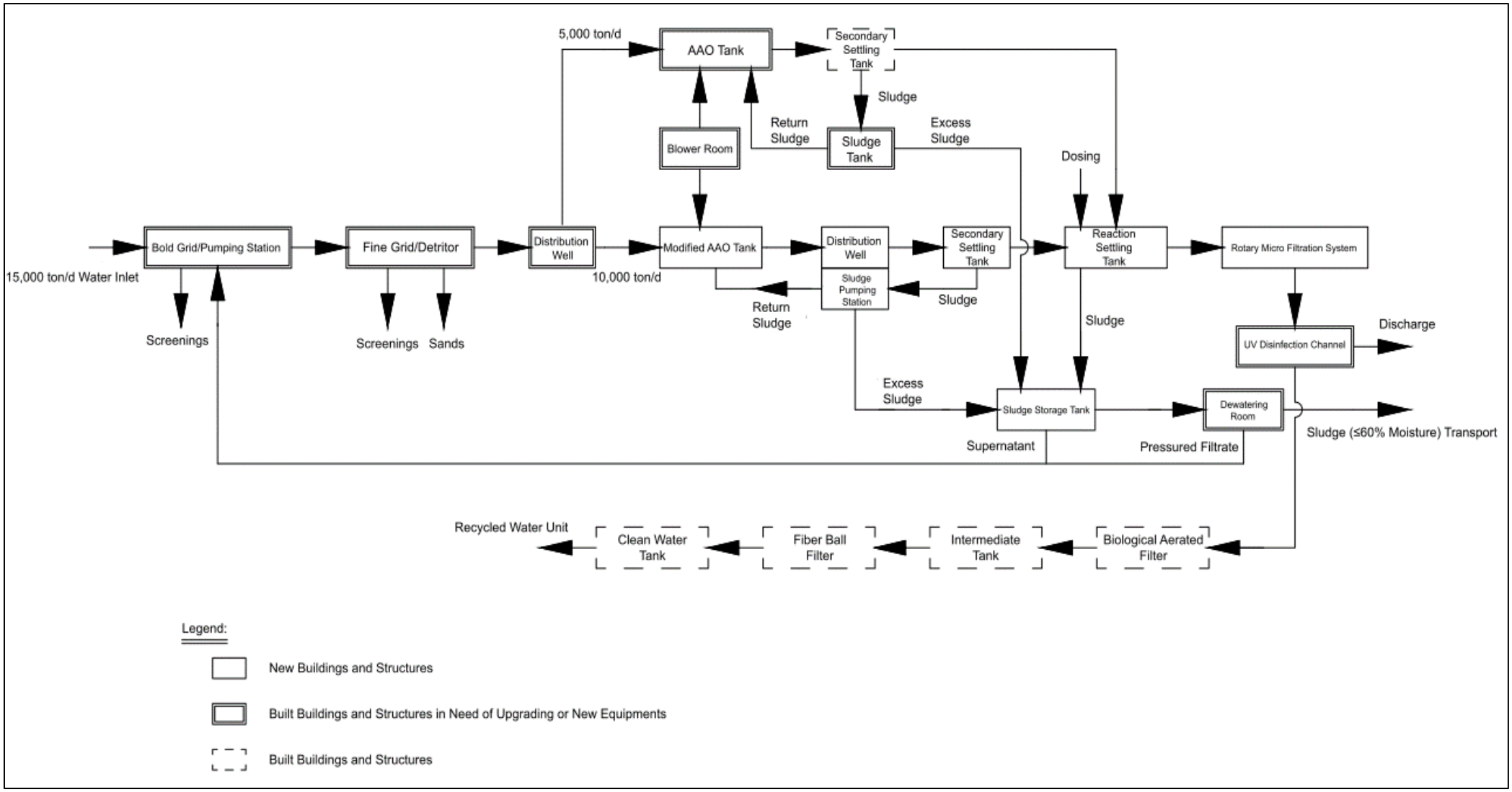


Figure IV-33. Design Treatment Process of Zuoquan WWTP Expansion Project

114. A layout plan of the Zuoquan WWTP (after expansion) is shown in Figure IV-34, and a summary of the various components shown in the layout plan provided in Table IV-17.

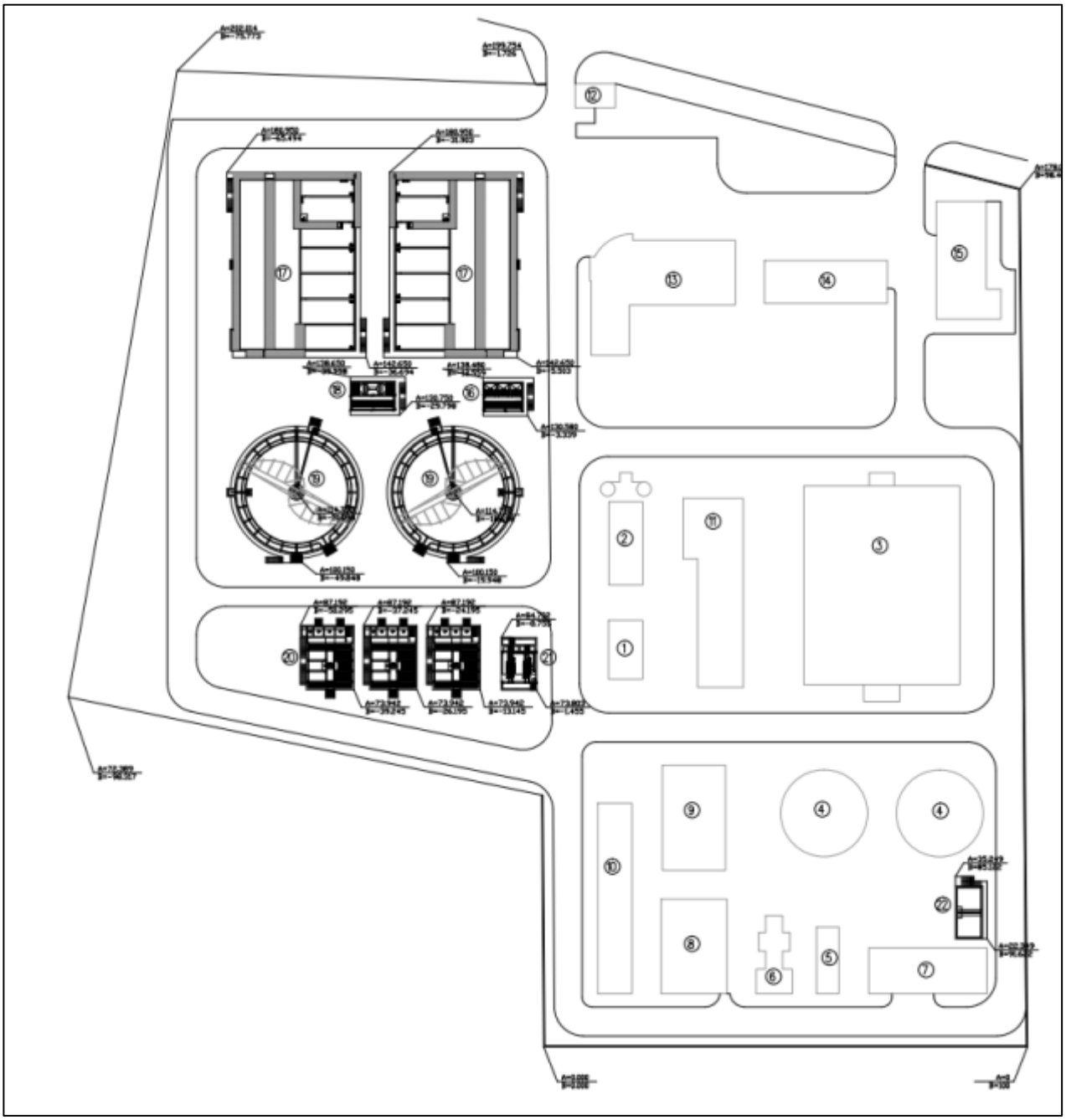


Figure IV-34. Zuoquan WWTP Expansion Project Layout

Table IV-17. Summary of Zuoquan WWTP Components

No.[1]	Structure	Size (m^2)	Remark
1	Bold Grid & Pumping Station	107.58	Existing equipment to be replaced
2	Fine Grid & Detritor	152.86	Existing equipment to be replaced
3	AAO Tank	1369.96	Existing equipment to be replaced
4	Secondary Settling Tank	548.91	Existing equipment to be maintained
5	Sludge Tank	65.46	Existing equipment to be maintained
6	Disinfection Channel	75.11	Existing equipment to be replaced
7	Dewatering Room	232.75	Existing equipment to be replaced
8	Biological Aerated Filter	274.12	Existing equipment to be maintained
9	Clean Water Tank, Intermediate Tank	285.58	Existing equipment to be maintained

No.[1]	Structure	Size (m^2)	Remark
10	Clean Water Room	280.11	Existing equipment to be maintained
11	Transformer Room & Blower Room	403.12	Existing equipment to be replaced
12	Reception Room	41.50	Existing equipment to be maintained
13	Multiple-use Building	474.53	Existing equipment to be maintained
14	Workshop, Garage, Warehouse	228.73	Existing equipment to be maintained
15	Boiler Room, Canteen, Bathroom	274.30	Existing equipment to be maintained
16	Distribution Well	72.83	New equipment
17	Modified AAO Tank	2095.74	New equipment
18	Distribution Well, Return & Excess Sludge Pump Station	88.68	New equipment
19	Secondary Settling Tank	1220.58	New equipment
20	Reaction Settling Tank	439.23	New equipment
21	Rotary Micro Filtration System	79.56	New equipment
22	Sludge Storage Tank	77.35	New equipment

Note: (1) Numbering refers to legend in Figure IV-34

115. **Sludge treatment and disposal.** Sludge will be transport to Zuoquan County Domestic Solid Waste Landfill for co-landfilling with domestic solid waste after dewatering to water content of 60% with high pressure elastic filter press dewatering press process. The sludge treatment process is shown in Figure IV-35, and the produced sludge with 60% moisture rate will be about 3.75-7.5 t/d (estimates from the designed capacity of WWTP, wastewater treatment process, and the moisture rate requirement of sludge for landfill). The Zuoquan County Domestic Solid Waste Land Fill Plant has a total capacity of 600,000 m^3 and maximum daily design treatment capacity of 80 t/d. It has been put into service at the end of 2010 and has a total design service period of 16 years. A Phase II construction for expansion has been planned. These disposal measures for sludge achieve compliance with the PRC guidelines on both the sludge treatment for WWTP and domestic solid waste landfill.

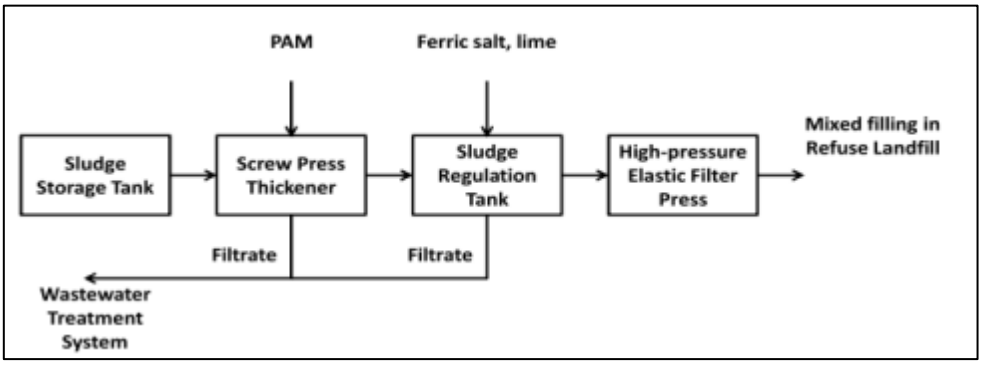


Figure IV-35. Sludge Treatment Process

116. **Sanitation sewers of the City West New District.** A total of 4.97 km trunk sewers (DN400-DN500) will be laid along Binhe Avenue, connecting to a 2.4 m*2.6 m box drain under the avenue. The trunk sewers will be constructed together with the road. Specification of the pipelines are summarized in Table IV-18.

Table IV-18. Sanitation Sewers of City West New District

Pipe Diameter (mm)	Depth (m)		Sub-total
	1.0-2.0	2.0-3.0	
400	2077 m	731 m	2808 m
500	550 m	1612 m	2162 m
Total			4970 m
Manhole			
φ1000	65 No.s	59 No.s	124 No.s

Drop Shaft	3 No.s

117. **Replacement of the existing interception trunk sewer.** The existing interception trunk sewer that links the box drain under Binhe Avenue and the Zuoquan WWTP will be replaced by DN800 reinforced concrete pipelines. The total length of pipe replacement will be 1.29 km. The designed pipelines are summarized in Table IV-19.

Table IV-19. Replacement of the Existing Interception Trunk Sewer

Pipe Dia.(mm)	Depth (m)		Sub-total
	1.0-2.0	2.0-3.0	
800	354 m	936 m	1290 m
Manhole			
φ1000	7 No	18 No	25 No

118. **Upgrading of overflow manholes.** Four existing overflow manholes with existing poor condition will be reconstructed to improve the interception ratio of the CSO in the built up area of the county city to 2.0, and to prevent pollution caused by overflow in dry weather. The locations of these wells are shown in Figure IV-36.

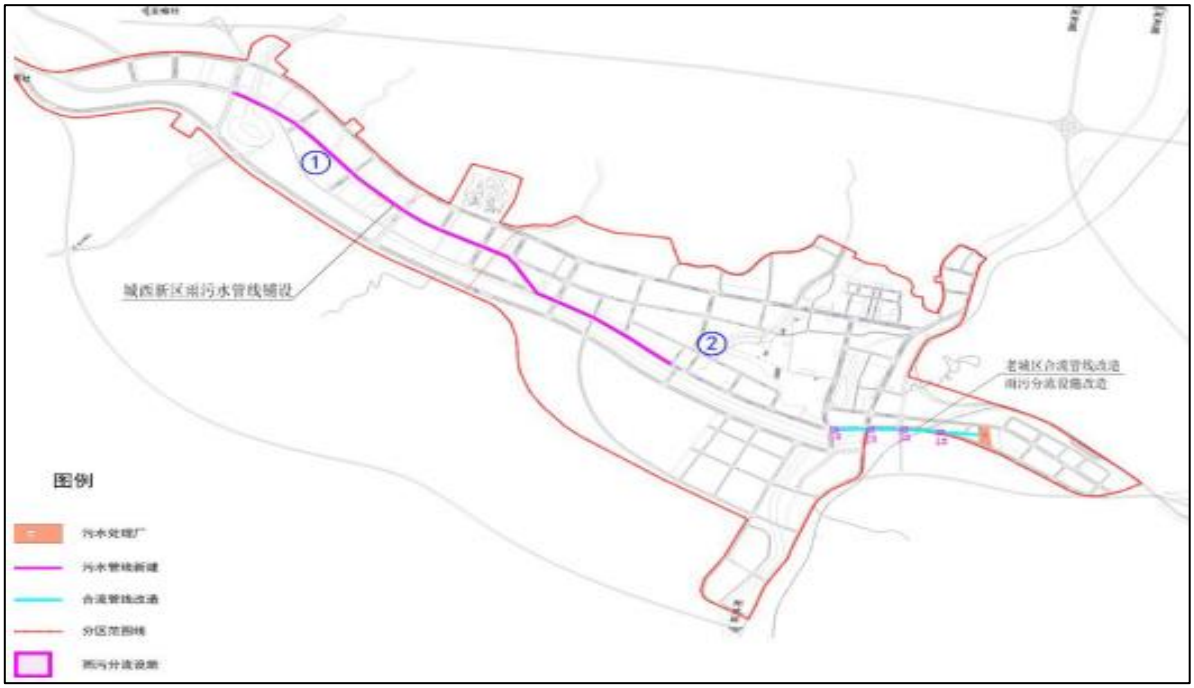


Figure IV-36. Location of the Overflow manholes Proposed for Reconstruction

119. Unlike conventional overflow manholes, regulating valves and adjustable overflow weirs with floats will be installed to better control the interception ratio, regulating the flow during heavy rain event and intercepting larger suspended solids. The sample design of the overflow manhole is shown in Figure IV-37.

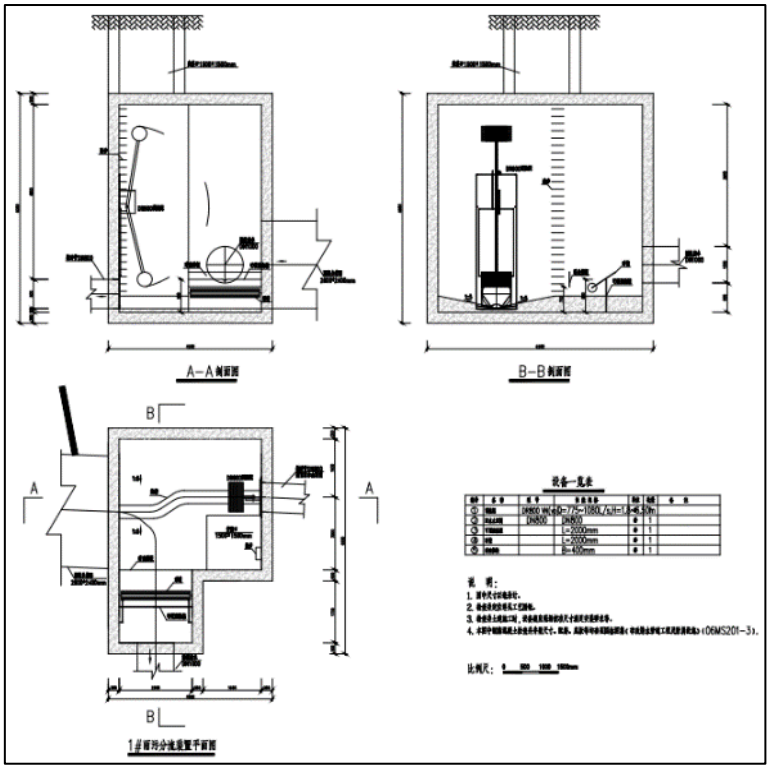


Figure IV-37. Sample of Overflow Manhole Design

4. Output 4: Institutional Capacity Strengthened

120. Capacity building and improved water resource management will comprise four components:

(i) **Project management.** The following capacity building will be provided:

- For IAs/PIOs: project management (business planning, performance management, organizational design, quality management and information management); planning; supervision of consultants; ADB requirements for monitoring, reporting, procurement, disbursement procedures, governance and anti-corruption, and safeguards; application of "3R" policies; design review; contract management; asset commissioning; capital investment planning and appraisal; and, financial management (budgeting, budget control, and management of financial risk for public utility services and capital projects).
- For O&M units: management capacity building (similar to IAs and PIOs); operations and maintenance (asset management and preparation of operational procedures); wetland park management (staff training in management of ecological processes and habitat protection); and integrated pest management (to ensure that constructed wetlands do not become a breeding site for mosquitoes and other disease vectors, whilst at the same time protecting wetland eco-systems.)
- Dam safety at Shixia Reservoir: provision of an automatic data acquisition system for dam safety monitoring; and dam safety training, including preparation of a reservoir operation and maintenance manual, and annual dam safety reports.
- Resettlement external monitoring. A national resettlement consulting firm will be engaged for the project as an external resettlement monitor.

(ii) **Flood warning system.** To enhance the existing flood warning system operated by the Zuoquan Water Resource Bureau (ZWRB) by incorporating real-time information collected from the 5 hydrological stations to be built under Output 1 and provision of appropriate equipment and software. The improved flood warning system will also include

- Telemetry system for water and rain

- Video Surveillance System
- Flood Control Dispatch Simulation System
- Rural rescue emergency equipment and alarm equipment

(iii) **Institutional and capacity strengthening for integrated urban–rural water supply.** The Water Resources Committee is responsible for development, allocation, use, and protection of water.The committee is headed by the County Mayor and consists of representatives from government offices:

Director: County Mayor
Deputy Directors: Vice County Mayor
Director of the Secretary Office of County Government
Director of the Water Resources Bureau

Members: Director of Development and Reform Commission (DRC)
Director of Economic & Trade Bureau
Director of Agricultural Committee
Director of Finance Bureau
Director of Housing and Construction Bureau
Director of Environmental Protection Bureau
Director of Land Bureau
Staff from WRB
Director of Statistics Bureau

The Water Resource Office acts as Secretariat of the Committee responsible for management of surface water, groundwater, reclaimed water and mine water. It has another title "Zuoquan Water Resource Tariff Collection and Inspection Team" for water resource tariff collection. The Office has 16 staff in three sections: (i) administration; (ii) management; and (iii) tariff collection.

There are three water supply stations for rural water supply under administration of Water Resource Committee and one water supply company for water supply for the county town area which is under administration of Zuoquan HURB. Zuoquan government plans to integrate the water supply services into the newly established company. The capacity building for the company include:

(a) Support to expedite the institutional reform process and to improve the operation efficiency
- Design organization setup to operate the water facilities in the county;
- Design operating manual and maintenance manual;
- Identify staff responsibility in key positions;
- Develop customer service satisfaction standards; and
- Establish MIS system.

(b) Private Sector Participation (PSP) Strategy
- Consider how market reforms could be introduced;
- Prepare a detailed strategy for PSP in the WW/WS sector;
- Identify opportunities for the application of service contracts (outsourcing);
- Provide advice on arrangements for corporate governance of water and service contract management;
- Actively support the process of market reform implementation, which is sanctioned by the Provincial Government

(c) Water Tariff Management and Financial Projections
- Study tariff billing, collection, transfer and utilization;

(iv) **Institutional and capacity strengthening for sponge city design (low-impact technologies) for city development.** To promote integration of "sponge city" practices for new urban development areas, the following four measures are proposed under this capacity building component:

- **Prepare a sponge city action plan for new urban development areas.** A consultant team will be procured during the loan implementation to support the local government in preparing a Sponge City Action Plan for new urban development areas. The Sponge City Action Plan will be prepared in accordance with the guidance provided in the *Technical Guideline for Sponge City Construction - Construction of low-impact development stormwater system* prepared by the Ministry of Housing, Urban-Rural Development (October 2014, as updated). The Action Plan will include an assessment of hydrological and meteorological conditions in Zuoquan County to establish clear LID goals and stormwater control targets (such as total runoff control, peak runoff control, runoff pollution control, rainwater utilization, etc.) for various land uses, landscape areas, and urban development zones that are designated in the *Regulatory Detailed Planning of Zuoquan Urban Area (2011-2030).*

- **Prepare low-impact development standards to be implemented in new urban construction.** The Action Plan will also identify LID technologies and practices that can be implemented in Zuoquan County to support the achievement of the LID goals and targets across various types of urban development (buildings and neighborhoods, roads, green space and water systems). The Sponge City Action Plan will also identify requirements for design and construction review, approval and inspection of LID technologies and practices that will be integrated with current review, approval and inspection processes for urban development in Zuoquan County. An economic assessment of the Sponge City Action Plan will be undertaken to ensure that the selected targets and project cost impacts related to the various LID technologies and practices proposed are economically viable. Also, the Consultant team will support consultations with various local government departments including, Housing Security and Urban & Rural Construction Management Bureau, Water Resources Bureau, Environmental Protection Bureau and Communication and Transportation Bureau during preparation of Sponge City Action Plan and technical standards.

- **Develop training of trainers on the sponge city action plan and LID standards.** The Consultant team will develop training materials including a toolkit and guidance materials to promote the implementation of the Sponge City Action Plan and related LID technologies and practices. Also, "training of trainers" will be conducted to increase awareness amongst the local government officials and urban development practitioners in the County with regards to the benefits of implementing the Sponge City Action Plan and to increase knowledge about how the various LID technologies and practices can be integrated with urban development. To promote innovative aspects, a demonstration project has been developed where sponge city technologies are proposed in the design of Binhe Road. These proposed technologies include: (i) rain garden with bioswales, open curbs and tree pits along both sides of the road,

collecting stormwater runoff from the paved road surfaces. The bioswales will be connected to the stormwater system under the road; and (ii) permeable paving will be used for >70% of cycle/pedestrian paths. The sponge city elements aim to manage >70% of stormwater runoff from the road, and increase green space along the road >20%. Binhe Road will provide a case study for showcasing the application of sponge city concepts on a road project.

- **Prepare monitoring framework for sponge city and LID implementation (pilot on Binhe Road).** A monitoring framework will be prepared to assess the impact of LID technologies and practices in the new urban development areas and whether the stormwater control targets established in the Sponge City Action Plan are met. A pilot test of the monitoring framework will be conducted in the Binhe Road area to assess if the stormwater management goal of 70% has been met. The purpose of the monitoring framework will be to determine the potential impact of the LID technologies on stormwater management in the new urban development areas and to identify if future modifications to the Sponge City Action Plan are required.

D. Associated Facilities

121. Solid waste management infrastructure servicing the project area that will interface with the project are described in the following sections.

1. Solid Waste Management

122. Dewatered sludge from the Zuoquan WWTP is transported to the Zuoquan Landfill, located several kilometres from the WWTP. The landfill has a capacity of 0.6 m^3 million, with only 0.1 m^3 million currently used. The average daily rate of dewatered sludge generation is 5-6 m^3/day, with around 80% moisture content.

V. DESCRIPTION OF THE ENVIRONMENT

A. Environmental Setting

123. **Hydrology and water resources.** The West Qingzhang River is a major tributary of the Zhang River is a water resource for 1.92 million people in six counties of Shanxi Province.

124. **Shixia Reservoir.** The Shixia Reservoir is located in the upper catchment of Shixia County, 10 km upstream and to the northwest of the Zuoquan urban centre (Figure IV-2). The catchment area of Shixia Reservoir is 754 km^2, including 137.8 km^2 of Huangtu plateau ravine area (18.28% of the catchment), and 616.18 km^2 of sand shale hills (81.72% of the catchment). The topography of the area around the reservoir is shown in Figure V-1.

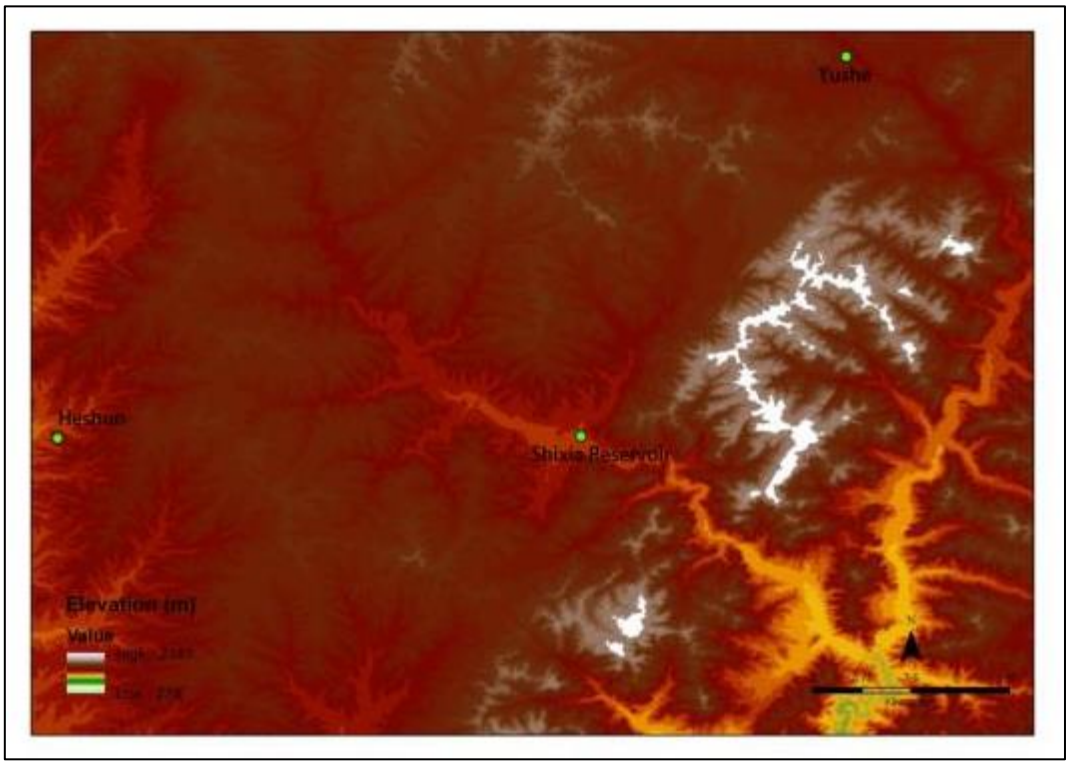


Figure V-1. Topography of Zuoquan County

125. The reservoir was built in the 1960s and has been augmented several times to increase storage capacity (Section IV). The facilities of the reservoir have aged and not have received regular maintenance for over 10 years. The existing facilities and operation of the reservoir do not meet flood control requirements, notably the rubber dam on top of the spillway has no pre-overflow function and has been abandoned for years. It is no longer used to regulate the reservoir water level to provide flood storage.

126. **Flooding.** Flooding occurs frequently in Zuoquan, with flood records dating back to 1928. The situation has worsened because of rapid economic development and population growth. The city area contains inadequate structural embankments for flood protection, while rural areas have only isolated earth bunds along river channels, which offer limited flood protection. For the City West New District, river bank protection is almost absent, with only a few soil slopes and earth bunds built during the 1950s to 1980s. These are in dilapidated condition, and some have been washed into the river, impeding the flow. The low elevations of the remaining embankments barely provide a flood protection level of 1 in 5 years. The river channel is also affected by unpermitted dumping and littering.

127. **Water quality protection.** The *Zuoquan County District Drinking Water Source Protection Zoning Technical Report (2007)* identifies two sources of drinking water in Zuoquan County: the Shixia Reservoir and the West Qingzhang River, and delineates protected areas to maintain the water quality in the reservoir and River. Protected areas are classified as Grade I, Grade II Protected Zones and Buffer Area (Figure V-2).

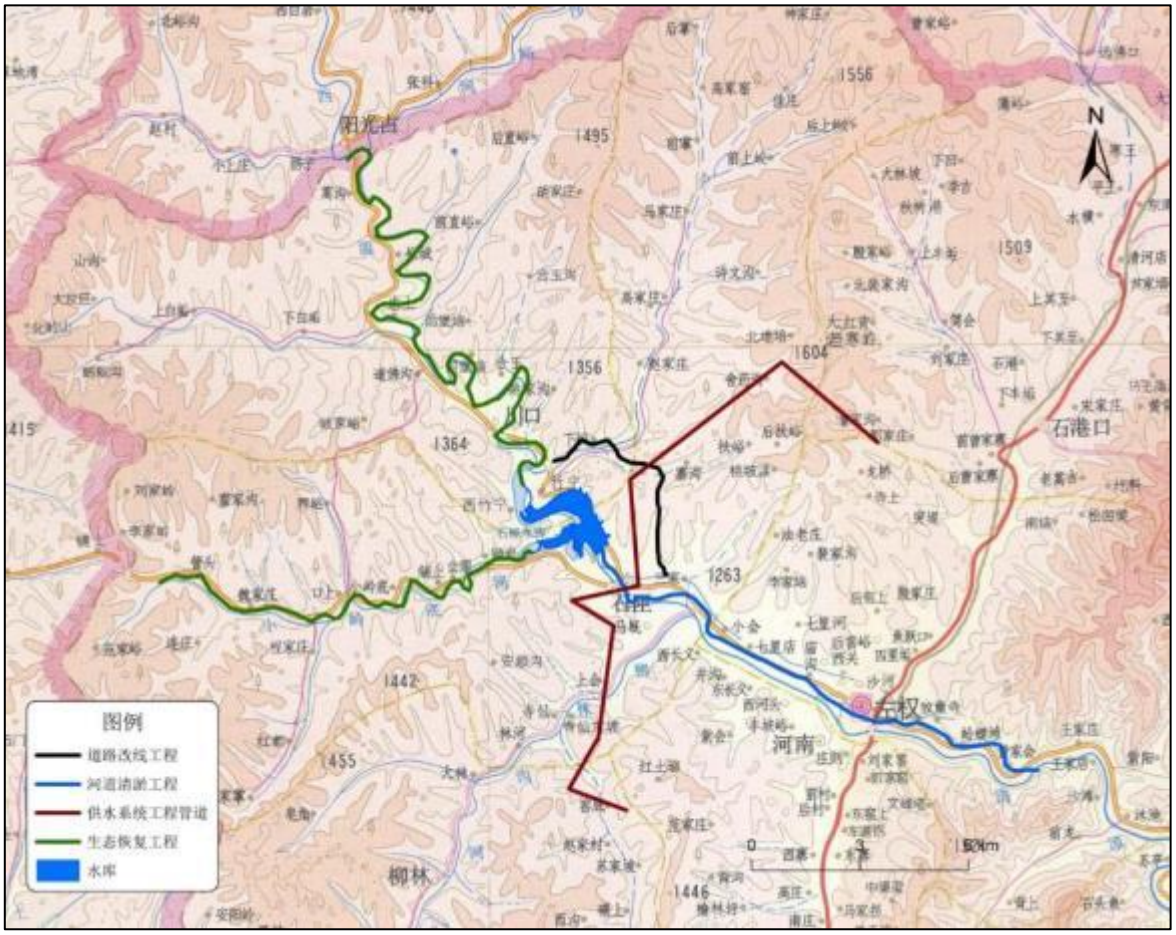


Figure V-2. Water Source Protection Zoning in Zuoquan

128. Grade I protected areas in the Shixia Reservoir comprise a protection zone around water intake pipes for domestic water supply. The zone extends up to 300 m across the water surface of the reservoir, and up to 200 m landward from the water intake (based on an average water level). The Grade II protected area covers 12 km^2 of the hillsides adjacent to the reservoir, and extends 3,000 m upstream from the reservoir of the Xiaolingdi and West Qingzhang Rivers. The Buffer Area covers the remaining catchment of the Shixia Reservoir outside of the Grade I and Grade II protected areas. These areas, particularly Grade II and Buffer Areas include numerous existing villages and agricultural land. These villages and farming activities would not be affected by the Project.

129. Zuoquan is situated in the catchment of the Niangziguan Spring Karst Water System. This extensive groundwater system receives water from a large area of the eastern Shanxi Province, which gradually flows northward and eastward, and forms an important drinking water resource for the Region. The *Regulations on the Protection of Water Resources in Shanxi Province Spring* were adopted in 1997 to better manage the Niangziguan Spring, and provide a broad zoning framework for water quality protection (Figure V-3). Core recharge sites for the groundwater system are naturally occurring springs and water abstraction facilities 70 km north of the project area, and would not be affected by project construction and operation. Nevertheless, regulations require that any development in the catchment is subject to assessment to ensure groundwater resources are protected. A report assessing potential

impacts to the Shanxi Province Spring resulting from this project was produced by Taiyuan Haomiao Water Supply Technology Consulting Limited Company and approved by Shanxi Provincial Water Resource Department in March 2016.

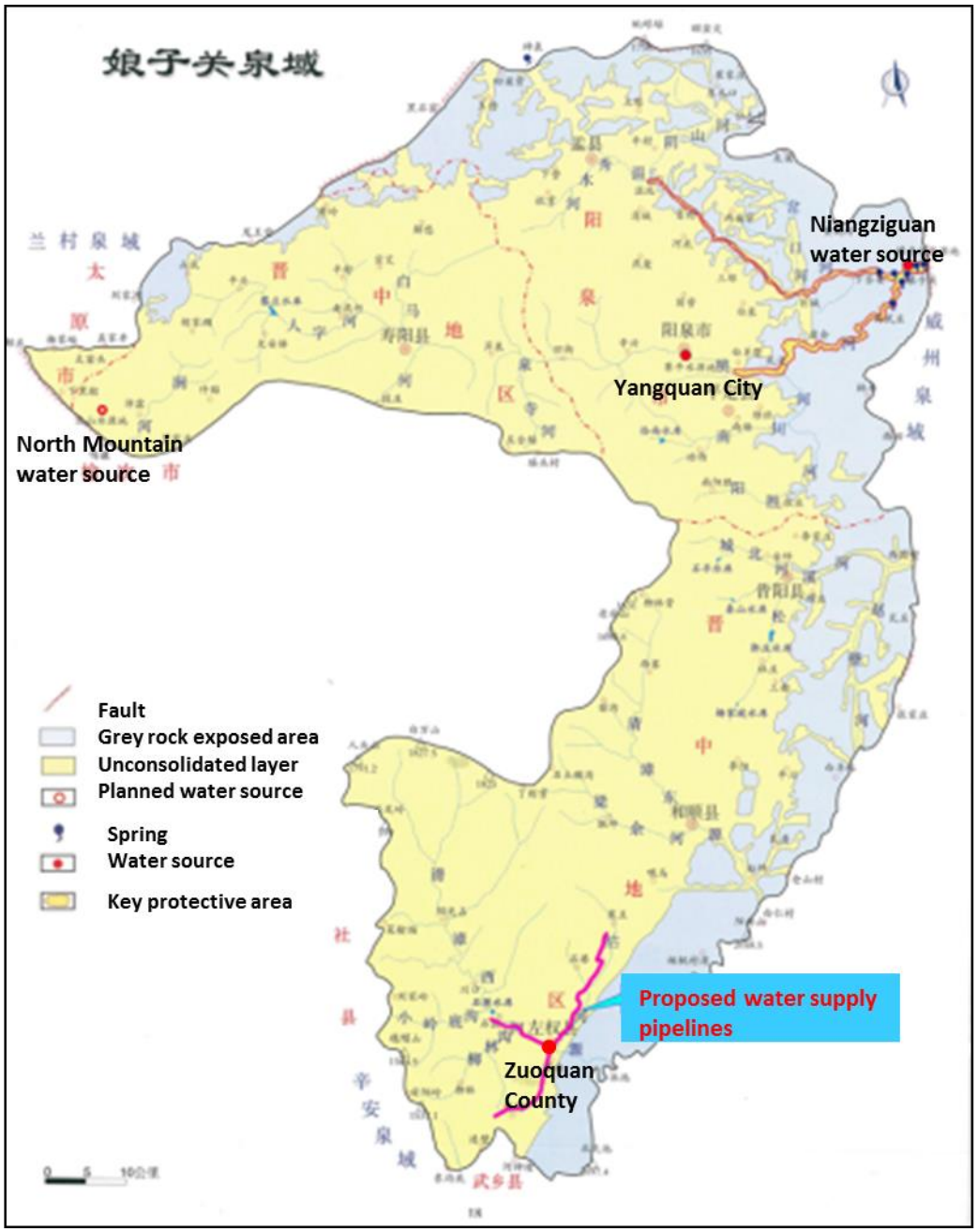


Figure V-3. Niangziguan Spring Karst Water System

Note: Project location indicated by the pink line, Protected Areas of the Spring System indicated by red lines

B. Physical Environment

130. Environmental baseline monitoring was conducted by Shanxi Huapu Test Center in July and August 2016.

131. **Surface water quality.** Water quality data was collected along Xiaolingdi River and West Qingzhang River upstream of Shixia Reservoir (Figures V-4 to V-6). Water quality samples were also collected at three locations near the outflow of Zuoquan WWTP (Figure V-6), and at the routine surface water monitoring section at the Shixia Reservoir outflow. Sampling and

analysis were conducted according to *Technical Specifications Requirements for Monitoring of Surface Water and Waste Water (HJ/T91-2002)* and *Surface Water Quality Standard (GB3838-2002)*. The monitoring locations and results are summarized in Table V-1 and Table V-2 respectively.

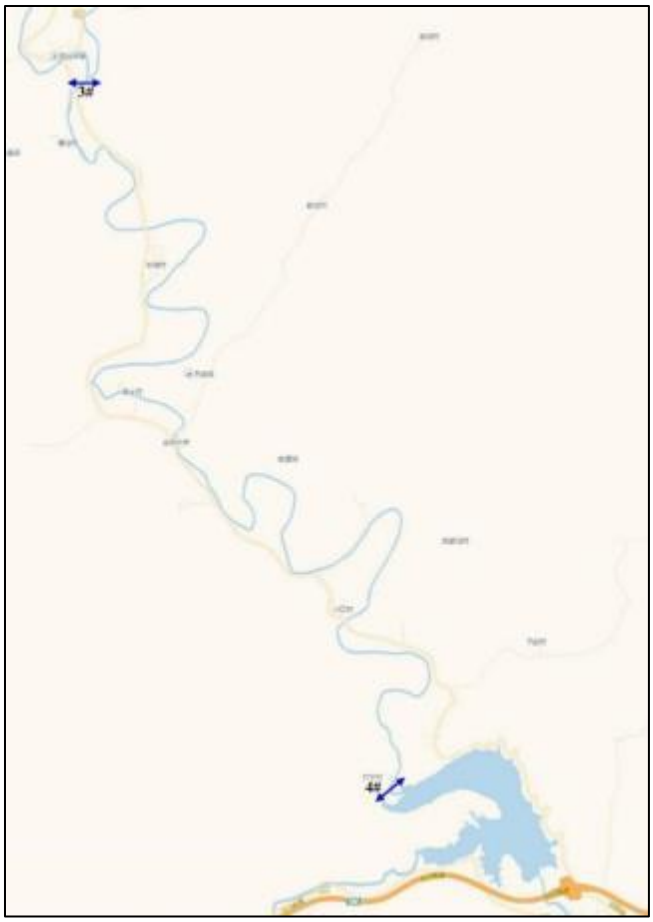


Figure V-4. Monitoring Location of Surface Water along Xiaolingdi River

Figure V-5. Monitoring Location of Surface Water along West Qingzhang River (Upstream of Shixia Reservoir)

Figure V-6. Monitoring Location of Surface Water along West Qingzhang River (Downstream of Shixia Reservoir)

Table V-1. Monitoring Sections of Baseline Surface Water Quality Sampling

No.	Area		Monitoring Location/Section
1	Xiaolingdi River		500 m down from the Guantou Village
2			where the Xiaolingdi River discharges into Shixia Reservoir
3	West Qingzhang River	Upstream of Shixia Reservoir	500 m down from the Yangguangzhan County
4			where the Xiaolingdi River discharges into Shixia Reservoir
5		Downstream of Shixia Reservoir	500 m down from Shixia County
6			500 m down from Xichangyi Village
7			under the Tianzilianlu Bridge down from the Shixia Reservoir
8	Area close to the outflow of Zuoquan WWTP	Upstream	500 m upstream of drain outlet
9		Downstream	500 m downstream of drain outlet
10			1000 m downstream of drain outlet
11	Location of the outflow of Shixia Reservoir		

Table V-2. Baseline Surface Water Quality Sampling and Water Quality Standards

No.	Date	Parameters (mg/L)																						
		pH	DO	I_{Mn}	CODcr	BOD_5	NH_3-N	TP	TN	Cu	Zn	F^-	Se (ug/L)	As (ug/L)	Hg (ug/L)	Cd	Pb	Cr^{6+}	CN^-	volatile phenol	Oil	LAS	S^{2-}	Coliform bacteria	Flow (m^3/s)
1#	7.4	8.09	7.82	2.1	19.2	1.49	0.216	0.9	0.36	ND	ND	0.35	ND	0.3	ND	ND	ND	0.007	ND	ND	0.02	ND	ND	4900	0.0056
	7.5	8.12	7.8	2.08	16.9	0.97	0.192	1.03	0.42	ND	ND	0.37	ND	0.3	ND	ND	ND	0.012	ND	ND	0.02	ND	ND	4600	0.0056
	7.6	8.09	7.77	2.16	16.7	0.79	0.236	1.14	0.46	ND	ND	0.36	ND	0.3	ND	ND	ND	0.005	ND	ND	0.03	ND	ND	4900	0.0057
2#	7.4	8.57	7.76	2.21	12.8	1.3	0.224	0.864	0.4	ND	ND	0.58	ND	3.4	ND	ND	ND	0.005	ND	ND	0.03	ND	ND	7000	0.15
	7.5	8.59	7.7	2.1	11.7	0.78	0.198	0.992	0.52	ND	ND	0.6	ND	3.6	ND	ND	ND	0.007	ND	ND	0.04	ND	ND	4900	0.16
	7.6	8.59	7.25	2.41	11	0.56	0.251	1.02	0.77	ND	ND	0.6	ND	3.8	ND	ND	ND	0.005	ND	ND	0.02	ND	ND	3300	0.17
3#	7.4	7.76	7.24	2.08	27.2	1.19	0.219	1.1	0.82	ND	ND	0.33	ND	1.5	ND	ND	ND	0.007	ND	ND	0.01	ND	ND	700	0.80
	7.5	8	7.31	2.25	22.5	2.73	0.195	1.22	0.77	ND	ND	0.3	ND	1.4	ND	ND	ND	0.006	ND	ND	0.02	ND	ND	1700	0.80
	7.6	7.99	7.28	1.79	24	0.94	0.235	1.16	0.79	ND	ND	0.31	ND	1.5	ND	ND	ND	0.005	ND	ND	0.07	ND	ND	600	0.86
4#	7.4	7.74	7.32	1.91	19.6	1.14	0.229	1.2	1.72	ND	ND	0.32	ND	1.6	ND	ND	ND	0.005	ND	ND	0.03	ND	ND	9400	1.68
	7.5	7.78	7.28	2.05	18.5	2.51	0.424	1.21	0.67	ND	ND	0.33	ND	3	ND	ND	ND	0.005	ND	ND	0.03	ND	ND	1300	1.68
	7.6	7.75	7.26	1.64	17.9	0.79	0.387	1.22	0.68	ND	ND	0.32	ND	2.9	ND	ND	ND	0.005	ND	ND	0.02	ND	ND	4600	1.75
5#	7.4	7.83	7.21	2.45	16	0.59	0.42	0.898	0.96	ND	ND	0.33	ND	0.8	ND	ND	ND	0.005	ND	ND	0.03	ND	ND	1100	0.3
	7.5	8.14	7.16	2.05	16.1	0.99	0.47	0.928	0.95	ND	ND	0.33	ND	0.6	ND	ND	ND	0.009	ND	ND	0.02	ND	ND	7000	0.3
	7.6	8.08	7.18	2.76	17.9	0.75	0.45	0.834	0.98	ND	ND	0.33	ND	0.9	ND	ND	ND	0.005	ND	ND	0.02	ND	ND	1400	0.3
6#	7.4	8.2	7.2	1.98	14.8	0.73	0.521	0.732	0.97	ND	ND	0.32	ND	ND	ND	ND	ND	0.005	ND	ND	0.03	ND	ND	3300	0.34
	7.5	8.35	7.15	2.03	13.7	1.1	0.593	0.776	0.97	ND	ND	0.32	ND	ND	ND	ND	ND	0.005	ND	ND	0.03	ND	ND	2300	0.34
	7.6	8.36	7.16	1.69	12.2	0.75	0.562	0.75	1.04	ND	ND	0.33	ND	ND	ND	ND	ND	0.005	ND	ND	0.03	ND	ND	3300	0.35
7#	7.4	8.66	7.49	4.7	21.2	0.85	1.88	1.15	4.21	ND	ND	1.73	2.7	0.8	0.07	ND	ND	0.005	ND	ND	0.03	0.135	ND	2200	0.49
	7.5	7.59	7.52	4.7	24.1	1.16	1.5	1.2	4.18	ND	ND	2.02	2.5	0.6	0.05	ND	ND	0.01	ND	ND	0.02	0.085	ND	7900	0.49
	7.6	7.58	7.6	5.92	22	1.42	1.5	0.99	4.13	ND	ND	2.02	2.7	0.6	0.07	ND	ND	0.006	ND	ND	0.03	0.065	ND	1400	0.50
8#	7.4	7.34	7.25	4.32	22.8	1.31	1.7	0.77	5.79	ND	ND	1.47	3.5	1.6	0.16	ND	ND	0.006	ND	ND	0.07	0.112	ND	1300	0.52
	7.5	7.41	7.32	4.15	24.5	1.37	1.47	1.1	6.17	ND	ND	1.73	3.5	1.3	0.11	ND	ND	0.1	ND	ND	0.11	0.072	ND	1700	0.52

No.	Date	Parameters (mg/L)																							
		pH	DO	I_{Mn}	CODcr	BOD_5	NH_3-N	TP	TN	Cu	Zn	F^-	Se (ug/L)	As (ug/L)	Hg (ug/L)	Cd	Pb	Cr^{6+}	CN^-	volatile phenol	Oil	LAS	S^{2-}	Coliform bacteria	Flow (m^3/s)
	7.6	7.39	7.41	5.31	26	1.49	1.4	0.692	5.91	ND	ND	1.6	3.6	1	0.13	ND	ND	0.006	ND	ND	0.08	0.06	ND	1100	0.59
9#	7.4	7.46	7.1	4.29	24.8	2.2	1.73	0.832	6.66	ND	ND	1.26	5.4	1.4	0.18	ND	ND	0.007	ND	ND	0.09	0.102	ND	9400	1.04
	7.5	7.51	7.02	3.23	27.4	1.89	1.9	0.958	7.8	ND	ND	1.17	5.7	1.4	0.19	ND	ND	0.012	ND	ND	0.11	ND	ND	7000	1.04
	7.6	7.53	7.16	4.7	32.1	2.81	1.6	0.805	6.67	ND	ND	1.12	5.2	1.2	0.19	ND	ND	0.009	ND	ND	0.08	ND	ND	4900	1.16
10#	7.4	7.49	6.98	4.13	27.2	2.69	1.44	0.796	7.14	ND	ND	1.17	5	1.7	0.07	ND	ND	0.009	ND	ND	0.01	0.089	ND	3500	1.10
	7.5	7.64	7.02	2.25	30.6	2.59	1.52	0.841	8.02	ND	ND	1.12	5	1.3	0.04	ND	ND	0.015	ND	ND	0.04	ND	ND	3500	1.10
	7.6	7.57	7.14	4.28	40.3	2.93	0.966	0.801	7.46	ND	ND	1	5.9	1.3	0.09	ND	ND	0.008	ND	ND	0.02	ND	ND	2400	1.22
11#	2016.3	7.35	10.4	1.5			0.316	0.023				0.27												86	
	2016.4	7.68	10.8	1.7			0.318	0.025				0.29												98	
	2016.5	7.43	9.8	1.5			0.321	0.023				0.27												92	
Class II standard of GB 3838-2002		6-9	6	4	15	3	0.5	0.1	0.5	1.0	1.0	1.0	10	50	0.05	0.005	0.01	0.05	0.05	0.002	0.05	0.2	0.1	2000	
Class III standard of GB 3838-2002		6-9	5	6	20	4	1.0	0.2	1.0	1.0	1.0	1.0	10	50	0.1	0.005	0.05	0.05	0.2	0.005	0.05	0.2	0.2	10000	

Note: ND=Not Detected

132. Samples from the Xiaolingdi and West Qingzhang Rivers upstream of Shixia Reservoir indicate that most of the monitoring indicators meet Class III requirements, except for Total Phosphorous (TP), which exceeded standards likely as a result of laundry wastewater from villages along the rivers. Total Nitrogen (TN) in monitoring stations (particularly downstream of Shixia Reservoir) exceeded PRC standards, likely as a result of agricultural non-point source pollution. Ammonium nitrate (NH_3-N) in the downstream reaches of West Qingzhang River was high as a consequence of domestic wastewater discharge from villages along the river. Elevated COD_{cr} and F- concentrations were also recorded in in downstream sections, likely from industrial and mining enterprises.

133. Water quality routine samples at the location of outlet of Shixia Reservoir indicate that the water quality in Shixia Reservoir can meet the Class II of GB3838-2002 requirements.

134. **Groundwater resources.** Downstream of Shixia Reservoir, the groundwater aquifer is around 20 m thick, but groundwater lies only 1-1.5 m below ground level. The two main recharge sources are precipitation infiltration and upstream Shixia Reservoir discharging water (Table V-3.

Table V-3. Groundwater Recharge from Precipitation Infiltration

Catchment area		Average precipitation (1956-2008)	Precipitation infiltration supply parameter	Supplementary amount (Q)	Remark
km^2		mm	a	10,000 m^3/yr	
Quaternary valley unconsolidated rock area	6.2	556.0	0.180	62.1	Supplies phreatic acquifer water

135. Groundwater quality parameters were sampled from three existing wells near the site of Zuoquan WWTP according to the *Technical Guidelines for Environmental Impact Assessment—Groundwater Environment (HJ610-2016)*. The monitoring locations are summarized in Table V-4 and shown in Figure V-7, and results are shown in Table V-5.

Table V-4. Baseline Groundwater Quality Sampling Locations

No.	Monitoring Date	Location
GW1	4 July 2016	Shanxi Xinxing Coal and Electricity Group (2 km upstream from Zuoquan WWTP)
GW2		300 m downstream from Zuoquan WWTP
GW3		Huangjiahui Village (3 km downstream from Zuoquan WWTP)

Figure V-7. Baseline Groundwater Quality Sampling Locations

Table V-5. Baseline Groundwater Quality Sampling and Groundwater Quality Standards (mg/L)

Item	Monitoring Location			Category III Standard of GB/T 14848-93
	GW1	GW2	GW3	
pH	7.39	7.7	7.57	6.5～8.5
NH_3-N	0.03	0.04	0.03	0.2
NO_3-N	29.2	4.4	4.9	20
NO_2-N	0.003	0.089	0.007	0.02
Volatile Penol	ND	ND	ND	0.002
CN^-	ND	ND	ND	0.05
As (ug/L)	ND	ND	ND	0.05
Hg (ug/L)	ND	ND	ND	0.01
Cr^{6+}	ND	0.006	ND	0.05
Total Hardness	557	571	437	450
F^-	0.3	0.5	0.4	1.0
Pb	ND	2.7	ND	0.05
Cd	ND	ND	ND	0.01
Fe	ND	ND	ND	0.2
Mn	ND	ND	ND	20
SS	778	988	688	1000
SO_4^{2-}	138	270	148	250
I_{Mn}	0.5	0.62	0.78	3.0
Cl^-	86.7	57.5	49	250
Total coliform bacteria (No./L)	＜2	＜2	＜2	3.0
Total Bacteria(No./mL)	97	98	83	100

Note: ND=Not Detected

136. Groundwater quality of the samples complied with GB/T 14848-93 Category III standards for most parameters. Total Hardness value was high at all sites probably due to local geological condition, and exceeded standards at GW1 and GW2., Some minor exceedences of other parameters (NO_3-N, NO_2-N and SO_4^{2-}) were recorded at GW1 and GW2.

137. **Noise.** Ambient noise sampling was conducted at nineteen sites including both representative sensitive receivers and at the boundary of the existing Zuoquan WWTP. Site No. N12-N19 are sensitive receivers located along Binhe Road (Figure V-8). Following standards for PRC EIA, noise measurements were taken once in the day and once at night on two consecutive days. Monitoring results are summarized in Table V-6.

Figure V-8. Ambient Noise Monitoring Locations

Table V-6. Ambient Noise Sampling and Applicable Noise Standards

No.	Monitoring Location	Monitored L_{eq} (dB(A)) 4 July 2016		Applicable Standard	
		Day	Night	Day	Night
N1	Mujiu City West Pumping Station	51.2	44.4	60	50
N2	Majiaguai Pumping Station	50.5	43.2	60	50
N3	Wilihou Pumping Station	50.1	43.8	60	50
N4	Silihou Pumping Station	50.9	44.2	60	50
N5	Shigangkou Pumping Station	51.1	44.3	60	50
N6	East Boundary of existing Zuoquan WWTP	56.3	48.3	60	50
N7	South Boundary of existing Zuoquan WWTP	54.6	49.1	60	50
N8	West Boundary of existing Zuoquan WWTP	53.7	48.3	60	50
N9	North Boundary of existing Zuoquan WWTP	67.7	65.5	70	55
N10	Qingshuiwa garden (East of the existing Zuoquan WWTP)	52.8	42.8	60	50
N11	Shixia Reservoir Monitoring Station	51.2	42.5	60	50
N12	Qili Village	49.0	43.7	70	55
N13	Xiaohui Village	47.5	42.4	60	50
N14	Xichangyi Village	41.3	40.8	60	50
N15	Qili Village Central School	54.6	42.9	55	45
N16	Zuoquan Vocational and Technical College Teaching Building	51.8	41.8	55	45
N17	Zuoquan Forth School Teaching Building	40.4	41.5	55	45
N18	Changtai Chemical Dormitory	44.6	43.2	60	50
N19	Fertilizer Factory Dormitory	51.3	42.7	70	55

138. Sampling results show noise during the daytime meets requirements for *Environmental Quality Standards for Noise (GB3096-2008)* Class II (appropriate for residential areas) and *Environmental Quality Standards for Noise (GB3096-2008) Class 4a* (areas adjacent to trunk roads) at all sampling sites. At night, levels at Site N9 (at the north boundary of the existing Zuoquan WWTP) exceeded the requirement of, appropriate for areas near to a highway. The

main noise pollution source at this site was from heavy goods vehicles on the S319 road close to the north boundary of Zuoquan WWTP. Noise levels along the Binhe Road (N12-N19) were lower than the PPTA team expected, given the location adjacent to a trunk road, and this is probably due to the limited sampling. The collection of additional baseline data is included in the EMP (Attachment 1).

139. **Air quality.** To provide a baseline for assessment of air quality at Zuoquan WWTP, daily monitoring data (January-March 2015) for SO_2, NO_2, PM_{10}, and $PM_{2.5}$ from Zuoquan was collated and analyzed (Table V-7). Continuous air quality monitoring for NH_3 and H_2S was conducted over seven days (27 July-2 August 2016) at Qinshuiwan Garden, 170 m east of Zuoquan WWTP (Table V-8).

Table V-7. Routine Air Quality Sampling and Air Quality Standards

Parameter	Number of samples	Daily average				Standard (Class II of GB 3095-2012) (mg/m³)
		Concentration range (mg/m³)	Ratio of maximum concentration to the standard (%)	Number of samples exceeding standard	Over standard rate (%)	
SO_2	90	0.022-0.216	14.67-144.00	1	1.11	0.15
NO_2	90	0.012-0.057	15.00-71.25	0	0	0.08
PM_{10}	90	0.042-0.184	28.00-122.67	4	4.44	0.15
$PM_{2.5}$	90	0.019-0.099	25.33-132.00	12	13.33	0.075

Table V-8. Baseline Air Quality Sampling and Air Quality Standards

Date	Location	Parameter	
		NH_3	H_2S
		24-hour average (mg/m³)	
2016.7.27-2016.8.2	Qinshuiwan Garden (about 170 m to the east of Zuoquan WWTP)	0.05-0.13	0.005-0.007
Design sanitary standard of Industrial Enterprises (TJ 36-79)		*0.2*	*0.01*

140. The results show that in the project area, the daily average concentration of SO_2 NO_2, PM_{10}, and $PM_{2.5}$ meet the requirement of Class II of *Ambient Air Quality Standards (GB3095-2012)*, and that the ambient levels of NH_3 and H_2S in the residential area close to the existing Zuoquan WWTP meet the allowable concentration standards in *Design Sanitary Standard of Industrial Enterprises (TJ 36-79)*.

141. The DEIA for works along the Binhe Road did not conduct any baseline air quality monitoring, and routine monitoring stations in Zuoquan are too distant from this works area to provide suitable baseline. The collection of baseline data along Binhe Road is included in the EMP (Attachment 1) to provide a baseline for the project construction works.

142. **River sediment.** The quality of river sediments to be removed as dredge spoil was sampled and analyzed by Shanxi Laboratory of Soil Pollution Remediation Technology Development, to ensure compliance with a range of standards and suitability for disposal. The PRC does not have a standard for waterbody sediments. However, since sediments are commonly disposed of on land (most likely for earthwork backfilling or landscaping use), it is common practice to use *Environmental Quality Standard for Soils (GB 15168-1995)* to assess sediment quality. Sediment samples were taken from five river sections to be dredged: Majiu Bridge, Dongchangyi Village Bridge, Abandoned suspension bridge of Binhe Park, east of Taizilianchilu Bridge, and the junction of Ku River and West Qingzhang River (Figure V-10). Eleven parameters were tested for, as shown in Table V-9.

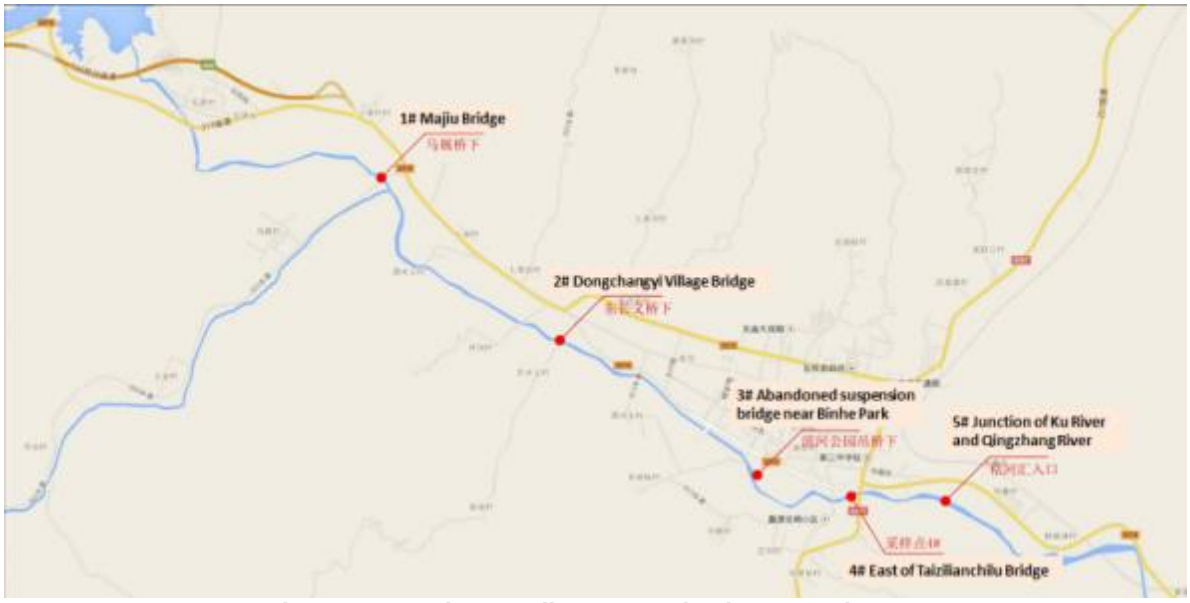


Figure V-10. River Sediment Monitoring Locations

Table V-9. Baseline Sediment Survey and Relevant Standards

Parameter (mg/kg)	Class II of GB15618-1995	Location				
		Majiu Bridge	Dongchangyi Village Bridge	Abandoned suspension bridge near Binhe Park	East of Taizilianchilu Bridge	Junction of Ku River and West Qingzhang River
pH	PH>7.5	8.62	8.26	8.65	8.62	8.38
Cr6+	250	46.3	41.0	51.4	63.6	50.1
Ni	60	26.0	25.0	29.1	115	103
Cd	0.6	0.111	0.126	0.124	0.164	0.284
Cu	100	18.6	20.3	32.9	34.9	48.5
Pb	350	20.0	25.7	22.9	22.1	29.4
Zn	300	50.1	47.5	59.6	93.0	137
Hg	1.0	0.043	0.084	0.074	0.338	0.529
As	20	5.49	3.12	8.57	7.70	10.1
BHC (Lindane)	0.5	0.0005L	0.0005L	0.0005L	0.0005L	0.0005L
DDT	0.5	0.0005L	0.0005L	0.0005L	0.0005L	0.0005L

Note: The "L" in results means not detected, the value is the detection limit

143. Results show that the sediment pollution for most parameters meet Class II *Environmental Quality Standard for Soils (GB 15168-1995)*. However nickel (Ni) content at the downstream monitoring points (east of Taizilianchilu Bridge, and the junction of Ku River and West Qingzhang River) exceeded the standards. Nickel contamination of aquatic systems typically results from domestic wastewater effluents and non-ferrous metal smelters [cadmium (Cd), Ni, lead (Pb) selenium (Se)]. In this instance, the main source is likely to be from industrial and mining enterprises along the river.

C. Ecological Resources

144. **Regional vegetation and habitats.** The catchment of West Qingzhang River has been degraded through forest clearance. The denuded rocky hills have poor, thin soils, which has hampered reforestation efforts. Nevertheless, the area still supports a moderate range of plant species. Habitats in the Area can be classified into four main categories, as shown in Figure V-11. Key features of these habitats are described below:

(i) Meadow or grassland for area elevation higher than 1,800 m, main species: *Stipa capillata*, *Pennisetum centrasiaticum*, *Hippophae rhamnoides*, *Cyperus* Linn., *Bupleurum chinensis*.

(ii) Mixed conifer-broadleaf forest for elevation from 1,500-1,800 m, main species include: *Pinus tabulaeformis*, *Betula platyphylla*, *Populus Davidian*, *Salix pseudotangii*, *Tilia tuan*, *Platycladus orientalis*, *Robinia pseudoacacia*, *Ulmus pumila*, *Amygdalus davidiana*, *Armeniaca sibirica*, *Pyrus betulifolia*, *Hippophae rhamnoides*, *Vitex negundo var. heterophylla*, *Ziziphus jujuba var. spinose*, *Corylus heterophylla*, *Chenopodium botrys*, *Elymus dahuricus*, *Scutellaria baicalensis*, *Anemarrhena asphodeloides*, *Setaria viridis*, *Bothriochloa ischcemum*, *Artemisia carvifolia*.

(iii) Secondary forest and plantation forest for the hills elevation around 1,200 m, main species include: *Pinus tabulaeformis*, *Betula platyphylla*, *Populus davidiana*, *Amygdalus davidiana*, *Armeniaca sibirica*, *Chenopodium botrys*, *Corylus heterophylla*, *Ziziphus jujuba var. spinosa*, *Malus baccata*, *Hippophae rhamnoides*, *Artemisia argyi*, *Elymus dahuricus* and *Xanthoceras sorbifolia*.

(iv) Mainly Plantation forest and orchards for valley area lower than 1,000 m, main species include: *Populus davidiana*, *Salix pseudotangii*, *Ulmus pumila*, *Robinia pseudoacacia*, *Toona sinensis*, *Juglans regia*, *Diospyros kaki*, *Zanthoxylum bungeanum*, *Paulownia tomentosa*, *Ziziphus jujube*, *Amygdalus persica*, *Ameniaca vulgaris*, *Prunus salicina*, *Malus pumila*, *Artemisia carvifolia*, *Phragmites australis*, *Ixeris denticulate*, *Elymus dahuricus*, *Setaria viridis*, *Iris lactea var. chinensis*, *Plantago asiatica*, *Portulaca oleracea*.

145. Remnant meadow and forest communities are largely restricted to the upper sections of the catchment (Figure V-11), upstream of the project area. The project area supports mainly planted forest, orchards, and scattered secondary regrowth (see below). Areas to be revegetated under this project range from 1000-1200 m elevation.

Figure V-11. Habitat Map of the Upper West Qingzhang River Catchment

146. **Regional wildlife resources.** Shanxi Province as a whole supports a moderate diversity of terrestrial and aquatic wildlife. There are more than 400 species of vertebrate terrestrial wild animals in Shanxi, including some 70 species under state protection. The 14 species under first-class protection include white stork, black stork, golden eagle, sea eagle, vulture, brown pheasant, red-crowned crane, great bustard, leopard, tiger and sika deer. The 56 species under second-class protection comprise 40 kinds of birds, two amphibians and 14 kinds of mammals and reptile.

147. **Project area vegetation and habitats.** Site visits were undertaken by the PPTA team to assess ecological conditions in various works areas. The visits focused on areas along the West Qingzhang River where direct/indirect ecological impacts were expected. These include the upper reaches of West Qingzhang and Xiaolindi Rivers, areas around Shixia Reservoir, and downstream reaches of West Qingzhang River. Habitats and vegetation in these areas is described in the following sections. A consolidated list of vegetation recorded from these area is provided in Table V-10. Species recorded are common and widespread, and no species of conservation interest were noted.

148. **Upper reaches of West Qingzhang and Xiaolindi rivers.** The West Qingzhang and Xiaolindi Rivers are the main tributaries of the Shixia Reservoir, meandering through upstream valleys before joining the reservoir from the north and west (Figure V-12). The existing land use types along the two rivers are mainly villages, roads and farmland. There are some existing riparian plantation forest areas along both the rivers, with the main tree species comprising *Populus simonii* and *Salix matsudana*. Other riparian areas are more open, supporting grasses and shrubs (Figure V-13).

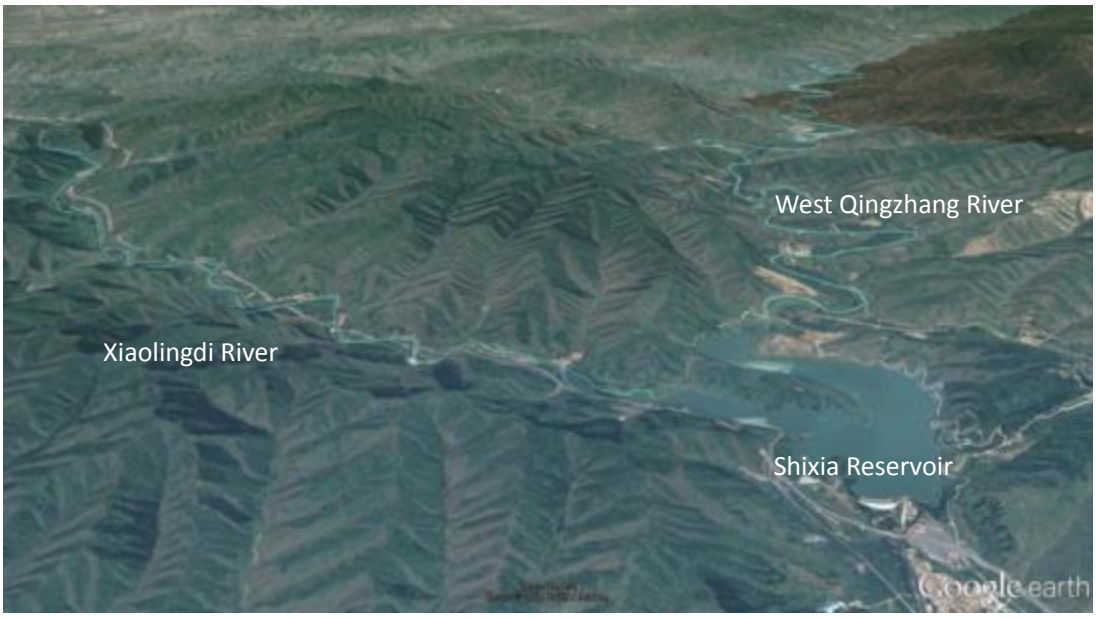


Figure V-12. Satellite Image of Shixia Reservoir and the Two Headwaters

Figure V-13. Existing vegetation types along the headwaters: (1) Lush and wide riparian forest along both banks (2) Wide Grassland along both banks (3) Narrow Grass and Shrubs Adjacent to Villages and Roads

149. Both of the rivers have a relatively narrow main channel (4-5 m) and wider floodplain (20-30 m). For most of the year, water flows in the main channel and the floodplain is inundated only in the wet season. Some river sections are adjacent to the roads or construction areas of the villages, so only a 3-5 m wide grass riparian buffer which is not sufficient for the runoff pollution control purpose can be found in these sections. Species recorded from these areas included:

(i) **Trees.** *Populus simonii*, *Populus davidiana*, *Robinia pseudoacacia*, *Salix matsudana*, *Ulmus pumila*
(ii) Shrubs and Grass: *Hippophae rhamnoides*, *Amorpha fruticose*, *Lycium chinense*, *Belamcanda chinensis*, *Medicago sativa*, *Humulus japonicas*, *Ranunculus japonicus*
(iii) **Wetland species.** *Juncus effuses*, *Phragmites communis*, *Typha orientalis*, *Scirpus triqueter*, *Hydrilla verticillata*, *Potamogeton pectinatus*, *Myriophyllum spicatum*, *Potamogeton crispus*.

150. **Areas around Shixia Reservoir.** Existing vegetation coverage of the hillsides around Shixia Reservoir is relatively high, shrubland is the dominant vegetation type (around 70% of vegetation present), with only a small portion of the mountain areas are covered by conifer or mixed forest (approximately 30% of vegetation). Figure V-14 shows typical images of these vegetation types.

Figure V-14. Typical forest (left) and shrub land (right) vegetation around the Shixia Reservoir

151. Site surveys and interviews with local authorities confirm that there is an extensive reforestation program in place around Shixia Reservoir, with thousands of young pine trees (*Pinus tabulaeformis*) planted during recent years. However, these efforts have been poorly documented, and there are no formal records showing where trees have been planted, aftercare programmer or success rates.

152. Species recorded from around Shixia Reservoir included:

(i) **Trees.** *Populus simonii*, *Populus davidiana*, *Robinia pseudoacacia*, *Platycladus orientalis*, *Salix babylonica*, *Salix matsudana*, *Pinus tabulaeformis*, *Toona sinensis*.
(ii) **Shrubs and grass.** *Corylus heterophylla*, *Vitex negundo*, *Anemone tomentosa*, *Ziziphus jujuba*, *Lycium chinense*, *Armeniaca sibirica*, *Setaria viridis*, *Xanthium sibiricum*, *Plantago asiatica*, *Leonurus Artemisia*, *Artemisia carvifolia*, *Cannabis sativa*, *Vicia cracca*, *Eleusine indica*, *Polygonum orientale*, *Melilotus officinalis*, *Cosmos bipinnata*, *Elymus dahuricus*, *Medicago sativa*.

153. **Downstream reaches of West Qingzhang River.** The downstream reaches of West Qingzhang River below the Shixia Reservoir pass through various land uses including rural, urban and industrial areas. There are some existing riparian planting along the river, mainly of *Populus simonii* and *Salix matsudana*. Overall, habitats in this area were relatively degraded due to the following factors:

(i) Water flow rates are very low due to upstream regulation by the Shixia Reservoir, with virtually no surface water observed in some areas. Two inflatable dams have been installed

where the river flows through the urban area of Zuoquan County. The water accumulated behind these dams supports some vegetation associated with lentic wetland habitats including *Typha orientalis*, *Phragmites communis*, *Sagittaria sagittifolia*, *Alisma plantago-aquatica*, *Juncus effuses*, *Potamogeton malaianus*, *Hydrilla verticillata*, *Polygonum lapathifolium*, *Potamogeton pectinatus*, and *Potamogeton crispus*. These wetland plants contribute to the river water quality improvement and provide habitat for birds and other wildlife.

(ii) Water quality in the river channel is very poor

(iii) Some areas of the embankment have been replaced by vertical concrete/masonry walls.

154. Species recorded from these areas included

(i) **Trees.** *Populus simonii*, *Pinus tabulaeformis*, *Salix matsudana*, *Salix babylonica*, *Euonymus maackii*

(ii) **Shrubs and grass.** *Sophora japonica*, *Sanguisorba officinalis*, *Polygonum orientale*, *Amaranthus retroflexus*, *Humulus japonicas*, *Setaria viridis*, *Taraxacum mongolicum*, *Rumex crispus*

(iii) **Wetland species.** *Juncus effuses*, *Phragmites communis*, *Typha orientalis*, *Scirpus triqueter*, *Alisma plantago-aquatica*, *Sagittaria sagittifolia*, *Hydrilla verticillata*, *Potamogeton pectinatus*, *Potamogeton malaianus*, *Myriophyllum spicatum*, *Potamogeton crispus*.

Table V-10. Summary of Vegetation Recorded from the project area

Type	Scientific Name	Distribution[a]	Protected Status
Trees	*Populus simonii*	1,2,3	-
	Sophora japonica.	1,2	-
	Platycladus orientalis	1	IUCN Near Threatened[b]
	Salix babylonica	1,3	-
	Salix matsudana	1,2,3	-
	Pinus tabulaeformis	1,3	-
	Toona sinensis	1,3	-
	Populus cathayana	1,2	-
	Ulmus pumila	1	-
Shrubs and grass	*Hazelnut*	1	-
	Vitex negundo	1	-
	Anemone tomentosa	1	-
	Ziziphus jujuba	1	-
	Lycium chinense.	1	-
	Armeniaca sibirica	1	-
	Setaria viridis	1,2	-
	Roegneria kamoji	1	-
	Xanthium sibiricum	1	-
	Plantago depressa	1	-
	Artemisia argyi	1	-
	Cannabis sativa	1	-
	Vicia cracca	1	-
	Eleusine indica	1	-
	Polygonum orientale	1	-
	Melilotus officinalis	1	-
	Cosmos bipinnata	1	-
	Elymus dahuricus	1	-
	Medicago sativa	1,2	-
	Hippophae rhamnoides	2	-
	Amorpha fruticosa	2	-
	Belamcanda chinensis	2	-
	Humulus scandens	2	-
	Ranunculus japonicas	2	-
	Sophora japonica	3	-

Type	Scientific Name	Distribution[a]	Protected Status
	Sanguisorba officinalis	3	-
	Polygonum orientale	3	-
	Amaranthus retroflexus	3	-
	Humulus scandens	3	-
	Taraxacum mongolicum	3	-
	Juncus effusus	3	-
Wetland	*Cyperus rotundus*	1,3	-
	Phragmites australis	1	-
	Typha orientalis	1,3	-
	Scirpus triqueter	1,3	-
	Hydrilla verticillata	1,3	-
	Myriophyllum spicatum	1	-
	Potamogeton crispus	1,3	-
	Alisma plantago-aquatica	1,3	-
	Sagittaria sagittifolia	3	-
	Potamogeton malaianus	3	-

[a]1 - Upper Reaches of West Qingzhang and Xiaolindi Rivers; 2 - Areas around Shixia Reservoir; 3 – Downstream reaches of West Qingzhang River; [b]widely planted as an ornamental. Individuals recorded during surveys for this project were planted and do not have conservation significance.

155. **Wildlife in the project area.** Wildlife recorded during site visits as well as interviews with local villagers are summarized in Table V-10. Overall species recorded were common and typical of rural habitats and in the northern PRC. Species richness in the lower West Qingzhang River particularly was affected by degraded habitat quality, including reduced water flow, poor water quality and human disturbance. Species of note recorded included:

(i) Up to eight individuals of black stork (*Ciconia nigra*) are regularly observed at an abandoned village in the upper West Qingzhang River catchment, outside of the project area. The birds stay for a few days every year on migration, as reported by local villagers.

(ii) Mandarin Duck (*Aix galericulata*) are also reported from the upper West Qingzhang River by local villagers. No records of breeding were made from the project area

(iii) A pair of Hobby (*Falco subbuteo*) were recorded hawking dragonflies along the upper Xiaolindi River. There was a large nest in riparian trees close to where these birds were observed, but breeding could not be confirmed.

Table V-10. Summary of Wildlife Recorded from the project area

No.	Chinese Name	Scientific Name	Status
Avifauna			
1	池鹭	*Ardeola bacchus*	-
2	苍鹭	*Ardea cinerea*	-
3	黑鹳	*Ciconia nigra*	National Grade I Protected Species
4	斑嘴鸭	*Anas poecilorhyncha*	-
5	鸳鸯	*Aix galericulata*	National Grade II Protected Species
6	红脚隼	*Falco subbuteo*	National Grade II Protected Species
7	金眶鸻	*Calidris dubius*	-
8	青脚鹬	*Tringa nebularia*	-
9	山斑鸠	*Streptopelia orientalis*	-
10	珠颈斑鸠	*Streptopelia chinensis*	-
11	冠鱼狗	*Ceryle lugubris*	-
12	蓝翡翠	*Halcyon pileata*	-
13	黑枕绿啄木鸟	*Picus canus*	-
14	家燕	*Hirundo rustica*	-
15	金腰燕	*Hirundo daurica*	-
16	黄鹡鸰	*Motacilla flava*	-

No.	Chinese Name	Scientific Name	Status
17	白鹡鸰	*Motacila alba*	-
18	白头鹎	*Pycnonotus sinensis*	-
19	红尾伯劳	*Lanius cristatus*	-
20	黑卷尾	*Dicrurus macrocercus*	-
21	红嘴蓝鹊	*Cissa erythrorhyncha*	-
22	喜鹊	*Pica pica*	-
23	红尾水鸲	*R.fuliginosus*	-
24	短翅树莺	*Cettia diphone*	-
25	黄眉柳莺	*Phylloscopus inornatus*	-
26	大山雀	*Parus major*	-
27	暗绿绣眼鸟	*Zosterops japonica*	-
28	树麻雀	*Passer montanus*	-
29	金翅雀	*Carduelis sinica*	-
30	灰头鹀	*Emberiza spodocephala*	-
31	三道眉草鹀	*Emberiza cioides*	-
32	树鹨	*Anthus hodgsoni*	-
Mammals			
1	草兔	*Lepus capensis*	-
2	花鼠	*Eutamias sibiricus*	-
Fish			
1	鲤鱼	*Cyprinus carpio*	-
2	鲫鱼	*Carassius auratus*	-
3	鲢鱼	*Hypophthalmichthys molitrix*	-
4	草鱼	*Ctenopharyngodon idellus*	-

D. Protected Areas and Physical Cultural Resources

156. Protected Areas in the vicinity of the project area include

(i) Longquan National Forest Park was accredited in 1992. It covers 24,119.6 ha and is famous for its vegetation, scenery, and cultural significance. It is located south of Zuoquan Urban Centre. At its closest, the park is 2.5 km away from the nearest works area proposed under this project.

(ii) The Shanxi Meng Xin Nao Nature Reserve is a provincial nature reserve located in the north of Zuoquan County. The Reserve covers 39,300 ha, and supports approximately 620 species of higher plants, 37 species of herpetofauna and 160 species of bird. Several species of Grade I and II National level protected species occur in the Reserve, including, leopards, black stork, golden eagle, great bustard and whistling swan. The reserve is 3.1 km away the nearest works area proposed under this project.

157. No direct or indirect impacts either of these protected areas are expected, and they are not discussed further in the IEE.

158. There are no known physical cultural resources within the project area.

E. Socioeconomic Conditions

1. Demographic Structure

159. **Population.** In 2014, Zuoquan had a permanent population of 164,450, comprising 84,300 males and 80,200 females. Population in the urban and rural areas are respectively 68,900 and 95,600, with the urbanization rate of 41.89% (Table V-12).

Table V-12. Population of Project area in 2014 (10,000)

Area	Total	By Gender		Region	
		Male	Female	Urban	Rural
PRC	136782	70079	66703	74916	61866
Shanxi	3648	1873	1775	1962	1686
Jinzhong	332.03	171.23	160.8	167.52	164.5
Zuoquan	16.46	8.44	8.02	6.89	9.57

160. **Urbanization.** PPTA observations indicate that actual urbanisation rates in Zuoquan County are higher than reported statistics. Nearly all surveyed villages are experiencing declining populations due to emigration. Except during summer and winter vacations, village residents are mainly middle and old-aged people. This is due to: (i) villagers who have accumulated wealth from mining have relocated to urban areas, (ii) most young people have left to work in non-agricultural industries in the urban areas of Zuoquan, Taiyuan, Jinzhong, and other neighboring cities; and (iii) people moving to urban areas for better education opportunities. These urbanization trends are reflected by surveys of village family members conducted for this project. According to the survey, the average number of family members is 3.48, including 3.26 living locally (within the county) and 0.25 live in the non-local region (i.e., population working in other areas in permanently, yet their Hukou is still in local. Table V-13). Despite declining village populations, most rural people still live within Zuoquan County, and will benefit from the project which will positively impact the whole county, especially northern districts. Furthermore, industrial facilities in rural areas will also benefit from the project.

Table V-13. Situation of Family Member of Respondent's Household (Person)

	Average Number
Number of Family Members	3.48
# Including: Male	1.79
Female	1.68
# Children under 16 (including 16)	0.51
Older People over 60 (including 60)	0.83
# People at work	1.55
# People with pension	0.52
# Disabled	0.04
# Permanent local residents	3.26
# Permanent non-local residents	0.25

2. Economy

161. **Gross domestic product.** As of the end of 2014, the PRC's GDP reached CNY63.6463 trillion and the primary, secondary, and tertiary industries accounted for 9.2%, 42.6% and 48.2% respectively. Shanxi's economic size exceeds CNY1 trillion. Secondary industries are the highest proportion of Shanxi's economy, reflecting the provincial focus on coal and energy. Despite this level of development, Shanxi's economic development is lower than the national average. In 2014, Shanxi's per capita GDP was 75.36% of the national level. Jinzhong's social economic development is less than the provincial average. In 2014, Jingzhong's per capita GDP is 67.55% of the national average and 89.65% of the provincial average. Zuoquan County, designated as national poverty-stricken county, has a per capita GDP of 53.33% the national average, 70.77% of the provincial average and 78.94% of Jinzhong's average in 2014 (Table V-14).

Table V-14. Economic Indicators of the project area (2014)

		GDP (CNYx100 million)	Primary industries	Secondary industries	Tertiary industries	Per capita GDP (Yuan)
PRC	Qty.	636463	58332	271392	306739	46531
	%	100%	9.2%	42.6%	48.2%	
Shanxi Province	Qty.	12759.4	788.1	6343.3	5628.0	35064

	%	100%	6.2%	49.7%	44.1%	
Jinzhong Municipal City	Qty.	1041.3	103.3	494.1	443.9	31434
	%	100%	9.9%	47.5%	42.6%	
Zuoquan County	Qty.	40.77	3.28	19.92	17.56	24815
	%	100%	8.1%	48.9%	43%	

162. **Disposable income.** In 2014, the per capita disposable income of rural and urban residents in Zuoquan was CNY 4,142 and CNY 20,954 respectively. The income of rural residents accounted for 39.49% and 47.02% and 41% of the national, provincial and municipal averages respectively. The income of urban residents accounted for 72.65% and 87.06% and 81.69% of the national, provincial and municipal averages respectively. In general, Zuoquan's income of rural residents is very low, but that of urban residents is slightly lower than the provincial average. The urban-rural ratio of per capita disposable income was 5.05, and the gap between urban and rural income is very large, far more than the national, provincial or municipal average (Table V-15).

Table V-15. Comparison of Income of Urban and Rural Residents in the project area (2014)

Region	Per capita disposable income of rural residents (CNY)	Per capita disposable income of urban residents (CNY)
PRC	10489	28844
Shanxi	8809	24069
Jinzhong	10100	25652
Zuoquan	4142	20954

163. **Household income.** Project surveys found that 71.4% of urban respondents and 85.2% of rural respondents have an annual household income of less than CNY 40,000, with nearly half below CNY 20,000 (Table V-16). The current incomes of urban and rural residents has decreased significantly due to the falling coal market. Three years ago, the market price of labor-based work was higher than CNY 150 per capita per day, but now it is only about CNY 100.

Table V-16. Respondents' Household Income

Household income (CNY)	Urban	Rural	Total
≤10000	7.10%	27.70%	25.50%
10001-20000	19.40%	24.80%	24.20%
20001-30000	25.50%	20.70%	21.20%
30001-40000	19.40%	12.00%	12.80%
40001-50000	5.10%	5.70%	5.70%
50001-60000	7.10%	3.50%	3.90%
60001-70000	2.00%	1.80%	1.80%
70001-80000	6.10%	1.80%	2.30%
80001-90000	1.00%	0.40%	0.40%
90001-10000	0%	0.60%	0.50%
100001-150000	6.10%	0.60%	1.20%
150001-200000	0%	0.40%	0.30%
≥200001	1.00%	0.10%	0.20%
Total	100.00%	100.00%	100.00%

164. **Income sources.** 73.7% of all surveyed households have various incomes sources (e.g. permanent jobs, temporary jobs and pension), reflecting the fact that most families have young people working and people over 60 years old receiving pensions (Table V-17). Over 40% of

rural households have no agricultural income at all. About 50% of respondents received various government subsidies, with more recipients in rural areas rather than urban areas due to high national agricultural subsidies.

Table V-17. Respondents' household income source

Income Source		Hukou type		Total
		Urban	Rural	
Salary income	YES	12.90%	27.70%	26.30%
	NO	87.10%	72.30%	73.70%
Agricultural income	YES	81.70%	40.20%	44.40%
	NO	18.30%	59.80%	55.60%
Business income (include migrating work income)	YES	88.20%	90.20%	90.00%
	NO	11.80%	9.80%	10.00%
Property rental income	YES	95.70%	99.20%	98.80%
	NO	4.30%	0.80%	1.20%
Stocks and bonds income	YES	100.00%	99.90%	99.90%
	NO	0%	0.10%	0.10%
Government subsidies	YES	75.30%	48.00%	50.70%
	NO	24.70%	52.00%	49.30%
Other incomes	YES	94.60%	90.40%	90.80%
	NO	5.40%	9.60%	9.20%

3. Social Development Situation

165. Progress has been made in social development covering the following key aspects: (i) Construction of urban and rural roads and infrastructure: all villages have been basically connected with paved roads, potable water supply and mobile communication signals; (ii) Medical care and public health: urban and rural residents have access to basic public medical care; (iii) Urban residents have access to social insurance including employees' basic pension and urban residents' basic pension system and rural residents' new farmers pension system; (iv) Urban and rural areas are all covered by comprehensive education.

166. Surveys and interviews identified the following issues as priorities for social development: (i) Widening inequality in wealth distribution. Households lacking labors and skills are facing with more difficulties to get stable payment in market economy. Existing systems of poverty alleviation and social insurance are incapable of resolving social inequality; (ii) Environment degradation due to years of large-scale mining. Some areas are suffering from severe water environment crisis and lack of drinking water for people and livestock resulting from water quality deterioration associated with mining activities; and (iii) Many village schools have been merged into the schools of townships and counties. Although education quality has improved, rural households are forced to move to urban areas, which result in untimely decentralization of villages.

F. Existing Climate and Climate Change

167. Average annual precipitation in the West Qingzhang River Watershed is 540.2 mm, with a recorded high and low annual precipitation of 756.8 mm (1956) and 326.3 mm (1986) respectively. Precipitation also varies considerably throughout the year, with 70% of rainfall occurring from June to September (Figure V-15).

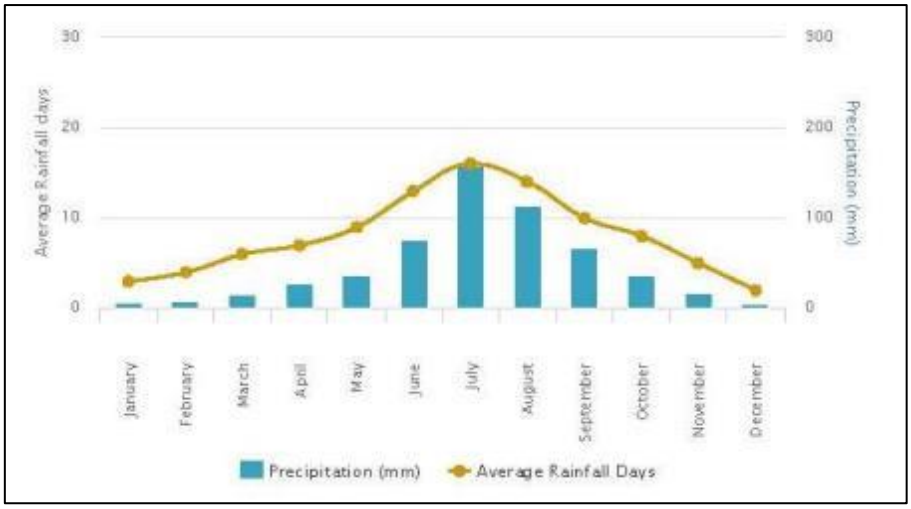


Figure V-15. Average Rainfall in Zuoquan

168. **Observed climate change.** The temperature has increased by 0.23°C every 10 years in Zuoquan, especially since the late 1980s, and the climate is characterized by warmer autumn and winters and a substantial warming in annual minimum temperature (Figure V-16). The annual precipitation features no obvious changing trend, but with big annual and decadal variation. Heavy precipitation occurs with more severe impacts of storms and floods (Figure V-17). More frequent and intense droughts occurs in 1980s and 1990s, and slight decrease since 2000s (Figure V-18). The number of cold days has decreased, but extreme low temperature events still occur occasionally; while more heat waves occurs after late of 1990s.

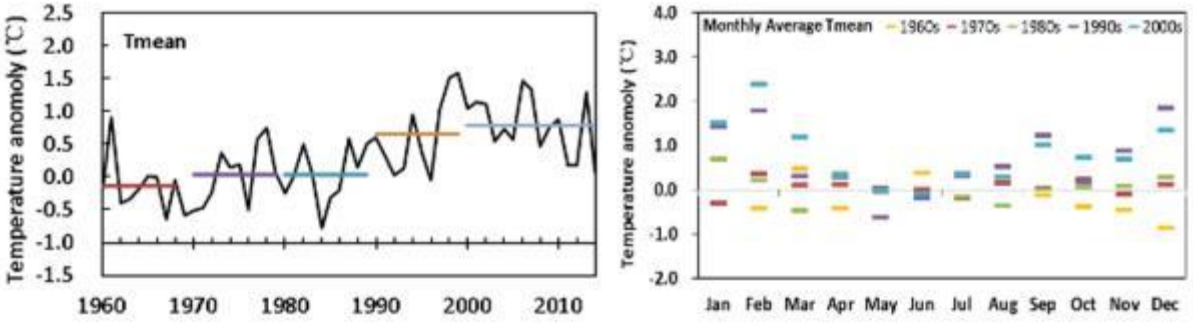


Figure V-16. Anomalies of annual mean temperature (Tmean) and monthly mean temperature for Zuoquan during 1960-2014 comparing with 1961-1990 (℃)

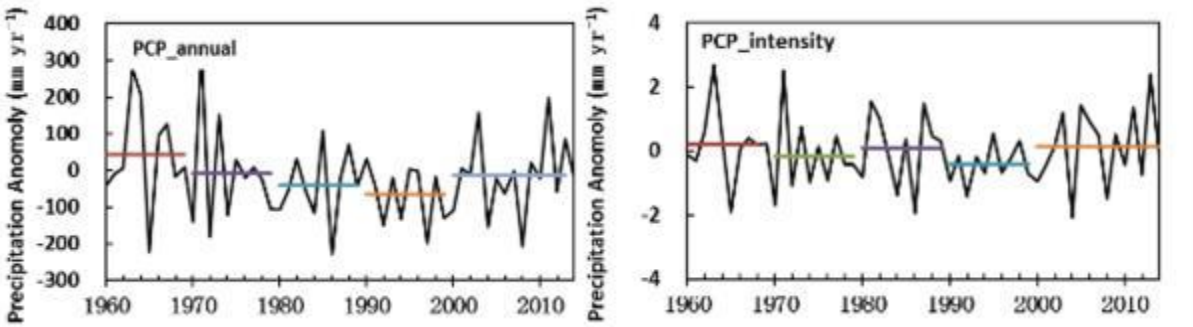


Figure V-17. Anomalies of annual precipitation (PCP annual), precipitation days (PCP day) and daily precipitation (PCP intensity) for Zuoquan during 1960-2014 comparing with 1961-1990

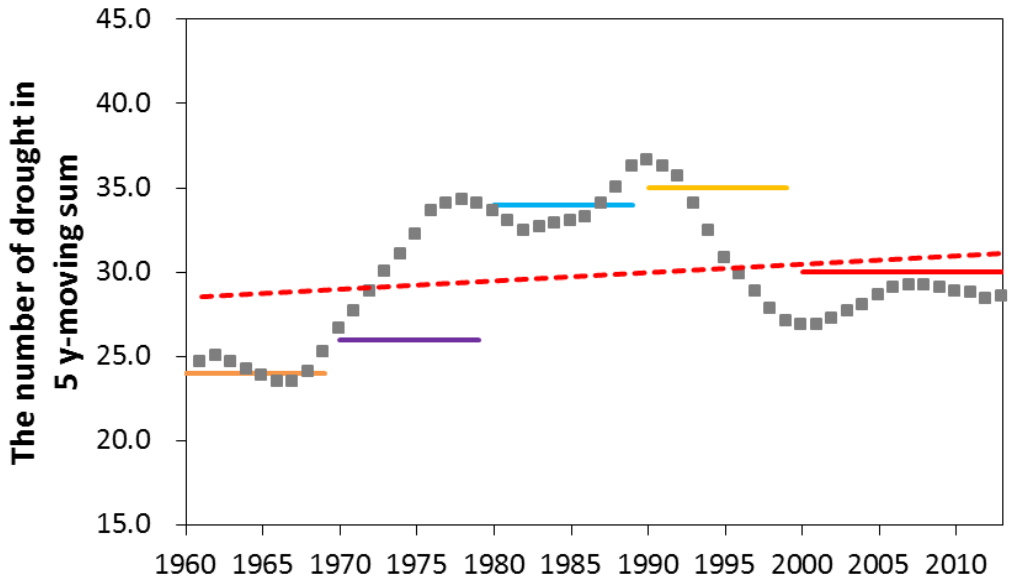


Figure V-18. Annual trend and average decadal of the moving-sum number of droughts in Zuoquan during 1960-2014

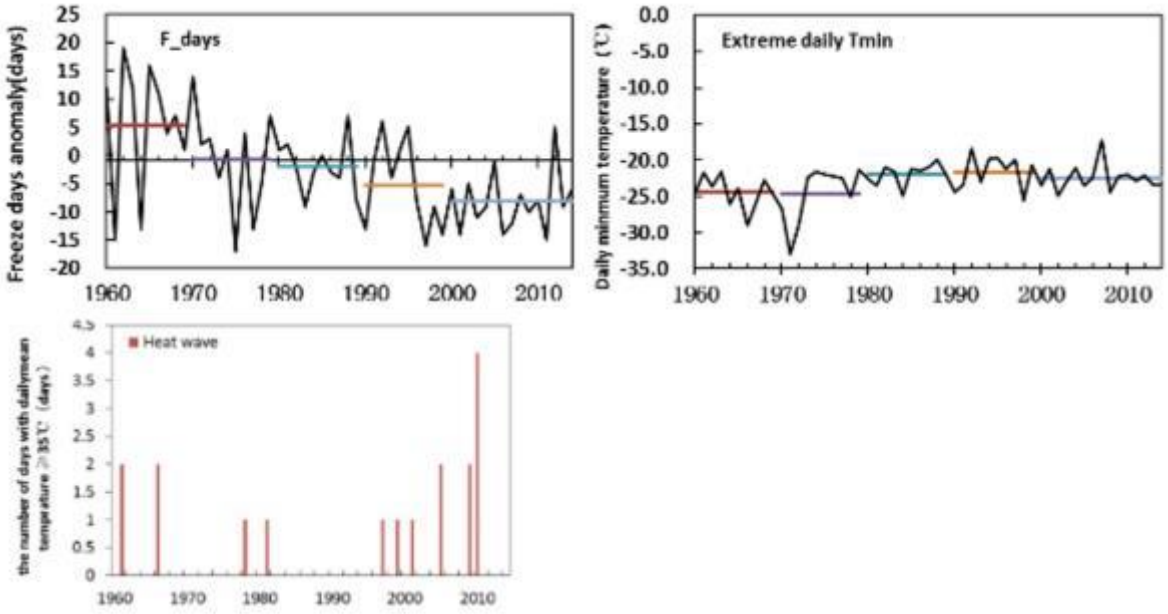


Figure V-19. Anomalies of freeze days (F_days) during 1960-2014 comparing with 1961-1990, daily minimum temperature (Extreme daily Tmin) and the number of heat waves for Zuoquan

169. **Projected climate change.** The temperature is projected to increase, and climate will be characterized by more complex seasonal warming patterns under different scenarios. Annual precipitation will increase slightly while snow will decrease. These changes will combine with large inter-annual variations (Figure V-20). The projected increase in temperatures with consequent evaporation might be offset by annual precipitation increase in Zuoquan. However the projected large inter-annual variations could afftect water security in the area.

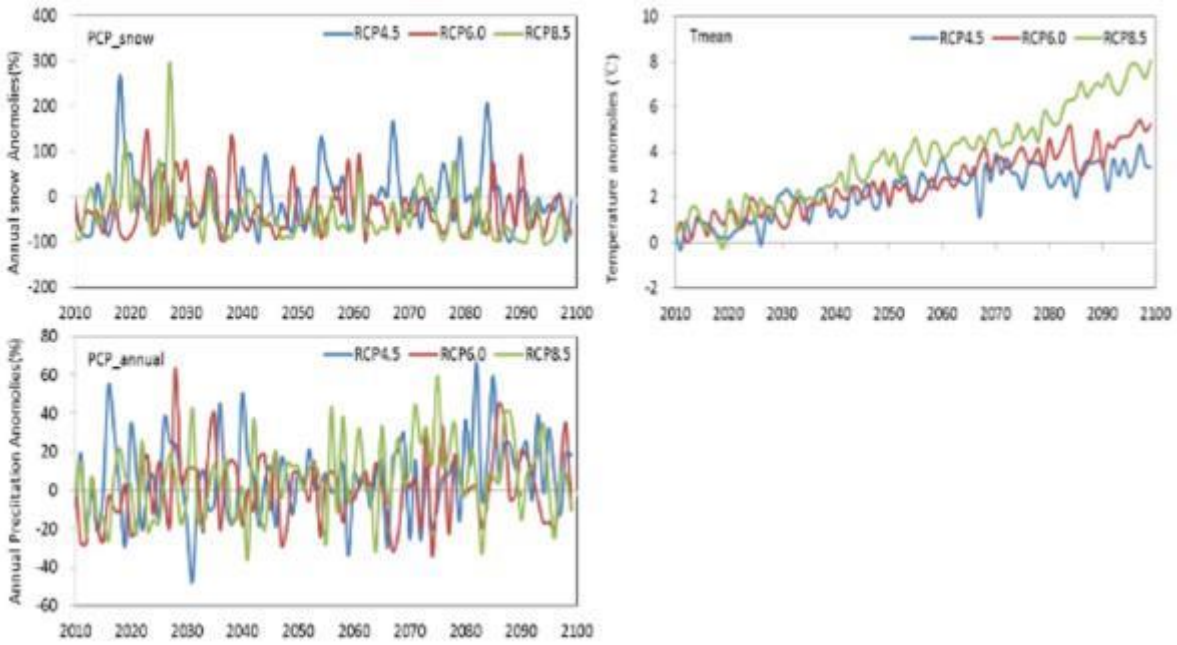


Figure V-20. Projected snow changes, annual mean temperature, and annual precipitation in Zuoquan under RCP4.5, RCP6.0 and RCP8.5 for 2010-2099 (baseline: 1986-2005, unit: ℃ for temperature, unit: % for precipitation)

VI. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Design Phase and Avoided Impacts

170. The integrated design and safeguard project planning approach, implemented through the PPTA, resulted in significant avoided impacts. The following aspects were proposed by the ZCG early in the design phase, and after review, were excluded from the project design due to potential environmental impacts: (i) construction of a new 6.5 km road, to divert traffic from the existing road running along the eastern bank of the Shixia Reservoir. The proposed road would have passed through hilly terrain covered with mature shrubland and several ephemeral streams and drainage lines. Due to the hilly terrain, a large amount of geotechnical works would have been required for road construction, greatly expanding the construction footprint. This would have caused direct and indirect ecological impacts, issues with spoil disposal, and potential water quality impacts during construction and operation. Due to these concerns, and cost considerations, the road was removed from the project scope; and (ii) dredging an area of 48.51 ha to remove 639,200 m^3 of sediments from Shixia Reservoir. This activity would have created potential environmental impacts from water quality deterioration, sediment disposal and ecological disturbance. A review of storage capacity of the reservoir determined dredging was not necessary to maintain reservoir functionality, so this element was removed from the project scope.

171. In addition, routes for water supply, stormwater and wastewater pipeline routes were selected along existing roadways and utility easements, to avoid and minimize potential adverse impacts to the environment and surrounding communities.

B. Pre-construction Phase

172. The following measures will be implemented in the pre-construction phase of the project to ensure the project's environment management readiness.

(i) **Institutional strengthening.** (a) A full-time PMO Environment Officer will be assigned to the project to coordinate EMP implementation. (b) Under the loan consulting services, the PMO will hire a Loan Implementation Environment Specialist (LIEC) to provide external support. (c) The terms of reference for these personnel are in the EMP (Attachment 1).

(ii) **Updating the EMP.** In the event of any changes in project design, the EMP will be updated as needed, including mitigation measures and monitoring. This will be the responsibility of the PMO, Implementing Agencies (IAs), and design institutes.

(iii) **Training in environmental management.** The LIEC and personnel from the Shanxi Environmental Protection Department (EPD) and municipal EPBs will give training in implementation and supervision of environmental mitigation measures to contractors and Construction Supervision Companies (CSCs).

(iv) **Grievance redress mechanism (GRM).** The PMO and IAs will implement the project GRM at least two months before the start of construction, to ensure that communities are well informed and have the opportunity to discuss any concerns (further to the public consultations already conducted for this IEE; Section VIII).

(v) Bidding document and contract documents. The EMP will be included in the bidding documents and contracts for procurement of civil works. All contractors and subcontractors will be required to comply with the EMP.

(vi) **Contractor obligations**. In their bids, contractors will respond to the environmental clauses for contractual terms and EMP requirements. Prior to construction, each contractor will develop a Site EMP, based on the project EMP (Attachment 1), and assign a person responsible for EHS. The site EMP shall include the following: (a) site drainage and soil erosion protection; (b) dredge spoil holding and treatment sites, material haulage routes, and waste disposal arrangements; (c) spill control and management; (d) health and safety; (e) surface water and groundwater protection; (f) temporary traffic management;

and (g) construction site access control. The site EMP will be submitted to the environmental officers of each county PMO for approval, with support of the local EPBs.

C. Construction Phase

1. Sensitive Receptors and Project area of Influence

173. Sensitive receptors are elements of the environment that will be potentially impacted during the construction and operation phases of the project. This includes receptors within and adjacent to the project area, where the project area refers to the footprint of infrastructure to be constructed under the project, including temporary works areas. The planned project works occur within or near 14 villages across Zuoquan County, as well as three educational facilities and two factory dormitories close to Binhe Avenue (Table VI-1). The project area of influence also includes water quality and ecological sensitive areas of the West Qingzhang River, 200 m downstream of the Zuoquan WWTP. Impacts to groundwater resources could extend further (based on previous EIA, up to 3km from the WWTP). Despite the wide range of activities to be conducted in the project, construction works for most components involve similar concerns for water quality impacts, earthworks, dust and noise control, ecological impacts, and occupational and community health and safety. These, along with site-specific mitigation measures, are described in the following sub-sections.

Table VI-1. Zone of Impact Assessment and Nearest Sensitive Receivers to Proposed Construction Activities

Period	Indicator	Village	Location	Population
Construction Phase	Air and Noise	Majiu	600 m from the south bank of West Qingzhang River	1310
		Xichangyi	170 m from the south bank of West Qingzhang River	370
		Jinggou	640 m from the south bank of West Qingzhang River	390
		Dongchangyi	580 m from the south bank of West Qingzhang River	560
		Liujiayao	Adjacent to the proposed water supply pipelines	260
		Wulihou		1050
		Dongzhai		680
		Majiaguai		350
		Silihou		1100
		Shigangkou		480
		Qinghedian		860
		Qili Village	Adjacent to Binhe Road Alignment	897
		Xiaohui Village		339
		Xichangyi Village		370
		Qili Village Central School		~ 700
		Zuoquan Vocational and Technical College Teaching Building		~ 1200
		Zuoquan Forth School Teaching Building		~ 1000
		Changtai Chemical Dormitory		~ 80
		Fertilizer Factory Dormitory		48
	Surface Water	West Qingzhang River		
	Ground Water	Shallow groundwater around the Zuoquan WWTP		
	Ecology	1) Areas of temporary and permanent land acquisition and adjacent areas 2) Areas covered under Surface Water Zone of Influence		
Operation Phase	Air and Noise	Qinshuiwan Garden	180 m from the northeast of the proposed location from Zuoquan WWTP extension.	1200
		Qili Village	Adjacent to Binhe Road Alignment	897
		Xiaohui Village		339
		Xichangyi Village		370
		Qili Village Central School		~ 700
		Zuoquan Vocational and Technical College Teaching Building		~ 1200
		Zuoquan Forth School Teaching Building		~ 1000
		Changtai Chemical Dormitory		~ 80
		Fertilizer Factory Dormitory		48
	Surface Water	West Qingzhang River		
	Ground Water	Shallow groundwater around the Zuoquan WWTP		

	Ecology	1) Areas of permanent land acquisition and adjacent areas 2) Areas covered under Surface Water Zone of Influence

2. Earthwork and Soil Erosion

174. Excavation works, backfill, and surplus soil volumes were estimated for the project components involving earthworks. The project will require importation of 650,600 m^3 of fill (Table VI-2). This fill will be sourced from government-funded projects elsewhere in Zuoquan County, which will produce excess soil of 1,227,000 m^3 in total. Soil Erosion Protection Plans (SEPPs) were being prepared by certified national institutes for these other projects in 2016, for approval by the Shanxi Water Resources Department. These plans will contain further details of the soil cut and fill, including source of fill required to complete construction works.

Table VI-2. Soil Cut and Fill Balance

No.	Works Item		Cut (m^3)	Fill (m^3)
1	Water source protection of the Qingzhang headwaters	Improve reservoir spillway gate; construct flood discharge tunnel	39,000	21,057
		Construc hydrological monitoring stations and water supply configuration station	400	400
		Subtotal	39,400	21,457
2	Qingzhang river rehabilitation to stabilize river banks and reduce flood risk	Flood Control and Ecological Remediation	79,100	192,000
		Dredge silted sections of river and tributaries	78,700	
		River rehabilitation associated facilities	123,500	315,700
		LID for road improvement	32,900	487,800
		Subtotal	314,200	995,500
3	Water supply and wastewater collection	Water supply system	178,800	178,800
		Water Pollution Control	76,200	47,900
		Subtotal	255,000	226,700
		Total	**608,600**	**1,243,700**
		Balance	**(650,600)**	

175. **Soil erosion.** Potential erosion is expected during river dredging, embankment construction, temporary storage of the spoil, and when surface vegetation and soil removed. Erosion may occur after construction if site restoration has been inadequate. To minimize soil erosion during construction, the following measures will be implemented by contractors:

(i) Works will be completed in the dry season (October to March)
(ii) Berms or drainage ditches will be constructed around the perimeter of the construction sites to minimize stormwater flow into the sites which would increase soil erosion.
(iii) Stockpiles of spoil and newly backfilled areas will be covered with tarpaulin or similar material to minimize soil erosion.
(iv) Immediately restore and replant temporary works areas upon completion of construction works.

176. With the proper implementation of mitigation measures, risks resulting from earthwork and soil erosion will be effectively addressed.

3. Water Resources

177. **Surface water quality**. Sedimentation impacts in the West Qingzhang River are a key potential water quality issue during the construction phase. Sedimentation impacts could result from various activities, including:

(i) Mobilization of sediments during dredging, embankment construction and in-stream

habitat creation works in the West Qingzhang River adjacent to the Zuoquan City Urban Area.
(ii) Uncontrolled construction site runoff discharging into drainage channels and entering the West Qingzhang River.
(iii) The flood discharge tunnel will be constructed in an area of high ground water, and water percolation into surrounding areas from the foundation ditch could potentially increase groundwater Suspended Solid (SS) concentrations.

178. **River dredging, embankment construction, and wetland creation.** To minimize potential water quality impacts during these activities, as well as to minimize the risk of exposure to the slightly elevated levels of nickel in dredged sediments, the following measures will be implemented:
(i) River dredging will be scheduled in the dry season (October to May) and outside of the agriculture irrigation season.
(ii) Dredging, embankment construction and wetland creation will be constructed under dry conditions by employing temporary coffer dams. Coffer dams would be constructed on one side of the channel at a time to maintain water flow to downstream areas. Water from within these works areas will be discharged into West Qingzhang River only after sedimentation treatment.
(iii) Temporary storage of dredged sediments will be held in clearly demarcated storage sites for dewatering (Figure V-11 refers). Wastewater from these areas will be carefully controlled: water draining from these sites will be treated by sedimentation in consolidation tanks. Wastewater from these tanks will be returned back to the river only when the level of SS is less than 20 mg/L (meeting Class I requirement of GB8978-1996).

179. **Construction site run-off.** To minimize potential water quality impacts from site run-off, the following measures will be implemented:
(i) Sedimentation tanks will be installed for construction sites generating runoff with high concentrations of suspended solids, and the waste residue in the tank will be cleared and transported to Zuoquan County Landfill.
(ii) Use of coffer dams and sedimentation tanks will be adopted to minimize sedimentation impacts from excavation of foundation pits for engineered structures.
(iii) Where possible construction (in particular works involving soil excavation/earth moving) will avoid the peak rainy season (July–August) to minimize potential water quality impact. If needed, mitigation measures such as placement of sandbags or berms around foundation works areas to contain muddy water runoff will be adopted.
(iv) Excavation works for wetland habitat enhancement in the wetland park will be undertaken 'in the dry', before the newly created wetland area is connected with the main West Qingzhang River channel.

180. **Construction wastewater.** Wastewater will be produced from the maintenance and cleaning of powered mechanical equipment (PME) and vehicles, water from mixing and curing concrete, inappropriate storage and handling of fuel, accidental spills, and disposal of domestic wastewater from construction camps. To control these potential issues, the following measures will be implemented:
(i) Sedimentation tanks will be installed on-site to treat process water (e.g. concrete batching for construction) and equipment cleaning water. If necessary, neutralizer and flocculants such as Calcium Oxide (CaO) and polyacrylamide will be used to facilitate sedimentation.
(ii) Oil separators will be installed to treat wastewater from cleaning of PME and vehicles. After site treatment, the wastewater will comply with Class I of *Integrated Wastewater Discharge Standard (GB8978-1996)*.
(iii) To control groundwater sedimentation impacts that may occur during the construction of silt flushing tunnel foundation ditches, two sedimentation tanks are proposed to be built that can meet a standard of 70 mg/L after 2 hours of sedimentation. The treated water will be used for road watering and dust reduction rather than discharged into the environment.
(iv) Concrete mixing and equipment cleaning can produce wastewater with high SS and pH. After neutralization and precipitation treatment, this wastewater will be considered

primarily for watering in construction area. Solid waste from the sediment tank will be disposed of at Zuoquan Landfill.

(v) Portable toilets and small package WWTPs (pre-fabricated plants for treating wastewater using an aerobic process) will be provided for the workers and canteens. If there are nearby public sewers, interim storage tanks and pipelines will be installed to convey wastewater to those sewers. The oil separation tank and septic tank are proposed to be built if there is no sanitary facility available. The treated domestic wastewater will be discharged by the municipal department after pretreatment and transferred to the WWTPs using sewage transport vehicles. Discharge of domestic wastewater from construction site directly to West Qingzhang River will be prohibited.

181. Water quality will be monitored by during construction as per the EMP.

182. With the proper implementation of mitigation measures, water quality risks resulting the project will be effectively addressed.

183. **Groundwater quality**. The project area lies within the Niangziguan Spring Karst Water System, forming part of the southern Niangziguan spring runoff recharge zone. No significant impacts to the Water System are expected from construction works associated with the project. Although groundwater in the project area can be relatively shallow (approximately 2 m below the ground), the Niangziguan aquifer lies in geological formations 20-30 m deep. As construction works for the project will only require excavations of 2-3 m, they are unlikely to affect this aquifer. Mitigation measures designed to protect surface waters (as described above) will also address pollution risks to ground water resources.

4. Air Quality

184. Air pollution from construction activities is likely to be generated from: (i) dust from earth works, traffic, and concrete mixing; (ii) fumes from PME/Vehicles; and (iii) odor from sediment spoil drying and temporary storage during river dredging. The main pollutants would be Total Suspended Particulates (TSP), Particulate matter with diameter <2.5μ ($PM_{2.5}$), Nitrogen Oxides and odor.

185. **Fugitive dust.** In general, levels of fugitive dust, measured as total suspended particles (TSP) are high within 50 m of works areas without the implementation of dust prevention measures. TSP levels drop quickly with distance from the source: impacts more than 200 m from the pollution source are generally negligible. If soil moisture content is high, the impact of TSP would not extend further than 100 m from works areas.

186. The following mitigation measures will be adopted to minimize air pollution impact from construction sites:

(i) Where construction sites are located within 50 m of residential areas, semi-closed construction measures will be adopted to minimize dust impacts. The enclosure around the construction site generating dust will be 1.8 m or above, and spray water during construction to reduce dust pollution. Sediment will be cleared within three days after completion of construction.
(ii) Dust suppression measures through water spraying of construction sites/roads will be implemented where sites are located within 200 m of residential areas.
(iii) Construction activities likely to generate dust will be suspended during strong windy days.
(iv) Stockpiled materials that could generate dust will be well managed: either watered or covering with tarpaulin. On-site storage of these materials will be minimized by regularly removing them off site for proper disposal.
(v) For temporary cement mixing site, choose the place away from residential areas in site selection.
(vi) Trucks transporting earth materials will not be overloaded to avoid spilling dusty materials onto public roads. Earth transported by truck will be covered by tarpaulin/other suitable

material during transportation.
(vii) Wheel washing equipment/ manual wheel washing will be adopted at the exit of works areas to prevent trucks from carrying muddy or dusty substance onto public roads.
(viii) Immediately cleanup all muddy or dusty materials on public roads outside the exits of the works areas.
(ix) Plan transportation routes and schedules involving earth materials to avoid busy traffic and heavily populated areas.
(x) Temporary mulching, curing, greening, spraying and other measures will be applied at the construction site to manage exposed areas of soil. The measures will be removed after temporary land use, and vegetation re-established to prevent soil erosion.

187. **Fumes from PME and vehicles.** Major pollutants of excavator fuel exhaust (SO_2 and NO_2) impact an area 15-18 m downwind of the source with a concentration of 0.016 mg/m^3 to 0.18 mg/m^3. In this project, only a limited number of PME/vehicles will be required, so the areas impacted by exhaust emissions will be small in extent and duration. Nevertheless, the following measures will be implemented to control air quality impacts from PME/Vehicles.
(i) PME/Vehicles will be routinely and properly maintained.
(ii) Retrofit construction plant with particulate reduction device to reduce dark smoke emission
(iii) Divert PME exhaust away from public areas

188. **Odor.** The main source of odor during the construction phase will be dredged spoil from the West Qingzhang River, which has the potential to cause nuisance during sludge dewatering and consolidation process. The standard for odor arising from the temporary storage and treatment of sediment spoil is from *PRC Classification of Temporary Odor Intensity*. These standards classify odor from '0' (no odor) to '5' (very strong odor). It was calculated that odor from the dredged spoil treatment site will be '2' beyond 30 m (a slight odor) and will be effectively odorless beyond 50 m.

189. The following mitigation measures to minimize odor pollution impact during river dredging will be adopted:
(i) Sludge dewatering and consolidation process will be concentrated in winter and spring. The relatively cold weather will reduce odor impacts
(ii) Sludge dewatering and consolidation activities will be sited at least 200 m to residential areas.
(iii) River dredging project will be undertaken in the dry season (October to May), reducing the likelihood of precipitation impacting dewatering and other activities which will accelerate the sludge treatment processing. River dredging will be undertaken in short (200 m) segments to minimize the amount of material to be treated at any one time.
(iv) Safety of construction staff is very important, the necessary protective equipment and sufficient access to emergency services will be provided.

190. With the proper implementation of mitigation measures, air quality risks resulting the project will be effectively addressed.

5. Noise

191. The main source of noise will be from PME during construction. Applicable construction noise standards (according to GB 12523-2011) are 70 dB(A) during daytime and 55 dB(A) at night-time at the construction site boundary. Noise intensity from the large machines is typically 80-100 dB(A) (measured 5 m from the operating machinery). The major construction machinery noise testing values from *Technical Guidelines for Environmental Impact Assessment of the Acoustic Environment (HJ/T2.4-2009)* are summarized in Table VI-3.

Table VI-3: Testing Values of Construction Machinery Noise

Machine Type	Distance between Measuring Site and Construction	Maximum Sound Level dB (A)

	Machinery (m)	
Mixer	5	87
Bulldozer		100
Excavator		98

192. For the current project, models recommended in *Technical Guideline on EIA Regarding Acoustic Environment (HJ2.4-2009)* to predict noise levels have been adopted:

$$L_i = L_0 - 20\lg\left(\frac{R_i}{R_0}\right) - \Delta\mathrm{L}$$

L_i and L_0 are equipment noise level at R_i and R_0 respectively, dB(A); $\Delta\mathrm{L}$ is additional diffusion attenuation caused by barriers, vegetation, air and earth, dB(A);

193. Noise levels at different distances have been calculated for machinery and equipment use and are shown in Table VI-4.

Table VI-4: Construction Equipment Noise Impact Distance

Source	Source strength (db)	Noise from the sound source different from the predicted values (db) at various distances (m)								Daytime Distance (m)	Night Distance (m)
		20	50	100	150	200	300	400	600		
Excavator	98	72	64	58	54	52	48	46	42	25	141
Bulldozer	100	74	66	60	56	54	50	48	44	32	178
Mixer	96	70	62	56	52	50	46	44	40	20	112

194. The results show that if PME are used singly, noise impacts will only meet the PRC standard of Construction Site Environmental Noise Emission Standards (GB12523-2011) at a distance of 20-32 m from the source during the day and 112-178 m at night. Given that some receivers (particularly along Binhe Road) are within 5 m of proposed works areas, there will likely be exceedances of relevant standards. Moreover, it is probable that several PME will be used concurrently during construction. When multiple machines are at work (which would be required in some instances), noise will increase 3-8 dB(A), generally no more than 10 dB(A). The DEIA has calculated the minimum complying distance for noise from multiple machines as 50 m in daytime and 300 m at night.

195. For the construction of Binhe Road, high noise levels will generate disturbance to nearby residents. The following mitigation measures will be implemented to minimize noise disturbance:

(i) The construction schedule was shortened from eight months to six months.
(ii) Construction at night will be prohibited and/or subject to community consultation.
(iii) For daytime construction, the contractor will ensure that: (a) noise levels from equipment and machinery conform to PRC standard GB12523-2011, and machinery is well-maintained to minimize noise; (b) equipment with high noise and/or vibration will not be used in urban areas; (c) only low noise machinery or equipment with sound insulation will be used; and, (d) for sensitive receptors (e.g. schools) within 50 m of works, anti-noise barriers will be installed.
(iv) Prior to works, residents will be notified by the PMO and/or contractors and any site-specific concerns or working arrangements addressed.
(v) Noise monitoring will be conducted at sensitive areas (Attachment 1). If standards are exceeded by more than 3 dB, equipment and construction conditions shall be checked, and further mitigation measures shall be considered to minimize impacts.

196. As a result of these measures, noisy PME will only be used 15-20% of the time over six months i.e. significant noise levels will last for approximately one month only. With the proper

implementation of mitigation measures, noise nuisance resulting the road construction will be effectively addressed.

6. Vibration

197. Potential vibration impacts could result from piling, soil compaction, pipeline trenching and embankment construction. Mechanical vibration can cause structural damage to nearby buildings. This impact will be minor as no construction techniques or equipment used (e.g., blasting) will result in substantial generation of ground vibration. Sudden and discontinuous vibration can also cause stress among workers and communities. To address these issues: (i) piling and compaction operations will be prohibited at night; (ii) communities will be consulted prior to large earthworks to ensure they are informed, and to avoid sensitive timing e.g. exams at nearby schools or festivals. All works will comply with the *Standard of Environmental Vibration in Urban Area (GB10070–88)*.

7. Solid waste

198. Solid waste generated during construction will include construction and demolition waste dominated by excavated spoil during earth works for embankment construction, river rehabilitation associated facilities construction, road improvement and expansion, dredged sediment from West Qingzhang River, and refuse generated by construction workers on construction sites. If not properly disposed of, such waste will create community health and sanitation problems, and may also be washed into the nearby waterbody by stormwater causing water pollution. To minimize issues with solid waste, the following measures will be implemented:

(i) General refuse generated by the workers will be stored in closed containers and regularly transported off-site for disposal at the Zuoquan County Landfill.
(ii) Dredged sediments totaling 78,700 m^3 from West Qingzhang River, will generate dried sludge of 26,200 m^3 after dewatering and compaction. The treated sludge will be reused for the construction of river embankment. Although samples from the river in this area indicate nickel exceeds Class II *Environmental Quality Standard for Soils (GB 15168-1995)*, it is still well below levels prescribed in other relevant standards. For example, the standard of soil quality assessment for exhibition site states that nickel should be less than 2,400 mg/Kg for greening, commercial, public municipal, and stadium land uses. The river embankments will subsequently be landscaped i.e. the sludge, and work sites, will not be used for agriculture or other avenues which might impact human health.
(iii) Other excavated spoil will be reused on-site to minimize adverse impacts. The soil cut and fill balance conducted for this project (Table VI-2) indicates a significant net shortfall in fill requirements across all project components. Any excess spoil generated during construction can therefore be reused on-site.

199. With the proper implementation of mitigation measures, solid waste issues resulting the project will be effectively addressed.

8. Ecology and Biodiversity

200. Project operation is expected to contribute to the environmental management of West Qingzhang River, in particular enhancing water quality and ecological functioning. Minor and short-term impacts to ecological resources are anticipated during the construction phase, as follows.

201. **Land use modification.** Construction works will result in direct and permanent modification of 217 ha of land within the footprint of the different project elements. In addition, temporary land use modification would result from the establishment of works areas, storage sites and access roads. Of the 217 ha of land affected, over half (128 ha) is included in the revegetation output, which would result in positive ecological impacts. Other land use

modifications would result in minor ecological impacts due to the limited area affected and low ecological value of affected habitats (primarily roads/rural/urban areas and dry agricultural land). There are no “critical habitats” (SPS, 2009) in the project area.

202. Key potential impacts would result from construction works along the West Qingzhang River, encompassing 11.6 km of dredging (27 ha) and 8.9 km of embankments. The affected river sections are highly degraded due to poor water quality, bank modification and low flow levels, but nevertheless support areas of wetland vegetation which provide feeding and breeding habitats for wetland fauna. The following measures will be adopted to mitigate short-term construction phase impacts:

(i) Measures to mitigate physical environmental impacts resulting from dredging and embankment works will also minimize ecological impacts. In particular: (a) scheduling dredging works in the dry season (October to May) will minimize impacts during key breeding season for wetland wildlife that utilize the river; and (b) river dredging will be undertaken in short (200 m) segments to minimize the section of disturbance at any one time.
(ii) Habitats in the wetland park will be established before dredging/embankment works in the river commence. This would provide a large area of wetland habitat (41 ha) to offset the disturbance caused by the river channel dredging and embankment works.

203. For all project construction activities, care will be taken to minimize potential impacts from temporary habitat loss by siting of works areas/storage sites and routing of access roads in areas of low ecological value (e.g., abandoned land/existing disturbed sites). Works sites and other areas associated with protect construction activities (e.g., temporary access routes) will be clearly demarcated. Temporary works areas will be fully reinstated following the completion of works.

204. **Species injury and/or mortality.** Vegetation clearance, dredging, earth works, increased construction traffic, and unauthorized actions of construction staff (e.g. fishing/hunting) could cause injury or mortality to fauna. These impacts are considered minor in scale due to the low probability that species of conservation concern would be affected.

205. **Noise and visual disturbance.** Disturbance to wildlife could result from noise and vibration from construction plant and vehicles and increased human presence and activity in works areas. Along the upper West Qingzhang and Xiaolindi Rivers (upstream of Shixia Reservoir), disturbance to fauna could come from construction of the hydrological stations and revegetation. Downstream of Shixia Reservoir, the tunnel construction, river dredging and embankment works, installation of pipeline networks, and expansion of Zuoquan WWTP will cause noise disturbance close to scattered patches of riverine vegetation along the West Qingzhang River, which support birds, small mammals, reptiles, and amphibians. Given the low ecological value of the habitats in the project area, short duration of construction works, restriction of dredging to 200 m sections, and (for works upstream of Shixia Reservoir) the small and temporary scale of works, no significant ecological impacts are anticipated.

206. Overall, the following site practices will be implemented to minimize disturbance to people and ecology:

- construction machinery and vehicles will be maintained, to reduce noise and air pollution;
- dust suppression measures (e.g., wheel washing) will be implemented;
- site run-off control measures (e.g., covering stockpiled soils with tarpaulin, routing site run-off through sediment traps) will be implemented;
- adequate toilets and litter bins will be provided on construction sites;
- a maximum speed limit for all vehicles of 40 km/h will be enforced;
- use of vehicle horns will be prohibited, except in emergency situations.

207. **Air pollution.** Construction phase activities could result in localized air quality impacts

from dust generation and exhaust emissions from construction plant and vehicles. Air quality degradation can result in ecological impacts through direct particle deposition on plants, and sub-lethal effects of pollutants on plants and animals. These impacts would be minor due to the small area and low ecological value of the habitats and species affected. Any potential impacts would be controlled through standard good site practices.

208. **Water quality.** The water quality of the Lower West Qingzhang River could be impacted by proposed construction phase activities. In particular, sediments mobilized by dredging and embankment works during can impact aquatic communities. Sediments can also be carried by run-off from work sites adjacent to drainage channels that discharge into the river. Other potential sources of water quality pollution could result from spillage or leaking of fuel, oils, cleaning chemical and other material stored or used within works areas. Measures to reduce water quality impacts from dredging works and general construction activities are described in Section VI.1. With the implementation of these measures, water quality impacts will be minor and localized in nature. No significant water quality impacts to aquatic communities in the West Qingzhang River are expected.

9. Social Issues

209. The project will permanently occupy approximately 2,000 mu of state-owned land, and 1,300 mu of collective land, of which the cultivated land is 500 mu. As this project focuses on environmental improvement, the greening works do not change the nature of farmland and do not require acquisition. The project will acquire approximately 700 mu land from 33 villages in four townships and towns, namely Shixia Township, Liaoyang Town, Hanwang Township, and Longquan Township. The land acquisition and cultivated land occupation will affect around 1,420 persons from 611 households. The project will require around 8,000 m^2 of house demolition, affecting around 104 persons from 24 households. A resettlement plan has been prepared and meets PRC and ADB requirements, to ensure that affected residents receive adequate compensation and/or support. Detailed analyses of impacts to livelihoods, resettlement, and economic analysis are included in these plans, which will be available in Chinese language at the PMO office and ADB website.

10. Community and Worker Health and Safety

210. The objective of Occupational Health and Safety (OHS) is to provide workers with safe and healthy working conditions and prevent accidents, injuries, and disease. It also covers the establishment of preventive and emergency preparedness and response measures to avoid, and where avoidance is not possible, to minimize, adverse impacts and risks to the health and safety of local communities. It is therefore a combination of occupational health and safety of staff/workers at the subproject facilities and community health and safety of people living nearby or potentially affected by failures or poor operation of facilities.

211. The civil works contractors will implement adequate precautions to protect the health and safety of the workers and community. Signs will be placed at construction sites in view of the public, warning people of potential dangers such as moving vehicles and constructions, and raising awareness on safety issues. At the end of each day, all sites and equipment will be made secure (through fencing and/or lock-down of equipment) to prevent public access.

212. The contractors will also implement precautions to protect the health and safety of construction workers. The occupational health and safety risks will be managed by applying measures in the following order of preference: avoiding, controlling, minimizing hazards, and providing adequate protective equipment. Each contractor's Site Environmental Management and Supervision Plan will include measures for health and safety for personnel. The plan will be submitted to the PMO for review and appraisal and will include the following provisions for health and safety:

213. Personal protection equipment (PPE) appropriate to the job, such as safety boots,

helmets, gloves, protective clothing, goggles, and ear protection, in accordance with relevant health and safety regulations, will be provided by the contractors for workers.

214. **Emergency preparedness and response.** An emergency response plan for accidents and emergencies, including environmental and public health emergencies associated with hazardous material spills and similar events will be prepared, and submitted to the IA for review and appraisal. A fully equipped first-aid base in each construction site will be provided.

215. **Records management.** A records management system will be established to document occupational accidents, diseases, and incidents, that: (a) includes a tracking system to ensure that incidents are followed-up; (b) can easily retrieve records; and (c) can be used during compliance monitoring and audits. The system will be backed up on at least one external hard drive to protect records against loss or damage.

216. **Safety communication.** Ensure that safety, rescue and industrial health matters are given a high degree of publicity to all persons regularly or occasionally on site. Posters drawing attention to site safety, rescue and industrial health regulations will be made or obtained from the appropriate sources and will be displayed prominently in relevant areas of the site.

217. **Training, awareness and competence.** Construction workers will be trained in basic sanitation and health care issues, health and safety, and the specific hazards of their work.

218. With the proper implementation of the above measures, community and worker health and safety risks resulting the project will be effectively addressed.

11. Physical Cultural Resources

219. No cultural heritage or archaeological sites are known from the project area. However, construction activities have the potential to disturb unknown underground cultural relics. The EMP (Attachment 1) includes measures for immediate suspension of construction activities if any archaeological or other cultural relics are encountered, in accordance with the PRC Cultural Relics Protection Law 2002. In such event, the Zuoquan Cultural Heritage Bureau, PMO, and IA would be promptly notified and construction would resume only after investigation and with the permission of the appropriate authority. The clause for protection of unknown underground cultural relics will be included in construction contracts.

D. Operation Phase

1. Water Resources

220. **Surface water quality.** Wastewater generated in the project area will be from domestic, commercial and light industrial premises. Existing influent quality is within design standards for the existing Zuoquan WWTP, and estimated future influent quality will be of a similar standard. The WWTP extension will be designed to achieve class 1A, the highest treatment standard possible [PRC *Discharge Standards of Pollutants for Municipal WWTPs (GB18918-2002)]* as it will discharge the treated effluent into the West Qingzhang River directly.

221. To ensure effective functioning of the upgraded Zuoquan WWTP, it is important that influent quality meets design standards. To address this issue, a project assurance has been agreed with the EA to: (i) ensure that industries contain adequate on-site pre-treatment processes; and (ii) monitor and supervise the quality of industrial wastewater discharged by industrial enterprises into the sewers to ensure compliance with the *Wastewater Quality Standard for Discharge to Municipal Sewers (CJ 343-2010)*.

222. Compliance monitoring at Zuoquan WWTP will be undertaken prior to and during plant

operation to ensure that treated discharges meet Class 1A of *Discharge Standards of Pollutants for Municipal WWTPs* (GB18918-2002) (refer to Section III). This is reflected in the EMP. Table VI-5 shows the design inflow and discharge for the WWTP.

Table VI-5. Influent Design Parameters and Effluent Discharge Quality Standards

Parameter	COD_{Cr}	BOD_5	SS	NH_3-N	TN	TP
Influent (mg/l)	350	200	220	40	60	6
Discharge (mg/l)	≤50	≤10	≤10	≤5(8)*	≤15	≤0.5
Treatment Rate %	≥85.7	≥95.0	≥95.5	≥87.5	≥75.0	≥91.7

* Numbers outside brackets are control targets of water temperature >12°C, numbers inside brackets are for water temperature ≤12°C

223. Water quality impacts to the West Qingzhang River downstream of the Zuoquan WWTP were assessed based on existing water quality of receiving waters (from sampling in July 2016) and the design quality and quantity of effluent from the upgraded Zuoquan WWTP. The results of this assessment show that under various WWTP discharge scenarios, COD, ammonium nitrate and TP in the West Qingzhang River will meet *"Surface Water Environmental Quality Standard" (GB3838-2002)* Class III. TN will not meet this standard due to very high existing levels in the West Qingzhang River. Effluent from the WWTP will have limited impact on this parameter.

224. The projects will result in further improvements to water quality in the lower West Qingzhang River in the Operation Phase. These will be achieved through:

(i) Improvements to the sewage collection and interception system will reduce discharge/leakage of untreated wastewater directly into the river;
(ii) River dredging will remove contaminants from river sediments;
(iii) The wetland park will route river waters through large areas of wetland habitat which will remove nutrients, sediments and organic loading from the water.
(iv) The Low-Impact Design (LID) for Binhe Road will remove sediment and nutrient loading from urban stormwater before it is discharged into the Binhe River.

225. **Irrigation water.** The project does not involve change in water resource allocations, and will not alter or affect irrigation supply, including to areas and communities downstream of the project area.

226. **Groundwater quality.** Due to the nature of their work, WWTPs may pose a risk to soil and groundwater quality through leakages, equipment failure, accidental spillage or other events. These risks are usually managed through implementation of standard plant design, management strategies and monitoring programmes. Additional consideration was given to these issues for the Zuoquan WWTP, due to the location of the project near an important groundwater recharge system, even though the WWTP is located at the very downstream end of this system. The following measures will be implemented at the WWTP to protect groundwater resources: (i) plant seepage zoning districts and seepage control measures. Based on treatment characteristics and risk factors, the Zuoquan WWTP will be divided into general impermeable and non-impermeable zones. Seepage management and treatment for these zones is listed in Table VI-6; (ii) groundwater quality monitoring. The project will establish a long-term groundwater monitoring system and emergency plan, monitoring data will be collected through wells to document any pollution incidents and determine the extent and range of such incidents to plan emergency measures and remedial actions; and (iii) groundwater environment management. Regular maintenance procedures for water treatment and discharge facilities across the whole plant will be established. Groundwater environment education will be provided under the local environmental protection authorities' regular monitor and guidance programmer to improve employees' environmental awareness.

Table VI-6. Main Seepage Control Measures of the Plant

Name	Impervious Area and Location	Impervious Area Degree	Detailed Measures	Cement Impermeability Grade

Water tank, secondary settling tank, sedimentation reaction tank, AAO tank, improved AAO tank, BAF, sludge tank	Underground water tank base and wall	Significant	Reinforced concrete tank; bottom thickness 300 mm, wall thickness 240 mm; waterproof paint on outside and the bottom; soil foundation treated by dynamic compaction	P8
Purification tank, clean water tank, sludge dewatering room	Bottom of tank and surrounding surface	General	300mm thick reinforced concrete floor	P8

227. With the proper implementation of the above measures, project risks to groundwater quality will be effectively addressed.

228. **Groundwater resources.** The increased domestic water supply proposed under this project will be sourced from groundwater. The risk of over-extraction was assessed. The wells of City West Water Supply station are located at the middle reaches of West Qingzhang River, downstream of Shixia Reservoir. The two main recharge sources are precipitation infiltration and upstream Shixia Reservoir discharging water. After accounting for water consumption by seven settlements (Shijia, Sanjia, and Majiu villages; and four villages along the western city), the remaining water quantity available for sustainable use by this project in the shallow layer of the aquifer is 1.3926 million m^3 /yr in 2016. This is expected to fall slightly to 1.3667 million m^3 /yr in 2020 and 1.3457 million m^3 /yr in 2030 (Table VI-7).

Table VI-7. Groundwater Availability in the City West Water Supply Station Catchment. Unit: 10 thousand m^3/a.

Level year	Allowable exploitation amount	Actual and proposed exploitation amount needs to be deducted		Exploitation potential
		Shijia, Sanjia, Majiu	Four villages in western city	
Current	150.4	8.40	2.74	139.26
2020	150.4	10.35	3.38	136.67
2030	150.4	11.94	3.89	134.57

229. From this analysis, groundwater resource of City West Water Supply Station is more than sufficient to provide sustainable domestic water supply under this project, which is only 774,100 m^3/yr in the short-term, and 892,500 m^3/yr in the long-term.

2. Air Quality

230. The key source of potential air quality impact during the operation phase is odor and fugitive emissions from the upgraded Zuoquan WWTP.

231. **Odor.** Odor generated during sewage treatment (including sewage grating room, sedimentation tank, sludge dewatering room, oxidation pond and secondary sedimentation tank) will impact areas within and around the Zuoquan WWTP. The concentration of odor is related to wastewater quality, and its dispersal is related to meteorological conditions and terrain. Odor is a composite of pollutants of which ammonia (NH_3) and hydrogen sulfide (H_2S) are the key parameters. Two national standards apply: *Class II of Emission Standards for Odor Pollutants (GB14554-93)* (for evaluation at the plant boundary) and *Design of Industrial Enterprises Hygiene Standards (TJ36-79)* (for evaluation at receiver sites). The standards for the level of odor pollutants at the plant boundaries are defined in Table VI-8.

Table VI-8. Boundary Standard of Odor Pollutants

Controlled Pollutants	Unit	Class I GB14554-93	Class II GB14554-93	
			New Sites	Existing Sites
Ammonia	mg/m3	1.0	1.5	2.0
Hydrogen sulfide	mg/m3	0.03	0.06	0.10

232. The distance from the plant where maximum concentrations of these gases will occur was calculated using the air environmental protection distance computation method regulated in *Guidelines for Environmental Impact Assessment Atmospheric Environment (HJ 2.2-2008)*. Assuming that WWTP pollutants are deodorised and then discharged through 15 m high exhaust emissions, the assessment showed maximum ground concentration of NH_3 and H_2S will be 1.28E-03 mg/m^3 and 5.06E-05 mg/m^3, respectively. These concentrations are only 0.64% and 0.51% of the relevant standards respectively, and it can be concluded the upgraded Zuoquan WWTP will have negligible odor impact.

233. **Fugitive emissions.** Table VI-9 lists potential fugitive emissions of exhaust gases after Zuoquan WWTP upgrading. The atmospheric environmental protection distance of fugitive emission source has been calculated according to *Technical Guidelines for Environmental Impact Assessment (HJ2.2-2008)*. Ammonia and hydrogen sulfide concentrations will be well below relevant standards at the WWTP boundary. Additional buffer zone protection orother measures are not required.

Table VI-9. Zuoquan WWTP Fugitive Emissions Statistics

No.	Pollutant Source	Dimensions (L*W*H, m)	Q_{NH_3} (t/a)	Q_{H_2S} (t/a)
1	Coarse grid/inlet pumping station	11*13.1*5	0.0044	0.00017
2	Fine grid/settling tank	15*4.1*5.4	0.0044	0.00017
3	Sludge Dewatering Plant	39.6*18*5.4	0.0396	0.00156
4	A/A/OTank1	64.8*48.9*6.8	0.0044	0.00017
5	A/A/OTank2	64.8*48.9*6.8	0.0044	0.00017
6	Secondary Settling Tank 1	D=45m, depth 4m	0.0044	0.00017
7	Secondary Settling Tank 2	D=45m, depth 4m	0.0044	0.00017

234. The *Urban Sewage Treatment Project Construction Standards (Build Standard [2001] No. 77)* state that “sewage with odor, sludge treatment facility should be located downwind of dominant summer wind in auxiliary production areas, and should kept away from residential areas in accordance with relevant national regulations. If not, the distance between residential areas to odor generating facilities should be at least 50-100 m.” The evaluation of health protection distance is set to be 100 m. The closest residential area to the Zuoquan WWTP, Qinshuiwanjiayuan, is 180 m from the WWTP, which satisfies the 100 m standard.

3. Noise

235. Noise impacts during the operation phase will result from operation of the Zuoquan WWTP, which will include various pumps and air compressors generating noise levels of 70 – 75 dB(A). As this is an upgrading project, the changing boundary condition between the existing project and the expansion project has been considered. Table VI-10 gives the main noise sources and its control measures of the expansion project.

Table VI-10. Main New Zuoquan WWTP Noise Sources and Control Measures

Source	Location	No.	Noise for each facility dB(A)		Mitigation Measure	Note
			Before mitigation	After mitigation		
Submersible sewage pump	Course grid; inlet pump station	3	90	70	Plant insulation, semi-underground	Existing facility. Will be subject to regular monitoring
Submersible	Improved	4	90	70	Plant	New (project-funded)

Source	Location	No.	Noise for each facility dB(A)		Mitigation Measure	Note
			Before mitigation	After mitigation		
Recirculation Pump	AAO tank				insulation, semi-underground	facility
Mixture Reflux Pump	Existing AAO tank	1	90	70	Plant insulation, semi-underground	Existing facility. Will be subject to regular monitoring
Return Sludge Pump	Secondary settling tanks with wells and reflux; excess sludge pump station	4	95	75	Plant insulation, semi-underground	New (project-funded) facility
Remaining sludge pump		1	95	75		
Sludge returning pump	Existing settling tank	1	95	75	Plant insulation, semi-underground	Existing facility. Will be subject to regular monitoring
Sludge pump	Reacting settling tank	3	95	75	Plant insulation, semi-underground	New
Maglev fan	Blower room	2	90	70	Plant insulation	1 new (project-funded) and 1 existing facility
Sludge transfer pump	Sludge dewatering room	1	90	70	Plant insulation, semi-underground	Existing facility. Will be subject to regular monitoring
Air compressor		1	90	70		

236. Noise predictions at Zuoquan WWTP boundary are listed in Table VI-11. The prediction results indicate that the contribution value of WWTP boundary are 40.33-48.63 dB(A) during daytime and nighttime, which meets the Class II of the *Boundary of Industrial Enterprises of Environmental Noise Emission Standards (GB12348-2008)*. Noise levels at the closest residential area to the WWTP expansion (Qingshuiwanjiayuan) are predicted to be 31.96 dB (A). This meets Class II of the *Acoustic Environmental Quality Standard (GB3096-2008)*.

Table VI-11 Zuoquan WWTP Boundary Noise Predictions (dB(A))

Location	Level	Standard		Status	
		Daytime	Nighttime	Daytime	Nighttime
1#East Boundary	40.33	60	50	Qualified	Qualified
2# East Boundary	41.98	60	50	Qualified	Qualified
3# South Boundary	45.01	60	50	Qualified	Qualified
4# South Boundary	48.63	60	50	Qualified	Qualified
5# West Boundary	47.08	60	50	Qualified	Qualified
6# North Boundary	44.74	60	50	Qualified	Qualified
7# North Boundary	40.61	60	50	Qualified	Qualified
Qinshuiwanjiayuan	31.96	60	50	Qualified	Qualified

4. Solid Waste

237. Solid waste generated during the operation phase will comprise: (i) solid waste and dried sludge from the Zuoquan WWTP. This waste will be delivered to Zuoquan Waste Landfill. Waste cloth filters will be recycled by raw material suppliers; (ii) domestic waste from the wetland park staff and visitors, hydrology monitoring and water pumping stations. This will be

collected and managed by the local Sanitation Department; and (iii) waste cotton and waste oil from equipment maintenance in spillway control chamber will be classified as hazardous waste. These materials will be regularly collected and properly disposed of by suitably qualified companies. The companies will be selected by standard local government procurement regulations.

5. Ecology and Biodiversity

238. The project is expected to have negligible negative ecological impacts during the operation phase, and positive impacts. Ecological benefits will comprise: (i) habitat restoration — reforestation of 128.2 ha in the catchment of the Shixia Reservoir with a mix of native species of trees, shrub and wetland flora. The 41 ha wetland park will include large areas of wetland habitat; (ii) species of conservation interest — bird species of conservation interest recorded from the Shixia Reservoir catchment (Section V.C) utilize a mix of open country and forested habitats and rivers. The reforestation programme conducted for this project may provide additional habitat for these species; (iii) water quality — improved water quality of the lower West Qingxhang River will result from dredging (the removal of accumulated litter and polluted sediments), improved wastewater infrastructure, and upgrading of the Zuoquan WWTP; and (iv) the increased volume of treated water from the Zuoquan WWTP will improve water flow rates in the river, enhancing ecological conditions downstream of the WWTP.

6. Physical Cultural Resources

239. No cultural heritage or archaeological sites are known from the project area. It is unlikely that operational phase activities could impact any currently unknown underground cultural resources. Nonetheless, if any archaeological or other cultural relics are encountered during the operation phase, the Zuoquan Cultural Heritage Bureau, PMO, and IA will be promptly notified.

E. Dam Safety

240. An independent dam safety assessment report for Shixia Reservoir was commissioned and approved by Jinzhong City Water Resource Bureau in February 2015. The main issues identified in this report comprised: (i) water seepage on both the left and right dam abutment; (ii) a temporary emergency gate constructed in 2013 is being used to access the dam for inspections; (iii) an existing rubber dam installed at the spillway has been in operation for 12 years and is close to the end of its design life; and (iv) water leakage has been observed between inlet and outlet pipes. Under the current project, a technical review for structural and O&M improvements to the reservoir was conducted by the PPTA dam safety consultant. Recommendations were made on: (i) provision of dam safety monitoring automatic system; and (ii) capacity building on reservoir O&M. Exact specifications of the monitoring system will be addressed at the detailed design stage, but is suggested that instruments are installed in the proposed sluice, such as displacement monitoring on gate piers. The project includes structural enhancement of the Shixia Reservoir flood discharge and regulation capacity, as well as training to improve O&M procedures. Both the independent review team and PPTA dam safety consultant verified the feasibility and value of these proposed measures to improve dam safety and O&M. ADB's SPS (2009) requires that for projects involving structural elements of dams that are situated in high-risk locations (and where their failure or malfunction may threaten the safety of communities), the borrower/client should engage qualified and experienced safety experts, separate from those responsible for project design and construction, to review project design, construction, and commissioning. For the current project, structural works are relatively minor, comprise improvements to flood discharge and regulation capacity, and do not present risks to the integrity of the dam wall. SPS requirements for independent dam safety experts are therefore not required for the project. Nonetheless, development of a dam emergency response plan is included in the project EMP (Attachment 1).

F. Induced, Indirect, and Cumulative Impacts

241. Induced impacts are adverse and/or beneficial impacts on areas and communities from unintended but predictable developments caused by a project which may occur later or at a different location. Indirect impacts are adverse and/or beneficial environmental impacts which cannot be immediately traced to a project activity but can be causally linked. Cumulative impacts are the combination of multiple impacts from existing projects, the proposed project, and anticipated future projects that may result in significant adverse and/or beneficial impacts that would not be expected in case of a stand-alone project. For the current project, one induced impact and one indirect impact have been identified.

242. **Induced impact.** The expansion of water supply to 43 rural villages will have the consequence of increasing wastewater generation in these communities. As the villages have no existing wastewater infrastructure, wastewater disposal could induce impacts on surface and groundwater resources, affecting water quality and aquatic ecological communities. To address this issue, a loan assurance has been agreed that adequate rural wastewater treatment systems (e.g., septic tanks) will be provided for all villages receiving improved water supply under project.

243. The implementation of the Binhe Road component has great significance in improving the road traffic conditions across the whole of Zuoquan County. At present, the main road networks of Zuoquan County only have two main east-west roads, the North Avenue in the north and Yanhe Avenue next to the Qingzhang River in the south which is also the county section of S319 provincial road. The existing roads have frequent traffic accidents as they were not properly designed for heavy trucks. The new Binhe road is designed to urban trunk road standards to facilitate urban expansion and relieve current urban traffic congestion. After completion of the Binhe road, the benefits will include reduction of noise and dust impacts on the surrounding residents and reduction of traffic accidents.

244. **Indirect impact.** Treated wastewater discharged from the upgraded Zuoquan WWTP will have indirect beneficial impacts on the ecology of the West Qingzhang River. This relatively clean water will increase base flow rate in the river, which is affected by upstream regulation at the Shixia Reservoir. The increased water volume will improve habitat conditions for aquatic communities.

G. Climate Change

1. Climate Risk Vulnerability Assessment

245. **Potential climate change impacts to the project.** Zuoquan is being affected by climate change, with temperatures and precipitation expected to increase further in the coming decades. These could affect some aspects of the project design including survival of vegetation and altered hydrological characteristics in the project area. To address these impacts, a climate risk vulnerability assessment (CRVA) was conducted for the project based on the projected climate changes, assuming a project design life of 30-40 years.

246. **Revegetation around Shixia Reservoir and planting of forest belts along two headwaters.** (i) Nativespecies selected among those which can withstand adverse environmental conditions, will be used as planting materials (seeds, seedlings, saplings and cuttings); and (iii) regular inspections will be included in the maintenance program to prevent plant diseases and avoid insect pests.

247. **Improvement of reservoir spillway gate and construction of flood discharge and spill tunnel.** The adaptation measures adopted in the project design include: (i) The dam structures are more vulnerable to damage due to climate change as more frequent extreme weather and flood incidents may occur. The proposed capacity building and training of the operators to conduct regular inspections to ensure the safety of dam structures can be

regarded as a climate change adaptation measure; (ii) The potential impact of climate change on the reservoir will be possible reduction of water volume and water supply due to (1) higher evaporation under higher temperature conditions; and (2) more frequent droughts. The increase of the spillway sluice gate level by 3 m to increase the reservoir storage capacity would alleviate this climate change impact.

248. **Hydrology and water quality monitoring station.** The stations are located at adequate elevations to avoid flood damage.

249. **River rehabilitation and construction of embankments.** The adaptation measures adopted in the project design include: (i) A sensitivity test increasing the 1 in 20 year design flow by 15% is carried out by the local design institute (LDI) to check the river embankment. It is noted that a short section of the embankment would be overtopped. The LDI will increase the height of embankment to cope with this. (ii) The selected species for landscaping have good resistance to high temperature, low temperature, waterlogging and floods which are suitable for future climate induced impacts.

250. **Construction of wetland park.** (i) Native climate-resilient species will be selectively used as planting materials (seeds, seedlings, saplings and cuttings); and (3) regular inspections will be included in the maintenance program to prevent plant diseases and avoid insect pests.

251. **Low-impact design (LID) for road improvement.** LID incorporated in the design of Binhe Road will include permeable paving, tree pits and bioswales, to manage stormwater runoff and reduce the heat effect caused by climate change. In addition, warning signs and lighting will be provided to give advance warning to the road users during extreme weather conditions.

252. **Water supply system.** Training in water demand management will reduce the use of water. (ii)

253. **Wastewater system.** The adaptation measures adopted in the project design include: (i) Not strictly a climate change adaptation measures, but the treatment plant has spare capacity. The daily flow variation coefficient of the sewage treatment plant has been increased to 1.53 to allow for a higher peak flow for design of the treatment units. In addition it is proposed to install a new type of flow separation device to accurately control the sewage flow entering the sewage treatment system. Also the aged sewage pipes will be replaced to reduce inflow of stormwater to the sewage system.

2. Greenhouse Gas Emissions

254. Project greenhouse gas (GHG) emissions were estimated for three key sources: (i) Carbon dioxide (CO_2) produced during aerobic component of wastewater treatment. (ii) nitrogen dioxide (N_2O) emissions in the WWTP treatment process; and (iii) power usage and fossil fuels and electricity for machinery and vehicles to be built, upgraded or used by the project, as follows.

- **Aerobic component of wastewater treatment.** The FSR provides an estimation of GHG production from the aerobic component of the modified A/A/O process in the Zuoquan WWTP. The estimation uses an IPCC carbon accounting method based on BOD removal, where the organic matter in the wastewater is decomposed by microbial action, producing CO_2. There is no estimation of GHG emissions from: (i) the anaerobic phase of the treatment, since the FSR cites the IPCC advice that “biogenic carbon” should not be included in carbon accounting; and (ii) the anaerobic sludge digester, since the FSR considers the deep dehydration process is used for sludge treatment. The results indicate that, excluding N_2O emissions, project GHG emissions for the aerobic component of WWTP operation will be around 302 t/yr CO_{2e}.

- **Potential N_2O emissions in the WWTP treatment process.** The FSR applies the following formula: $M_{N2O}=Q\ (TN_{influent}-TN_{effluent})\ FNi\times10^{-3}$, where Q is the influent volume and FNi is an empirical emission factor of N_2O during nitrogen removal. The total estimated N_2O emissions for the project are 2.9 t/yr (equivalent to 861 t/yr CO_{2e}).

- Power usage and fossil fuels and electricity for machinery and vehicles to be built, upgraded or used by the project: total estimated emissions from these sources are 7,989 t/yr CO_2e (Table VI-12).

255. **Carbon sequestration.** In the PRC, annual carbon sequestration capacity of forest is estimated to be 0.3-12 t C/ha depending on forest type, species, and age, as well as soil, water and weather (average annual sunshine hours, rainfall and temperature). Considering the weather conditions of Shanxi Province, the value of 0.5 t/ha.yr was applied for the calculation of carbon sequestration for the project. It is estimated the project tree and shrub planting will achieve 640 tons of carbon sequestration per year (Table V-12).

Table VI-12. Project greenhouse gas emissions (CO_{2e}) and sequestration (t/yr)

Items	Units	As CO_{2e}
Zuoquan WWTP 5,000 m^3/day (CO_2)	1	302
Zuoquan WWTP 5,000 m^3/day (N_2O)	1	861
Vehicles (<10t) –(13,200 km/yr)	2	7
Boats	6	21
Reservoir Spillway Gate (kw-hr/year)	1,000	1
Water Supply – pumping and treatment (kw-hr/year)	7,300,000	6,315
Wastewater treatment (kw-hr/year)	1,387,000	1,200
River Rehabilitation(kw-hr/year)	328,500	195
Wetland (kw-hr/year)	146,000	87
Water Monitoring Stations (kw-hr/year)	273,750	163
Total Emissions		**9,152**
Tree Planting (ha)	128.2	640
Total Sequestration[2]		**640**
Total Estimated Emissions		**8,512 t/ yr**

Source: Estimates of unit numbers are from the detailed engineering design report for the project.

256. Based on these calculations, the total estimated GHG emissions by the project would be around 8,512 t/yr CO_2e. This is well below ADB's SPS threshold level of around 100,000 t/yr CO_{2e}.

VII. ANALYSIS OF ALTERNATIVES

257. During project preparation, alternative designs for were assessed in consideration of technical, economic, and energy efficiency and environmental and social impacts. Six alternatives were assessed: (i) 'no project' alternative; (ii) revegetation around the Shixia Reservoir and planting of forest belt along two headwaters; (iii) improvements to the spillway gate; (iv) stormwater drainage, (v) rural water supply system; and (vi) water pollution control.

A. No-Project Alternative

258. If the project is not implemented, adverse environmental, social and economic impacts can be expected in the Zuoquan County. Existing issues with poor water quality, flooding, inadequate water supply and degraded ecological resources would not be addressed. Moreover, as Zuoquan County develops and the population increases, these issues would become more severe without project implementation.

B. Output 1—Shixia Reservoir Operation and its Watershed Vegetation Improved

1. Revegetation around the Shixia Reservoir and Planting of Forest Belt Along Two Headwaters

259. **Riparian forest planting layout plan alternatives.** Two alternatives were evaluated: (a) whole river restoration: vegetation rehabilitation alongside the total river length, in which new riparian strips were established in non-forested and/or thinning areas of forest; and (b) replanting in current non-forested zone: existing riparian strips are retained and create new one only in none forest area. Whole river restoration would result in high mixed level forest structure. However, it requires more works in general, while inappropriate thinning of the existing forest can cause potential issues such as increased soil erosion, hydrological disturbance in the floodplain and ownership towards existing poplars. Under option b, newy planted species will naturally colonize other areas and current mono-stands of poplars will gradually become mixed forest. Option b was selected as most efficient.

260. **Planting density.** Zuoquan is located in arid northern PRC where deciduous tree and shrub species grow best in direct sunlight. Planting density will not be too high with consideration of floodplain land condition, otherwise is not healthy towards under vegetation growing. Trees planting density is adapted as 800-1200 trees/ha based on relevant codes.

261. **Spacing of planting.** Plant spacing for reforestation can adopt various patterns including square, rectangular, triangular and group configuration. Square planting configuration is of equal tree spacing in which each trees has the uniform distance to grow accordingly, it is commonly used for the productive forest and economic forest. Rectangular planting has uniformed spacing that is good for tree tending and intercropping between the rows, and is suitable for mechanical reforestation in a flat region. Triangular planting configuration requires shifting spacing between the adjacent planting spots to create a soil, wind and sand conservation forest environment, thus is conductive to even tree growth and protection. Equilateral triangular planting configuration is the most uniform spacing by 15% tree planting increase per unit. This configuration is better adapted for economic forest in a flat land with no intercropping; Group planting configuration requires a less regular grouping distribution with high planting density and larger spacing, and it is adapted to secondary forest improvement or to create ecological public forest with poor land condition. Water conservation forest as in this project is focus mainly on soil, wind and sand erosion control with almost no intercropping and thinning. Thus equilateral triangular planting configuration is adopted for optimization of environmental benefits.

262. **Species mix.** Existing riparian forest strips have been planted with a single tree species, *Populus simonii*. Multi-plant species are more conducive for soil protection, bank stabilization, and ecosystem function. A multi-species mix will be implemented, with key species including *P. simonii, Salix matsudana, Robinia pseudoacacia, Ulmus pumila, Hippophae rhamnoides, Ziziphus jujube, Medicago sativa, Ranunculus japonicus*, *Juncus effuses* and *Phragmites communis.*

263. **Planting method and maintenance.** Localized planting method includes seedling and seeding afforestation. For trees and shrubs, seedling afforestation is adopted, while seeding afforestation is proposed for grass and wetland vegetation.

2. Improving the Reservoir Spillway Gate and Construction of Flood Discharge Tunnel.

264. **Reservoir spillway gate.** According to the topographical condition of the spillway and the inlet construction layout, the gate could be placed at the upstream arch bridge at the spillway inlet or at the existing rubber dam. The bridge is located at Y0+016.0; if the control chamber is located at the upstream arch bridge (Y0+000.0), possible disadvantages include: (i) due to the limited distance to the arch bridge, it will cause interference between the designing chamber and existing bridge, thus it is necessary to rebuild the existing bridge. A temporary bridge will also be constructed during the project process, resulting in increased investment cost; (ii) it is difficult to control gate foundation seepage and main dam curtain grouting. Existing main dam curtain grouting is located at (Y0+028.0) the downstream chamber. Chamber uplift pressure cannot be reduced, since it has negative impact on the chamber stability and may also cause other seepage problems around the dam; and (iii) from the geology perspective, the lower the bed rock surface, the more the foundation treatment depth, resulting an increase in the cost.

265. For these reasons, the spillway gate chamber will remain where the existing rubber dam is; thus removing the existing rubber dam and rebuild the new 2-hole gate chamber with a dimension of 8.0 m wide. A flat steel gate for accident repair will be located at the upstream chamber, and the curved steel gate will be placed downstream; maintenance platform and hoist room will be located in the upper chamber.

266. **Construction of flood discharge tunnel.** Venting spillway tunnel layout has been considered based on topography, geology, operational management, and other aspects:

(i) **Topographical analysis.** According to the topographical analysis of Shixia Reservoir, venting spillway tunnel can be placed at either left or right side of the main section of the dam. If placed on the right side of the dam, the tunnel axis will form a larger curve segment, and intersect with the water tunnel surface of Dongshan Water Supply Project, with a tunnel length of 500 m. Geological structure analysis states that the right side bedrock surface elevation is relatively low, making the construction more difficult. If placed on the left side of the dam, the tunnel will meet the linear arrangement requirements, with a tunnel length of 300 m. The bedrock surface elevation is relatively high; it is beneficial for construction transportation, site layout. Thus, the left side is a better option according to the hydraulic tunnel short line principle.

(ii) **Geological analysis.** Geological analysis suggests that the minimum thickness of vertical and lateral rocks should be verified in accordance to topography, geology, rock stability, and anti-penetration characteristics. Geological cross-sectional view shows that the surrounding rocks are mainly sandstone, mudstone and conglomerate. They are mostly moderate-strong weathered rocks, which can be easily broken. Tunnel line is located below the water line, and the bedrock surface is relatively low, the bedrock roof with a thickness of 0-6 m. If a high spillway design is selected, it can reduce the tunnel height and increase the thickness of surrounding roof rocks, but with an outlet ground elevation of 1120 m, there is an 8 m difference with the inlet elevation of 1,128 m. Thus it is subject

to outlet topographical restrictions, and there is limit to increase the thickness of the surrounding rocks.

(iii) **Construction analysis.** Analysis indicates that the lower the tunnel axis is arranged, the thicker the covering base rock layer above the tunnel is. It is easy in construction, but limited by the inlet and outlet elevation. According to rock foundation location determined in geological investigation, it suggests to design the tunnel axis at the rock stratum with respect to 1x overlay requirement. Thinner area of inlet and outlet overlay will undertake special measures to support the construction. Meanwhile to reduce the impact on the tunnel blasting, excavation of dam, spillway, and control office, tunnel axis will be located on the left side of spillway and the control office.

(iv) **Existing layout of Shixia Reservoir.** Shixia Reservoir overall layout is, from left to right, control office, spillway, the main section of the dam, and the second section of the dam; water supply tunnel will be placed on both left and right side on the main section of the dam. Due to the limited distance between spillway and control office, the tunnel line can be placed between the dam and spillway (option 1) or at the left side of the spillway (option 2). The inlet in option 1 is located between the dam and the spillway, with a limited topographic condition, which is not conducive to the inlet tower arrangement, venting spillway tunnel return outlet will be harmful to the safety of power plants. The outlet is located next to Hefeng Highway Bridge, and could result in scouring of the bridge piers, thus venting spillway tunnel should be located on the left side of spillway and control office for centralized management. Option 2 was selected.

C. Output 2—Qingzhang River and Binhe Road Rehabilitated

1. River Rehabilitation and Construction of Embankment

267. **Embankment design.** Various embankment designs were reviewed during the design phase. Four main designs were selected for construction to allow flexibility to accommodate different conditions along the section of West Qingzhang (Figure IV-13).

2. Low-Impact Design for Road Improvement and Stormwater Drains Installation

268. **Stormwater piping.** After comparing the data of various pipe performances (Table VII-1), high-density polyethylene (HDPE) double-walled pipe is selected as the drainage pipe for diameter ≤Φ1200, and reinforced concrete pipe is selected as the drainage pipe for diameter >Φ1200.

Table VII-1. Comparison of Stormwater Pipe Material

Pipe Performance	Reinforced concrete pipes	Glass fiber reinforced mortar pipes	HDPE double - walled pipe	UPVC Pipe
Quality	Good	Excellent	Excellent	Excellent
Construction progress	Average	Fast	Fast	Fast
Life span	Relatively Long	Long	Long	Long
Friction coefficient	Average	Small	Small	Small
Price	Average	Expensive	Expensive	Average
Pipe transportation	Somewhat Difficult	Easy	Easy	Easy
Corrosion resistance	Average	Good	Good	Good
Internal pressure load	Average	Large	Large	Average
Adaptability	Notching, pipe jacking	Notching, pipe jacking	Notching	Notching

D. Output 3—Inclusive Water Supply and Wastewater Collection Services Achieved

1. Rural Water Supply System

269. **Pipeline design.** As the design capacity of the potable water supply system is small, the delivery and distribution pipelines can remain as single pipeline system. For industrial water supply, the *Design Code for Rural Water Supply Engineering (SL 687-2014)* requires that 70% of total water supply volume should be remain in the case of an accident occurring. To meet this requirement, two options were assessed: (i) twin pipeline + adjusting tank (design capacity:15% of daily consumption on highest day); and (ii) single pipeline + adjusting tank (design capacity: 70% of daily consumption on highest day). Since the adjusting tank required in option 2 is large and difficult to implement, and construction costs are higher, option 1 was selected.

270. **Pipe material.** Six commonly used pipe materials for water supply were compared (Table VII-2). Corrosion-resistant materials were selected (polyethylene, PE pipes, and steel wire reinforced PE pipe) (Tables VII-3 and Table VII-4).

Table VII-2. Comparison of Various Water Supply Pipe Materials

Property of pipe materials	Prestressed Concrete Cylinder Pipe (PCCP)	Fiberglass Reinforced Plastic Mortar (FRPM)	Steel Pipe (SP)	Ductile Iron Pipes(DIP)	PE water supply pipe	Steel Wire Reinforced PE Pipe
Anti-corrosion	☆☆☆	☆☆☆☆☆	☆☆	☆☆☆	☆☆☆☆☆	☆☆☆☆☆
Internal pressure-bearing	☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
Material price	Low	General	Relatively high	High	Relatively high	Relatively high
Construction period	Long (bell socket, heavy, need larger lifting appliance)	Short (sleeve joint, light, easy to install)	Long (pipes need welding)	Short (bell socket, easy to install)	Short (hot melting, bell socket, easy to install)	Short (hot melting, easy to install)
Hydraulic performance	☆☆☆	☆☆☆☆	☆☆☆	☆☆☆	☆☆☆☆☆	☆☆☆☆☆
O&M cost	Low	Low	High	High	Low	Low
Transportation	Difficult	Easy	Easy	Easy	Easy	Easy
Imperviousness	☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
Joint leakproofness	☆☆☆	☆☆☆	☆☆☆☆☆	☆☆☆	☆☆☆☆☆	☆☆☆☆☆
Anti-scaling	☆☆☆	☆☆☆☆☆	☆☆☆	☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆
Anti-seismicity	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆☆
Cathodic protection	Needed	Needless	Needed	Needless	Needless	Needless
Service life	20-30	30-50	20-50	30-50	30-50	30-50
Comprehensive cost	Lowest	Relatively low	High	Highest	Relatively high	Relatively high
Comprehensive benefits	☆☆☆☆	☆☆☆	☆☆☆☆	☆☆☆	☆☆☆☆	☆☆☆☆☆

Note: ☆= Bad, ☆☆=Relatively Bad, ☆☆☆=General, ☆☆☆☆=Relatively Good, ☆☆☆☆☆=Good, ☆☆☆☆☆☆=Best.

Table VII-3. Overall Comparison between Steel Wire Reinforced PE Pipe and PE Pipes

No.	Item	PE Pipe	Steel Wire Reinforced PE Pipe
1	Working Pressure	Actual operating pressure of PE Pipe is generally between 0.2-0.6 Mpa due to the effect of temperature and pressure correction factor. Nominal pressure cannot be increased in the absence of steel frame.	Oressure resistance of SRTP at least twice that of PE pipe due to presence of high-strength of steel wire. Pressure can still reach 1.0-2.5 Mpa even under the effect of temperature and pressure correction factor.
2	Diameter	Diameter and wall thickness of pure PE pipe depend on SDR value.	Pressure rating is increased due to the steel frame in the pipe, with

No.	Item	PE Pipe	Steel Wire Reinforced PE Pipe
		When the diameter is greater than 200 mm, the material cost will be too expensive due to the thick wall thickness.	proper wall thickness, light in weight, and reasonable price. It has more advantages in performance and usage than PE pipe.
3	Hydraulic Characteristics	Since wall thickness of PE pipe is greater, which results a smaller inner diameter when PE pipe and SRTP occupy the same outer diameter, thus the flow capacity is smaller than SRTP.	SRTP retains a large effective inner diameter because of its thin wall thickness. e.g. The flow rate increased in De500 is 19.7%.
4	Stress Cracking Effect	Indentation are formed by pipe scratches, this is because the stress concentration is located at the indentation when the external force is applied; the crack initially starts at the indentation and then rapidly extends (notch effect), even cause pipeline rupture.	Radial load carrying capacity is improved due to steel wire mesh, as well as the resistance to rapid crack of pipe wall and surrounding stress crack.
5	Impact Resistance	HDPE retains high strength and stiffness but with relatively low impact resistance; LDPE has good flexibility, elongation, and impact resistance but with relatively low intensity. The impact resistance for commonly used HDPE pipe for water supply is not ideal.	Due to the strengthen effect from steel frame in SRTP, its rigidity, impact resistance, and dimensional stability is better than any of the pure plastic pipe. It retains the flexible characteristics because of mesh-shape steel frame, it still has the capability to resist from earthquakes, land subsidence or slip, anti-surface overloaded vehicles.
6	Welding Characteristics	Using butt-fusion jointing for welding, with unstable jointing surfaces. They will be easily fractured under the variation of pressure and environmental conditions.	Using electric welding procedure to connect pipelines, with high strength interface, high tensile strength, seam strength and the pipe body are basically the same.
7	Allowable Bending Radius	Pipes should be laid strictly following the requirement of the minimum allowable radius because of stress relaxation. It is necessary to pay more attention in the installation and construction.	Steel frame limits the stress relaxation effect of polyethylene and restricts the creep of the plastic substrate, so requirement of bending radius remains the same when laying pipe.
8	Tracing Capability	Since PE pipeline is only made of polyethylene, it is impossible to detect its location directly. It shall be buried with a metal tracer in order to search for maintenance.	It is possible to detect pipeline by using the existing underground pipeline metal detect in the presence of steel frame, and it is much easier to navigate to pipeline locations for maintenance.
9	Safety Performance	Large temperature difference will result in softening the material, thus affecting the bearing capacity of internal pressure, causing a certain impact of the service life and safety issues.	SRTP has strong pressure resistance, in addition with the new structure of high strength adhesive resin, so the pressure is less affected by the temperature and it is relatively safe to use.

Table VII-4. Price Comparison between PE Pipe and Steel Wire Reinforced PE Pipe

Diameter (mm)	Price (CNY/m)

	Pure PE Pipe	Steel Wire Reinforced PE Pipe
DN110	59.5	64.00
DN200	199.8	152.00
DN315	336.60	312.00
DN400	536.00	472.00
DN500	846.00	715.00
DN630	1341.40	1160.00

271. The technical performances of PE pipe and steel wire reinforced PE pipe are similar, with steel wire reinforced PE pipe performing better in pressure resistance and easy navigation for future maintenance. Taking cost into consideration, steel wire reinforced PE pipe is selected for pipelines of DN 200 or more, and traditional PE pipe is selected for DN110 Pipelines.

272. **WTS treatment process.** Since the raw water quality is good, turbidity is always below 10 NTU, raw water can be directly filtered without coagulation and sedimentation process. Disinfection is required to remove pathogens in the treated water.

(i) **Filtration.** Several filters were compared, including siphon filter, valveless filter, V filter and pressure filter tank. Pressure filter tanks (Figure VII-1) were selected due to small design capacity of the two WTSs; site constraints and requirement for small footprint facilities; and City South Water Company previous experience in using pressure filter tank.

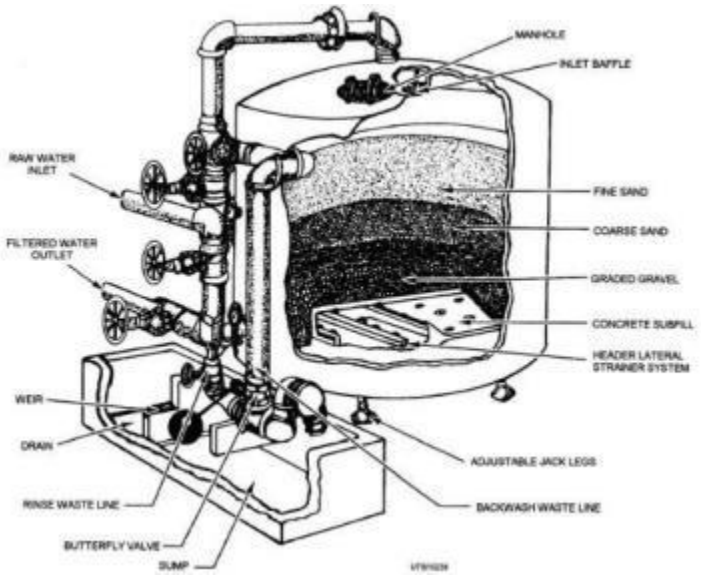


Figure VII-1. Pressure Filter Tank

(ii) **Disinfection.** Several commonly used disinfectants for rural water supply were compared (Table VII-5), including chlorine, chlorine dioxide and sodium hypochlorite. Due to small treatment volume of the WTS, and easy operation and safety considerations, sodium hypochlorite disinfection was selected.

Table VII-5. Comparison of Disinfection Methods

	Chlorine	Chlorine Dioxide	Sodium Hypochlorite
Advantages	• Continuous disinfection effect • Low cost • Easy operation • Small equipment	• No organic chloride will be generated. • Good disinfection performance. • Strong oxidation effect which can help to remove odor and color • Small dosage, short contact time, long lasting disinfection effect	• Long lasting disinfection effect • Easy operation • Chemicals needed are just sodium chloride and water
Disadvantages	• Disinfection byproduct will be generated for raw water with organic pollutants • Chlorine is hazardous. Special safety measures should be taken in operation.	• High cost • Need on-site preparation • Equipment is relative complicated. • Need to control byproducts such as chlorates and chlorites.	• Need on-site preparation • small equipment • high power consumption
Suitable application	For plants with convenient chlorine cylinder supply	For raw water with high organic pollutants	For small WTP

2. Wastewater Treatment

273. Based on the influent and effluent quality analysis, the required pollutant removal rate are calculated in Table VII-6.

Table VII-6. Required Pollutant Removal Rate

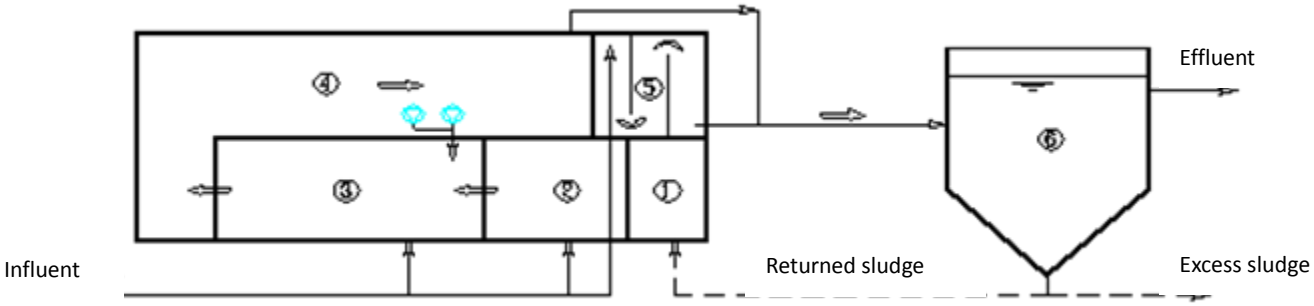
Item	pH	CODcr	BOD_5	SS	TN	NH_3-N	TP
Unit	/	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Influent	6~9	350	200	220	60	40	6
Effluent (1A)	6~9	50	10	10	15	5(8)	0.5
Removal Rate	/	85.7%	95%	95.5%	75%	87.5%	91.7%
Biological Process Empirical Removal Rate	/	65%~90%	65%~95%	70%~90%	10%~78%	0%~90%	20%~75%

274. It can be concluded that the influent is suitable for biological wastewater treatment process (which is preferable from cost consideration perspective); and advanced treatment is needed to ensure the effluent meet the Class 1A standard.

275. **Biological treatment process.** Three widely used biological treatment processes were compared - Modified A2/O, Carrousel Oxidation Ditch and Modified Sequencing Batch Reactors (SBR).

276. Modified A2/O is an improved process of traditional A2/O which provides the optimum living environment for microorganisms by adding a pre-anoxia tank at the front of the process so as to mitigate the impact of returned sludge to the anoxia section. Therefore, modified A2/O has better phosphorus removal efficiency than the traditional A2/O. The process diagram is shown in Figure VII-2. The pre-anoxia tank is used for returned sludge's anoxia denitrification,

whose carbon resource of denitrification is mainly the sludge component or partly added by municipal sewage; anaerobic tank is used for anaerobic phosphorus release in biochemical phosphorus removal of the system; anoxia tank is used for denitrification; aerobic tank is used for aerobic reactions like organic matter degradation, ammonia nitrogen nitration, absorption of phosphorus; flocculation basin can be used as an supplementary physicochemical treatment unit to strengthen phosphorus removal effect of the system as well as to intensify post-aeration effect as a biochemical unit when it is in biochemical and physicochemical series operation, and when in biochemical and physicochemical multiple operation, it can undertake the physicochemical treatment task of part sewage as an individual physicochemical treatment unit.



① -pre-anoxia tank, ②-anaerobic tank, ③-anoxia tank, ④-aerobic tank, ⑤-flocculation tank , ⑥-sedimentation tank.

Figure VII-2. Schematic Process Diagram of Modified A2/O Process

277. Carrousel Oxidation Ditch largely comprises annular aeration tanks. With advantages like good effluent water quality, stable treatment efficiency and convenient operation management, it can also meet the requirements of biological removal of nitrogen. There are many forms of oxidation ditch layout, including common rotary brush type oxidation ditch, carrousel oxidation ditch with vertical shaft surface aeration impellers and orbal oxidation ditch with rotary plate aerators. A typical process diagram of the proposed Carrousel Oxidation Ditch is shown in Figure VII-3.

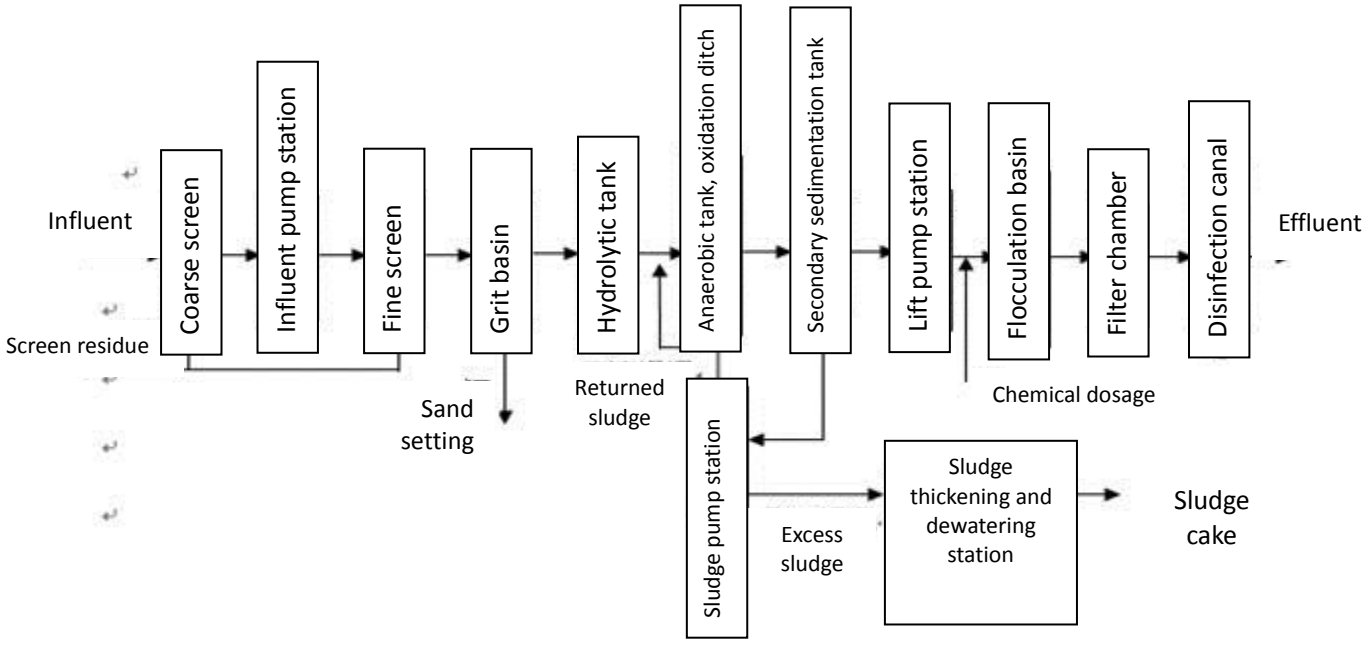


Figure VII-3. Schematic Process Diagram of Oxidation Ditch Process

278. Modified SBR process is a series of A2/O and SBR processes. It creates the best environmental conditions for the growth and reproduction of dominant microorganisms, to maintain efficient reactiveness of biochemical processes like degradation of organics, nitrification and denitrification of ammonia nitrogen, and release/absorption of phosphorus. This process uses combined-type conjoined structure, in which aeration tank and sedimentation basin are in the same tank and secondary sedimentation basin is omitted, so it covers a small area and excess sludge is minimal (Figure VII-4).

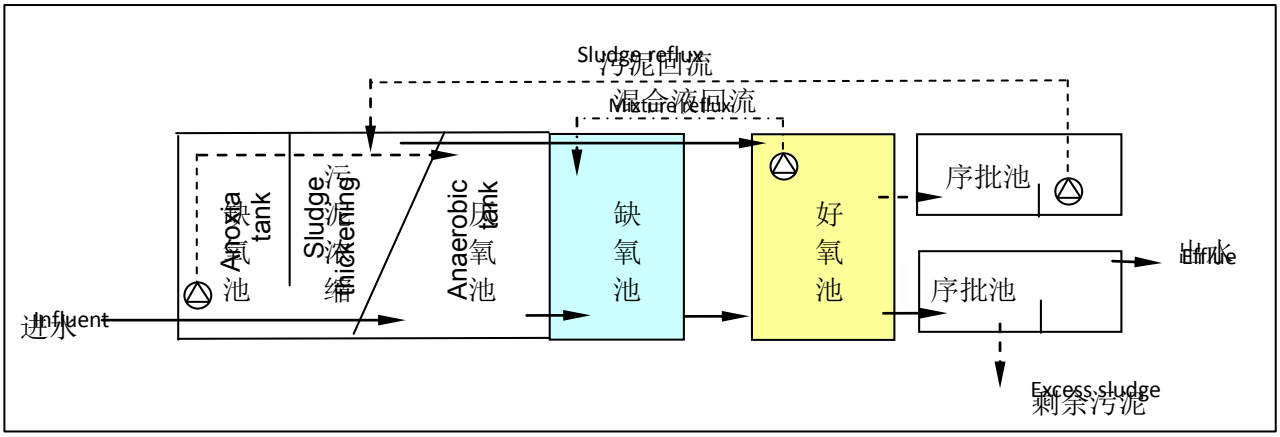


Figure VII-4. Schematic Process Diagram of Modified SBR Process

279. A comparison of various aspects of modified A2/O process, oxidation ditch process and improved SBR process are provided in Tables VII-7 to VII-10.

Table VII-7. Main Technological Parameters of Alternative Biochemical Treatment Processes

Technological parameter	Modified A2/O	Oxidation Ditch Process	Modified SBR
1. Pre-anoxia tank			
Retention time (h)	1.0	1.0	1.0
Effective volume (m^3)	417	417	417
2. Anaerobic tank			
Retention time (h)	1.5	1.5	1.5
Effective volume (m^3)	625	625	625
3. Anoxia tank			
Retention time (h)	3.5	3.5	2.2
Effective volume (m^3)	1460	1460	910
4. Aerobic tank or oxidation ditch			
Retention time (h)	8.5	8.5	8.5
Effective volume (m^3)	3542	3542	3542
5. Sequencing batch area			
Quantity (cell)	-	-	2
Effective volume per cell (m^3)	-	-	1550
6. Separation area of sludge and water			
Effective volume (m^3)	-	-	417
Total effective volume (m^3)	6044	6044	6814
Effective depth (m)	6	4	6 m for aerobic tank + sequencing batch tank; 8 m for others
Floor area (m^2)	1008	1511	1145
MLSS (g/l)	4	4	4
Sludge yield (kgMLSS/kgBOD_5)	0.7	0.6	0.6
Excess sludge yield (kg/d)	616	576	576
Aeration form	Tube-type aerator	Inverted-umbrella type impeller	Tube-type aerator

Technological parameter	Modified A2/O	Oxidation Ditch Process	Modified SBR
Aerator pipe quantity	600	2 machines	720
7. Sludge reflux and internal reflux			
Sludge return ratio (%)	50-150	50-150	50-150
Sludge pump quantity	3	3	3
Internal reflux sewage pump quantity	2	2	3
Reflux ratio (%)	200	200	300

(calculated as 10^4 m^3/d)

Table VII-8. Main Wattmeter of Alternative Biochemical Treatment Processes

Technological parameter	Modified A2/O			Oxidation Ditch Process			Modified SBR		
1.Aeration equipment	2 air blowers (1 in use and 1 standby)			2 Inverted-umbrella type impellers			2 air blowers (1 in use and 1 standby)		
Performance parameter	25 m^3/min, H=7.0m			90 kgO_2/hr			25 m^3/min, H=7.0m		
Service power (kw)	45			75			45		
2.Mixing equipment	1	1	2	1	1	2	1	1	10
Power (kW)	2.2	3	5.5	2.2	3	5.5	2.2	3	3.5
Total calculated power	16..2			16..2			40.2		
3.Sludge reflux pump	3			3			3		
Flow (m^3/h)	210			210			210		
Lift (m)/ power(kw)	10/11			10/11			10/11		
Total calculated power	33			33			33		
4.Internal reflux pump	2			2			3 (frequency conversion)		
Flow (m^3/h)	420			420			850		
Lift (m)/ power(kw)	0.9/4.0			0.9/4.0			0.9/5.5		
Total calculated power	8.0			8.0			11		
5.Total service power (kw)	102.2			132.2			115.2		

(calculated as 10^4 m^3/d)

Table VII-9. Treatment Cost of Alternative Biochemical Treatment Processes

No	Item compared	Modified A2/O	Oxidation Ditch Process	Modified SBR
1	Cost (CNY x10,000)	750	650	795
2	Annual wastewater treating amount (x10,000 m^3)	365	365	365
3	Unit treatment cost (CNY/m^3)	0.330	0.370	0.363
4	Unit treatment variable cost (CNY/m^3)	0.196	0.254	0.221

Table VII-10. Comprehensive Comparison of Alternative Biochemical Treatment Processes

Item	Modified A2/O	Oxidation Ditch Process	Modified SBR
Structure amount	Many	Ordinary	Few
Aeration way	Supply air by air blower and oxygen use ratio is high.	Supply air and maintain flow rate in ditch by impeller; good mixing; resistant to impact load.	Supply air by air blower and oxygen use ratio is high.
Technological characteristics	Nitrogen and phosphorus removal by pre-anoxia tank, anaerobic tank, anoxia tank, aerobic tank; pre-anoxia tank helps strengthen biological	Multitudinous, resistant to impact load, stable effluent water quality.	Flexible operation and can be adjusted according to water quality. Time scale of aeration/ mixing can be adjusted flexibly in the

Item	Modified A2/O	Oxidation Ditch Process	Modified SBR
	removal of phosphorus; successful examples in PRC and globally.		sequencing batch to ensure TN index.
Supporting facilities	Air blower room and secondary sedimentation tank are needed to be set.	Secondary sedimentation tank is needed to be set.	Air blower room is needed to be set.
Operation and management	Simple technological process, sufficient operation experience, not high requirement for operation workers, relatively simple operation and management.	Relatively few structures and simple management.	High degree of automation, low worker labor intensity while high requirement for operation workers, relatively simple operation and management.
Facility	Few facility categories and quantity	Few facility categories and quantity	Many facility categories and quantity
Investment of infrastructure	AAO tank + air blower room + secondary sedimentation tank	Oxidation ditch + secondary sedimentation tank	Improved SBR tank + air blower room
Operation fee	Relatively low power consumption	High power consumption due to low aeration efficient	Relatively high power consumption
Land use	Many structures and large area	Shallow tank depth and large area	Structures are combined in one tank and covers smallest land.

280. It is concluded that modified A2/O process has high efficiency in nitrogen and phosphorus removal by inflow from various points. Effluent water quality from this process has been proven to be stable through many projects in the PRC. The limitation of this technique is that the operation of the modified A2/O process is relatively complicated when compared to oxidation ditch process. However, it has a smaller footprint and consumes less energy as compared to oxidation ditch process. While the modified SBR process has the smallest footprint, it is even more complex than modified A2/O process and the Zuoquan County has no local experience in operation SBR process.

281. Considering that the existing Zuoquan WWTP uses A2/O process, is stable in treatment performance, and that the WWTP staff are experienced in operating A2/O, the modified A2/O process was selected for the Zuoquan WWTP expansion in this project.

282. **Advanced treatment process.** Commonly used advanced treatment processes reviewed for this project include: (i) Secondary Treatment – Filtration – Disinfection; (ii) Secondary Treatment – Coagulation – Sedimentation – Filtration – Disinfection; and (iii) Secondary Treatment – Mico-flocculation- Filtration –Disinfection.

283. “Secondary Treatment – Filtration – Disinfection” is simple but poor in COD and TP removal. The filter load in “Secondary Treatment – Mico-flocculation – Filtration–Disinfection” process is high due to increased suspended solids formed after coagulants dosing. “Secondary Treatment – Coagulation – Sedimentation – Filtration – Disinfection” is a comprehensive and reliable process. Although the capital investment of this process is relatively high, it is more adaptable to changes in water quality and quantity and easy to operate. Therefore, “Secondary Treatment – Coagulation – Sedimentation – Filtration – Disinfection” is adopted for advanced treatment.

284. Three filtration tanks/devices for advanced wastewater treatment are compared in the FSR – Micro Rotary Filter, Fiber Wheel Filtration Tank and V-type Inlet Channel Filtration Tank (Table VII-11 & VII-12). Considering the footprint and treatment cost, which are the two major concerns, microrotary filter is selected as the filtration unit for the advanced treatment process (Figure VII-5).

Table VII-11. Comparison of the Main Parameters of Filtration Units

Indicator	Micro Rotary Filter	Fiber Wheel Filtration Tank	V-type Inlet Channel Filtration Tank
Flow (10,000 m^3/d)	Design Flow 15,000 m^3/d，Peak Flow 956.25 m^3/h		
Discharge Water Quality	Constantly meets Class A1 criteria	Mostly meets Class A1 criteria; SS levels in late filtration may vary	Meeting first class A criteria, with fluctuation in terms of SS values of filtrate in the early stage of filtration
Filter Media	316 L Stainless steel mesh	Synthetic fiber filter cloth	Quartz sand
Area（m^2）	small（50 m^2）	small（~60 m^2）	large（~300 m^2）
Operation Model	Continuous model	Continuous model	Intermittent model
Total Installed Power（kW）	5.9	11.75	48.5
Impact of Transformer Capacity	Small installed power; no need to upgrade volume	Small installed power; no need to upgrade volume in most cases	Large installed power; need to upgrade volume, with evident impact and costly power fee
Secondary Lifting Pump	N/A	N/A	Lifting 3-5 m
Backwash	Backwashing with the filtrate	Sucking the surface of filter cloth with counter suction pump under negative pressure	Backwashing with air and water
Self-used Backwash Water Consumption	＜0.3%	1-2%	5-10%
Filtration Layer Water Head Loss（m）	≤ 0.3	≤ 0.3	2~2.5
System Water Head Loss	≤ 0.8	≤ 0.8	2.5~3
Filtration Rate（$m^3/m^2 \cdot h$）	265	≤ 20	≤ 15
Construction Difficulty	Simple structure without embedded components, easy to build	Simple tank body with less embedded components, relatively easy to be built	Complex body structure, hard to be built
Installation	Integrated equipment only in need of pipe connection, easy to install	In need of hanging installation during the construction, with various pipe, motor and pump components	Complex structures and complicated pipe connection, hard to be installed
Overhaul and Maintenance	Less overhaul and maintenance equipment with module design of filtration mesh, easy to maintain	Regular replacement of filtration cloth and sprinkler head because of frequent block, regular manual refloatation of floating debris, in need of dismantling of filtration	Traditional filter head and filter plate, easy to be broken and blocked;

Indicator	Micro Rotary Filter	Fiber Wheel Filtration Tank	V-type Inlet Channel Filtration Tank
		disk and discharging filter, hard to manipulate;	
		Filtration disk being easy to be blocked when excess coagulants are used in previous stage or in presence of algae.	Filtration bed being easy to be hardened, in need of regular sand replacement;
			Most components being on the ground of the tank, hard to be maintained;
			Lots of accessory equipment and valves, in need of regular maintenance.
Spare Parts （Accessory Equipment）	Less amount of spare parts with low maintenance rate and easy overhaul and maintenance, only in need of regular replacement of bearing	Lots of accessory components, counter suction sparkler head being easy to be blocked by debris on the filtration disk, hard to be maintained, high maintenance rate of electromagnetic valves etc.	Electric/pneumatic valves being easy to be broken and hard to be overhauled
			In need of regular supplement of quartz sand

(Calculated as 15,000 m^3/d)

Table VII-12. Economic Indicators Comparison of the Filtration Units

No.	Indicators	Micro Rotary Filter	Fiber Wheel Filtration Tank	V-type Inlet Channel Filtration Tank
1	Civil Engineering Cost Estimation (CNY 10,000)	Approximately 35	Approximately 40	Approximately 180
2	Installation Cost	50,000 (connection of pipes only)	50,000 (less components)	100,000 (lots of pipes, supplementary materials and cranes)
Sub-total: Construction Cost		**400,000**	**450,000**	**1,900,000**
1	Filter Media Replacement Period	10 years	Generally 2~3 years	Generally 3 years
2	Filter Media Replacement Cost	0 yuan/10a	Accounting for 1/4 of equipment cost	Accounting for 1/4 of equipment cost
3	Operating Personnel Cost	Negligible	In need of professional operator with 0.5 capita and 25,000 yuan/(a·cap), namely 12500 yuan/a	Negligible
4	Annual Treated Water Volume （10,000 m^3）	548	548	548
5	Unit Treatment Cost（yuan/m^3）	0.075	0.144	0.002

No.	Indicators	Micro Rotary Filter	Fiber Wheel Filtration Tank	V-type Inlet Channel Filtration Tank
6	Unit Variable Cost (yuan/m^3)	0.06	0.124	0.002

(Calculated as 15,000 m^3/d)

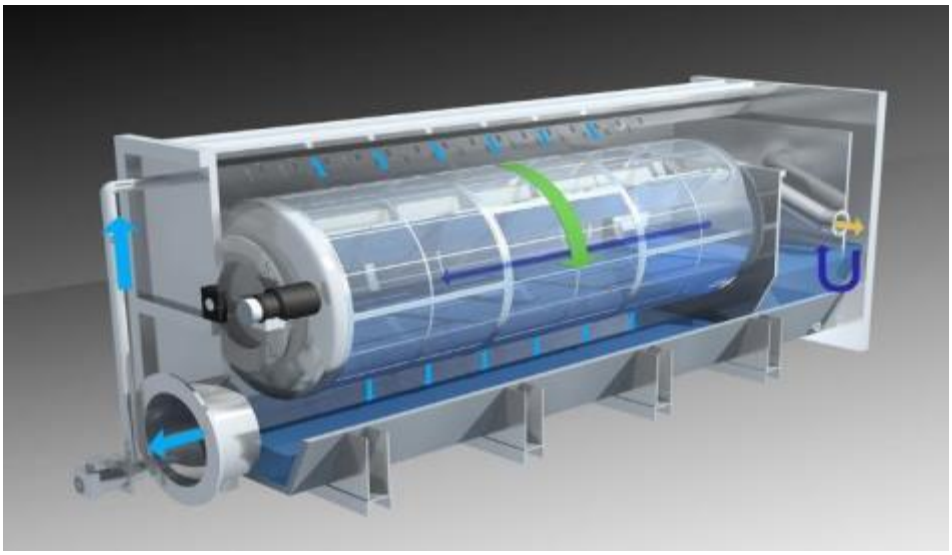


Figure VII-5. Micro Rotary Filter

285. **Pipe alignment.** Two alternative wastewater pipeline alignments were reviewed for the design of wastewater network in the City West New District (Figures VII-6 and VII-7).

- Option 1 – To lay the trunk sewer along Binhe Avenue; DN 300 branch sewers will be laid along West Qingzhang River to collect wastewater from the area between Binhe Avenue and West Qingzhang River; DN 300 will connect to the trunk sewer at Xihetou Village; DN 500 trunk sewer finally connect to the 2.4 m*2.6 m box drain under Binhe Avenue.
- Option 2 – Lay the trunk sewer along West Qingzhang River; branch sewers will be laid to collect wastewater from the area north to West Qingzhang River; DN 500 trunk sewer finally connects to the 2.4 m*2.6 m box drain under Binhe Avenue.

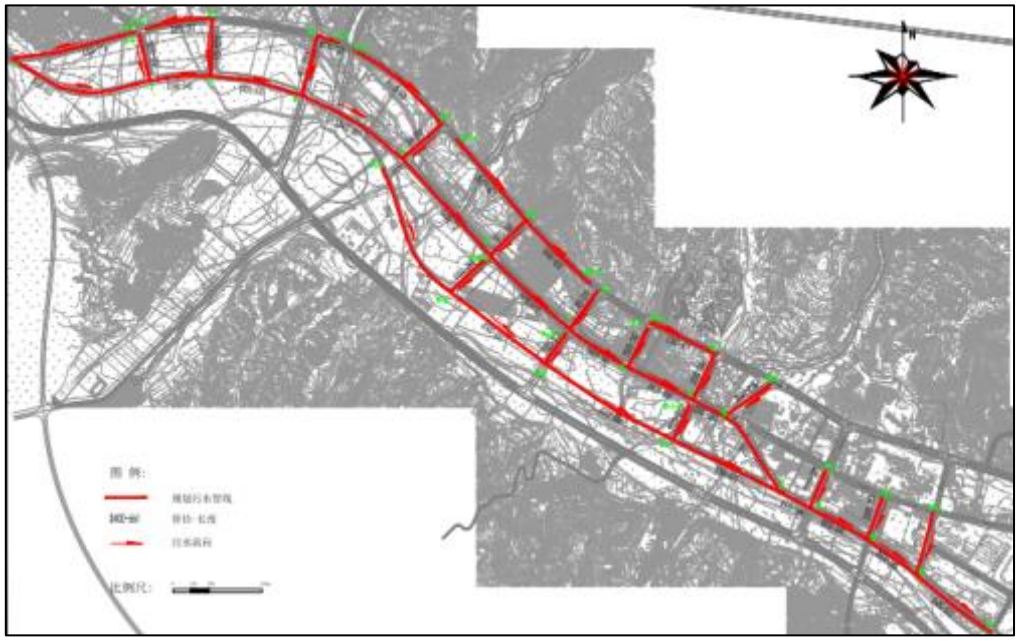


Figure VII-6. Sanitation Sewers in City West New District - Option 1 (Adopted)

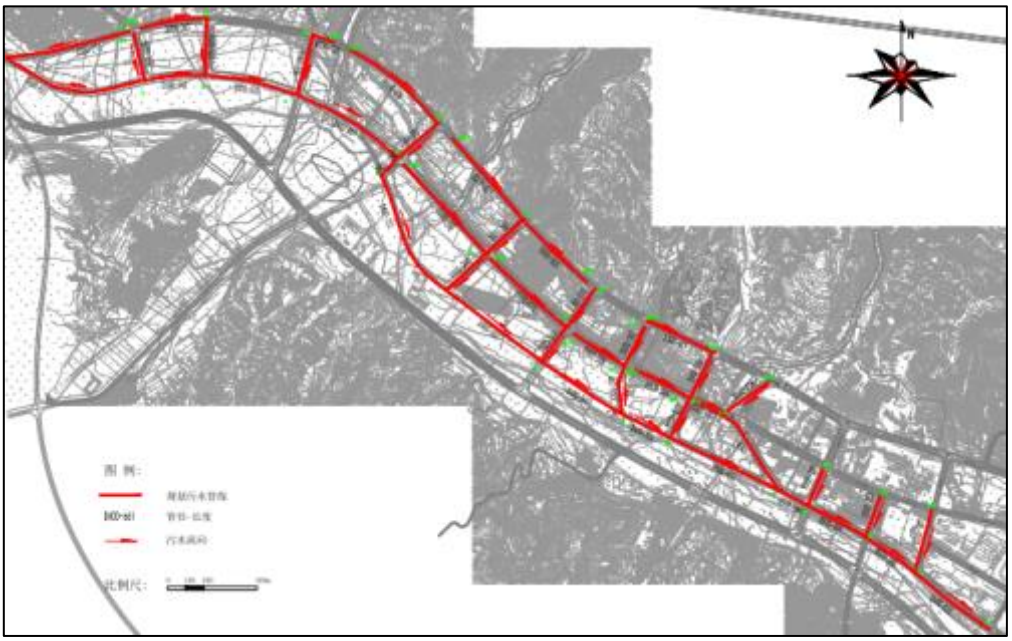


Figure VII-7. Sanitation Sewers in City West New District - Option 2

286. Key parameters for both options are compared in Tables VII-13 and VII-14.

Table VII-13. Depth of Trunk Sewers – Option 1 (Adopted)

Trunk Sewers	Depth (m)							Sub total
Dia. (mm)	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	
300	2,337	661	672					3,670
400	2,077	731						2,808
500		736						736
Total								7,214

Table VII-14. Depth of Trunk Sewers – Option 2

Trunk Sewers	Depth (m)							Sub total
Dia. (mm)	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	
300			1,116	641		1,070	917	3,744
400	757				138			895
500		1,506	672					2,178
Total								6,817

287. Although the total pipeline length of option 2 is shorter, the average depth is deeper, and the total construction cost will be higher. Option 1 was selected.

288. **Pipe materials**. Five commonly used pipe materials for sanitation sewers are compared from both technical performance and cost (Tables VII-15 and VII-16). Based on the technical and economic comparison and in association of past experience in construction of drainage pipelines, HDPE pipes are selected for pipe diameter no less than 600 mm, and Reinforced Concrete pipes are selected for pipe diameter above 600 mm.

Table VII-15. Comparison of Pipe Materials

Property	HDPE Pipe	UPVC Pipe	Steel Pipe	Reinforced Concrete Pipe	Ductile Iron Pipe
Service life	Long	Long	Relatively short	Long	Long
Imperviousness	Strong	Strong	Relatively strong	Relatively weak	Strong
Anti-corrosion	Strong	Strong	Relatively weak	Strong	Relatively strong
External pressure-bearing	Relatively bad, proteiform	Relatively bad, proteiform	Can be deep-buried, bear higher pressure	Can be deep-buried, bear higher pressure	Can be deep-buried, bear higher pressure
Construction difficulty	Easy	Easy	Easy	Easy	Easy
Construction method	Large excavation, pipe-drawing	Large excavation, pipe-drawing	Large excavation, pipe-jacking	Large excavation, pipe-jacking	Large excavation, pipe-jacking
Interface type	Hot melting adhesion	Bell and spigot, rubber ring for sealing	Field welding, rigid joint	Bell and spigot, tongue and groove, flat	Bell and spigot, rubber ring for sealing
Roughness (n value) & Head loss	0.010, relatively smaller loss	0.010, relatively smaller loss	0.013 (cement lining), relatively bigger loss	0.013, relatively bigger loss	0.013 (cement lining), relatively bigger loss
Weight, material transportation	Lighter, easy to transport	Lighter, easy to transport	Heavier, field fabrication	Heavier, difficult to transport	Heavier, difficult to transport
Base requirement	Relatively low	Relatively low	Relatively low	Relatively low	Relatively low

Table VII-16. Cost Comparison of Pipe Materials (Unit: CNY/m)

Pipe Diameter	Steel Pipe	Reinforced Concrete Sewer Pipe	Ductile Iron Pipe	Plastic Pipe	
				HDPE Hollow-wall Twined Pipe	HDPE Double-wall Corrugated Pipe
D400	659	262.5	623	476.7	354.9
D500	894	294.5	808	732.9	535.5
D600	1068	403	1066	774.4	608
D800	1184	533.6	1263	1033.6	816
D1000	1320	650	1568	1297.9	937.6
D1200	1414	813.8	1832	1517.6	887.6

VIII. PUBLIC CONSULTATION, PARTICIPATION AND INFORMATION DISCLOSURE

289. Meaningful participation and consultation during project planning, feasibility study, design and implementation are important safeguard requirements under both PRC regulations and ADB SPS. The PRC *Environmental Protection Law and Regulations on the Administration of Construction Project Environmental Protection (Order No. 253 of the State Council)* require that a DEIA solicits the opinions of organizations concerned and residents within and near the project sites. In August 2012, the PRC National Development and Reform Commission issued a requirement for "Social Risk Assessment of Large Investment Projects", which emphasizes the importance of public consultation in an effective manner, and requires that the results of public consultation are clearly summarized in the DEIA report, including the dates of consultations, number of stakeholders, who the affected people are, and the comments received. The updated Environmental Protection Law (effective January 2015) strengthens public involvement and information disclosure requirements (including disclosure of full EIAs for projects or programs with significant environment impacts).

290. ADB's SPS (2009) also requires meaningful public participation, consultation and information disclosure. The consultation process for this project followed PRC law and the SPS.

A. Information Dissemination

291. The first round information disclosure was conducted by the DEIA institute on 12 October 2015, to solicit the public comments and suggestions on the project and on the environment protection. The information was publicized on the ZCG website (Figure VIII-1) and the posters (Figure VIII-2), and explained the basic specifications of the project construction, work procedure and content of the EIA, main purpose for public consultation, and public comments collection. The web address is:

http://www.sxzqw.com/plus/Announce.asp?AnnounceID=211.

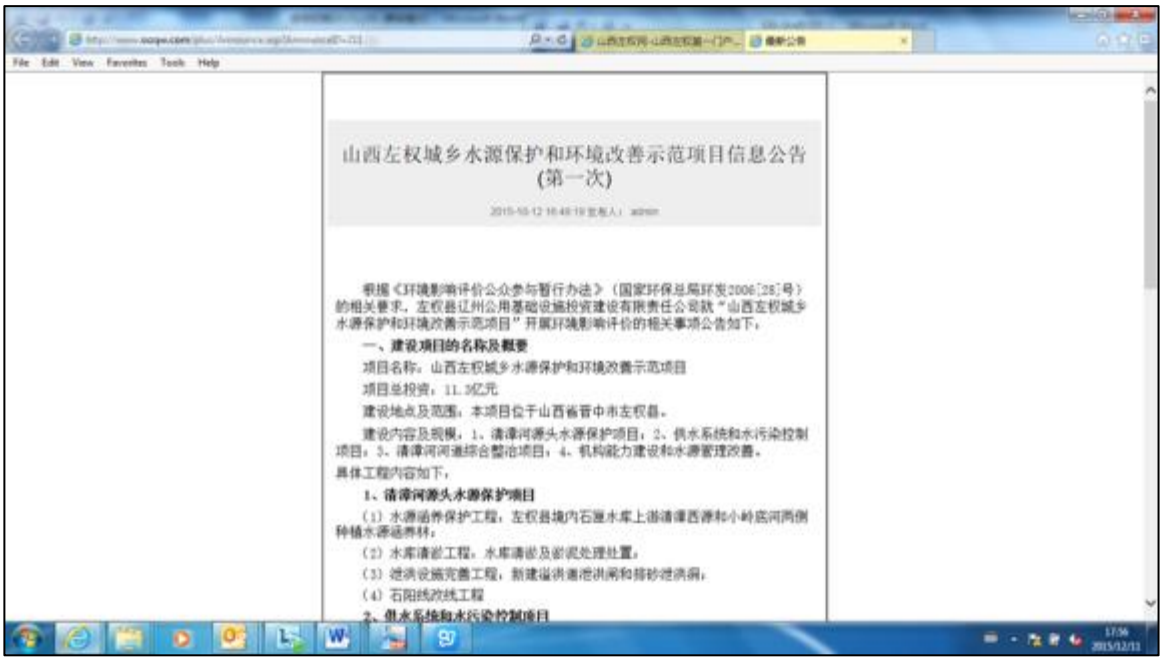

山西左权城乡水源保护和环境改善示范项目信息公告
(第一次)

Figure VIII-1. First Round of Information Disclosure on Website of Zuoquan County Government

Figure VIII-2. Community Information Posters

292. In translation, the notice reads:

The first information disclosure of EIA of Shanxi Urban-Rural Water Source Protection and Environmental Demonstration Project

In accordance with the "*Interim Measures for Public Participation in Environmental Impact Assessment, State Environmental Protection Bureau 2006 [the 28th*]", information disclosure on the Shanxi Urban-Rural Water Source Protection and Environmental Demonstration Project, as follows:

1. Project description
2. Name and contact information of the project construction company
3. Name and contact information of the domestic EIA institute
4. Environmental impact assessment procedures and main tasks
5. Main items for public comments
6. The main ways for public comments collection

(details are included under each of these headings)

293. The second round of information dissemination phase was undertaken by the DEIA Institute on 9 August 2016, when the initial environmental impacts had been assessed and mitigation measures formulated, to solicit public comments on the preliminary DEIA findings. This was also supported by internet disclosure at Zuoquan Government website.

Figure VIII-3. Second Round of Information Disclosure on Website of Zuoquan County Government

294. The web page is translated as follows:

The second information disclosure of EIA of Shanxi Urban-Rural Water Source Protection and Environmental Demonstration Project

1. Project Overview
2. Pollution source analysis and the mitigation measures
3. Conclusion of the EIA report
4. The main ways for public to consultant EIA report and supplementary information, and the duration
5. Main items for public comments
6. Main way for public comments collection
8. Contact information

(Details are included under each of these headings)

B. Public Consultation

295. **First round of public consultation.** The first public consultations were conducted on 20 July 2016 in the meeting room of Shixia Country Government and Liaoyang Town Government, after the preliminary draft DEIA was completed. It was conducted as a public forum (Figure VIII-4). A total of 45 participants attended (Table VIII-1) representing local communities and enterprises in the project area, and related government agencies. The gender and age breakdown of the participants is shown in Table VIII-2. The number of respondents is relatively small, but the total number of residents directly and permanently affected by project construction would form a very small proportion (1,420 people; or less than 0.9%) of the total population of the county.

Figure VIII-4. Consultation Meeting

Table VIII-1. Communities and Government Agencies Participated in the Public Forum

No.	Communities/Government Agencies	
1	Zuoquan Shixia Reservoir Management Office	
2	Zuoquan County PMO	
3	Shixia Township	Guantou Village
4		Dianshang Village
5		Chuankou Village
6		Majiu Village
7		Songgou Village
8		Changcheng Village
9		Dianshang Village
10		Daofo Village
11		Heyu Village
12		Shixia Village
13		Zhuning Village
14		Baigou Village
15	Liaoyang Town	Weipoling Village
16		Qilidian Village
17		Weipoyu Village
18		Xiaohui Village
19		Jinggou Village
20		Xihetou Village
21		Dongchangyi Village
22		Xichangyi Village
23		Xihetou Village
24		Wulihou Village
25	Longquan Township	Gaozhuang village

296. The forum explained the basic specifications of the project, EIA process, status of the surrounding environment, potential pollutants, control measures and grievance redress mechanism (GRM). Main concerns expressed were air quality, noise, and construction and domestic wastes generated during construction. The PPTA environment specialist and PMO presented the planned mitigation measures (Table VIII-2). Participants expressed support for the project.

Table VIII-2: Main issues Raised and Response

Main issues Raised	Response
Pollution of upper river and catchment from solid waste disposal	Rural solid waste management is being developed by the government separately from the project
Upstream planting is just for ecological protection; consider hard revetment and other measures to protect the river	Hard revetment does not meet the requirement of ecological protection. Ecological revetment will be used to preserve the original nature.

297. **Second round public consultation.** The second round of public consultation was undertaken in the form of a questionnaire survey, in July 2016. One hundred questionnaires were distributed and 100% were returned. They focused on the understanding of the project, and the view on the potential impacts on the environmental during construction and operation stage. The breakdown of participants and the results of questionnaire survey are listed in Tables VIII-3 and VIII-4 respectively.

Table VIII-3. Round 2 of Public Consultation Undertaken by PMO, EIA Institute and PPTA Team. Breakdown of Participants

Item	Sex		Education			Occupation			Age Range		
	M	F	Junior High	Senior High	College o Above	Farmer	Leader	Labor / Other	<30	30-50	>50
People	79	21	62	22	16	51	26	23	7	57	36
Proportion (%)	79	21	62	22	16	51	26	23	7	57	36

Table VIII-4. Round 2 of Public Consultation Undertaken by PMO, EIA Institute and PPTA Team. Results of Questionnaire Survey

Question	Choices	Results	
		People	Proportion (%)
1. What do you think of the environmental quality of the project?	A Good B General C Poor	65 26 9	65.0 26.0 9.0
2. What is the major local environmental problem?	A Atmospheric Pollution B Water Pollution C Noise Pollution D Solid Waste Pollution	43 13 10 40	40.6 12.3 9.4 37.7
3.How well do you know about this project?	A Good Understanding B General Understanding C Poor Understanding	62 36 2	62.0 36.0 2.0
4. How will this project affect the local air quality?	A Improve B Worse C Unclear	94 0 6	94.0 0 6.0
5. Does this project benefit your work and improve the living environment?	A Benefit B Not Benefit C Unclear	89 0 11	89.0 0 11.0
6. Your attitude toward this project:	A Support B Oppose C Unclear	96 0 4	96.0 0 4.0
7. What environmental issues in the construction and operation are you most concerned with?	A Atmospheric Pollution B Water Pollution C Noise Pollution D Solid Waste Pollution	44 33 20 46	30.8 23.0 14.0 32.2
8. Do you accept the environmental impact after conducting the environmental protection measures?	A Acceptable B Not Acceptable C Unclear	97 0 3	97.0 0 3.0

C. Future Plans for Public Participation

298. Public consultation will continue throughout the construction and operation phases. The PMO will be responsible for organizing five public consultations, including one before the construction starting, once per year during the construction stage, and one after construction completion, to collect the residents' opinion on the environment impacts during construction. The future public consultation program is included in the project EMP.

IX. GRIEVANCE REDRESS MECHANISM

299. A GRM has been developed in compliance with ADB's SPS requirement to address environmental, health, safety, and social concerns associated with project construction, operation, land acquisition, and leasing arrangements. The GRM is designed to achieve the following objectives: (i) provide channels of communication for local communities to raise concerns about environment- and social-related grievances which might result from the project; (ii) prevent and mitigate adverse environmental and social impacts caused by project construction and operation, including those associated with resettlement; (iii) improve mutual trust and respect and promote productive relationships between the project agencies and local communities; and (iv) build community acceptance of the project. The GRM is accessible to all members of the community, including women, youth, and poverty-stricken residents. Multiple points of entry are available, including face-to-face meetings, written complaints, telephone conversations, e-mail, and social media.

300. Public grievances related to project construction to be addressed by the GRM may include damage to public roads, vegetation, residences, and/or dust emissions, construction noise, odor from dredging sediment, wastewater from construction, soil erosion, inappropriate disposal of construction wastes, and safety for the general public and construction workers. Grievances related to involuntary resettlement may relate to the lack, or un-timely payment of, compensation monies, other allowances, and/or lease monies as per entitlements described in the resettlement plan and associated documents.

301. The GRM meets the regulatory standards of the PRC that protect the rights of citizens from construction-related environmental and/or social impacts. Decree No. 431 Regulation on Letters and Visits, issued by the State Council of PRC in 2005, codifies a complaint acceptance mechanism at all levels of government and protects the complainants from retaliation. Based on the regulation, the former State Environmental Protection Administration published updated Measures on Environmental Letters and Visits (Decree No. 34) in 2006.

302. Currently in Shanxi Province (and generally in the PRC), when residents or organizations are negatively affected by a development, they may complain, by themselves or through their community committee, to the contractors, developers, the local or provincial environmental protection departments (including via a public hotline service), or by direct appeal to the local courts. The weaknesses of this system are: (i) the lack of dedicated personnel to address grievances; and (ii) the lack of a specific timeframe for the redress of grievances. The project GRM addresses these weaknesses.

303. The Zuoquan PMO has appointed an Environment Officer and a Social Officer to coordinate the GRM. These officers will inform the communities, contractors and CSCs about the GRM procedures. The officers will also establish a GRM tracking and documentation system to record and report all complains received. (To be confirmed with PMO)

304. The details of the GRM, including a time-bound flow chart of procedures, are included in the project EMP (Attachment 1 of this IEE).

X. ENVIRONMENTAL MANAGEMENT PLAN

305. A project EMP has been prepared (Attachment 1). Development of the EMP drew on the domestic EIA reports, discussions with the PMO, implementing agencies, Zuoquan EPBs, other government agencies, and local communities. The EMP defines mitigation measures for the anticipated environmental impacts, institutional responsibilities, and mechanisms to monitor and ensure compliance with PRC's environmental laws, standards and regulations and ADB's SPS. The EMP specifies major environmental impacts and mitigation measures, roles and responsibilities, inspection, monitoring, and reporting arrangements, training, and the GRM. The EMP will be updated after detailed design, as needed. It will be included as separate annex in all biding documents for subcomponents involving civil works. Contractors will be required to develop site-EMPs that are fully responsive to the EMP.

XI. PROJECT ASSURANCES

306. All ADB-funded projects are required to comply with a standard set of loan assurances for environmental safeguards, which focus on compliance with national laws and the project EMP. In addition, the following project-specific assurances are included in the project agreement between ADB and the ZCG.

- For the project river dredging and embankment excavation works, ZCG shall ensure that: (i) river dredging will only be conducted between October and May (the dry season); (ii) dredging, embankment construction and wetland creation works will be constructed under dry conditions, by employing temporary coffer dams. Coffer dams will only be constructed on one side of the river channel at a time, to maintain an uninterrupted water flow to downstream areas; (iii) all tailings and wastewater from within these works areas will only be discharged into West Qingzhang River after sedimentation treatment, and when the concentration of suspended solids (SS) is less than 20 mg/L. The dewatering of the dredged sediment will be treated within consolidation tanks, as described in the project Environment Management Plan.

- ZCG shall ensure continuous water and wastewater services should be provided during civil works related to the expansion of existing water and wastewater treatment plants.

- ZCG shall ensure that all planting activities under the project, including re-vegetation, embankment construction, LID elements, wetlands, landscaping, and rehabilitation of construction sites, shall only use plant species which are (a) native (i.e. naturally occurring) to Zuoquan City, and (ii) are sourced from local stock within Zuoquan County or neighboring counties. In the event that non-native seedlings are required for rapid stabilization of exposed soils and sites, ZCG shall ensure that only sterile seedlings are used to prevent weed spread.

- ZCG shall ensure that all re-vegetation activities under the project, including for the wetlands, landscaping, and embankments, will be subject to operation and maintenance procedures after planting, to ensure the planted vegetation is adequately protected and maintained.

- ZCG shall ensure that to avoid pollution of the Shixia Reservoir waters and rivers, no pesticides and no top dressing fertilizers shall be used for any of the re-vegetation, planting, or landscaping activities under the project.

- ZCG shall ensure that the noise and air quality monitoring program, to be undertaken as part of the Environmental Monitoring Program (described in the project Environment Management Plan), shall: (i) include a component for *baseline* monitoring for the Binhe

Road project component; (ii) monitoring at the Binhe Road site shall begin at least 2 months before any construction, to develop a baseline for this site.

- ZCG shall ensure that at least one full-time, qualified PMO Environment Officer is assigned for the entire duration of the project. The officer will be responsible for coordinating the implementation of the project Environment Management Plan. Terms of reference for this position are described in the project Environment Management Plan.

- As part of the loan implementation consultant support, ZCG shall engage one national wetland specialist (at least 6 person-months) and one national re-vegetation specialist (at least 2 person-months), to support the design and monitoring of the project components on the wetland park and re-vegetation. Terms of reference for these positions are described in the project Environment Management Plan.

- The project will result in improved drinking water supply to residents in Zouquan County. This may result in increased volumes of wastewater being generated. ZCG shall ensure the wastewater generated as a consequence of improved water supply shall be treated by suitable rural wastewater treatment facilities before discharge into the West Qingzhang River.

- ZCG shall ensure that: (i) industries discharging wastewater to the municipal collection system will provide adequate on-site pre-treatment processes; and (ii) the quality of industrial wastewater discharged by industrial enterprises complies with the *Wastewater Quality Standard for Discharge to Municipal Sewers (CJ 343-2010),* to contribute to the maintenance of water quality standards in the West Qingzhang River.

XII. CONCLUSIONS

307. The project will help the ZCG improve water and environmental management in Zuoquan County, facilitate future sustainable development, and enhance climate resilience. The project has been developed based on the approved Zuoquan County City Master Plan (2010-2030) and Zuoquan County City Drainage Special Plan.

308. Key potential construction phase impacts include (i) air quality and noise impacts to sensitive receivers adjacent to road improvement and water supply/sewerage pipeline construction; (ii) water quality impacts to the West Qingzhang River below Shixia Reservoir, primarily from dredging and embankment works; (ii) minor ecological impacts due to habitat loss from dredging and embankment works; (iii) permanent and temporary acquisition of land, involuntary resettlement; and (iv) occupational and community health and safety. Key operational risks are impacts would result from using groundwater to improve rural water supply. All of these impacts can be addressed with standard good site practices and mitigation measures.

309. Measures to avoid, minimize, and mitigate potential project impacts have been developed within the project EMP (Attachment 1). Meaningful public consultation has been conducted in accordance with PRC and ADB requirements. Public concerns have been integrated into the domestic FSR and project EMP. Public consultation will continue throughout project implementation. A project GRM has been developed and will be implemented at the county and site levels.

310. A CRVA was conducted for the project based on the projected climate changes assuming a project design life of 30-40 years. Many of the project components and outputs will have significant positive effects and contributions to the climate change resilience of the project area. Key adaptation measures which have been included in the project design include revegetation and forest planting components, improvements to Shixia Reservoir management,

enhanced hydrological and water quality monitoring, river and wetland habitat restoration, improved stormwater and wastewater management and enhanced wastewater treatment.

311. **Project assurances.** Project assurances have been developed to strengthen confidence in the implementation of key measures in the project EMP, and, to address potential issues that may affect project viability and which are beyond the project scope. The assurances have been discussed and agreed between the ZCG and ADB, and are described in Section XI.

312. Based on the information presented in this IEE, and assuming full and effective implementation of the project EMP, training, and loan assurances, potential adverse environmental impacts are expected to be minimized and/or mitigated to within the standards applied in this IEE.

ATTACHMENT 1: ENVIRONMENTAL MANAGEMENT PLAN

ENVIRONMENT MANAGEMENT PLAN FOR THE SHANXI URBAN–RURAL WATER SOURCE PROTECTION AND ENVIRONMENTAL DEMONSTRATION PROJECT

People's Republic of China

Prepared by the Zuoquan County Government for the Asian Development Bank

A. Objectives

1. This Environmental Management Plan (EMP) is for the Shanxi Urban-Rural Water Source Protection and Environmental Demonstration Project in Zuoquan County of Shanxi Province, the People's Republic of China (PRC). The EMP complies with the Asian Development Bank's (ADB) Safeguard Policy Statement (SPS, 2009) and is based on the domestic Environmental Impact Assessment (DEIAs) prepared by (i) China Institute for Radiation Protection; and (ii) Shanxi Qingyuan Environmental Consulting Co. Ltd, and project Initial Environmental Examination (IEE). The EMP describes: roles and responsibilities of all project agencies to implement this EMP; mitigation measures; inspection, monitoring, and reporting arrangements; training and institutional strengthening; Grievance Redress Mechanism (GRM); and future public consultation.

2. In the design stage the PMO will pass this EMP to the Design Institutes for incorporating mitigation measures into the detailed designs. The EMP will be updated at the end of the detailed design, as needed. To ensure that bidders will respond to the EMP's provisions, the PMO and Implementation Agency (IA) will prepare and provide the following specification clauses for incorporation into the bidding documents: (i) a list of environmental management requirements to be budgeted by the bidders in their proposals, based on this EMP; (ii) environmental clauses for contractual terms and conditions; and (iii) this EMP.

B. Organizations and Their Responsibilities for EMP Implementation

3. The EMP implementation arrangements and responsibilities of governmental organizations are summarized in Table EMP-1.

Table EMP-1: Project Operation and Maintenance Arrangements in Zuoquan County

No.	Component / Sub-component	Implementing agency	Operation and Maintenance Unit
Output 1 - Shixia Reservoir Operation and its Watershed Vegetation Improved			
1.1	Revegetation around the Shixia Reservoir and planting of forest belt along two headwaters	ZSRMO	ZSRMO
1.2	Improving the reservoir spillway gate and construction of flood discharge tunnel		
1.3	Construction of hydrological and water quality monitoring stations around the Shixia Reservoir		
Output 2 - Qingzhang River and Binhe Road Rehabilitated			
2.1	Dredging silted sections of river	ZHCB	Zuoquan Landscaping Bureau for wetland park
2.2	River rehabilitation and embankment		
2.3	Construction of wetland and river amenity facilities		
2.4	Low impact design (sponge city concept) for road improvement and stormwater drains installation		ZMMB for stormwater pipelines and roads
Output 3 - Inclusive Water Supply and Wastewater Collection Services Achieved			
3.1	Rural water supply system	ZWRB	Zuoquan Liaorun Water Affair Construction Investment Limited Company
3.2	Water Pollution Control (sewers and associated facilities)	ZHCB	Zuoquan WWTP; ZMMB
Output 4 – Institutional Capacity Strengthened			
4.1	Project management	PMO	-
4.2	Flood warning system	ZWRB	-
4.3	Institutional and capacity strengthening for integrated urban-rural water supply	ZWRB	-

No.	Component / Sub-component	Implementing agency	Operation and Maintenance Unit
4.4	Institutional and Capacity Strengthening for Sponge City (Low Impact) Design	ZWRB	-

ZSRMO = Zuoquan Shixia Reservoir Management Office, ZHCB = Zuoquan Housing Security and Urban & Rural Construction and Management Bureau, ZMMB = Zuoquan Municipal Management Bureau, ZWRB = Zuoquan Water Resource Bureau, PMO = Project management office, WWTP = wastewater treatment plant.

4. **Executing agency.** Zuoquan County Government (ZCG) is the project Executing agency (EA). The EA is responsible for communication with ADB, loan on-lending and repayment, as well as supervision and guidance of the Zuoquan Project management office (PMO) and Implementing agency (IA) during the project implementation.

5. **Project leading group.** A Project Leading Group (PLG) has been established, chaired by the vice mayor and comprises senior officials from relevant government agencies, to facilitate inter-agency coordination, and resolve any institutional problems affecting project implementation at municipal level.

6. **Project management office.** The EA has established a Project management office (PMO). The PMO will provide guidance, coordination, supervision and management of project implementation during both construction and operation phase on behalf of PLG.

7. **PMO environment officer.** The PMO will have primary responsibility for EMP implementation, through the PMO environment officer. The officer will: (i) supervise the implementation of mitigation measures in the EMP for the project design, construction and operation phases; (ii) ensure that environmental management, monitoring, and mitigation measures are incorporated into bidding documents, construction contracts and operation management plans; (iii) prepare the semi-annual EMP progress reports for PMO to submit to ADB; (iv) coordinate the Grievance Redress Mechanism (GRM); and (v) respond to unforeseen adverse impacts. The PMO Environmental Officer will be technically supported by the Loan Implementation Environment Consultant (LIEC).

8. **Implementing agencies (IAs).** There are three Implementing Agencies (IAs) for the project: Zuoquan Water Resource Bureau, Zuoquan Shixia Reservoir Management Office, and Zuoquan Housing Security and Urban and Rural Construction and Management Bureau. The IAs will: (i) engage and supervise engineering design institutes, tendering company and the project management consulting services; and (ii) report on progress. Each IA will also assign an environmental coordinator to assist the PMO Environment Officer.

9. **Loan implementation consultants.** The loan implementation consultant team will include a Loan Implementation Environment Consultant (LIEC), wetland specialist, and revegetation specialist. The LIEC will advise the PMO, IAs, Contractors and Construction Supervision Companies (CSCs) on all aspects of environmental management and monitoring for the project. The wetland and revegetation specialists will support the design and implementation of the wetland and revegetation components of the project.

10. Terms of reference for key environment personnel are described in Appendix 1.

11. **Construction contractors and construction supervision companies (CSCs).** Construction contractors will be responsible for implementing relevant EMP mitigation measures during construction, under the supervision of the CSCs and IAs. Contractors will develop site-specific EMPs on the basis of this project EMP. CSCs will be selected through the PRC bidding procedure by the IAs. The CSCs will be responsible for supervising construction progress and quality, as well as EMP implementation on construction sites. Each

CSC shall have at least one environmental engineer on each construction site to: (i) supervise the contractor's EMP implementation performance; and (ii) prepare the contractor's environmental management performance section in monthly project progress reports submitted to the IAs and PMO.

12. **Environmental monitoring station (EMS).** The IAs will contract the EMS under the Zuoquan Environmental Protection Bureau to implement the external monitoring program defined in this EMP (Table EMP-5).

C. Potential Impacts and Mitigation Measures

13. Table EMP-2 lists the potential project impacts and mitigation measures. The mitigation measures will be incorporated into the detailed design, bidding documents, construction contracts and operational management manuals, by the design institutes (during detailed design) and contractors (during construction), under the supervision of CSCs and IA, with technical support from the LIECs. The effectiveness of these measures will be evaluated based on environmental inspections and monitoring to determine whether they should be continued, improved or adjusted.

Table EMP-2. Potential Impacts and Mitigation Measures during Design, Construction and Operation Phases

Item	Potential issues	Mitigation measures	Implement	Supervise
A. DESIGN PHASE				
Detailed design stage	Detailed design of revegetation - Shixia Reservoir; forest belts	• Protection of existing forest and plantings • Only utilize native plant species of local provenance, adapted to local climate and soil conditions. • Loan consultants for revegetation and wetland to provide technical assistance.	PMO, IAs, Design Institute,	EA
	Detailed design of dredging, embankment, wetland and river amenity facilities	• Define spoil disposal sites and borrow pit locations in the construction tender documents. • Use identified spoil sites, which will be: (i) in low-lying areas of wasteland/dryland. Farmlands are forbidden to be used; (ii) downwind and at least 200 m from residential areas. • Technical design of embankments shall be adequate and stable enough to withstand the strong force of heavy storm water flow but maximize the adoption of eco-friendly embankment designs. • Only utilize native plant species for the wetland park and other plantings for embankments.	PMO, IAs, Design Institute,	EA
	Low Impact Design (Sponge City Concept) for Road Improvement	• The bridge design included in the road improvement will meet the flood control standard.	PMO, IAs, Design Institute,	EA
	Design of water supply system	• Ensure the rural wastewater treatment stations and other infrastructure is constructed in the same phase of water supply components.	PMO, IAs	EA
	Detailed design of Zuoquan WWTP expansion	• Confirm the layout of Zuoquan WWTP extension. • Ensure preliminary design of expansion plan is adhered to. Odor-generating and noise-producing facilities will be located downwind from and as far from residential areas as possible. • Verify design influent volume, quality, and ability of treatment processes to achieve 1A discharge. • Anti-seepage and concrete reinforcements to be included in WWTP design to minimize risk of effluent seepage to groundwater (Table VI-6 of EMP). • Local Spring Water Administrative Department will be consulted during detailed technical design.	PMO, IAs, Design Institute,	EA
	Project site and Construction schedule	• Confirm final designs and layout for all project infrastructures. • River dredging, embankment, and wetland construction will only be conducted between October and May (dry season), to avoid erosion and flood risks in the wet season. • Plan daily schedules to minimize impacts to agricultural activities. • Coordinate excavation and spoil disposal between sites to limit duration of temporary spoil piles.	PMO, IA, Design Institute,	EA
	Construction worker camp sites	• Rented houses will be used as far as possible. • Camps to be located ≥200 m away from residential areas, hospitals, schools and other environmentally sensitive sites, and located downwind of such sites. • Sewage (domestic, washing) will not be discharged directly into West Qianzhang River.	PMO, IA, Design Institute,	EA
	Construction phase wastewater treatment measures	• Constructed wastewater discharge: The supplementary sedimentation tank will be built in permanently owned land (to avoid acquisition of other land). The wastelands and dry lands are considered to be utilized in priority. Farmlands are forbidden to be used;	PMO, IA, Design Institute,	EA

Item	Potential issues	Mitigation measures	Implement	Supervise
		• No sewage discharge port is allowed to be built within 200m the West Qingzhang River. No treatment facilities will be placed in the first and second class water source protection zones of Shixia Reservoir.		
	Temporary construction roads	• Temporary construction roads will not be built near residential areas, and will not destroy existing roads, rivers and other rural infrastructures.	PMO, IA, Design Institute,	EA
Implementation Support	Institutional strengthening for EMP implementation and supervision	• Within six months of project effectiveness, appoint PMO Environmental Officer, IA Environment Officer, and LIEC. See TORs in Appendix 1. • Within six months of project effectiveness, train staff for EMP implementation and supervision. • IAs has contractual agreements with EMS to conduct environmental monitoring in this EMP. • Conduct training on this EMP for PMO, IAs, contractors, and CSCs.	PMO, IAs	EA
Construction Preparation	Update EMP	• Update mitigation measures defined in this EMP based on final detailed design. • Submit the updated EMP to ADB for review. • In case of major changes of project location and/or components, conduct EIA and public consultation. Submit to EPB and ADB for approval and disclosure.	PMO, LIEC	EA
	Bidding and contract documents	• Incorporate mitigation measures in this EMP to bidding documents. • Bidding documents sent to ADB for review. • Prepare environmental contract clauses for contractors.	PMO, IA, DI	EA, LIEC, EPB, ADB
	Construction site management planning	• Prepare Site Environmental Management and Supervision Plan (SEMSP), including health and safety plan. • Assign site environmental health and safety officer. • IAs and PMO review and approve the SEMSP.	Contractors	IAs, PMO
	EMP training	• Provide training on implementation of this EMP to all relevant agencies, especially the IAs and contractors.	LIEC, PMO	EPD
	Establish GRM	• Within 2 months of project effectiveness, PMO and IA Environmental Officers and PMO Social Officer establish GRM with LIEC. • All PMO and IA personnel trained in GRM. • Distribute contact details for GRM on PMO and EPB public websites and construction sites.	IA, PMO	LIEC
B. CONSTRUCTION PHASE				
Topography and Soils	Earthwork, soil erosion, soil contamination	• River dredging and embankment works to be conducted in coffer dams. • Limit construction and material handling during periods of rains and high winds. • Construct intercepting channels to prevent both construction and rainwater runoff entering the river. Divert runoff from sites to sedimentation ponds. • Minimize open excavation areas and use compaction techniques for pipe trenches. • Rehabilitate all spoil disposal sites and construction sites. • Stabilize earthwork areas within 30 days after earthworks have ceased at the sites.	Contractor, CSCs	IA, PMO

Item	Potential issues	Mitigation measures	Implement	Supervise
		• Preserve existing vegetation where no construction activity is planned. Pay close attention to the growth of vegetation cover on backfilled area to prevent soil erosion		
Ambient Air	Generation of dust by construction activities	• Equip material stockpiles and concrete mixing equipment with dust shrouds. • Spray water on construction sites and earth/material handling routes. • Cover materials during truck transport. • All roads and tracks used by vehicles of the contractors or any subcontractors or supplier are kept clean and clear of all dust, mud, or extraneous materials dropped by vehicles. • Washing wheels of vehicles leaving the construction sites.	Contractor, CSCs	IA, PMO
	Gaseous air pollution (SO_2, CO, NO_x) from construction machinery and asphalt fume from pavement of Binhe Road	• Equipment and machinery to be well maintained to ensure efficient running and fuel-burning. High-horsepower equipment that require the installation of tail gas purifiers, ensuring emissions be in compliance with PRC-GB16297-1996. • Ensure emissions from vehicle and machinery comply with PRC standards of GB18352-2005, GB17691-2005, GB11340-2005, GB2847-2005, and GB18285-2005. • A regular inspection and certification system for equipment and machinery is initiated. • Place the asphalt mixing plants at least 300 m upwind of any sensitive receptors, enclose these plants and equip them with bag house filter or similar air pollution control equipment.	Contractor, CSCs	IA, PMO
	Odor from dredge spoil	• After sediment and dewatering, transport spoil for reuse in embankment construction. • .	Contractor, CSCs	IA, PMO
Noise	Noise generated from construction activities	• Sensibly schedule construction activities, avoid noisy equipment working concurrently. • Noise levels from equipment and machinery conform to PRC standard GB12523-2011. • Control speed of bulldozer, excavator, crusher and other transport vehicles travelling on site. • Adopt noise reduction measures on equipment; strengthen equipment repair and maintenance to keep them in good working condition. • Maximum speed of 20 km/h for all project and construction vehicles in works areas • Use of horn is prohibited by drivers of project and construction vehicles except in case of emergency • Speed limit signs for project and construction vehicles to be installed 100 m ahead of residential areas when the construction transport roads cross villages. • Avoid transport activities at night. • Comply with local requirements in areas close to the sensitive receptors, in particular minimize road construction works from 2200 to 0600 hr. If night time work is needed, set up temporary noise barrier, minimize use of noisy equipment, and consult and notify local communities beforehand. • Maintain continual communication with residents adjacent to construction sites to identify and resolve issues, including adjustment of work hours of noise-generating machinery.	Contractor, CSCs	IA, PMO
Surface water pollution	Increase SS concentrations in groundwater due to	• Unauthorized discharge of water from the foundation ditch into either the Shixia Reservoir or the West Qingzhang River is prohibited • Sedimentation tanks will be installed for the wastewater treatment to meet the GB 8978-1996 Class	Contractor, CSCs	IA, PMO

Item	Potential issues	Mitigation measures	Implement	Supervise
and dredging	percolation of water from foundation ditch of flood discharge tunnel	l standard. • Where possible, the de-silted water will be used for road watering and dust reduction rather than discharged into the environment.		
	Sediment and dewatering	• Water generated from dewatering of dredged sediments will be treated by sedimentation in consolidation tanks, and the SS concentration of the treated water will be less than 20 mg/L (complied with Class I requirement of GB8978-1996)	Contractor, CSCs	IA, PMO
	Domestic wastewater from construction sites	• Portable toilets and on-site wastewater pre-treatment systems will be installed at construction camps along with proper maintenance protocols. • Labor camps will be located ≥300 m from rivers.	Contractor, CSCs	IA, PMO
	Construction wastewater (pouring concrete, repairs etc.) is managed	• Settling ponds and oil-water separators implemented. • Recycled water is used to spray for dust control. • All earthworks along river will be accompanied by measures to minimize sediment runoff, including sediment traps. • Residues are removed from site and disposed in municipal landfills.	Contractor, CSCs	IA, PMO
	Handling of hazardous and harmful materials	• Guidelines for handling and disposal, including spill responses, are prepared and included in the SEMSP. • Construct storage facilities (including fuel and oil storage), with bunds and clean-up equipment. • Fuel supplier is properly licensed and follows the proper protocol for transferring fuel, and complies with JT 3145-88 (Transportation, Loading and Unloading of Dangerous or Harmful Goods). • Vehicles and equipment are parked in designated areas to prevent contamination of soil and surface water. • Vehicle, machinery, and equipment maintenance and refueling are carried out so that spilled materials do not seep into the soil or into water bodies. • Locate storage / cleaning areas for fuel, machinery and vehicles ≥200 m from rivers. • Oil traps for service areas, and parking areas.	Contractor, CSCs	IA, PMO
Solid Waste	Domestic waste from construction sites	• Provide appropriate waste collection and storage containers at locations away from surface water or sensitive receivers. • Arrange with municipal waste collection services for regular collection of waste. • Provide sufficient garbage bins at strategic locations within active construction sites and ensure that they are covered, and emptied regularly by the municipal waste collection systems. • Burning of waste is strictly prohibited.	Contractor, CSCs	IA, PMO
	Construction waste management	• Construction waste that cannot be reused will be regularly transported off-site for disposal, and not allowed to accumulate on site over long periods. • Paving or vegetating shall be done as soon as the materials are removed to stabilize the soil.	Contractor, CSCs	IA, PMO

Item	Potential issues	Mitigation measures	Implement	Supervise
Biological resources	Protection of flora and fauna around construction sites	• Prior to construction, demarcate vegetation and fauna habitats e.g. vegetated roadsides, trees, riverbanks. • As far as possible avoid clearance of any vegetation. • After construction, immediately replant vegetation in any sites subject to clearance. • In compliance with PRC Forestry Law, the compensatory planting must be the same as, or larger than, the area cleared. • All project activities requiring the use of plants, including the project embankments, wetlands, landscaping, LID road improvement, and post-construction rehabilitation, will only use native plant species from Zuoquan County and which are locally sourced, to strengthen the rehabilitation of natural habitats and avoid the introduction of non-native invasive weeds. • Any fauna found during construction, will be immediately reported to the EPBs and PMO Environment Officer, photographed, and released on the same day in the nearest suitable habitat.	Contractor, CSCs	IA, LIEC
Socio-economic resources	Impact on physical cultural resources	• Establish chance-find procedures for physical cultural resources. • If a new site is unearthed, work shall be stopped immediately and local CHB and the IAs promptly notified.	Contractor, CSCs	IA, PMO
	Traffic management – all components	• Select haulage routes to reduce disturbance to regular traffic. • Trucks hauling treated dredge spoil to the embankment site will have light loads (not exceeding 10 t per trip), and fully covered. • Divert or limit construction traffic at peak traffic hours. • At all times, safe and convenient passage is given to community vehicles, pedestrians, and livestock to and from side roads.	Contractor, CSCs	IA, PMO
	Community health and safety	• Residents and businesses will be informed in advance through media and information boards of the construction activities, dates and duration of expected disruption. • Signs will be placed at construction sites informing people of the project GRM, potential dangers (e.g. moving vehicles, hazardous materials, excavations) and safety issues. • Heavy machinery will not be used at night. • All sites will be secured from unauthorized public access. • For residential areas next to construction (especially loud noise), ensure residents are aware of the duration and nature of works, potential hazards, and offer to provide basic safety equipment, such as acoustic screen.	Contractor, CSCs	IA, PMO
	Occupational health and safety	Prepare environmental, health and safety plan which complies with PRC State Administration of Worker Safety Laws and Regulations, including: • Clean and sufficient supply of fresh water for construction sites, camps, offices. • Sufficient latrines and other sanitary arrangements at construction sites and work camps. • Garbage receptacles and regular emptying.	Contractors	CSCs, IA

Item	Potential issues	Mitigation measures	Implement	Supervise
		• Provide protective equipment and clothing (goggles, gloves, respirators, dust masks, hard hats, steel-toed boots) for construction workers and enforce their use. • Emergency response plan for accidents prepared and approved by IAs and EPB. Establish emergency phone links with township hospitals and maintain a first-aid base in each construction camp. • Establish a records management system for occupational accidents, diseases, incidents. The records will be reviewed during compliance monitoring and audits. • Safety communication. Ensure that occupational health and safety matters are given a high degree of publicity to all persons on-site. Display posters prominently. • Training, awareness and competence. Train all workers in basic sanitation, health and safety matters, and work hazards. Implement awareness and prevention program for HIV/AIDS and other diseases – target the local community and construction workers.		
C. OPERATION PHASE				
Water quality	Performance of WWTP process	• Prior to commissioning of the extended WWTP, test the functioning of the WWTP and ability to achieve Class 1A discharge standard.	IAs,PMO	Zuoquan EPB
	Water discharge monitoring of WWTP	• Install wastewater quality monitoring devices for real-time monitoring at WWTP • Establish real-time monitoring framework	IAs,PMO	Zuoquan EPB
	Groundwater management	•Long-term underground water monitoring system and emergency plan will be established, especially for the location area of Zuoquan WWTP •Regular maintenance procedures for WWTP facilities for seepage control will be established.	IAs,PMO	Zuoquan EPB
	Rural wastewater and industry wastewater management	•The rural wastewater treatment stations will be constructed and operated in the same phase of water supply components •Wastewater management of the industrial users will be closely monitored to ensure the discharge can meet the corresponding national standard requirement. .	IAs,PMO	Zuoquan EPB
Air	Odor from WWTP	• Equip odor generating facilities with ventilation or odor containment. • Implement regular sludge removal and avoid stockpiling. • Institute regular check, repair and maintenance of all treatment facilities and equipment.	IA,PMO	Zuoquan EPB
Noise	Noise produced during wastewater treatment – mechanical equipment	• Design and implement noise absorbing, noise reduction, noise insulation and vibration reduction measures. Adopt low noise level equipment. • Create green buffer zone/noise absorption zone along WWTP expansion boundaries using native trees and shrub planting.	IA,PMO	Zuoquan EPB
	Noise impact to future roadside developments	• No new development to be permitted within 35 m of the Binhe Road landuse perimeter • Any buildings ≤35 m from the road red line will have double glazed windows installed with specification to comply with Function Area Category 4a standard of GB 3096-2008. • No school, residential building and hospitals and medical clinics will be built within 35 m from the perimeter of Binhe Road.	IA,PMO	Zuoquan EPB

Item	Potential issues	Mitigation measures	Implement	Supervise
		• If there is no first row building within 35 m from Binhe Road to provide noise shielding effect, any development beyond 35 m from the road perimeter would need to be set back from the perimeter in order to comply with Functional Area Category 2 standard of GB 3096-2008.		
Flora and fauna	Manage the built habitats – revegetation, planting, embankments, and wetlands	• Maintain the landscaping – watering, weeding, stabilizing, survival and growth of planted trees, shrubs and herbs, with replacement and corrective action as necessary. • Provide security and surveillance to guard against misuse, theft and littering. • Pest control: the guiding principle will be prevention first followed by integrated treatment to avoid/reduce pollution from pesticide. Use of pesticides prohibited by the Ministry of Agriculture in the upstream of West Qingzhang River and around Shixia Reservoir will be forbidden. • Regularly remove litter and transport to landfill.	IA,PMO	Zuoquan EPB
Emergency preparation and response	WWTP emergency response plan	• Prepare preparedness and response plan before WWTP is operational. The plan will include staff training, resources, responsibilities, communication, procedures, and other aspects required to respond effectively to emergencies.	WWTP, IAs	Zuoquan EPB
	Shixia Dam emergency response plan	• Prepare a dam emergency response plan, including emergency response system and responsibilities, monitoring and pre-forecasting mechanism, responses, safeguard measures including training, public awareness activities and practices.	IA, PMO	EA
Health and safety	Health and safety of WWTP operating staff	• Compulsory use of safety equipment and clothing as necessary, including shoes or boots with non-slip soles, protective and chemical resistant clothing, safety goggles • Wear respiratory mask in sludge dewatering and de-odor workshops and when moving and transporting sludge; • Posting and briefing on safety instructions for the storage, transport, handling or pouring of chemicals, and entry into confined spaces	WWTP, IAs	Zuoquan EPB
Social	Traffic	• Regularly inspect and maintain the road surface and clean up the drains. • Strictly enforce traffic law to prohibit large vehicles carrying dangerous goods travelling on the urban roads and bridges.		
	All areas	• If unexpected environmental impacts occur during project operations, inform the PMO immediately; assess the impacts; and update the EMP	IA,PMO	Zuoquan EPB

Sources: ADB = Asian Development Bank, CSC = construction supervision company, EA = executing agency, EIA = environmental impact assessment, EMS = environmental monitoring Station, EPB = environment protection bureau, GRM = grievance redress mechanism, IA = implementing agency, DI = design institute, LIEC = loan implementation environmental consultant, O&M = operation and maintenance, PMO = project management office, SEMSP = site environmental management and supervision plan, WTP = water treatment plant, WWTP = waste water treatment plant.

D. Project Readiness

14. Prior to construction, the PMO will assess the project environmental readiness using Table EMP-3 and review with ADB. If necessary, corrective actions will be identified to ensure that all requirements are met.

Table EMP-3. Project Readiness Assessment Indicators

Indicator	Criteria	Assessment	
		Yes	No
EMP update	The EMP was updated after technical detail design, and approved by ADB	☐	☐
Compliance with loan covenants	The borrower complies with loan covenants related to project design and environmental management planning	☐	☐
Public involvement effectiveness	• Meaningful consultation completed • GRM established with entry points	☐ ☐	☐ ☐
Environmental supervision in place	• IA to assign environmental coordinator • LIEC is in place • Environment Officer appointed by PMO • EMS and CSCs contracted by IAs • EMS appointed by the IAs	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐
Bidding documents and contracts with environmental safeguards	• Bidding documents and contracts incorporating the impact mitigation and environmental management provisions of the EMP.	☐	☐
Site construction planning (Environmental)	Site environmental management and supervision plan prepared for each work site by the IAs, and contractors.		
EMP financial support	The required funds have been set aside by contractors, and IAs to support the EMP implementation	☐	☐

Note. ADB=Asian Development Bank; CSCs = Construction Supervision Companies; EMS = Environment Monitoring Station, LIEC = Loan Implementation Environmental Consultant, PMO = Project management office, IAs = Implementing Agencies.

E. Monitoring and Reporting

15. Three types of project monitoring will be conducted under the EMP: (i) internal monitoring – to be conducted by the IAs and the Construction Supervision Companies (CSCs) during construction stage, and by the Zuoquan WWTP, Shixia Reservoir Management Office, and Zuoquan Liaorun water company during the operation stage; (ii) external monitoring – of air, water, noise and soil standards – to be conducted by the local environment monitoring station (EMS); and (iii) compliance monitoring – to be conducted by the LIEC, to ensure the EMP is being implemented. The project monitoring program is in Table EMP-4. Monitoring shall comply with the PRC standards for environmental monitoring and quality.

16. **Internal monitoring.** During construction, the contractors, IAs and CSCs will be responsible for conducting internal environmental monitoring in accordance with the monitoring plan.

17. **External monitoring.** The IAs will contract the Zuoquan EMS to conduct environmental monitoring in accordance with the monitoring program. A detailed cost breakdown will be provided by the local EMS when the environmental monitoring program is updated at the start of each component implementation. Monitoring will be conducted during construction and operation period, until a project completion report (PCR) is issued. Semi-annual monitoring reports will be prepared by the EMS and submitted to PMO and the IAs.

18. **Compliance monitoring for EMP and progress reporting.** The LIEC will review project

progress and compliance with the EMP based on field visits, and the review of the environmental monitoring conducted by the EMS. The findings of the LIEC will be reported to ADB through the semi-annual EMP monitoring and progress reports. The reports will include (i) progress made in EMP implementation, (ii) overall effectiveness of the EMP implementation (including public and occupational health and safety), (iii) environmental monitoring and compliance, (iv) institutional strengthening and training, (v) public consultation (including GRM), and (vi) any problems encountered during construction and operation, and the relevant corrective actions undertaken. The LIEC will help PMO prepare the reports and submit the English report to ADB for appraisal and disclosure.

19. **Project completion environmental audits.** Within three months after each subproject completion, or no later than one year with permission of the local EPBs, environmental acceptance monitoring and audit reports of each subproject completion shall be (i) prepared by a licensed environmental monitoring institute in accordance with the PRC Guideline on Project Completion Environmental Audit (2001), (ii) reviewed for approval of the official commencement of individual subproject operation by environmental authorities, and (iii) finally reported to ADB through the semi-annual EMP monitoring and progress reporting process.

20. **Quality assurance (QA)/Quality control (QC) for EMP implementation monitoring.** To ensure accuracy of the monitoring, QA/QC procedures will be conducted in accordance with the following regulations:

i) Regulations of QA/QC Management for Environmental Monitoring issued by the State Environmental Protection Administration in July 2006;
ii) QA/QC Manual for Environmental Water Monitoring (Second edition), published by the State Environmental Monitoring Centre in 2001; and
iii) QA/QC Manual for Environmental Air Monitoring published by the State Environmental Monitoring Centre in 2001.

Table EMP-4. Environmental Monitoring Program

Subject	Parameter	Location	Frequency	Implement	Supervise
DESIGN STAGE					
Ambient air quality along Binhe Road	PM_{10}, SO_2, NO_2	7 locations: 1. Xiaohui Village 2. Xichangyi Village 3. Qilidian Village Central Junior School 4. Teach building of Zuquan Vocational Technical Institute 5. Teach builing of No.4 Middle School 6. Dormitory of Changtai Chemical Plant Dormitory of Fertilizer Plant	1 day (24-hr continuous sampling)	EPB	PMO
CONSTRUCTION STAGE					
Internal monitoring (contractors, CSCs, IAs, PMO Environment Officer)					
Ambient air quality	Dust mitigation measures in EMP; equipment maintenance	Visual inspection at all construction sites	Daily	Contractor, CSC	IAs, PMO, LIEC, EPB
Solid waste	Garbage and construction waste	Visual inspection at all construction sites and work-camps	Daily	Contractor, CSC	IAs, PMO, LIEC, Sanitation bureau
Wastewater	Provision and operation of domestic and	Visual inspection at all construction sites and work-camps	Daily	Contractor, CSC	IAs, PMO, LIEC, EPB

Subject	Parameter	Location	Frequency	Implement	Supervise
	construction wastewater facilities				
Soil erosion and re-vegetation	Soil erosion intensity	Visual inspection at spoil sites and all construction sites, especially roadsides, water pipelines, banks of river, wetlands. PRC compliance monitoring.	1 time / week; and immediately after heavy rainfall	Contractor, CSC	IAs, PMO, LIEC, EPB
	Re-vegetation of spoil temporary storage sites, construction sites	Visual inspection at all sites. PRC compliance monitoring.	At least 4 times / year	Contractor, CSC	IAs, PMO, LIEC, EPB
Occupational health and safety	Camp hygiene, safety, availability of clean water, emergency response plans	Inspection at all construction sites and work-camps	1 time / month	Contractor, CSC	IAs, PMO
EXTERNAL MONITORING (Zuoquan Environment Monitoring Station)					
Construction wastewater	SS, oil, pH	At wastewater discharge points of all construction sites	4 times / year during construction in all active site	EMS	IAs, PMO, EPB
Surface water quality	pH, DO, I_{Mn}, NH3-N, TP, F^-, fecal coliform	Location of the outflow of Shixia Reservoir	4 times / year during construction	EMS	IA, PMO, EPB
	SS	West Qingzhang River dredging: Two locations at dredging section: 1. 50 m upstream of dredge section (control site) 2. 100 m downstream of dredge site (impact site) Embankment works on West Qingzhang River: Two locations at dredging section: • 50 m upstream of dredge section (control site) • 100 m downstream of dredge section (impact site)	1 time per day; 1 day per month during construction in all active sites	EMS	IA, PMO, EPB
	pH, COD, BOD5, NH_3-N, Oil	Bridge construction sites: Three locations at each bridge crossing • 500 m upstream of the bridge (control site) • 500 m downstream of the bridge (impact site) • 2000 m downstream of the bridge (impact site) Downstream of the project area 200 m downstream of the Zuoquan WWTP	1 time per day; 1 day per month during construction in all active sites	EMS	IAs, PMO, EPB
Ambient air quality	SO_2, NO_2、	All construction sites (at least 1 point upwind, 1 point	4 times / year during	EMS	IAs, PMO, EPB

Subject	Parameter	Location	Frequency	Implement	Supervise
	TSP、PM_{10}	downwind) and nearby sensitive receivers (see IEE Section IV)	construction		
Odor	H_2S, NH_3	Nearest residence from each dredge spoil storage site	1 day (24-hour continuous sampling) per week, during construction activity	EMS	IA, PMO, EPB
Noise	LAeq	Boundaries of all construction sites and sensitive receivers (described in Section IV of IEE)	2 times / year (twice a day: once in day time and once at night time, for 2 consecutive days) during construction	EMS	IAs, PMO, EPB
Solid waste (garbage, construction waste)	Work camps and construction waste at construction sites	Visual inspection at all construction sites and work-camps	Twice a year	LIEC	IAs, PMO, EPB
Soil erosion and re-vegetation	Soil erosion intensity	Visual inspection at spoil sites and construction sites, especially water pipeline route and embankments of rivers, wetlands	Twice a year, and 1 after completion of construction	LIEC	IAs, PMO, EPB
	Re-vegetation of spoil temporary storage sites and construction sites	Visual inspection at sites, and temporary occupied lands	Compliance Monitoring: Twice a year, and 1 after completion of construction	LIEC	IAs, PMO, EPB
Occupational health and safety	Work camp hygiene, safety, availability of clean water, emergency response plans	Inspection at all construction sites and work-camps	Twice a year, and once after completion of construction	LIEC	IAs, PMO, EPB
OPERATION PHASE					
Wastewater quality	pH, COD，BOD, NH3-N, TN, TP, E.coli,	At outlet of WWTP	4 times during the first year of WWTP operation	EMS	IA, PMO, EPB
Groundwater Quality	pH, NH_3-N, NO_3-N, Total Hardness, SS $SO4^{2-}$,CI- Total coliform bacteria, Total Bacteria	In the area around WWTP: • 2 km upstream from Zuoquan WWTP • 300 m downstream from Zuoquan WWTP • 3 km downstream from Zuoquan WWTP	4 times during the first year of WWTP operation	EMS	IA, PMO, EPB
Air quality	NH_3, H_2S	Nearest residence from WWTP	2 days per month for 12 consecutive months. during the first year of operation phase	EMS	IA, PMO, EPB
	PM_{10}, NO_2	Sensitive locations along Binhe Road			
Noise	L_{Aeq}	Sensitive locations along Binhe Road	2 days per month for 12 consecutive	EMS	IA, PMO, EPB
		At WWTP boundary			

Subject	Parameter	Location	Frequency	Implement	Supervise
			months. during the first year of operation phase		
Soil and Vegetation	Plant survival and coverage	All re-vegetated sites	Spot check, twice a year	IA	PMO, EPB

COD_{cr} = chemical oxygen demand; CSC = construction supervision company; EMS = environmental monitoring station; EPB = environmental protection bureau; IA = implementation agency; LAeq = equivalent continuous A-weighted sound pressure level; NH_3-N = ammonia nitrogen; NO_x = nitrogen oxide; PM_{10} = particles measuring ≤10μm; PMO = project management office; SO_2 = sulfur dioxide; SS = suspended solids; TSP = total suspended particle; WWTP = wastewater treatment plant

21. Environmental reporting for the project will follow the program in Table EMP-5.

Table EMP-5: EMP Reporting Plan

Reports		From	To	Reporting Frequency
CONSTRUCTION PHASE				
Internal progress reports by contractors	Internal project progress report by construction contractors, including monitoring results by CSCs	IAs Contractors, CSCs	PMO	Monthly (during construction season)
Environmental impact monitoring reports	Environmental impact monitoring report	Zuoquan EMS	IAs PMO	Semi-annual (during construction season)
Reports to ADB	Environment progress and monitoring reports	PMO with support of LIEC	ADB	Semi-annual
Acceptance reports	Environmental acceptance monitoring and audit report	Licensed institute	Zuoquan EPB	Once for each engineering subcomponent, not later than one year after completion of physical works
OPERATION PHASE				
Environmental impact monitoring	Environmental impact monitoring report (during first year of operation)	Zuoquan EMS	IAs, PMO	Quarterly
Reports to ADB	Project progress report (including section on EMP implementation and monitoring)	PMO with support of LIEC	ADB	Semi-annual
	Environment progress and monitoring report	Zuoquan EMS	IAs, PMO	Semi-annual
	Environmental progress report	PMO with support of LIEC	ADB	Once (after first year of operation)

ADB=Asian Development Bank; CSCs = Construction Supervision Companies; EMS = Environment Monitoring Station, IAs = Implementing Agencies, LIEC = Loan Implementation Environmental Consultant, PMO = Project management office.

F. Training

22. The project agencies have no previous experience with ADB-funded projects or safeguard requirements. To ensure effective implementation of the EMP, a capacity building program will be implemented on EMP implementation, supervision, and reporting, the GRM, and the design and operation and maintenance of “Sponge City” and wetlands (Table EMP-6). Training will be provided by the LIEC with the support of other experts under the loan implementation consultant services. Trainees will include the PMO, IAs, contractors, and CSCs. The PMO will arrange and support the training programs, supported by the loan implementation consultants.

The training program is in **Table EMP-6**.

Table EMP-6: Training Program

Training	Attendees	Contents	Times	Period (days)	No. of persons
EMP adjustment and implementation	PMO, IAs, contractors, CSCs	Development and adjustment of EMP, roles and responsibilities, monitoring, supervision, reporting procedures, review of experience (after 12 months)	Twice - Once prior to, and once after one year of construction completion	2x0.5	16
Grievance Redress Mechanism	PMO, IAs, contractors, Zuoquan EPB	Roles and responsibilities, Procedures, review of experience (after 12 months)	Once prior to, and once after one year of construction completion	2x0.5	16
Environmental protection and monitoring	PMO, IAs, Zuoquan EPB	Pollution control on construction sites (air, noise, waste water, solid waste)	Once (during project implementation)	1	20
Sponge City concepts	PMO, ZHCB, ZMMB, Zuoquan EPB	Principles of sponge city design, design best practices	Once during detailed design stage	1	16
Wetland O&M	PMO, ZHCB, Zuoquan Landscaping Bureau for the Park, Zuoquan EPB	Principle of wetland design, O&M best practice (maintain flood capacity and ecological value)	Twice - Once during detailed design stage, and once after completion of physical works	2	16
Revegetation	As above	Principles of revegetation, species selection, O&M	Twice - Once during detailed design stage, and once after completion of physical works	2	16
WWTP operation – sludge disposal, GHG, and safeguards.	PMO, Zuoquan Wastewater Treatment Center for WWTP, ZMMB, Zuoquan WWTP O&M supervisors, Zuoquan EPB	Operation of treatment processes, environmental safeguards and safety, sludge treatment and final disposal, and greenhouse gases.	Once (before expanded facilities commissioning)	1	20

CSC = construction supervision company; EMS = environment monitoring station, IAs = implementing agencies, EPB = Environmental Protection Bureau, LIEC = loan implementation environmental consultant, O&M = operation and maintenance, PMO = project management office, WWTP = wastewater treatment plant, ZHCB = Zuoquan Housing Security and Urban & Rural Construction and Management Bureau, ZMMB = Zuoquan Municipal Management Bureau, ZWRB = Zuoquan Water Resource Bureau

G. Public Consultation

23. Two rounds of public consultation were conducted during project preparation (Section VIII of the IEE). During construction, the project will continue to seek public consultation and raise awareness of project activities, especially those which may impact the public such as noise. The project public consultation plan is in Table EMP-7, and includes public participation in evaluating environmental benefits and impacts. The IAs is responsible for public participation during project implementation. They will be supported by the PMO Environment

and Social Officers and the LIEC.

Table EMP-7. Public Consultation and Participation Plan

Organizer	Approach	Times/Frequency	Subjects	Participants
CONSTRUCTION				
PMO, IAs, LIEC	Public workshops	For each construction site, at least once before construction; and at least twice during peak construction	Construction schedule EMP implementation progress; construction impacts; adjusting mitigation measures if necessary; feedback	Residents, affected persons, social sectors
	Site visits and informal interviews	Frequent throughout construction	Construction impacts; adjusting mitigation measures if necessary; feedback	Workers, residents in construction areas
	Public satisfaction survey (questionnaire)	Once a year during peak construction	Construction impacts; adjusting mitigation measures if necessary; feedback	Workers, residents in construction areas
OPERATION				
PMO, IAs, operators of project facilities	Public workshop	As needed based on public consultation	Effects of mitigation measures, impacts of operation, feedback	Residents, affected persons, social sectors
	Site visits and informal interviews	Frequent throughout construction	Construction impacts; adjusting mitigation measures if necessary; feedback	As above
	Public satisfaction survey (questionnaire)	At least once after one year of operation	Comments and suggestions	Project beneficiaries

IAs = Implementing Agencies, LIEC = loan implementation environmental consultant, PMO = project management office.

H. Grievance Redress Mechanism

24. A Grievance Redress Mechanism (GRM) has been established as part of the project EMP to receive and manage any public environmental and/or social issues which may arise due to the project. The PMO will ensure that potentially affected communities are informed about the GRM at an early stage of the project. The PMO environment and social officers will coordinate the GRM. All project agencies and staff will be trained in the GRM and will take an active role in supporting these staff as and when necessary.

25. At the PMO level, the PMO environment and social officers will establish a GRM tracking and documentation system, conduct daily coordination with the IA officers, arrange meetings and conduct site visits as necessary, maintain the overall project GRM database, and prepare the reporting inputs for progress reports to ADB. At the IA level, the PMO environment and social officers will instruct CSCs on the GRM procedures, and coordinate with the county EPBs and other government divisions as necessary. PMO and IA staff will be trained and supported by the LIEC and Loan Implementation Social Consultant (LISC).

26. The contact persons for different GRM entry points, such as the PMO and IA Environmental and Social Officers, contractors, operators of project facilities, and Zuoquan EPB, will be identified prior to construction. The contact details for the entry points (phone numbers, addresses, e-mail addresses) will be publicly disclosed on information boards at construction sites and on the websites of the PMO and Zuoquan EPB.

27. Once a complaint is received and filed, the PMO and IA officers will identify if complaints

are eligible. Eligible complaints include those where (i) the complaint pertains to the project; and (ii) the issues arising in the complaint fall within the scope of environmental and/or social issues that the GRM is authorized to address. Ineligible complaints include those where: (i) the complaint is clearly not project-related; (ii) the nature of the issue is outside the mandate of the environmental and social GRM (such as issues related to resettlement, allegations of fraud or corruption); and (iii) other procedures are more appropriate to address the issue. Ineligible complaints will be recorded and passed to the relevant authorities, and the complainant will be informed of the decision and reasons for rejection. The procedure and timeframe for the GRM is as follows and also summarized in Figure EMP-1.

- **Stage 1 (5 days)**: If a concern arises during construction and operation stage before the ICR completed, the affected person may submit a written or oral complaint to the contractor. Whenever possible, the contractor will resolve the issue directly with the affected person. The contractor shall give a clear reply within five (5) working days. The contractor will keep the IAs fully informed at all stages. Written records will be made of all stages and outcomes.

- **Stage 2 (5 days)**: If the issue cannot be resolved in Stage 1, after five days, the IAs and/or PMO will take over responsibility. Eligibility of the complaint will be assessed and a recommended solution given to the complainant and contractors within five (5) working days. If the solution is agreed by the complainant, the contractors and/or facility operators will implement the solution within seven days. Written records will be made of all stages and outcomes.

- **Stage 3 (10 days)**: If no solution can be identified by the PMO and/or IAs, and/or the complainant is not satisfied with the proposed solution, the PMO and/or IAs will organize, within ten (10) days, a stakeholder meeting (including the complainant, contractor and/or operator of the facility, Zuoquan EPB, IAs, PMO). A solution acceptable to all shall be identified including clear steps. The contractors (during construction) and facility operators (during operation) will immediately implement the agreed solution. Written records will be made of all stages and outcomes.

28. The GRM does not affect the right of an affected person to submit their complaints to any agency they wish to, for example the local village committee, community leaders, courts, PMO, IAs, and/or Asian Development Bank. However, efforts shall be made to avail of this project level GRM.

29. The PMO and IAs shall bear any and all costs of implementing the GRM, including meeting, travel, and/or accommodation costs of the project staff or affected person. The GRM will be implemented throughout project construction and operation until when the PCR completed..

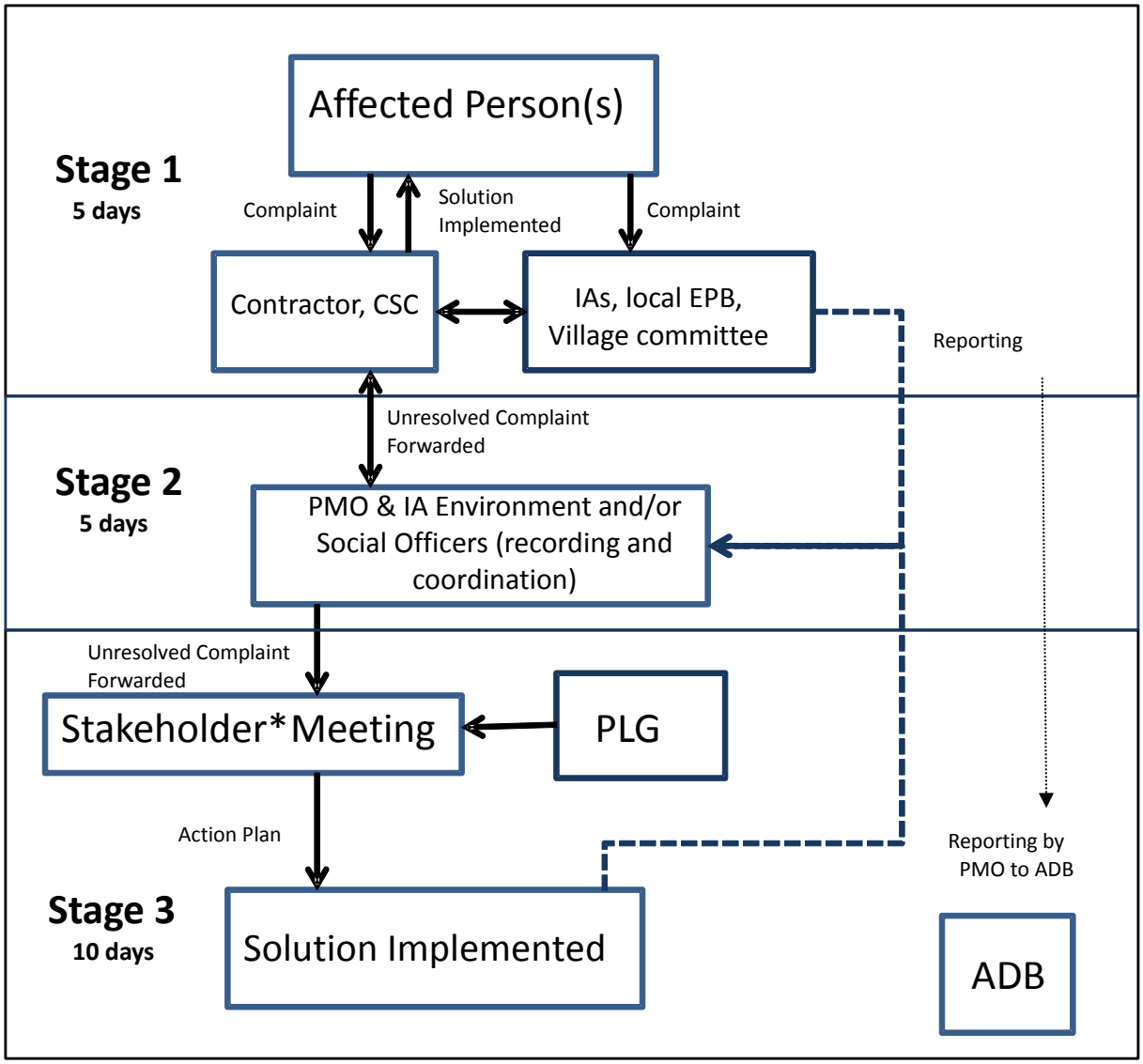


Figure EMP-1. Grievance Redress Mechanism

I. Cost Estimates

30. This section provides an estimate of the cost of EMP implementation. The cost comprises three categories: mitigation measures (Table EMP-2); monitoring (Table EMP-4); and training (Table EMP-6). Costs are presented for the construction phase of five years and the first year of operation i.e. a total of six years. The costs do not include: (i) detailed design revisions and adjustments; (ii) costs during construction of monitoring and inspection for solid waste disposal, soil erosion, re-vegetation and occupational health and safety (these costs will be included in the contracts of the construction supervision companies); and (iii) salaries of PMO and IA staff. Costs for mitigation measures and training are based on estimates in the domestic EIAs and/or the experience of the PPTA team from other projects. All costs were discussed with the PMO.

31. The total estimated cost for EMP implementation is CNY32.70 million ($4,939,577) for six years construction (Table EMP-8). The estimated cost for the PMO is CNY265,000 (0.81%) and for contractors is about CNY31,645,000 (96.77%). About CNY790,000 (2.42%) will be paid from ADB loan consulting services and remaining costs by the IAs. Total costs are small given the large scale of the project and when spread over six years.

Table EMP-8. Estimated Cost for EMP Implementation for Five Years of Construction and the

First Year of Operation (xCNY10,000). Construction-phase costs will be paid by the contractors (as part of their contracts). **Operational-phase costs** will be paid by each implementing agency (IA).

Item	Unit cost	No. units	5-yr Cost (CNY)
MITIGATION (Table EMP-3)			
1. PRE-CONSTRUCTION			
1.1 Public consultations	5,000	2	10,000
1.2 LIEC	50,000	10 person-months	500,000
1.3 Wetland Specialist	50,000	3 person-months	150,000
1.4 Re-vegetation Specialist	50,000	2 person-months	100,000
1.4 GRM	5,000	1	5,000
Sub-total			**765,000**
2. CONSTRUCTION			
2.1 Water source protection of the Qingzhang headwaters	3,332,000	1	3,332,000
2.2 Qingzhang river rehabilitation and integrated low impact facilities	16,655,000	1	16,655,000
2.3 Inclusive water supply and wastewater collection services	11,658,000	1	11,658,000
Sub-total			**31,645,000**
3. MONITORING (Table EMP-4)			
External environmental monitoring	250,000	1	250,000
Sub-total			**250,000**
4. TRAINING (Table EMP-6)			
EMP Implementation	10000	2	20,000
GRM	5000	2	10,000
Environmental monitoring	5000	1	5,000
WWTP-safeguards	5000	1	5000
Sub-total			**40,000**
GRAND TOTAL CNY			**32,700,000**
Total USD (USD1=CNY6.62)			**4,939,577**

EMS = Environmental Monitoring Station; GRM = Grievance Redress Mechanism; LIEC = Loan Implementation Environmental Consultant; PM = person-months.

J. Mechanisms for Feedback and Adjustment

32. Based on environmental inspection and monitoring reports, the PMO and IAs shall decide, in consultation with the LIEC, whether (i) further mitigation measures are required as corrective actions, or (ii) some improvements are required for environmental management practices. The effectiveness of mitigation measures and monitoring plans will be evaluated by a feedback reporting system. Adjustment to the EMP will be made, if necessary. The PMO Environmental Officer will play a critical role in the feedback and adjustment mechanism.

33. If during inspection, substantial deviation from the EMP is observed or any changes are made to the project that may cause substantial adverse environmental impacts or increase the number of affected people, then the PMO and IAs will immediately consult with ADB and form an environmental assessment team to conduct additional environmental assessment. If necessary, further public consultation will be undertaken. The revised domestic EIAs and project IEE, including this EMP, will be submitted to ADB for review, appraisal, and public disclosure. The revised EMP will be passed to the contractors, CSCs and operators of project facilities, for implementation.

APPENDIX 1. DRAFT TERMS OF REFERENCE FOR ENVIRONMENTAL POSITIONS

PMO ENVIRONMENT OFFICER

BACKGROUND

1. Development projects supported by the Asian Development Bank (ADB) routinely include a Project management office (PMO). The PMO is responsible for project implementation and comprises the provincial and/or municipal agencies involved in the project. Compliance with the Loan and Project Agreements includes implementation of an Environment Management Plan (EMP), which is prepared as part of the project environment impact assessment. The EMP is the critical guiding document to manage, monitor, and report upon potential project environmental impacts. Implementation of the EMP is a full-time task. For this reason, the PMO assigns at least one full-time officer for this role. These terms of reference describe the requirements for this officer.

SCOPE AND DURATION OF WORK

2. The officer will work on behalf of the PMO to implement the project EMP. The officer will report directly to the PMO. The position is for the entire project duration.

QUALIFICATIONS

3. The officer will have: (i) an undergraduate degree or higher in environmental management or related field; (ii) at least five years of experience in environmental management, monitoring, and/or impact assessment; (iii) ability to communicate and work effectively with local communities, contractors, and government agencies; (iv) ability to analyze data and prepare technical reports; (v) willingness and health to regularly visit the project construction sites and in different seasons; and (vi) ideally, proficiency in spoken and written English.

DETAILED TASKS

4. The PMO Environment Officer will have a detailed understanding of the project EMP and supporting documents, including the domestic environmental reports, the project initial environmental examination (IEE), and project environmental assurances. The officer will have the following tasks.

(i) Assess whether the EMP requires updating due to any changes in project design which may have occurred after the EMP was prepared.

(ii) Distribute the Chinese language version of the EMP to all relevant agencies, including the implementing agencies, provincial and municipal agencies for environment protection. This should occur within three months of project effectiveness

(iii) Conduct meetings with agencies as necessary to ensure they understand their specific responsibilities described in the EMP.

(iv) Ensure that relevant mitigation, monitoring and reporting measures in the EMP are included in the bidding documents, contracts and relevant construction plans.

(v) Confirm that the Implementing Agencies (IAs) responsible for the internal environment monitoring described in the EMP understand their tasks and will implement the monitoring in a timely fashion.

(vi) Within two months of project effectiveness, establish and implement the project Grievance Redress Mechanism (GRM) described in the EMP. This will include: (a) prepare a simple table and budget identifying the type, number and cost of materials needed to inform local communities about the GRM and starting dates and scope of construction; (b) design, prepare and distribute these materials, and plan and conduct the community meetings; (c) prepare a form to record any public complaints; (d) prepare a summary table to record all complaints, including dates, issues, and how they were resolved; and (e) ensure that all relevant agencies, including contractors, understand their role in the GRM.

(vii) Prior to construction, ensure that IAs and their contractors have informed their personnel, including all construction workers, of the EMP requirements. This will include all mitigation measures relating to impacts to air, water, noise, soil, sensitive sites, ecological values, cultural values, worker and

community health and safety, respectful behavior when communicating with local communities, and responding to and reporting any complaints.

(viii) During project construction, make regular site visits with LIEC to assess progress, meet with contractors and/or local communities, and assess compliance with the EMP.

(ix) Ensure that all relevant agencies submit required progress reports and information, including environmental monitoring and reports of any issues or grievances.

(x) Compile, review, and store environmental progress reports from the IAs, records of any grievances, and any other relevant issues. Maintain digital copies of all information. When necessary, enter data into summary tables in digital format (e.g. to transfer records of grievances from hard copy forms). Ensure that all information is stored in the PMO filing system, backed up, and can be easily retrieved.

(xi) Prepare semi-annual environment progress reports.

(xii) Work closely with the PMO, IAs, loan implementation consultants, and other agencies and personnel as necessary to conduct these tasks.

REPORTING REQUIREMENTS

Semi-annual environment monitoring reports, using the template provided by ADB or a domestic format reviewed and approved by ADB.

LOGISTICAL SUPPORT PROVIDED BY PMO TO THE ENVIRONMENT OFFICER

(i) Provision of hard and soft copies of the project EMP, domestic and project environmental reports, feasibility study reports, loan and project agreements, maps, and other supporting materials as necessary to ensure the officer can implement the tasks.

(ii) Vehicle transport, office materials, and other logistical support as necessary for the officer to visit the project construction sites and local communities, arrange and conduct meetings, and prepare and distribute consultation materials.

(iii) Overall coordination, including review of the draft semi-annual monitoring reports and final responsibility for submission of the monitoring reports to ADB.

LOAN IMPLEMENTATION ENVIRONMENTAL CONSULTANT

I. BACKGROUND

1. The project will be coordinated by a Project management office (PMO), whose overall responsibility includes implementation of the project Environment Management Plan (EMP). At the field level, the project will be implemented by a Project Implementation Unit (PIU). The PMO and PIUs will be assisted by a Loan Implementation Consultant team. The Loan Implementation Environmental Consultant (LIEC) will be a part of this team and will support the PMO and PIUs to implement the project EMP.

II. SCOPE AND DURATION OF WORK

2. This is an independent position (recruited as part of a consultant team or individually) which is not part of the PMO in-house environmental team. The specialist will report to the PMO. The position is for the entire project duration (intermittent over six years). The LIEC will be recruited as soon as possible after loan effectiveness, as the first task is to confirm project environmental readiness.

III. QUALIFICATIONS

3. The specialist will have: (i) an undergraduate degree or higher in environmental management or related field; (ii) at least eight years of experience in environmental management, monitoring, and/or impact assessment; (iii) familiarity with ADB project management requirements and national environmental management procedures; (iv) ability to communicate and work effectively with local communities, contractors, and government agencies; (v) ability to analyze data and prepare technical reports; (vi) willingness and health to regularly visit the subproject sites; and (vii) proficiency in spoken and written English.

IV. TASKS

4. Working closely with the PMO and PIU Environmental Officers, the LIEC will do the following.

Before construction

(i) Ensure project environmental readiness, including: (i) all contractor contracts include, and will comply with, the EMP; and (iii) relevant sections of the EMP are incorporated in construction plans and contracts.
(ii) Assist the PMO and PIUs to implement the GRM, including: (i) establish and publicize the GRM; and (ii) collate and evaluate grievances received.
(iii) Develop procedures to: (i) monitor EMP implementation progress; (ii) collate and evaluate data collected in the EMP environmental monitoring program; and (iii) prepare and submit the semi-annual environmental monitoring reports to ADB (to continue until Project Completion Report).
(iv) Train project agencies in on-site ecological management and rehabilitation for the river dredging component, and, operation of the constructed wetlands.
(v) Provide hands-on support and on-the-job training to the PMO, IAs and contractors on the specific requirements of the EMP as required.

During project implementation

(i) Undertake site visits to all IAs during subproject construction and operating phase.
(ii) Assist in the ongoing public consultation process as described in the project IEE.
(iii) Conduct EMP compliance assessments, identify any environment-related implementation issues, and propose necessary responses in corrective action plans.
(iv) Undertake training of project agencies as required by the EMP training plan.
(v) Assist PMO to prepare semi-annual environmental monitoring progress reports for submission to ADB.

WETLAND SPECIALIST

I. BACKGROUND

1. Asian Development Bank (ADB) is supporting the Zuoquan County Government (ZCG) to implement the Shanxi Urban-Rural Water Source Protection and Environmental Demonstration Project. The project includes the establishment of a wetland park. The ZCG Project management office (PMO) will be assisted by a Loan Implementation Consultant team, which will include a wetland specialist.

II. SCOPE AND DURATION OF WORK

2. The specialist will support the ZCG in the detailed planning, design, and monitoring of the wetland park. The position is for six person-months over at least five years, and be involved in the detailed design, construction, and operational phases of the project.

III. QUALIFICATIONS

3. The specialist will have: (i) a master's degree or higher in environmental management or related field; (ii) at least 10 years' demonstrated experience in wetland design, relating to ecological habitat restoration and flood attenuation ; (iii) professional understanding of wetland ecological systems and processes, and, selection of native flora for use in wetland design; (iv) ability to communicate and work effectively with local communities, contractors, and government agencies; (v) ability to analyze data and prepare technical reports; and (vi) ideally, proficiency in spoken and written English.

IV. TASKS

4. Working closely with the ZCG, PMO, other loan consultants, and other stakeholders as needed, the specialist will do the following.

During Design Stage

(i) Review the existing proposed designs for the wetland park for the project.
(ii) Prepare detailed engineering designs for the wetlands. The designs will include: (a) selection of native species for planting; (b) design specifications; and (c) operation and maintenance (O&M) plan, including costs and roles and responsibilities.
(iii) Identify plant nurseries in Zuoquan County and neighboring counties and inspect the range of species present and where they are sourced. Prepare a short-list of nurseries which meet the following criteria: (a) stock native species to Zuoquan County **and** whose source stock was collected locally (Zuoquan or neighboring counties); (b) support a range of native plant species that will provide the required structural and species diversity for the project.
(iv) Ensure that the proposed designs conform with PRC regulations for National Wetland Parks, Sponge City Guidelines, and other relevant policies.
(v) Prepare a monitoring program for the project operational phase, to enable the ZCG to monitor (a) condition of the wetlands, and (b) the effectiveness of the wetlands in achieving ecological and flood management targets. The program will include methods, sites, roles, and costs.
(vi) Arrange and facilitate planning meetings and workshops between the design institutes and all relevant ZCG bureaus, to ensure the designs achieve an integrated approach for water quality treatment, Sponge City, landscaping and recreation, and urban design.
(vii) Support the ZCG to prepare construction tenders which address the design requirements for construction and O&M.
(viii) Provide training on constructed wetland management, O&M, and reporting, to ZCG agencies.
(ix) Review the possibility to include civil society organizations in the design and/or monitoring of the constructed wetlands, including local universities and/or schools.

During project implementation

(i) Support the ZCG to initiate the monitoring program, and participate in the initial sessions.
(ii) Review the effectiveness of the wetlands.
(iii) Provide progress reports, including identification of any issues, and lessons learned.

REVEGETATION SPECIALIST

I. BACKGROUND

5. Asian Development Bank (ADB) is supporting the Zuoquan County Government (ZCG) to implement the Shanxi Urban-Rural Water Source Protection and Environmental Demonstration Project. The project includes the extensive re-vegetation activities, including for a new wetland park, river embankments, and landscaping. The ZCG Project management office (PMO) will be assisted by a Loan Implementation Consultant team, which will include a re-vegetation specialist.

II. SCOPE AND DURATION OF WORK

6. The specialist will support the ZCG in the detailed planning, design, and monitoring of the re-vegetation activities. The position is for two person-months, anticipated to comprise one month during the project detailed design and construction, and one month during operation.

III. QUALIFICATIONS

7. The specialist will have: (i) a master's degree in botany, ecology, or applied landscaping using native plant species; (ii) at least 10 years work experience in site environmental rehabilitation and/or landscaping using native vegetation; (iii) demonstrated knowledge in the ecology and botany of native species of the project region; (iv) ability to communicate and work effectively with local communities, contractors, and government agencies; and (v) ideally, some proficiency in spoken and written English. Working with the other team members, design institutes (DIs), EA and ADB, the specialist will do the following

IV. TASKS

8. Working closely with the ZCG, PMO, other loan consultants, and other stakeholders as needed, the specialist will do the following.

During Design Stage

(i) Visit all of the proposed project sites, to be familiar with the project area and gain an adequate understanding of the key environmental issues.
(ii) Review (a) existing data on the vegetation in the project area, collected during the project design phase, and collect and review other documents as needed; (b) the existing project designs for re-vegetation.
(iii) Facilitate a participatory design process, with the wetland specialist and design institutes, to review the specific objectives of each project component involving re-vegetation.
(iv) On the basis of this, modify and/or strengthen the design components for re-vegetation. In particular, review the species proposed for the revegetation, and the proposed spacing, numbers, and operation and maintenance (O&M) of the plantings.
(v) As needed, prepare and/or modify detailed re-vegetation design plans. The designs will include: (a) selection of native species for planting; (b) design specifications; and (c) operation and maintenance (O&M) plan, including costs and roles and responsibilities.
(vi) Identify plant nurseries in Zuoquan County and neighboring counties and inspect the range of species present and where they are sourced. Prepare a short-list of nurseries which meet the following criteria: (a) stock native species to Zuoquan County and whose source stock was collected locally (Zuoquan or neighboring counties); (b) support a range of native plant species that will provide the required structural and species diversity for the project.
(vii) Prepare a monitoring program for the project operational phase, to enable the ZCG to monitor the survival and condition of all revegetation components. The program will include methods, sites, roles, and costs.
(viii) Support the ZCG to prepare construction tenders which address the design requirements for construction and O&M.
(ix) Provide training on revegetation to relevant ZCG agencies.
(x) Review the possibility to include civil society organizations in the revegetation program, including local universities and/or schools.

During project implementation

(xi) Support the ZCG to initiate the monitoring program, and participate in the initial sessions.

(xii) Review the effectiveness of the revegetation activities.

(xiii) Deliverables: (a) progress reports addressing the outputs above, prepared and provided to the Government after each mission to the project area, including confirmation whether the revised designs have been included in the domestic design institute final designs.