Initial Environmental Examination

Project Number: 50010-002

June 2017

PRC: Shandong Spring City Green Modern Trolley Bus Demonstration Project

Prepared by the Jinan Municipal Government for the Asian Development Bank (ADB).

CURRENCY EQUIVALENTS

(as of 25 April 2017)

Currency unit	–	yuan (CNY)
CNY1.00	=	$0.1454
$1.00	=	CNY6.875

ABBREVIATIONS

ADB	–	Asian Development Bank
APU	–	auxiliary power unit
AQG	–	air quality guideline
BOD_5	–	5-Day biochemical oxygen demand
BRT	–	bus rapid transit
C&D	–	construction and demolition
CNY	–	Chinese yuan
CO	–	carbon monoxide
COD	–	chemical oxygen demand
CPS	–	country partnership strategy
EA	–	executing agency
EHS	–	environment, health, and safety
EIA	–	environmental impact assessment
EIR	–	environmental impact report
EIRF	–	environmental impact registration form
EIT	–	environmental impact table
EMoP	–	environmental monitoring plan
EMP	–	environmental management plan
EMS	–	environmental monitoring station
EPB	–	Environmental Protection Bureau
EPD	–	Environmental Protection Department
FSR	–	feasibility study report
FYP	–	Five-Year Plan
GDP	–	gross domestic product
GHG	–	greenhouse gas
GRM	–	grievance redress mechanism
HC	–	hydrocarbon
IA	–	implementing agency
IEE	–	initial environmental examination
I_{Mn}	–	permanganate index
IPCC	–	International Panel on Climate Change
JEMS	–	Jinan Environmental Monitoring Station
JEPB	–	Jinan Environmental Protection Bureau
JMG	–	Jinan Municipal Government
MEP	–	Ministry of Environmental Protection
NH_3-N	–	ammonia nitrogen
NO_2	–	nitrogen dioxide
O&G	–	oil and grease
O&M	–	operation and maintenance
OCL	–	overhead contact line

PAH	–	poly-aromatic hydrocarbon
PAM	–	project administration manual
PM	–	particulate matter
PM_{10}	–	particulate matter with diameter ≤ 10 micrometers
$PM_{2.5}$	–	particulate matter with diameter ≤ 2.5 micrometers
PME	–	powered mechanical equipment
PMO	–	Project Management Office
PMO ESO	–	Project Management Office Environment and Safety Officer
PRC	–	People's Republic of China
RP	–	resettlement plan
RSP	–	respirable suspended particulates
SO_2	–	sulfur dioxide
SPG	–	Shandong Provincial Government
SPS	–	Safeguard Policy Statement
SS	–	suspended solids
STI	–	sustainable transport initiative
TDM	–	travel demand management
TN	–	total nitrogen
TP	–	total phosphorus
TSP	–	total suspended particulates
VOC	–	volatile organic compound
WHO	–	World Health Organization

WEIGHTS AND MEASURES

a	–	annum
^oC	–	degree centigrade
μ	–	micron
cm	–	centimeter
h	–	hour
ha	–	hectare
kg/d	–	kilogram per day
km	–	kilometer
km/h	–	kilometer per hour
km^2	–	square kilometer
m	–	meter
m^2	–	square meter
m^3	–	cubic meter
m/s	–	meter per second
m^3/d	–	cubic meter per day
m^3/s	–	cubic meter per second
mg/l	–	milligram per liter
mg/m^3	–	milligram per cubic meter
mm	–	millimeter
s	–	second
t	–	metric ton
toe	–	ton oil equivalent
y	–	year

NOTE

In this report, “$” refers to US dollars.

CONTENTS

EXECUTIVE SUMMARY

A. Introduction

1. This is the initial environmental examination (IEE) report for the proposed Shandong Spring City Green Modern Trolley Bus Demonstration Project in Jinan City, the capital of Shandong Province in the People's Republic of China (PRC). The project will establish a modern zero-emission electric powered trolley bus rapid transit (BRT) network in Jinan City.

2. ADB's environmental safeguard requirements are specified in the Safeguard Policy Statement (SPS, 2009). The project has been screened and classified by the Asian Development Bank (ADB) as environment category B, requiring the preparation of an IEE (this report) including an environmental management plan (EMP). The EMP is presented in **Appendix A**.

3. This report has been prepared based on an approved domestic feasibility study report (FSR), an approved domestic environmental impact table (EIT) report, additional analyses undertaken by the domestic EIT consultant under the direction of ADB project preparatory technical assistance (PPTA) team, site visits and analyses conducted by the PPTA team, ADB review mission discussions and agreements with relevant government agencies, and consultations with affected persons and stakeholders.

B. Project Description

4. The proposed project will establish a 111.2 kilometers (km) of prioritized high quality BRT lanes served by electric trolley buses over 39 routes. Along the network corridors, there will be (i) 158 high quality median trolley bus stations, including 93 new bus stations and upgrading of 65 existing bus stations; (ii) 16 trolley bus depots, including 8 new depots and upgrading of 8 existing depots; (iii) 40 power traction substations along or nearby the network corridors; (iv) 111 km of overhead power wires; and (v) a total of 735 modern trolley buses, including 292 18-meter (m) long buses and 443 12-m buses.

5. The project will be implemented through three outputs:

(i) **Output 1:** Zero-emission BRT network constructed;
(ii) **Output 2:** Modern trolley bus and service standards implemented; and
(iii) **Output 3:** Travel demand management (TDM) measures for Jinan prepared.

6. The project is estimated to cost $377.1 million, of which ADB has been requested to finance $150 million from its ordinary capital resources. The Jinan Municipal Government (JMG) will finance the remaining $227.1 million equivalent. The project is included in ADB's PRC project pipeline and programmed for ADB Board approval in 2017. The implementation period will be 5 years from 2018 to 2022.

C. Project Benefits

7. The project will benefit the 3.086 million residents of Licheng, Lixia, Tianqiao, Shizhong, and Huaiyin districts, including both public transport users and residents in general.

(i) Once operational, ridership on the trolley BRT network is expected to reach 804,000 passengers every day. Users will benefit from an improved and more efficient service, with on-time performance expected to exceed 90%.
(ii) Travelling on dedicated bus lanes will reduce stop-and-go in congested traffic, allowing the buses and other vehicles to travel at faster and more constant speeds, improving traffic flow, reducing traffic jams, and providing better road safety and faster travel times for passengers. This will also result in reduced carbon emissions per vehicle per mile travelled (see below).
(iii) The provision of a BRT-trolley corridor will reduce traffic noise compared with the "no project" scenario, due to (a) the low noise nature of electric trolley buses; and (b) trolley buses will be travelling more smoothly on dedicated lanes in the center of the carriageway, instead of the present in-and-out, stop-and-go conditions.
(iv) Universal access for vulnerable users including elderly, disabled, women, and children will be provided for at least 93 new BRT stations.
(v) An efficient public transport system will reduce the costs of transport in serving the major districts, industrial sites and transport hubs, and will provide better accessibility to employment and services in the city. It will enhance economic growth compared with the existing public transport system.
(vi) By 2043, total urban transportation-related pollutant emissions in Jinan City by 53,554 tons of carbon monoxide (CO), 5,830 tons of nitrogen oxides (NO_x), 3,157 tons of hydrocarbons (HC), and 169 tons of particulate matter (PM) and 5.2 million tons of carbon dioxide (CO_2). The project will result in significant and long-term reductions in transport sector emissions and greenhouse gases (GHGs), and associated benefits in terms of human health and well-being.

D. Project Impacts and Mitigation Measures

8. The project is located in degraded airshed. The use of trolley buses, which have zero tail gas emissions, will significantly contribute to the improvement of local air quality. The project zone of influence is defined as:

(i) 200 m to either side of the centerline of the 111.2 km of zero-emission high quality BRT trolley bus corridors (this includes all trolley bus stations);
(ii) 100 m upstream to 1,000 m downstream of the trolley bus corridors bridge crossings on the Xiaoqing River;
(iii) the 8 existing and 8 new trolley bus depot sites (one of which includes a Command and Control Center site); and
(iv) the 40 traction substation sites (if not already within the trolley bus corridor zone of influence).

9. **Siting and land acquisition.** The trolley bus corridors, stations, and power lines will be within the right-of-way of existing roads and will not require any land acquisition. The only project activities requiring land acquisition will be construction of traction substations and trolley bus depots. The traction substations will be on vacant state-owned land and road side landscaping. A total of 0.32 hectares (ha) will be permanently acquired, but no persons will be affected and no resettlement is required. Most depots will also be on state-owned land, and only one will require permanent acquisition of 1.64 ha of collectively owned land. The project has been classified as resettlement category B and a resettlement plan (RP) with time-bound actions has been prepared with CNY6.37 million in compensation.

10. **Construction phase.** Potential negative construction phase environmental impacts are short-term and localized and are associated with fugitive dust, construction noise, disruption of traffic, and risks to worker health and safety. These can be effectively mitigated through good construction and health and safety practices, including construction soil and spoil management; dust controls including site watering and the use of ready-mix concrete; noise controls including limiting times when noisy activities can occur, selecting low noise equipment and scheduling materials delivery to avoid densely populated or sensitive areas; water quality protection measures including limiting excavation depths to avoid contaminating groundwater, managing site runoff and provision of worker sanitary facilities; and good solid and hazardous waste management practices. Construction will not affect any parks, protected areas or rare or threatened species, and re-greening will be provided at depots and other sites. Occupational health and safety plans will be implemented to protect workers, and a traffic management plan will be implemented to minimize traffic disruptions.

11. **Operation phase.** Potential operation phase impacts include traffic accidents and threats to public safety. Operation of the project will not have any potential negative impacts on ecology or biodiversity and will result in reduced noise levels, improved traffic flows, and reduced transport related emissions of air pollutants and GHGs. Traffic safety will be enhanced through the provision of lanes for pedestrians and nonmotorized vehicles, infrastructure inspections, training of trolley bus drivers, and strict enforcement of traffic laws and regulations.

E. Environmental Management Plan

12. A comprehensive environmental management plan (EMP) was developed to ensure (i) implementation of identified mitigation and management measures to avoid, reduce, mitigate, and compensate for anticipated adverse environment impacts; (ii) implementation of monitoring and reporting; and (iii) project compliance with the PRC's relevant environmental laws, standards, and regulations and ADB's SPS. Organizational responsibilities and budgets are clearly identified for execution, monitoring, and reporting.

13. The EMP includes a project-level grievance redress mechanism (GRM) established to receive and facilitate resolution of complaints about the project during the construction and operation phases. The GRM includes procedures for receiving grievances, documenting key information, and evaluating and responding to the complainants in a reasonable time.

F. Information Disclosure, Consultation, and Participation

14. Project information was disclosed on the Jinan Public Transportation Company (JPTC) website in January 2017. In April 2017, the domestic EIT was disclosed on the Jinan Environmental Protection Bureau website, and the public were given the opportunity to comment though no comments were received.

15. A public consultation forum attended by over 60 participants was held in March 2017. The forum discussed the scope of the project, EIT and IEE preparation, potential environmental impacts and mitigation measures during construction and operation, and next steps. In addition, a survey questionnaire was administered to residents or community committees along the proposed trolley rapid transit corridors and bus depot sites. Of those surveyed, 98% endorsed the project while the remaining 2% indicated that the project was acceptable. There were no participants who objected to the project. Almost all participants (98%) expected the proposed construction and operation phase mitigation measures to be effective.

16. Meaningful consultation will continue throughout detailed design, construction, and operation phases, including information disclosure by the project proponent and posting of project information on community notice boards and discussion forums.

G. Key EMP Implementation Responsibilities

17. The JMG will be the project executing agency responsible for overall guidance during project preparation and implementation. JPTC, a state-owned company under the JMG will be the implementing agency, responsible for implementing project components and administering and monitoring contractors and suppliers. A project management office (PMO) will be responsible for day-to-day management of the project.

H. Risks and Key Assurances

18. The project implementing agency have limited previous experience in ADB safeguard procedures. To support effective implementation of the project EMP, (i) a full-time Environment and Social Officer will be appointed in the PMO; (ii) a part-time loan implementation environmental consultant (LIEC) will be recruited to support the PMO; (iii) pre-construction readiness monitoring and defined roles and responsibilities of all relevant agencies have been included in the EMP; and (iv) staff will receive training on EMP implementation. Project-specific environmental assurances (Section IX) have been agreed and are included in the project agreement between the Government of the PRC and ADB.

I. Overall Conclusion

19. The project IEE has (i) identified potential negative environmental impacts and established mitigation measures; (ii) assessed public support from the project beneficiaries and affected people; (iii) established a project GRM; and (iv) prepared a project EMP, including environmental management and supervision structure, environmental mitigation and monitoring plans, and capacity building and training.

20. It is concluded that the project will not result in adverse environmental impacts that are irreversible, diverse, or unprecedented. Any minimal adverse environmental impacts associated with the project will be prevented, reduced, or minimized through the implementation of the project EMP.

I. INTRODUCTION

1. This is the initial environmental examination (IEE) report for the proposed Shandong Spring City Green Modern Trolley Bus Demonstration Project in Jinan City, the capital of Shandong Province in the People's Republic of China (PRC) (**Figure I-1**).

2. The proposed project will establish a 111.2 kilometers (km) of prioritized high quality bus rapid transit (BRT) lanes served by electric trolley buses over 39 routes. Along the network corridors, there will be (i) 158 high quality median trolley bus stations, including 93 new bus stations and upgrading of 65 existing bus stations; (ii) 16 trolley bus depots, including 8 new depots and upgrading of 8 existing depots; (iii) 40 power traction substations along or nearby the network corridors; (iv) 111 km of overhead power wires; and (v) a total of 735 modern trolley buses, including 292 18 meter (m) long buses and 443 12 m buses (**Figure I-2**).

3. The project will be implemented through three outputs:

(i) **Output 1:** Zero-emission bus rapid transit (BRT) network constructed;
(ii) **Output 2:** Modern trolley bus and service standards implemented; and
(iii) **Output 3**: Travel demand management (TDM) measures for Jinan prepared.

4. The project will benefit 3.086 million residents of Jinan's urban districts, including both public transport users and non-users. Users will benefit from the improved transit service provided by the zero-emission trolley BRT corridors, bus stations, and depots. Residents who are non-users will also benefit from reduced traffic congestion, improved road safety, and reduced air pollution.

5. The project is estimated to cost $377.1 million, of which ADB has been requested to finance $150 million from its ordinary capital resources. The Jinan Municipal Government (JMG) will finance the remaining $277.1 million equivalent. The project is included in ADB's PRC project pipeline and programmed for ADB Board approval in 2017. The implementation period will be 5 years from 2018 to 2022.

6. The JMG will be the project executing agency (EA) responsible for overall guidance during project preparation and implementation. The Jinan Public Transportation Company (JPTC), a state-owned company under the JMG, will be the implementing agency (IA), responsible for day-to-day management during project preparation and implementation.

7. ADB's environmental safeguard requirements are specified in the Safeguard Policy Statement (SPS, 2009). The project has been screened and classified by ADB as environment category B, requiring the preparation of an IEE (this report) including an environmental management plan (EMP). The EMP is presented in **Appendix A**.

8. This report has been prepared based on an approved domestic feasibility study report (FSR),[1] a technical due diligence review of the FSR undertaken by ADB project preparatory technical assistance (PPTA) technical specialists;[2] an approved domestic environmental impact

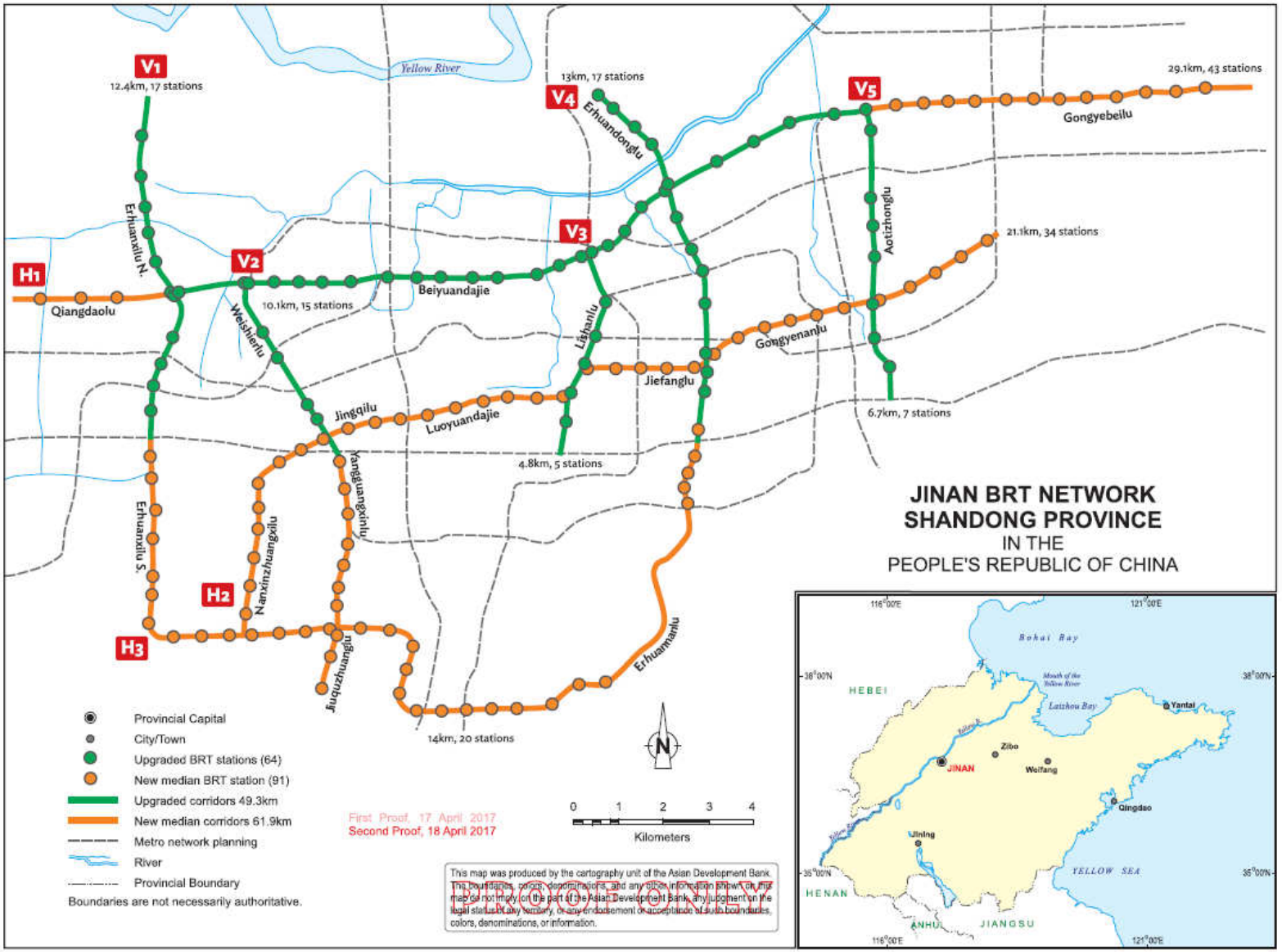
[1] ADB Shandong Spring City Green Modern Trolley Bus Demonstration Project Feasibility Report. Prepared by Shandong Engineering Consultancy Institute, March 2017.
[2] TA 9208-PRC: Shandong Spring City Green Modern Trolley Bus Demonstration Project.

table (EIT) report;[3] additional analyses undertaken by the domestic EIT consultant under the direction of the PPTA team; site visits and analyses conducted by the PPTA team; ADB review mission discussions and agreements with relevant government agencies; and consultations with affected persons and stakeholders.

[3] Construction Project Environmental Impact Statement, Shandong Green Modern Trolley Bus Demonstration Project. Construction unit: Jinan City Public Transport Corporation. Prepared by the Zhonghuanbohong Environmental Source Company, Jinan Division. April 2017.

Figure I-1: Jinan City, Shandong Province

Figure I-2: Jinan City Trolley Bus Rapid Transit Network



II. POLICY, LEGAL, AND ADMINISTRATIVE FRAMEWORK

A. Applicable ADB Policies, Regulations, and Requirements

9. The major applicable ADB policies, regulations, requirements, and procedures for environmental management and environmental impact assessment (EIA) are the *Safeguard Policy Statement* (SPS, 2009) and the *Environmental Safeguards – A Good Practice Sourcebook* (2012), which jointly provide the basis for this IEE. The SPS promotes good international practice as reflected in internationally recognized standards such as the World Bank Group's *EHS Guidelines*. The policy is underpinned by the ADB Operations Manual for the SPS (Operations Manual [OM] Section F1, 2010).

10. The SPS establishes an environmental review process to ensure that projects undertaken as part of programs funded through ADB loans are environmentally sound, designed to operate in line with applicable regulatory requirements, and not likely to cause significant environment, health, social, or safety hazards.

11. At an early stage in the project cycle, typically the project identification stage, ADB screens and categorizes proposed projects based on the significance of potential project impacts and risks. A project's environment category is determined by the category of its most environmentally sensitive component, including direct, indirect, induced, and cumulative impacts. Project screening and categorization are undertaken to:

(i) reflect the significance of the project's potential environmental impacts;
(ii) identify the type and level of environmental assessment and institutional resources required for the safeguard measures proportionate to the nature, scale, magnitude, and sensitivity of the proposed project's potential impacts; and
(iii) determine consultation and disclosure requirements.

12. ADB assigns a proposed project to one of the following categories:

(i) **Category A.** Proposed project is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented; impacts may affect an area larger than the sites or facilities subject to physical works. A full-scale EIA including an EMP is required.
(ii) **Category B.** Proposed project's potential environmental impacts are less adverse and fewer in number than those of category A projects; impacts are site-specific, few if any of them are irreversible, and impacts can be readily addressed through mitigation measures. An IEE, including an EMP, is required.
(iii) **Category C**. Proposed project is likely to have minimal or no adverse environmental impacts. No EIA or IEE is required although environmental implications need to be reviewed.
(iv) **Category FI.** Proposed project involves the investment of ADB funds to, or through, a financial intermediary.

13. The project has been classified by ADB as environment category B, requiring the preparation of an IEE (this report).

14. The SPS 2009 requires a number of additional considerations, including (i) project risk and respective mitigation measures and project assurances; (ii) project-level grievance redress

mechanism (GRM); (iii) definition of the project area of influence; (iv) physical cultural resources damage prevention analysis; (v) climate change mitigation and adaptation; (vi) occupational and community health and safety requirements (including emergency preparedness and response); (vii) economic displacement that is not part of land acquisition; (viii) biodiversity conservation and natural resources management requirements; (ix) provision of sufficient justification if local standards are used; (x) assurance of adequate consultation and participation; and (xi) assurance that the EMP includes an implementation schedule and measurable performance indicators. These requirements, which may not be covered in the domestic EIA have been considered and all applicable environmental requirements in the SPS 2009 are covered in this IEE.

15. During the design, construction, and operation of a project, the SPS also requires the borrower to follow environmental standards consistent with good international practice, as reflected in internationally recognized standards such as the World Bank Group's *Environment, Health, and Safety Guidelines* (hereafter referred to as the *EHS Guidelines*).[4] The *EHS Guidelines* contain discharge effluent, air emissions, and other numerical guidelines and performance indicators as well as prevention and control approaches that are normally acceptable to ADB and are generally considered to be achievable at reasonable costs by existing technology. When host country regulations differ from these levels and measures, the borrower/client is to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, the borrower/client is required to provide justification for any proposed alternatives.

B. Project Policy Framework

16. **ADB assistance to the PRC.** The project is aligned with the key thrusts of ADB's assistance to the PRC under the PRC country partnership strategy (CPS)[5] in the areas of (i) managing climate change and the environment, such as transportation modes with lower emissions and energy consumption, sustainable urban public transport systems; and (ii) supporting inclusive economic growth (reducing poverty and inequality) to promote integrated, green, inclusive, and competitive urban development, focusing on small- and medium-sized cities in the less-developed regions that could be used as a model for other cities in Asia and support city cluster development, including urban infrastructure development and institutional coordination (including functions and policies).[6] The focus on public transport and multimodal integration also fits well with ADB's Sustainable Transport Initiative (STI).[7]

17. **Jinan City policies and plans.** Jinan has been nominated as one of the pilot cities for several different urban transport initiatives in the PRC. The Jinan Municipal Government (JMG) has developed a comprehensive urban public transport development plan for urban rail network development, a trolley bus network development plan, and a public transport infrastructure plan

[4] *World Bank Group, Environmental, Health, and Safety Guidelines*, April 30, 2007, Washington, USA. http://www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

[5] ADB. 2016. *Transforming Partnership: People's Republic of China and Asian Development Bank, 2016–2020*. Manila.

[6] Transit-oriented development refers to mixed-use residential and commercial areas designed to maximize access to public transport and facilitate pedestrian movement. A transit-oriented development is typically centered on a transit station (train station/metro station/bus terminal), surrounded by relatively high-density development with progressively lower-density development further from the high capacity public transport facility.

[7] The STI, approved by ADB management on 20 July 2010, has set a new direction for ADB's transport sector efforts to promote more environmentally and socially sustainable transport solutions in developing member countries in line with ADB's *Strategy 2020*.

including stations, depots, and low emission buses. Specifically, the project is consistent with and supportive of the following plans:

(i) **13th Five-Year Plan for Jinan City Economic and Social Development.**[8] One of the targets in Jinan's 13th Five-Year Plan (FYP) is to promote advanced infrastructure network and reduce urban traffic congestion, and the construction of a BRT trolley bus corridor project was listed as one of the projects to be completed within the 13th FYP period.

(ii) **Jinan City Urban Master Plan (2011–2020).**[9] The *Jinan City Urban Master* Plan (2011–2020) structures the spatial layout of the urban core as "One City, Two Regions" covering an area of 1,022 square kilometers (km^2). The permanent population in the central urban area of Jinan City will be capped at 4.3 million, and by 2020 the urban development will be focused on a central core with an area of 410 km^2. Under the plan, Jinan City will promote improved urban infrastructure that is green, recyclable, and low-carbon; will further improve roads, railways, airports and other transport infrastructure to ease regional transit and strengthen the city's internal and external traffic convergence; and will further develop public transit.

(iii) **Guidelines Establishing Low Carbon Transport System and Piloting Program on Establishing Low Carbon Transport System.** The guidelines, issued by the Ministry of Transport (MOT) in May 2011, encourage the application of alternative energy technologies in operating vehicles and promote the use of hybrid, natural gas power, biomass, electric, and other energy-saving and environment-friendly buses. Jinan was listed as a bus transit city pilot in October 2012 and national low-carbon pilot city in February 2017. The project will support these objectives by establishing a low-carbon public transport demonstration project in Jinan.

(iv) **Jinan City Integrated Transport Plan.** The *Jinan City Integrated Transport Plan,* which has been incorporated into the *Jinan City Urban Master Plan (2011–2020),* promotes dedicated BRT trolley bus corridors in Jinan's urban area positioned along and adjacent to the urban area, connecting the urban districts and by passing the city center. These corridors are meant to connect urban roads with major regional roads and divert intercity traffic away from the urban center, thus alleviating traffic congestion in the urban center as well as providing infrastructure for urban expansion in line with the vision of the *Urban Master Plan*. The proposed project is in accordance with Jinan's urban master plan, low carbon development initiatives, and integrated transport plan.

18. With the above visions and plans established, JMG requested ADB to support upgrading and integrating its urban public transport infrastructure by developing a trolley bus network and sustainable urban mobility strategies built around urban public transport.

C. PRC Environmental Legal Framework

19. The environmental protection and management system in the PRC consists of a well-defined hierarchy of regulatory, administrative, and technical institutions. At the top level, the People's Congress of the PRC has the authority to pass and revise national environmental laws; the Ministry of Environmental Protection (MEP) under the State Council promulgates national

[8] JMG. 2016. *Outline of the 13th Five-Year Plan for Jinan Citizens' Economic and Social Development*. Jinan.
[9] Prepared by JMG, approved by State Council in July 2016.

environmental regulations; and the MEP either separately or jointly with the Administration of Quality Supervision, Inspection and Quarantine issues national environmental standards and guidelines. Provincial and local governments can also issue provincial and local environmental regulations and guidelines in accordance with the national ones. In addition, national and local five-year environmental protection plans form an important part of the legal framework.

20. Key PRC environmental laws are listed in **Table II-1**, including associated regulations and decrees that support their implementation. Guidelines for EIA implementation are listed in **Table II-2**.

21. The most far-reaching law on pollution prevention and control is the *Environmental Protection Law* (EPL) (1989, amended 2014, effective 2015 and item 2 in **Table II-1**), which sets out key principles for the country's pollution control system, including the policy known as the "Three Simultaneities,[10]" the application of pollution levies, and requirements for EIA. The implementation of the "Three Simultaneities" was further strengthened by decrees on its implementation (items 26 and 28) and the *Construction Project Environmental Protection Management Regulation* (item 17).

22. The amended EPL further defines enforcement and supervision responsibilities for all levels of environmental protection authorities, imposes stricter obligations and more severe penalties on enterprises and construction units regarding pollution prevention and control, and allows for environmental public interest litigation including through nongovernment organizations. The procedures and requirements for the technical review of EIA reports by authorities have been specified (**Table II-2**, item 4), and environmental inspection and enforcement on design, installation, and operation of project-specific environmental protection and control measures are regulated under the "Three Simultaneities" (**Table II-1** items 5, 15, 25, 26, and 28).

23. Public participation and environmental information disclosure provisions are among the most significant changes introduced in the amended EPL, further supported by the decrees on the preparation of EIA summaries for public disclosure (item 24), information disclosure on construction project EIAs by government (item 22), method for public participation in environmental protection (item 20), and technical guidelines for public participation in EIAs.

24. For grievance redress, a hotline number (12369) was established in March 2011 at each level of environmental protection authority throughout the country for receiving and resolving environmental complaints, in accordance with the *Management Measures for Operation of the Environmental Complaint Hotline* (MEP Decree 2010 No. 15 [item 27]).

25. The PRC also provides protection for community health and occupational health and safety through the *Labor Law* (1994) (item 12), the *Occupational Disease Prevention and Control Law* (2001) (item 4), and environmental and hygiene standards for construction sites.

[10] The "Three Simultaneities Policy" requires the design, construction, and operation of pollution control and treatment facilities to occur simultaneously with the project design, construction, and operation.

Table II-1: Applicable PRC Environmental Laws, Regulations, and Decrees

No.	Laws	Year Issued/ Updated
1	*Environmental Impact Assessment Law*	2016
2	*Environmental Protection Law*	2015
3	*Atmospheric Pollution Prevention and Control Law*	2015
4	*Occupational Disease Prevention and Control Law*	2011
5	*Water and Soil Conservation Law*	2011
6	*Water Pollution Prevention and Control Law*	2010
7	*Urban and Rural Planning Law*	2008
8	*Solid Waste Pollution Prevention and Control Law*	2005
9	*Water Law*	2002
10	*Cultural Relics Protection Law*	2002
11	*Noise Pollution Prevention and Control Law*	1999
12	*Labor Law*	1995
	Regulations	
13	Atmospheric Pollution Prevention and Control Action Plan (State Council Announcement No. 37)	2013
14	Policy on Integrated Techniques for Air Pollution Prevention and Control of Small Particulates (MEP Announcement No. 59)	2013
15	Planning Environmental Impact Assessment Regulation	2009
16	Cultural Relics Protection Law Implementation Regulation	2003
17	Construction Project Environmental Protection Management Regulation	1998
18	Wild Plant Protection Regulation	1996
	Decrees and Announcements	
19	Directory for the Management of Construction Project EIA Categorization (MEP Decree 2015-33)	2015
20	Measures for Public Participation in Environmental Protection (MEP Decree 2015-35)	2015
21	Management Measures for Environmental Impact Post Assessment of Construction Projects (on trial) (MEP Decree 2015-37)	2015
22	Government Information Disclosure of Construction Project EIA (on trial) (MEP Announcement No. 103)	2013
23	Measures for Environmental Supervision (MEP Decree 2012-21)	2012
24	Requirement for Preparation of EIA Report Summary (MEP Announcement 2012-51)	2012
25	Strengthening of EIA Management for Prevention of Environmental Risk (MEP Announcement 2012-77)	2012
26	Opinion from the State Council on Important Tasks for Strengthening Environmental Protection (State Council Announcement 2011-35)	2011
27	Management Measures for Operation of the Environmental Complaint Hotline (MEP Decree 2010-15)	2010
28	Management Procedures for the Supervision, Inspection and Environmental Acceptance of Construction Projects under the “Three Simultaneities” (on trial) (MEP Announcement 2009-150)	2009
29	Specifications on the Management of Urban Construction and Demolition Waste (Ministry of Construction Decree 2005-139)	2005
30	Management Measures for Inspection and Acceptance of Environmental Protection at Construction Project Completion (MEP Decree 2001-13)	2001

Source: ADB PPTA consultants.

D. PRC Environmental Impact Assessment Framework and Procedures

26. **EIA administrative framework.** The administrative framework for EIA in the PRC consists of national, provincial, and local (city and county) environmental protection authorities. The national authority is the MEP, which promulgates laws, regulations, administrative decrees,

technical guidelines, and environmental quality and emission standards on EIA and pollution prevention and control. At the provincial level, there are environmental protection departments (EPDs), which act as gatekeepers for EIA and pollution prevention and control in the provinces. They are often delegated authority by the MEP to approve EIA reports for development planning and construction projects, except for those projects with national interest and those that cross provincial boundaries. The local (city or county level) environmental protection bureaus (EPB) enforce environmental laws and conduct environmental monitoring within city or county limits. Local EPBs can also be delegated the authority to approve EIA reports by the provincial EPDs. EPDs and EPBs are supported by environmental monitoring stations (EMS), which are subsidiaries of EPDs or EPBs and are qualified entities to carry out environmental monitoring.[11]

27. The PRC has a qualification and registration system for EIA and only qualified and registered institutes and individuals are allowed to prepare EIAs. Under MEP Decree 2015-36, as of 1 November 2015 qualified institutes for conducting EIAs for construction projects in the PRC can no longer be a subsidiary of an environmental authority responsible for approving EIAs.

28. **EIA legal framework.** EIA is governed by the *Environmental Impact Assessment Law* (2002) (**Table II-1** item #1), covering EIAs for (i) plans (such as new development areas and new industrial parks) and strategic environmental assessments (SEA), and (ii) construction projects. This was followed by the promulgation of two regulations: the *Construction Project Environmental Protection Management Ordinance* (1998) (item 17) and the *Planning Environmental Impact Assessment Regulation* (2009) (item 15), both of which require early screening and environmental categorization.

29. **EIA procedures.** Under MEP decree, *Directory for the Management of Construction Project Environmental Impact Assessment Categorization* (MEP Decree 2015-33) (item 19) classifies EIAs for construction projects into three categories with different reporting requirements based on the "significance" of potential environmental impact due to the project and the environmental sensitivity[12] of the project site as described in the directory:

(i) Projects with significant adverse environmental impacts, for which a full environmental impact report (EIR) is required;
(ii) Projects with adverse environmental impacts which are of a lesser degree and/or significance than those of category A, for which a simplified tabular EIT is required; and
(iii) Projects unlikely to have adverse environmental impacts, for which an environmental impact registration form (EIRF) is required.

30. A full EIR and a simplified EIT report are similar to ADB's category A EIA and category B IEE reports, respectively. The EIRF is similar to an ADB category C project (Section II.F).

[11] In this report, "environmental monitoring" refers to the activity of collecting environmental data either through *in-situ* measurements or through sampling followed by laboratory testing of samples.

[12] Environmentally-sensitive areas are defined in the Decree, and include (i) nature reserves and protected areas, scenic areas, world cultural and natural heritage sites, drinking water source protection zones; (ii) basic farmland and grassland, forest parks, geological parks, important wetland, natural woodland, critical habitats for endangered plant and animal species, important aquatic spawning/nursery/wintering/migration grounds, regions suffering from water resource shortage, serious soil erosion areas, desertification protection areas, eutrophic water bodies; and (iii) inhabited areas with major residential, health care, scientific research, and administration functions, cultural heritage protection sites, and protection areas with historical, cultural, scientific, and ethnic values.

31. **EIA follow-up actions.** In 2015, the MEP issued decree *Management Measures for Environmental Impact Post Assessment of Construction Projects* (MEP Decree 2015-37, item 21). Under this decree, a trial program was implemented on 1 January 2016 requiring follow-up actions 3 to 5 years after commencement of project operation for large infrastructure and industrial projects or projects located in environmentally-sensitive areas. These actions include environmental monitoring and impact assessment to verify the effectiveness of environmental protection measures and to undertake any corrective actions that might be needed. The decree also specifies that the institute that did the original impact assessment for the project cannot undertake environmental impact post-assessment for the same project.

32. **EIA guidelines.** The MEP has issued a series of technical guidelines for preparing EIAs (**Table II-2**). These include impact assessment guidelines on general EIA implementation and principles, atmospheric environment and ambient air quality, noise, surface water, groundwater, ecology and regional biodiversity, biodiversity monitoring, quality management on environmental monitoring, and public participation.

Table II-2: PRC EIA Guidelines

	Guidelines	Date
1	HJ 192-2015 Technical Criterion for Ecosystem Status Evaluation	2015
2	HJ 130-2014 Technical Guidelines for Planning EIA - General Principles	2014
3	HJ 663-2013 Technical Regulation for Ambient Air Quality Assessment (on trial)	2013
4	HJ 2.1-2011 Technical Guidelines for EIA – General Program	2011
5	HJ 19-2011 Technical Guidelines for EIA – Ecological Impact	2011
6	HJ 616-2011 Guidelines for Technical Review of EIA on Construction Projects	2011
7	HJ 623-2011 Standard for the Assessment of Regional Biodiversity	2011
8	HJ 630-2011 Technical Guideline on Environmental Monitoring Quality Management	2011
9	Technical Guidelines for EIA - Public Participation (public comment version), (Jan. 2011)	2011
10	HJ 610-2011 Technical Guidelines for EIA – Groundwater Environment	2011
11	HJ 2.4-2009 Technical Guidelines for EIA – Acoustic Environment	2009
12	HJ 2.2-2008 Technical Guidelines for EIA – Atmospheric Environment	2008
13	HJ/T 393-2007 Technical Specifications for Urban Fugitive Dust Pollution	2007
14	JG/J 146-2004 Environmental and Hygiene Standards for Construction Sites	2004
15	HJ/T 2.3-1993 Technical Guidelines for EIA – Surface Water Environment	1993

Source: ADB PPTA consultants.

E. Project Domestic Environmental Assessment

33. Under MEP Decree *Management Measures for Environmental Impact Post Assessment of Construction Projects* (MEP Decree 2015-37), the project was classified as requiring the preparation of an EIT report. The report was prepared by the Zhonghuanbohong Environmental Source Company, Jinan Division. The company has 30 staff and is certified by the MEP to undertake category A, B, and C assessments, including transportation projects for 2010 to 2019.

34. The domestic EIT report was reviewed by JEPB. A draft report was submitted in early March 2017, and a revised report was submitted in 7 April 2017. The EIT report was formally approved by JEPB on 3 May 2017.

F. Environmental Standards

35. **PRC environmental standards.** Standards issued by the MEP generally consist of environmental quality (ambient) standards applicable to the receiving environment and emission

standards applicable to the pollution source. The former includes standards for ambient air quality, noise and vibration, surface water, groundwater, soil, etc. The latter includes standards for integrated wastewater discharge, construction and community noise, odor and air pollutants, etc. (**Table II-3**).

Table II-3: Applicable PRC Environmental Standards

No.	Standards
1	GB3095-2012 Ambient Air Quality Standards
2	GB16297-1996 Air Pollutant Integrated Emission Standards
3	GB3096-2008 Environmental Quality Standard for Noise
4	GB3838-2002 Environmental Quality Standards for Surface Water
5	GB8978-1996 Integrated Wastewater Discharge Standard
6	GB22337-2008 Emission Standard for Community Noise
7	GB10070-88 Standard of Environmental Vibration in Urban Area
8	GB12523-2011 Emission Standard of Environmental Noise for Boundary of Construction Site
9	GB/T 15190-2014 Technical Specifications for Regionalizing Environmental Noise Function
10	GB12348-2008 Noise Standards for Industrial Enterprises at Site Boundary
11	GB50118-2010 Design Specifications for Noise Insulation of Buildings for Civil Use
12	GB14554-93 Emission Standards for Odor Pollutants
13	GB/T 14848-93 Quality Standard for Ground Water
14	GB15618-1995 Environmental Quality Standard for Soils
15	GB50210-94 Standard for Flood Control
16	GB11340-2005 Limits and Measurement Methods for Crankcase Pollutants from Heavy-duty Vehicles Equipped with Pressure Ignition Engines
17	GB17691-2005 Emission Limits and Measurement Methods for Exhaust Pollutants from Vehicle Compression-Ignition and Gas Fueled Ignition Engines
18	GB18285 -2005 Limits and Measurement Methods for Exhaust Pollutants from Vehicles Equipped with Ignition Engines
19	GB18352-2005 Limits and Measurement Methods for Emissions from Light Duty Vehicles

Sources: ADB PPTA Consultants and domestic EIT report (2017).

36. As noted above, ADB's SPS requires borrowers to follow environmental standards consistent with good international practice as reflected in internationally recognized standards such as the World Bank Group's *EHS Guidelines.* When host country regulations differ from these levels and measures, the borrower is to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, the borrower/client is required to provide justification for any proposed alternatives. Both PRC standards and EHS guidelines are used in this assessment as described below.

37. **Air quality.** Ambient air quality limits are intended to indicate safe exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Limits are given for one or more specific averaging periods, typically 1-hour average, 24-hour average, and/or annual average. The longer averaging period such as 1 year is more applicable to assessing impacts from multiple or regional sources, while shorter averaging periods such as 24 hours and 1 hour are more applicable to assessing short-term impacts from project-related activities such as from peak hour traffic or daily or peak construction activities. The PRC's updated *Ambient Air Quality Standards* (GB3095-2012) has two classes of limit values: class 1 standards apply to special areas such as nature reserves and environmentally-sensitive areas;

and class 2 standards apply to all other areas, including urban and industrial sites. The PRC standards for class 2 areas are applicable for the project.[13]

38. The World Health Organization (WHO) Air Quality Guidelines are international standards and are adopted in the *EHS Guidelines*. In addition to guideline values, interim targets (IT) are given for each pollutant as incremental targets in a progressive reduction of air pollution.

39. The WHO guidelines and corresponding PRC standards are presented in **Table II-4**. From a review of the table, it can be observed that:

(i) For TSP, there are PRC standards but no corresponding WHO guidelines.
(ii) For PM_{10}, PRC class 2 annual average and 24-hour average standards meet WHO IT-1 guidelines (there are no 1-hour average standards or guidelines for PRC or WHO).
(iii) For $PM_{2.5}$, PRC class 2 annual and 24-hour standards meet WHO IT-1 guidelines (there are no 1-hour standards or guidelines for either PRC or WHO).
(iv) For SO_2, WHO only has a 24-hour average guideline (0.125 mg/m^3), which is slightly lower than the PRC standard (0.150 mg/m^3). However, SO_2 levels are low in the project area, and the project will not contribute SO_2 emissions so the very minor difference is inconsequential.
(v) For NO_2, the PRC standard is equivalent to the WHO annual average guidelines, there is no WHO 24-hour average guideline; and the 1-hour average PRC standard is equivalent to the WHO guideline.

40. Overall, the PRC standards show a high degree of equivalency to the WHO guidelines or IT-1 values, and are adopted for use in this report.

41. **Fugitive particulate matter.** Fugitive emission of particulate matter such as dust from construction sites is regulated under the PRC's *Air Pollutant Integrated Emission Standard* (GB16297-1996), 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 particle diameter). There is no equivalent standard recommended in the *EHS Guidelines,* and the PRC standard is adopted for use in this IEE report.

[13] On 29 February 2012, the China State Council approved the roadmap for ambient air quality standards to improve the environment and human health. The Ambient Air Quality Standards (GB3095-2012) prescribes the first-ever limits for $PM_{2.5}$. It also modified the previous area classifications by combining class III (special industrial areas) with class II (residential, mixed use areas).

Table II-4: Comparison of PRC Ambient Air Quality Standards (GB3095-2012*)* and WHO Ambient Air Quality Guidelines

Air Quality Parameter	Averaging Period	PRC *GB3095-2012* (μg/m^3)		WHO/EHS Guidelines (μg/m^3)	
		Class I	Class II	Interim Targets	AQG
TSP	1-year	80	200	n/a	n/a
	24-hour	120	300	n/a	n/a
PM_{10}	1-year	40	70	30 - 70	20
	24-hour	50	150	75 - 150	50
$PM_{2.5}$	1-year	15	35	15 - 35	10
	24-hr	35	75	37.5 - 75	25
SO_2	1-year	20	60	n/a	n/a
	24-hour	50	150	50 - 125	20
	1-hour	150	500	n/a	n/a
NO_2	1-year	40	40	n/a	40
	24-hour	80	80	n/a	n/a
	1-hour	200	200	n/a	200
O_3	8-hour	n/a	n/a	160	100
	1-hour	n/a	n/a	n/a	n/a
CO	24-hour	4,000	4,000	n/a	n/a
	8-hour	n/a		n/a	30
	1-hour	10,000	10,000	n/a	n/a

n/a = not applicable.
Sources: WHO Air Quality Guidelines (2006) in IFC *EHS Guidelines* (2007), and PRC GB3095-2012.

42. **Noise. Table II-5** presents the relevant PRC *Environmental Quality Noise Standards* (GB3096-2008) compared with relevant international guidelines from WHO (as presented in the *EHS Guidelines*). The classes within the standards are not directly comparable as the PRC noise standards are set in different zones and WHO standards concern noise at specific receptors. Traffic noise and noise at sensitive receptors need different standards to be applied: the PRC *Environmental Quality Noise Standards* (GB3096-2008) will be used for traffic noise while the EHS Guidelines will be applied for noise at sensitive receptors.

43. **Table II-6** presents the relevant PRC and international standards (US EPA, IFC EHS Guideline: Occupational health and safety standards) for on-site construction noise. The PRC's *Emission Standard of Environmental Noise for Boundary of Construction Site* (GB12523–2011) regulates construction noise, limiting construction noise levels at the construction site boundary to 70 dB(A) in the day time (0600–2200 hours) and 55 dB(A) at night (2200–0600 hours).

Table II-5: PRC Environmental Quality Standards for Noise (GB3096-2008)

PRC Standards Leq dB(A)			International Standards One Hour Leq dB(A)		Comparison
Class	**Day** 06-22h	**Night** 22-06h	**Day** 07-22h	**Night** 22-07h	
0: Areas needing extreme quiet, such as special health zones	50	40	WHO Class I: Residential, institutional, educational: 55 WHO Class II: industrial, commercial: 70	WHO Class I: Residential, institutional, educational: 45 WHO Class II: Industrial, Commercial: 70	Classes are not directly comparable, but PRC Class II standards exceed WHO Class II standards. PRC standards are utilized in this report.
I: Mainly residential; and cultural and educational institutions	55	45			
II: Mixed residential, commercial and industrial areas	60	50			
III: Industrial areas	65	55			
IVa: Area within 35 m on both sides of urban trunk roads (Class II and above)	70	55			
IVb: Both sides of railway lines	70	60			

Sources: WHO Noise Quality Guidelines (1999) in IFC *EHS Guidelines* (2007), and PRC GB*3096-2008*.

Table II-6: PRC Noise Emission Standard for Construction Site Boundary (GB12523-2011) and Relevant International Guidelines

Day Leq dB(A)	Night Leq dB(A)	International Standards Leq dB(A)	
70	55	US EPA 85 (day, 8 hour exposure)	IFC EHS Guideline: Occupational Health and Safety: 85 (Equivalent level LAeq,8h) 110 (Maximum LAmax,fast)

Source: US EPA, IFC Occupational Health and Safety standard and PRC *GB12523-2011*.

44. **Surface water.** The PRC's *Surface Water Ambient Quality Standard* (GB3838-2002) defines five water quality classes for different environmental functions (**Table II-7**). Class I is the highest quality, suitable for head waters and national nature reserves. Class II is suitable for drinking water sources in class I protection areas, habitats for rare aquatic organisms, breeding grounds for fish and crustaceans, and feeding grounds for fish fry. Class III is suitable for drinking water sources in class II protection areas, wintering grounds for fish and crustaceans, migration routes, water bodies for aquaculture and capture fishery, and swimming activities. Class IV is suitable for general industrial use and non-contact recreational activities. Category V is the worst quality, suitable only for agricultural and scenic water uses. Class III standard is applicable to the project.

Table II-7: PRC Surface Water Ambient Quality Standard (GB3838-2002)

Parameter	Water Quality Category				
	I	II	III	IV	V
pH	6-9	6-9	6-9	6-9	6-9
Dissolved oxygen (DO) [mg/L]	90% saturation or ≥7.5	≥6	≥5	≥3	≥2
Permanganate index (I_{Mn}) [mg/L]	≤2	≤4	≤6	≤10	≤15
Chemical oxygen demand (COD) [mg/L]	≤15	≤15	≤20	≤30	≤40
5-day Biochemical oxygen demand (BOD_5) [mg/L]	≤3	≤3	≤4	≤6	≤10
Ammonia nitrogen (NH_3-N) [mg/L]	≤0.15	≤0.5	≤1.0	≤1.5	≤2.0
Total phosphorus (as P) [mg/L]	≤0.02	≤0.1	≤0.2	≤0.3	≤0.4
Lakes & reservoirs	≤0.01	≤0.025	≤0.05	≤0.1	≤0.2
Total nitrogen (lakes, reservoirs, as N) [mg/L]	≤0.2	≤0.5	≤1.0	≤1.5	≤2.0
Copper (Cu) [mg/L]	≤0.01	≤1.0	≤1.0	≤1.0	≤1.0
Zinc (Zn) [mg/L]	≤0.05	≤1.0	≤1.0	≤2.0	≤2.0
Fluoride (as F^-) [mg/L]	≤1.0	≤1.0	≤1.0	≤1.5	≤1.5
Selenium (Se) [mg/L]	≤0.01	≤0.01	≤0.01	≤0.02	≤0.02
Arsenic (As) [mg/L]	≤0.05	≤0.05	≤0.05	≤0.1	≤0.1
Mercury (Hg) [mg/L]	≤0.0005	≤0.0005	≤0.0001	≤0.001	≤0.001
Cadmium (Cd) [mg/L]	≤0.001	≤0.005	≤0.005	≤0.005	≤0.01
Chromium (Cr, hexavalent) [mg/L]	≤0.01	≤0.05	≤0.05	≤0.05	≤0.1
Lead (Pb) [mg/L]	≤0.01	≤0.01	≤0.05	≤0.05	≤0.1
Cyanide (CN) [mg/L]	≤0.005	≤0.05	≤0.2	≤0.2	≤0.2
Volatile phenol [mg/L]	≤0.002	≤0.002	≤0.005	≤0.01	≤0.1
Total petroleum hydrocarbon (TPH) [mg/L]	≤0.05	≤0.05	≤0.05	≤0.5	≤1.0
Anionic surfactant (=LAS) [mg/L]	≤0.2	≤0.2	≤0.2	≤0.3	≤0.3
Sulfide [mg/L]	≤0.05	≤0.1	≤0.2	≤0.5	≤1.0
Fecal coliform bacteria [number/L]	≤200	≤2000	≤10000	≤20000	≤40000

Sources: IFC *EHS Guidelines* (2007) and PRC *GB3838-2002.*

45. **Groundwater.** The PRC's *Groundwater Water Ambient Quality Standard* (GB/T14848-93) is presented in **Table II-8**. Class III standard is applicable to the project. There is no equivalent standard recommended in the *EHS Guidelines,* and the PRC standard is adopted for use in this report.

46. **Wastewater.** Discharge of wastewater from construction sites is regulated under the PRC's *Integrated Wastewater Discharge Standard* (GB8978–1996) (**Table II-9**). Class 1 standard applies to discharge into class III water bodies under GB3838–2002; class 2 standard applies to discharge into class IV and V water bodies; and class 3 standard applies to discharge into municipal sewers going to municipal wastewater treatment plants (WWTPs) with secondary treatment. No new discharge of wastewater into class I and II water bodies is allowed. The *EHS Guidelines* does not have ambient water quality standards, and recognizes the use of national and local ambient water quality criteria. Class III standard is applicable to the project.

Table II-8: Applicable Groundwater Standard (Class III, GB/T14848-93 Quality Standard for Groundwater)

No	Parameter	Unit	Class III Standard
1	pH	-	6.5-8.5
2	COD_{Mn}	mg/l	3.0
3	Sulfate	mg/l	250
4	Chloride	mg/l	250
5	Volatile Phenols	mg/l	0.002
6	Total hardness ($CaCO_3$)	mg/l	450
7	Nitrate NO_{3-}	mg/l	20
8	Nitrite NO_{2-}	mg/l	0.02
9	Ammonia Nitrogen NH_3-N	mg/l	0.2
10	Molybdenum	mg/l	0.1
1	Cyanide	mg/l	0.05
12	Cadmium	mg/l	0.01
13	Chromium VI	mg/l	0.05
14	Arsenic	mg/l	0.05
15	Zinc	mg/l	1.0
16	Fluoride	mg/l	1.0
17	Lead	mg/l	0.05
18	Iron	mg/l	0.3
19	Manganese	mg/l	0.1
20	Copper	mg/l	1.0
21	Selenium	mg/l	0.01
22	Total coliforms	/L	3.0

Sources: ADB PPTA Consultants and *GB/T14848-93*.

Table II-9: PRC Standards for Discharging Wastewater from Construction Sites (GB8978–1996)

Parameter		Class 1 (Discharge into Class III water bodies)	Class 2 (Discharge into Class IV and V water bodies)	Class 3 (Discharge into municipal sewers)
pH	no unit	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
Ammonia Nitrogen NH_3-N	mg/L	15	25	---
PO_4^{2-} (as P)	mg/L	0.5	1.0	---
Anionic Surfactants	mg/L	5.0	10	20

Source: PRC GB8978-1996.

47. **Soil quality.** Soil quality in the PRC is divided into three classes according to the *Environmental Quality Standard for Soils* (GB15618-1995). Class 1 represents the best and class 3 the worst (**Table II-10**). The *EHS Guidelines* do not have standards for soil quality.

Table II-10: Soil Quality Standard GB15618-1995

Parameter		Maximum Allowable Concentration (mg/kg dry weight)				
		Class 1	Class 2			Class 3
pH		Back ground	<6.5	6.5~7.5	>7.5	>6.5
Cadmium (Cd)		0.20	0.30	0.30	0.60	1.0
Mercury (Hg)		0.15	0.30	0.50	1.0	1.5
Arsenic (As)	Paddy	15	30	25	20	30
	Dry land	15	40	30	25	40
Copper (Cu)	Farm land	35	50	100	100	400
	Orchard	---	150	200	200	400
Lead (Pb)		35	250	300	350	500
Chromium (Cr)	Paddy	90	250	300	350	400
	Dry land	90	150	200	250	300
Zinc (Zn)		100	200	250	300	500
Nickel (Ni)		40	40	50	60	200
DDT		0.05		0.50		1.0
666 (Lindane)		0.05		0.50		1.0

Source: PRC GB15618-1995.

48. **Electromagnetic radiation and traction substations.** The PRC standard *Controlling Limits for Electromagnetic Environment* (GB8702-2014) was developed for the purpose of implementing the *Environmental Protection Law* with respect to enhancing the management of electromagnetic environment and safeguarding public health.[14] The standard refers to international accepted guidelines and standards including "*ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (300 GHz and less) (1998)*" and *IEEE Standard for Safety Level of Human Exposure to 0-3 kHz Electromagnetic Field,* The standard specifies the limits and assessment method for public exposure to electric, magnetic and electromagnetic fields (1 Hz-300 GHz) and the scope for exemption of relevant facilities and equipment. With the precondition of meeting the limits of the current standard, owners of facilities (equipment) generating electric, magnetic and electromagnetic fields are encouraged to comply with the precautionary principle and take effective measures to reduce public exposure. The standard was released in 1988 and revised in 2014.

49. Under the standard power transmission and transformation facilities with alternating current (AC) voltages less than 100 kilovolts (kV) are exempt from electromagnetic environment management because at such voltage levels measured electromagnetic field values do not exceed standard limits. The project will construct or rehabilitate a total of 44 10 kV traction substations. In accordance with the standard, these substations are exempt from electromagnetic impact assessment and management.

50. **Summary of environmental standards applicable to the project. Table II-11** presents the environmental standards applicable to the project based on requirements set forth by the Jinan EPB as presented in the domestic EIT report and the above review of equivalency of the PRC and international standards.

[14] The standard is an integration and revision of *Regulations for Electromagnetic Radiation Protection* (GB8702-88) and *Hygienic Standard for Environmental Electromagnetic Waves* (GB9175-88).

Table II-11: Environmental Standards Applicable to the Project

Parameter	Applicable PRC Standard	Remarks
Ambient air quality	*Ambient Air Quality Standard* (GB3095-2012), Class II	Yearly average: PM_{10}: 0.070 mg/m^3 $PM_{2.5}$: 0.035 mg/m^3 SO_2: 0.06 mg/m^3 NO_2: 0.04 mg/m^3 CO: 4.0 mg/m^3 Daily average: TSP: 0.30 mg/m^3 PM_{10}: 0.15 mg/m^3 $PM_{2.5}$: 0.075 mg/m^3 SO_2: 0.15 mg/m^3 NO_2: 0.08 mg/m^3 CO: 4.0 mg/m^3 Hourly average: SO_2: 0.50 mg/m^3 NO_2: 0.20 mg/m^3 CO: 10.0 mg/m^3
Construction air pollutant emission	*Air Pollutant Integrated Emission Standard* (GB16297-1996)	Maximum allowable emission concentration: Particulate matter (PM): 120 mg/m^3 Fumes from asphalt plant: 40 mg/m^3 during production and 75 mg/m^3 during mixing Limits for fugitive emission: PM: ≤1.0 mg/m^3 at construction site boundary Fumes from asphalt plant: no obvious emission at asphalt production plant
Environmental noise	*Environmental Quality Standard for Noise* (GB3096-2008): • Class IVa for areas within 35 m of the trolley bus corridors • Class II for areas 35 to 200 m from the trolley bus corridors	Class Iva areas: Day time: 70 dB(A) Night time: 55 dB(A) Class II areas: Day time: 60 dB(A) Night time: 50 dB(A)
Construction noise	*Emission Standard of Environmental Noise for Boundary of Construction Site* (GB12523-2011)	Noise level at construction site boundary: Day time: 70 dB(A) Night time: 55 dB(A)
Surface water quality	*Environmental Quality Standards for Surface Water* (GB3838-2002), see **Table II-7**	• Class III standard for Yellow River (drinking water source), and Mulizhuang section of Xiaoqing River • Class IV for Daming Lake • Class IV for Xiaoqing River (excluding Mulizhuang section)
Wastewater discharge	*Integrated Wastewater Discharge Standard* (GB8978-1996)	Discharge into Class III water body: COD: ≤100 mg/l BOD_5: ≤20 mg/l SS: ≤70 mg/l TPH: ≤5 mg/l NH_3-N: ≤15 mg/l Discharge into Categories IV and V water bodies COD: ≤150 mg/l BOD_5: ≤30 mg/l SS: ≤150 mg/l TPH: ≤10 mg/l NH_3-N: ≤25 mg/l

Sources: Domestic EIT report (2017) and PPTA consultant.

G. International Agreements

51. **Relevant international agreements.** The PRC is a signatory to a number of international agreements relevant to environment protection. Those relevant to the project, along with the dates of signing by the PRC, are listed in **Table II-12**.

Table II-12: Applicable International Agreements with the PRC as a Signatory

No.	Name of Agreement	PRC Signing Date	Agreement Objective
1	Convention Concerning the Protection of the World Cultural and Natural Heritage	1985.12.12	Conserving cultural and natural heritage sites.
2	Montreal Protocol on Substances That Deplete the Ozone Layer	1989.01.01	To protect the ozone layer by controlling emissions of substances that deplete it
3	United Nations Framework Convention on Climate Change	1994.03.21	To achieve stabilization of greenhouse gas concentrations in the atmosphere at a low enough level to prevent dangerous anthropogenic interference with the climate system
4	Kyoto Protocol to the United Nations Framework Convention on Climate Change	2005.02.23	To further 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

Source: ADB PPTA consultants.

III. DESCRIPTION OF THE PROJECT

A. The Project

52. The proposed project will establish a 111.2 km of prioritized high quality BRT lanes served by electric trolley buses over 39 routes. Along the network corridors, there will be (i) 158 high quality median trolley bus stations, including 93 new bus stations and upgrading of 65 existing bus stations; (ii) 16 trolley bus depots, including 8 new depots and upgrading of 8 existing depots; (iii) 40 power traction substations along or nearby the network corridors; (iv) 111 km of overhead power wires; and (v) a total of 735 modern trolley buses, including 292 18 meter (m) long buses and 443 12 m buses.

B. Rationale

53. Jinan, the capital of Shandong Province, is one of the most congested and polluted cities in the PRC. The project is intended to improve the urban environment through creation of a high quality zero-emission BRT network, complemented by policy measures to reduce demand for travel by private vehicles. Building the infrastructure for integrated BRT routes and providing modern electric trolley buses will reduce pollution and traffic congestion, increase public transport ridership, and improve the overall energy efficiency of the city's transport system. The project will demonstrate how a large city developed with private vehicle-oriented policies can be converted to a public transport-oriented city, and change the course of urban transport development to a more sustainable direction.

54. **Strategic context.** Cities in the PRC have achieved remarkable rates of urbanization, and urban transport has been vital to this development. However, rapid urbanization has also induced new challenges including growing traffic congestion, worsening air quality that threatens public health, increasing GHG emissions that contribute to climate change, and more road crashes. These challenges have serious implications for urban transport policy, but cities in the PRC still have many unexploited opportunities to reduce the negative impacts of these challenges. Developing high quality urban public transport in the PRC cities is a trigger to change urban transport development directions from options that favor private vehicles to more sustainable urban transport and nonmotorized-oriented options supported by integrated multimodal passenger transport facilities and TDM measures.

55. **Urban transport in Jinan.** As of 2016, Jinan has a population of 7.07 million and a fleet of 1.74 million private vehicles that is growing by 20% a year. [15] The city has grown physically by a factor of four over the last 10 years with a high spatial concentration of traffic in the city center and growing travel demand from new outlying districts to the east and west. As in many PRC cities, traffic congestion and air pollution have worsened as urban development progressed. Jinan overtook Beijing as the most congested city in the PRC in the first quarter of 2016 and is ninth of the 10 most air polluted cities in the PRC overall, with transport contributing 15% of the most harmful PM2.5 emissions.[16]

56. JMG owns JPTC, which operates over 5,000 buses serving 2.1 million passengers per day. Although the city is trying to retain its 18% public transport mode share with seven BRT routes, ordinary bus services, and four trolley bus lines, the share is declining and the quality of the current public transport system is not capable of reversing the trend. The city is developing three underground metro lines, but none can serve the urban center due to restrictions to protect the city's many natural artesian springs.

57. Jinan is developing a low emission zone (LEZ) in the densest part of the city, roughly bounded by the moat and springs that historically protected the old city center, where centers of retail and other businesses, cultural and natural heritage, leisure, and government are situated closely together. The LEZ will be supported by TDM measures including restrictions on private vehicles, parking management, and improved nonmotorized transport. These combined measures will encourage the use of public transport and serve as a demonstration for the rest of the metropolitan area for solving the city's accessibility and environmental problems.

58. A modern BRT system can greatly increase efficiency and level of service through dedicated lanes, signal prioritization, and reduced delays through external fare payment, longer bays, and passing lanes at median stations. When the speed and convenience of public transport are improved and integrated with other modes including nonmotorized options, then passenger demand can be expected to increase.

59. Trolley bus systems are a sustainable option for urban public transport due to their energy efficiency and environmental and financial advantages compared with conventional buses and rail-based public transport. A trolley bus system integrated with the BRT routes can provide high capacity and zero emission public transport for the central area where the underground metro cannot be built, and thus increase mode share.

60. **Urban transport needs.** The Jinan transport system faces the following challenges:

[15] Jinan Statistics Bureau and Jinan Municipal Police data.
[16] PRC. 2017. *Ministry of Environmental Protection. Air Quality Report.*

(i) the rapidly increasing mode share of passenger cars needs to be controlled and providing better incentives for mode-shift is in urgent need;
(ii) the public bus network with designated bus lanes needs to be expanded and upgraded to adequately function with desirable flow speed, which requires improvement of station design with sufficient capacity, signaling system and intersection alignment;
(iii) bus routes are not matching with passenger travel flows and demand;
(iv) the use of clean fueled vehicles and/or vehicles with less tail gas emissions needs to be promoted to improve local air quality; and
(v) better provision for TDM is required, including infrastructure and traffic policy measures.

61. Responding to these challenges, the proposed project aims to improve the urban environment through creation of a high quality zero-emissions BRT network, complemented by policy measures to reduce demand for travel by private vehicles. Building the infrastructure for integrated BRT routes and providing modern electric trolley buses will reduce pollution and traffic congestion, increase public transport ridership, and improve the overall energy efficiency of the city's transport system. The project will demonstrate how a large city developed with private vehicle oriented policies can be converted to a public transport-oriented city, and change the course of urban transport development to a more sustainable direction.

C. Impact, Outcome, and Outputs

62. The impact of the project will be an improved urban environment in Jinan City. The outcome will be reduced traffic congestion and air pollution in Jinan City. The project will have three outputs:

63. **Output 1: Zero-emission BRT network constructed.** This output will establish 111.2 km of prioritized high quality BRT served by electric trolley buses over 39 routes; 93 new and 65 upgraded median stations with real time passenger information systems; 8 upgraded and 8 new bus depots; 40 new traction substations and power lines. The existing control center will be upgraded in tandem with advanced information technology (IT) on board the buses to provide real-time monitoring and dispatching to increase overall operational efficiency. These features will be complemented by upgraded intersection designs to facilitate better nonmotorized transport.

64. **Output 2: Modern trolley bus and service standards implemented.** Updated and improved trolley bus standards and service standards will be developed. The project will provide 735 modern trolley buses equipped with advance power storage technology and IT systems for driving assistance and vehicle and power monitoring.

65. **Output 3: TDM measures for Jinan prepared.** New TDM measures will target the mode shift from private vehicles to public transport. Measures include integration of different modes including bicycles and electric bikes, bus services, urban rail and railway stations, parking management, and a LEZ in the urban center. Capacity building for their implementation will be conducted in the EA and IA.

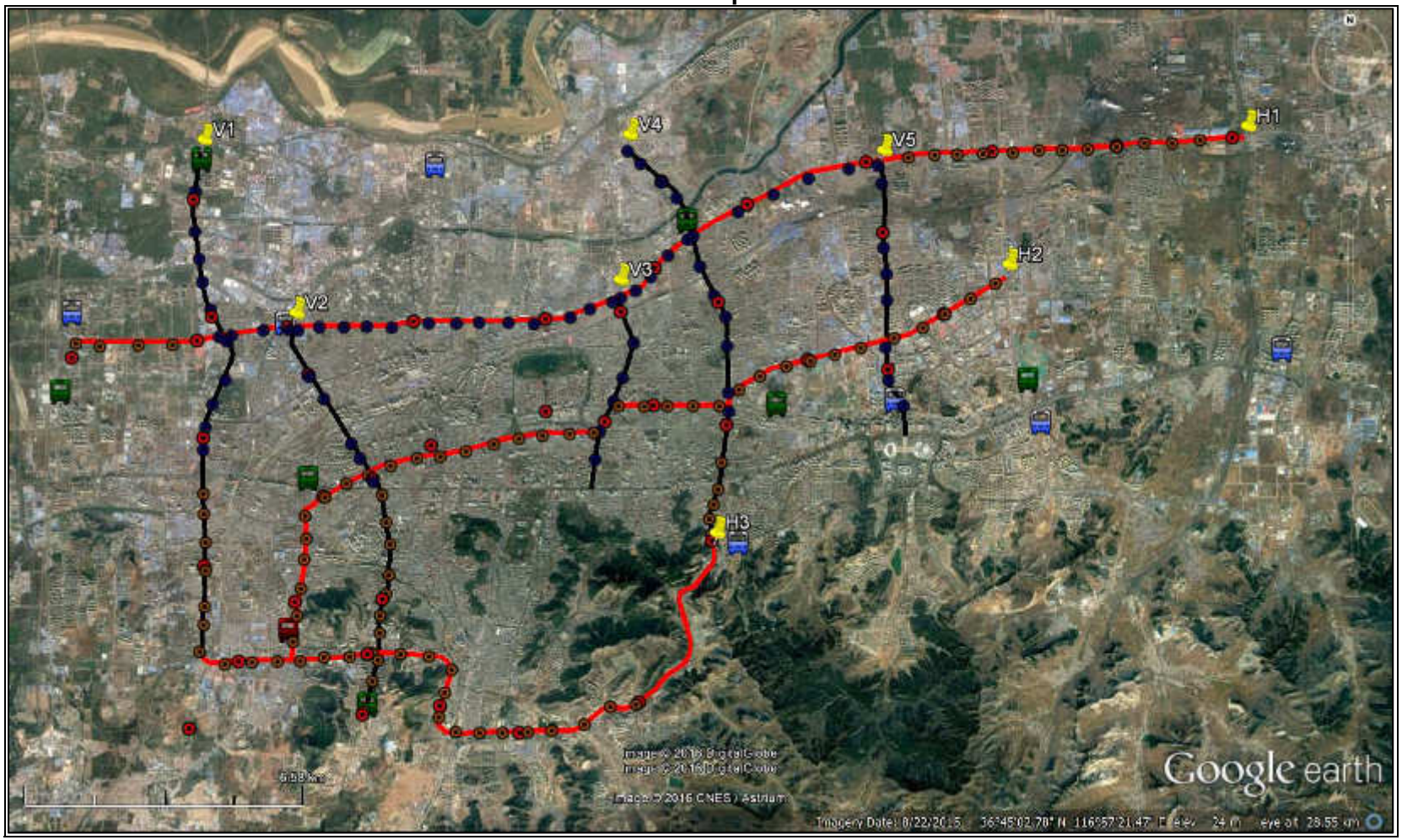
D. Detailed Project Description

66. **Prioritized trolley bus corridors.** A prioritized bus corridor refers to a section of road or contiguous roads with dedicated bus lanes, served by one or more bus routes. The 111.2 km of

prioritized trolley bus network is comprised of three horizontal (east-west) and five vertical (north-south) corridors. **Figure III-1** shows the 8 prioritized trolley bus network corridors and locations of the 158 high quality median bus stations, 16 bus depots, and 40 power traction substations.

67. **Corridor modifications.** To establish dedicated bus lanes with traffic signal priority, the proposed corridors will require lane modifications to the existing roads. The prioritized and dedicated bus lanes will occupy the middle section of the corridors. Depending on the existing road width, total traffic volume, traffic volume per each vehicle type including e-bikes and other nonmotorized vehicles, potential mode shift and expected bus ridership, and other traffic flow analyses, a specific lane configuration will be determined during the detailed engineering design stage. The provision of pedestrian lane from a safety point of view will be considered. To some extent, environmental and public health buffer between the road traffic and road side developments will be also taken into consideration. **Figure III-2** provides different conceptual options for lane modification using several examples of existing roads and their conditions in Jinan City.

Figure III-1: Key Project Outputs, including High Quality Prioritized Trolley Bus Network, Bus and Power Stations, and Bus Depots

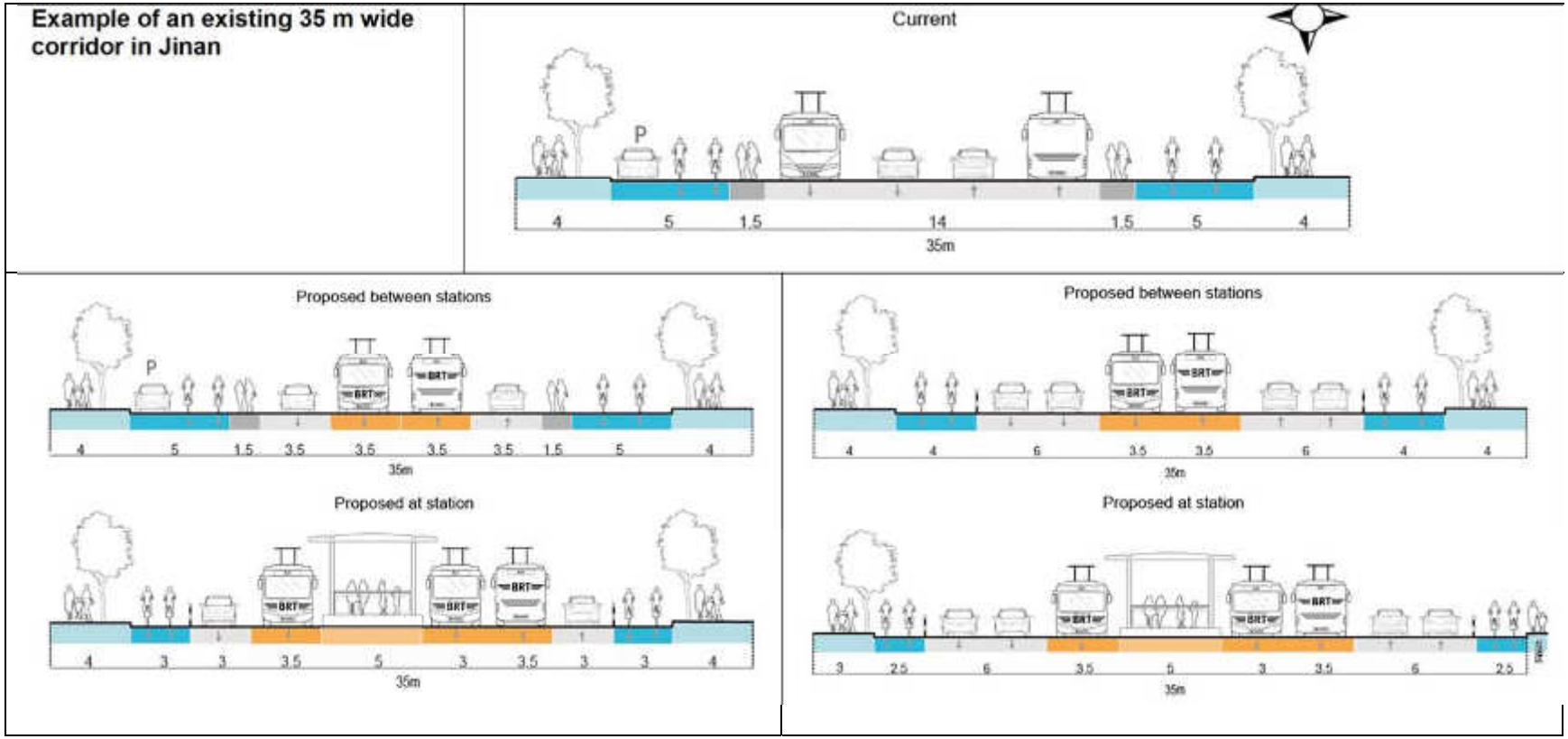


Symbol		Legend
		Trolley Bus Rapid Transit Corridors (111.2 km)
	H1	Qingdaolu-Beiyuandajie-Gongyebeilu (29.0 km, 43 BRT Stations)
	H2	Nanxinzhuang-Jingqilu-Louyuan-Jiefang- Gongyenanlu (21.1 km, 34 BRT Stations)
	H3	Erhuannanlu (14.0 km, 20 BRT Stations)
	V1	Erhuanxilu (12.4 km, 17 BRT Stations)
	V2	Weishierlu- Yangguang-Jiuquzhuang (9.8 km, 15 BRT Stations)
	V3	Lishan (4.8 km, 5 BRT Stations)
	V4	Erhuandonglu (13.4 km, 17 BRT Stations)
	V5	Aoitizhonglu (6.7 km, 7 BRT Stations)

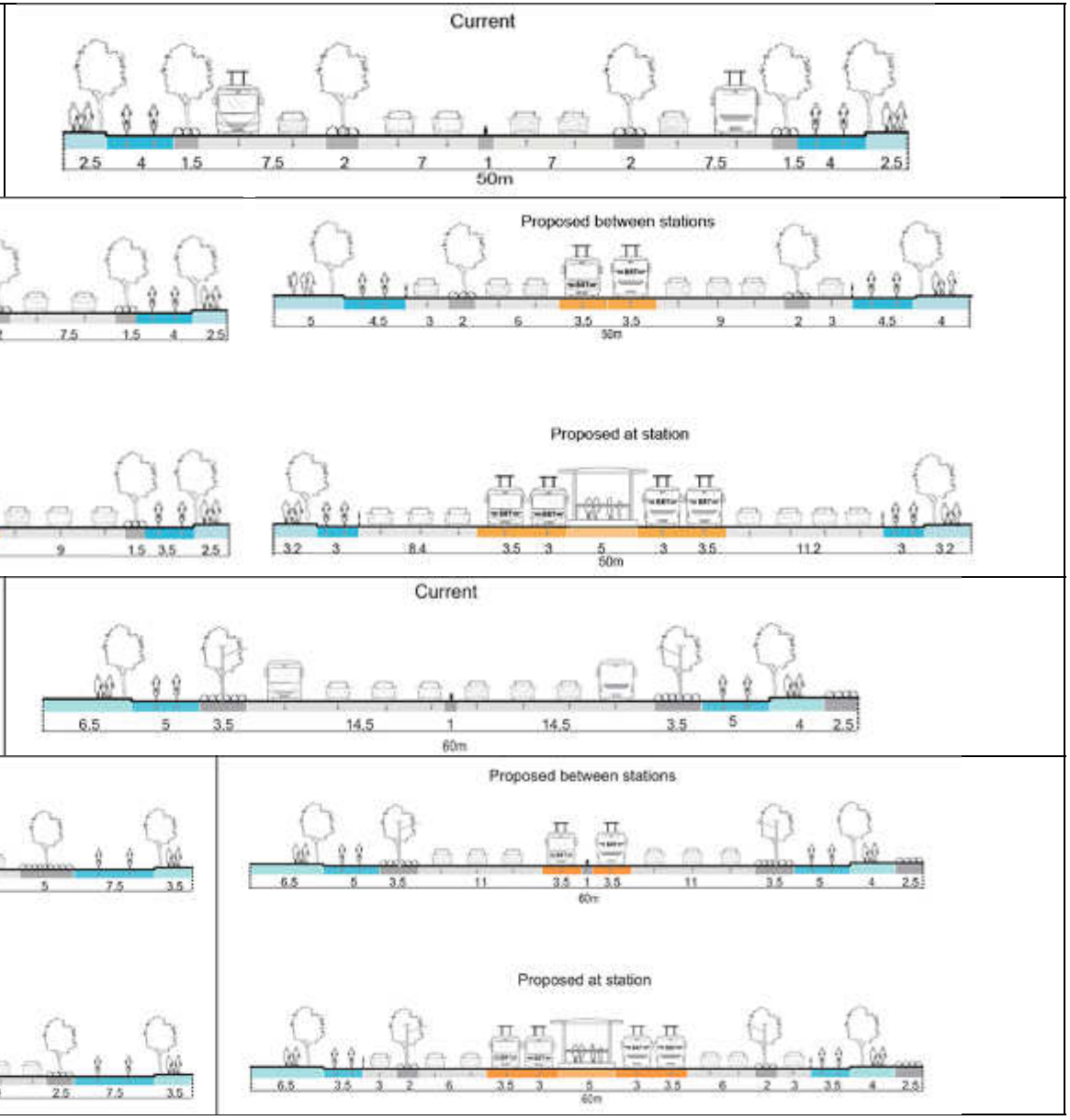
	BRT Stations – Improved (65)
	BRT Stations – New (93)
	Bus Depots – Improved (8)
	Bus Depots – New (8)
	Command and Control Center (included in new Bus Depots)
	Traction Substations (40)

Sources: Project FSR (2017) and Google Earth (2017).

Figure III-2: Lane Modification Options under Consideration



Example of an existing 50 m wide corridor in Jinan



Example of an existing 60-63 m wide corridor in Jinan

Source: ADB PPTA consultants.

68. **Prioritized bus stations.** To facilitate rapid bus flow, the network will use median bus stations instead of curbside stations. **Figure III-3** presents conceptual designs for the two types of median stations that will be constructed, island style and split style. The typical footprint of an island style station will be approximately 115 m long and 6 m wide, while the typical footprint of each sectional station in one direction (in a split type median station) will be approximately 55 m long and 6 m wide. The average distance between stations will be between 600 m and 1.2 km.

69. Flood risks will be incorporated into the detailed engineering design of the stations. They will be elevated to approximately 36 centimeters (cm) above from the existing road level and adequate drainage systems will be designed taking into consideration the result of Jinan hydraulic modelling. [17]

70. **Trolley bus depots.** Sixteen trolley bus depots will be established, including 8 existing depots which will be upgraded to accommodate trolley buses and 8 new depots.

71. The main activities involved in upgrading existing depots include surface hardening with concrete or asphalt and installing trolley bus charging facilities. No depot area expansion will be required, as all upgrading activities will be within the existing bus depot premises. The establishment of new depots will include construction of dispatching offices, workshops, and transformer rooms. **Table III-1** provides summary descriptions of the depots to be upgraded.

Table III-1: Existing Bus Depots

Existing Depots	Depot footprint (m^2)	Building area (m^2)	Total floor area (m^2)	Improved parking area (m^2)	Improvement Activities
1. Dawei	12,000	500	500	10,000	Surface hardening, charging facility.
2. Quanfu flyover	9,000	800	800	8,143	Surface hardening, charging facility
3. West passenger railway station	23,000	300	500	10,000	Surface hardening, charging facility
4. Yaojiazhuang	5,000	500	500	4,000	Surface hardening, charging facility
5. Jinan University	16,000	500	500	13,000	Surface hardening, charging facility
6. Xinxi road north intersection	12,000	500	500	10,000	Surface hardening, charging facility
7. Jinan bus driver school	37,000	550	800	8,000	Surface hardening, charging facility
8. Jinqu	20,000	400	800	8,000	Surface hardening, charging facility

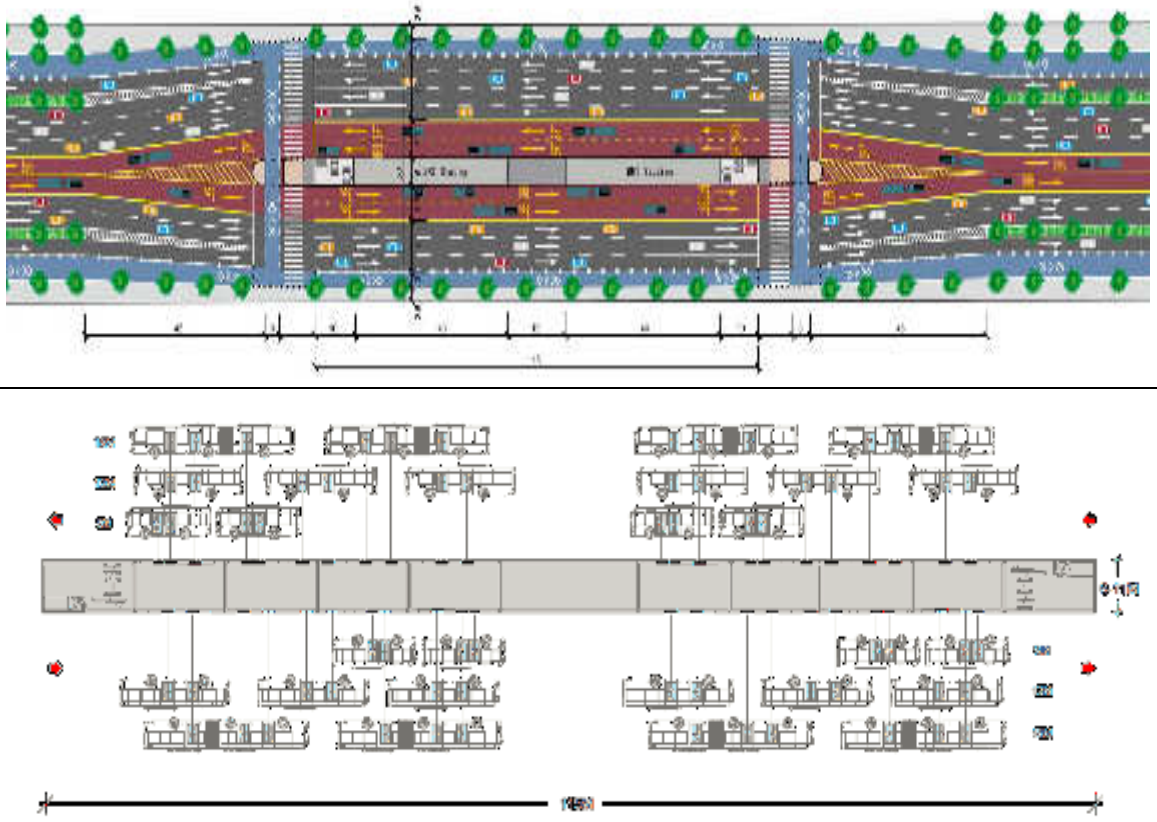
Source: FSR (2017).

72. Eight new bus depots will be established nearby the trolley bus network. New bus depots will have (i) the construction of a single or multi-storey building that can accommodate operation dispatching, safety inspection, vehicle repair, materials, and part storage and other office support; (ii) ground leveling and surface hardening at parking space; and (iii) landscaping activities. **Table III-2** provides summary descriptions for the new depots.

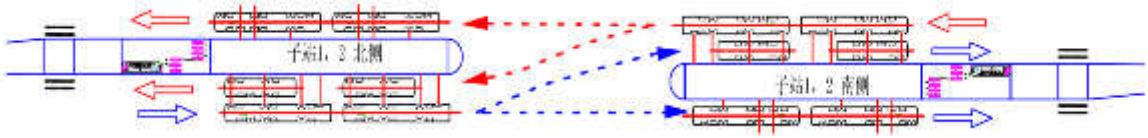
[17] Discussion on flood risk and mitigation efforts are included in the CRVA (Appendix C).

Figure III-3: Conceptual Median Bus Station Designs

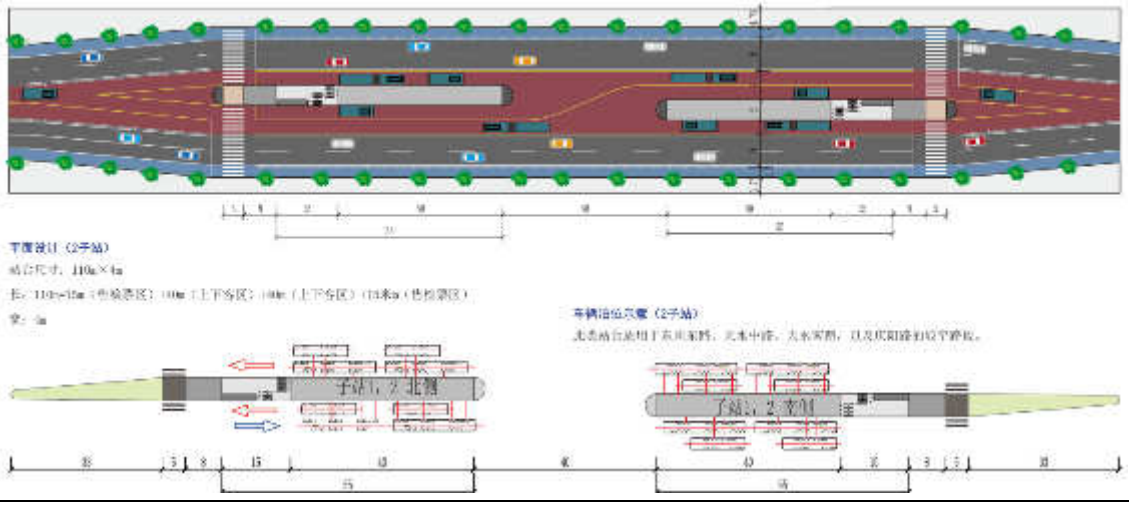
Median Island Station



Median Split Station



Note: Arrows show directions of traffic flow



Source: ADB PPTA consultants.

Table III-2: New Bus Depots

New Depots	Depot footprint (m^2)	Building area (m^2)	Total floor area (m^2)	Parking space (m^2)	Land-scaping (m^2)	Facilities
1. Bus depot at Tangye bus interchange hub	15,000	2,627	4,540	10,000	2,373	Office, repair workshop area, material storage, fleet cleaning area, transformer & utility room, drivers' room, charging facility
2. Huanggang bus depot	12,000	5,435	27,455	5,500	1,065	Office, drivers' room, transformer & utility room, charging facility
3. Bus depot at East branch of provincial hospital	12,400	1,578	6,108	9,000	1,822	Office, repair workshop area, drivers' room, transformer & utility room, charging facility
4. Jiangshui spring bus terminal depot	8,000	401	760	7,000	599	Office, repair workshop area, charging facility
5. Bus depot at Suncun bus repair center	49,800	21,345	55,028	23,000	5,455	Repair workshop area, material storage, drivers' room, charging facility
6. Bus depot at West Passenger railway station settlement zone 1	8,200	1,220	7,700	6,000	980	Office, repair workshop area, charging facility
7. Jiluo road bus depot	10,000	1,200	2,000	7,800	1,000	Office, repair workshop area, drivers' room, transformer & utility room, charging facility
8. Bus depot at Hanyu bus interchange hub	16,400	1,450	1,450	13,000	1,950	Office, overhaul workshop area, fleet cleaning area, transformer & utility room, charging facility

Source: FSR (2017).

73. The detailed engineering design of the bus depots will incorporate flood risks, as some of the depots are located in lower catchment areas with higher flood risks. Drainage system design will also be included and will take into account the results of Jinan hydraulic modelling, particularly with respect to those depots at risk. [18]

74. **Table 1** of **Appendix B** provides aerial and site views of both existing and new depot sites, as well as site ecological conditions.

75. **Modern trolley buses.** A trolley bus is an electrically propelled bus using an electrical motor that receives its energy from an overhead contact line (OCL). Modern trolley bus uses a direct current (DC) motor. Electricity from the overhead contact line (OCL) powers the DC motor and other operational on-board electrical and electronic equipment such as lighting, heating, air conditioning, and ventilation. Trolley buses are equipped with two trolley poles, fitted in parallel on the top of the buses, which draw the traction current from the two OCLs. Modern systems allow automatic lowering of the trolley poles and wire engagement.

[18] Discussion on flood risk and mitigation efforts are included in the CRVA (Appendix C).

Figure III-4: Reference Pictures of Trolley Buses

Reference pictures of a 12 m long trolley bus

Reference pictures of a 18 m long trolley bus

Source: ADB PPTA team.

Table III-3: Trolley Bus Technical Parameters

Items	Technical Parameters	
	12 Trolley Buses	**18 m Trolley Buses**
Total length * Total width (mm)	11,990*2,540	17,990*2,540
Total height (mm)	3,480	3,480
Front overhang (mm)	2,640	3,350
Headroom (mm)	2,540	2,540
Step height (cm)	36	36
Gross weight (kg)	18,000	28,000
Passenger seats	34	37
Maximum passenger capacity	90	150
Maximum speed (km/h)	69	69
Power battery	Lithium ion battery	Lithium ion battery
Monomer battery capacity (AH)	89	147
Total voltage/capacity	400V/105Ah	400V/105Ah
Battery driving range (km)	10	10
Motor model	100kw/150kw permanent magnet synchronous motor, control voltage: 750 (DC);	100kw/150kw permanent magnet synchronous motor, control voltage: 750 (DC);
Driving mode	Direct Drive	Direct Drive
Controller voltage	750 DC	750 DC
Rated/peak power (kw)	100	150
Turning circle (m)	25	25

AH = amhea, kg = kilogram, km = kilometer, kw = kilowatt, m = meter, mm = millimeter.
Sources: Domestic FSR (2017) and ADB PPTA team.

76. Modern trolleybuses are usually equipped with an auxiliary power unit (APU) that takes over as the energy source when a trolleybus must disconnect from the OCL. Trolley buses in this project will use battery APUs charged via trolley poles. Considering recharging time, the off-wire distance needs to be planned. Trolley buses to be used in this project will use have strong battery systems with an average driving range of 10 km.

77. **Overhead contact lines.** The OCL network will be installed along the trolley bus network. OCLs will be held in position using either anchors to building walls or poles, though the use of poles is the prevailing method. The pole design can ensure different urban utility uses can be mutualized into a single pole, including street lighting and OCLs for trolley buses, so that the OCL network can blend into local architecture and landscape.

78. Trolley buses will leave, enter, or cross OCLs. Electrical switches will separate two lines, mechanical switches will link two lines, while crossings will enable a trolleybus to cross two lines at different angles. The pipe (also called tube) system design is common where switches and crossings are suspended under the two continuous uninterrupted OCLs (positive and negative) and are interconnected by copper tubes. This system is simple to implement and to repair in case of a failure, like derailing, because only the pipe gets damaged but the contact wire remains in place. In addition, in case of changing operational requirements and/or changes in the assignment of trolley bus routes, it is easy to move switches and crossings.

79. Unlike old networks where trolley buses must pass at reduced speed at OCL crossings to avoid uncontrolled wire disengagement, technological advancements in modern overhead wire systems allow trolley bus speeds of 50 to 70 km/h. The lifespan of contact wires is up to 35 years.

80. **Traction power substations.** Traction power substations are required to convert high voltage alternating current (AC) from the public utility service into an appropriate voltage, current type and frequency to supply trolleybuses with traction current, which is usually low voltage DC. Transformers at power traction substations needs to be properly sized. If too small, the OCL will lack power, while if too big, it will be unnecessarily expensive to acquire and will generate significant no-load losses of power.

81. Box type transformers and power supply outlet devices will be installed at each power traction substation. A total of 40 traction substations will be required to provide an adequate supply of electricity to the trolley bus fleet, which was calculated taking into consideration various factors including the number of trolley buses running at the same time, power cable load flows, and material and type of OCLs. The estimated optimal power supply radius is 1.5 km from each substation.

82. Traction substations will typically have an 80 m^2 footprint, and will be installed on roadside or underpass landscape strips. **Figure III-5** presents pictures of a typical traction substation,[19] **Table III-4** shows their locations along the corridors, and **Table 2** in **Appendix B** presents traction substation site photos and conditions.

[19] Also see **Figure III-1**.

Figure III-5: Typical Traction Power Substations

Source: ADB PPTA team (2017).

Table III-4: Location of Traction Power Substations

Corridor	No.	Descriptive Location	Footprint (m^2)	Site Status
H1. Qingdaolu-Beiyuandajie-Gongyebeilu	1	400 meter south from Qizhou road of Qingdao road	80	Road-side landscaping
	2	100 m east from Weifang intersection of Qingdao road	80	Road-side landscaping
	3	100m east from Huanggang intersection	80	Underpass landscaping
	4	80 m west from West Gongshang River Intersection	80	Underpass landscaping
	5	140m from west of Shuitun Road	80	Underpass landscaping
	6	340m from west of kiln ditch bridge	80	Underpass landscaping
	7	Qilu Pharmaceutical Factory at Gongye North Road	80	Road-side landscaping
	8	300m from east of Xingfuliu Square	80	Road-side landscaping
	9	East side of Ledong sport center	80	Road-side landscaping
	10	Jigang (#21, Gongye North Road)	80	Road-side landscaping
	11	Guodian flyover	80	Road-side grasses and shrubs
H2. Nanxinzhuang-Jingqilu-Louyuan-Jiefanglu-Gongyenanlu	12	Qinglongshan long-distance passenger station	80	Road-side landscaping
	13	Vicinity of Nanxinzhuang bus stop	80	Road-side landscaping
	14	100m west from Jingqi Xiaowei 2nd Road	80	Road-side landscaping
	15	Vicinity of Luowen Road of Quancheng Square	80	Road-side landscaping
	16	200m west Shanda Intersection of Jiefang Road	80	Road-side landscaping
	17	Provincial prison dormitory	80	Road-side landscaping
	18	Blank land in vicinity of tobacco logistics center	80	Road-side landscaping
H3. Erhuannanlu	19	Yangjiazhuang intersection	80	Road-side baren land
	20	CNPC 25 Gas Station (Jinan Red-cross Ophthalmic Hospital)	80	Road-side landscaping
	21	300m north from gate of Diequan mountain villa of open sea	80	Road-side landscaping
	22	Shandong Electric Power Research Institute	80	Road-side landscaping
	23	Vicinity of south campus zone of Shandong University	80	Road-side landscaping
	24	South of Lvyou Road intersection of the Erhuan East Road	80	Road-side landscaping
V1. Erhuanxilu	25	300m south from Meili road of Erhuan West Road	80	Road-side landscaping
	26	Kuangshan Steel Market	80	Underpass landscaping

Corridor	No.	Descriptive Location	Footprint (m^2)	Site Status
	27	200m north from Jingliu Road of Erhuan West Road	80	Underpass landscaping
	28	Joint Logistics Department of military region of Erhuan West Road	80	Road-side landscaping
	29	1000m north of the intersection of south extension section of west ring 2 road and state way 104	80	Road-side landscaping
V2. Weishierlu-Yangguangxinlu-Jiuquzhuang	30	Vicinity of fruit wholesale market at Dikou Road	80	Road-side landscaping
	31	East gate of Harmony Square	80	Road-side landscaping
	32	Quanjin Wolong Park	80	Road-side landscaping
	33	Vicinity of Jiuqu parking lot	80	Road-side landscaping
V3. Lishan	34	Vicinity of railway bridge of Lishan Road	80	Road-side landscaping
	35	Yizheng Mansion of Lishan Road	80	Road-side landscaping
V4. Erhuandonglu	36	Central green land in opposite to Shimen gas station	80	Underpass landscaping
	37	375m north of Park intersection	80	Road-side landscaping
	38	125m north of Hepeingbeilu	80	Road-side landscaping
V5. Aoitizhonglu	39	100m south from Yangliu Road of Aoti Middle Road	80	Road-side landscaping
	40	250m south from Tianchen Road of Aoti Middle Road	80	Road-side landscaping

Source: Domestic FSR (2017).

83. **Power supply remote control center.** The network power supply remote control center will be established at the Jinan University bus depot. The main functions of the remote control center will include electrical monitoring, cable power supply monitoring, video monitoring, and charging facility monitoring.

84. **Trolley bus routes.** Once the project is fully operational in 2022, the zero-emission prioritized trolley BRT network will accommodate 39 bus routes (green lines indicated in **Figure III-6**) with a total of length of 750.9 km, a predicted daily ridership of 804,000, and a fleet consisting of 718 zero-emission trolley buses and 237 low-emission hybrid CNG buses (**Table III-5**).

Figure III-6: Bus Routes (Green) to be supported by the Zero-Emission Prioritized Trolley Bus Network (Yellow)

Source: ADB PPTA consultants.

E. Budget and Time Schedule

85. The project is estimated to cost $377.1 million (**Table III-6**), of which ADB has been requested to finance $150 million from its ordinary capital resources. JMG will finance the remaining $227.1 million equivalent. The project is included in the ADB's PRC project pipeline and programmed for ADB Board approval in 2017.

86. The implementation period will be 5 years from 2018 to 2022. The project is expected to begin full operation in 2022, and will have a 30-year life span.

Table III-5: Description of the 39 Trolley Bus Routes Supported by the Prioritized Trolley Bus Network During Project Operation

#	Bus Route	Starting Station	End Station	Type	Length (one way, km)	Length on Network (one way, km)	Fleet Type	Daily Ridership in 2020	Daily Ridership in 2043
1	2	Kuangshanxiaoqu	Fenghuangluhuaaolu	Modified	22.6	17.2	18m-trolleybus	25663	34611
2	3	Huochezhan	Shimen	Existing	12.4	6.8	12m-hybrid CNG	9687	10766
3	6	Wangguanzhuang-xiaoqudongqu	Jinandongzhan	Modified	11.4	5.8	12m-trolleybus	15723	26977
4	8	Yuhanxiaoqunanqu	Jigangdongmen	Modified	26.2	20.6	12m-hybrid CNG	26876	37463
5	21	Dangjiazaolin	Jigang	Modified	33.5	27.4	12m-hybrid CNG	28108	45438
6	37	Lvyoululiyangdajie	Shilihe	Modified	14.9	6.2	12m-hybrid CNG	14693	15267
7	47	Daba	Zhaozhuang	Modified	22.5	14.6	18m-trolleybus	30298	32565
8	49	Huochezhan	JiangshuiquanxiluBeiduan	Existing	10.6	5.7	12m-trolleybus	9934	13872
9	53	Daba	Youyiyuanxiaoqu	Modified	15.3	11.2	12m-trolleybus	15482	18345
10	57	Daba	Jigangxincun	Existing	21.4	18.1	12m-trolleybus	23076	31957
11	70	Yuhanxiaoqunanqu	Gaijiagou	Modified	20.8	14.1	12m-hybrid CNG	23727	29843
12	76	Yanqianhuxiaoqu	Dongbaliwa	Modified	18.6	12.0	12m-hybrid CNG	25188	42873
13	79	Gaijiagou	Huanshanxiaoqu	Existing	11.5	4.8	18m-trolleybus	24073	24658
14	84	Huochezhan	Gaijaigoupeihuozhongxin	Existing	10.9	4.6	12m-trolleybus	12405	13564
15	87	Danshantun	Fenghuangluhuaaolu	Modified	19.6	16.4	12m-trolleybus	14015	19043
16	93	Yuhanxiaoqunanqu	Huanxiangdian	Modified	20.1	11.3	12m-hybrid CNG	21687	29515
17	95	Jiancaishichang	Liuxuerenyuanchuangyeyuan	Modified	16.5	11.4	12m-trolleybus	25351	31492
18	96	Shigoufuzhuangguangchang	Jinshanluerhuandonglu	Modified	18.8	13.4	12m-trolleybus	30200	28475
19	99	Jinandaxue	Xiejiatun	Modified	33.8	25.6	18m-trolleybus	39711	43017
20	100	Shandongqipeicheng	Lvyoululiyangdajie	Modified	14.3	7.4	12m-hybrid CNG	16068	21703
21	107	Shandongqipeicheng	Shancaidayanshanxiaoqu	Modified	20.4	12.8	12m-trolleybus	21485	24617
22	113	Quanchenguangchang	Gongjiaozhudianchechang	Modified	20.2	13.4	12m-hybrid CNG	8292	12086
23	116	Daba	Gaoxinkaifaqu	Modified	23.1	16.9	18m-trolleybus	42475	63024
24	120	Xiyuanxiaoqu	Zhonghaiyufengguandi	Modified	12.9	10.3	18m-trolleybus	17854	22853
25	125	Shimaoyuanshanshouf	Changtuqichezhan	Modified	19.1	17.7	12m-trolleybus	22254	35301
26	132	Zhengdiancun	Yanshanlijiaoqiaodong	Modified	24.3	16.2	18m-trolleybus	31837	50774
27	164	Shiliwuyuan	Shiqingyazhuang	Existing	10.7	9.1	12m-trolleybus	6088	10506
28	165	Xinshijieshang-cheng	Huanxiangdian	Existing	15.5	9.7	12m-trolleybus	15332	21703
29	167	Jinanxizhangong-jiaoshuniu	Changtuzongzhannanqu	Modified	26.9	25.2	18m-trolleybus	37442	46690
30	205	Jinandaxue	Gogniaozhudianchechang	Modified	19.2	13.3	12m-trolleybus	17528	23386
31	209	Gaijiagou	Tangyegongjiaoshuniu	Modified	18.1	12.3	12m-trolleybus	12933	14432
32	313	Jinandaxue	Xianggongjixiangyuan	Modified	33.4	30.3	18m-trolleybus	23884	30308
33	905	Lashanlijiaoqiao	Majiadian	Modified	20.8	16.8	12m-trolleybus	19510	28933
34	907	Dawucun	Gaoxinkaifaqu	Modified	15.0	11.9	12m-trolleybus	6734	9884
35	1001	Yingxiongshanlijiaoqia	Fenghuangluhuaaolu	New	22.2	19.1	18m-trolleybus	34053	40787
36	1002	Jianbanghuanghedaqiao	Shandongdaxuexinglongshanxiaoqu	New	24.9	24.9	12m-trolleybus	14439	23954
37	79b	Jinandaxue	Gaijiagou	New	18.0	14.1	12m-trolleybus	15762	20862
38	b6	Beiquanfu	Fenghuangluhuaaolu	Modified	16.6	12.4	12m-trolleybus	11153	13379
39	b7	Daweixi	Jinandaxue	Existing	13.9	10.9	12m-trolleybus	13057	24604
		TOTAL			**750.9**	**551.9**		**804,074**	**1,069,528**

Source: PPTA consultants (2017).

Table III-6: Summary Cost Estimates ($ million)

Item			Amount[a]
A.	**Base Cost**[b]		
	1.	Zero emissions bus rapid transit network	194.77
	2.	Modern trolley bus and service standards	111.80
	3.	Travel demand management measures	15.04
		Subtotal (A)	**321.61**
B.	**Contingencies**[c]		**29.85**
C.	**Financial Charges During Implementation**[d]		**25.64**
		Total (A+B+C)	**377.10**

[a] Includes taxes and duties of $40.24 million to be financed from government resources and the Asian Development Bank (ADB) loan resources. Such amount does not represent an excessive share of the project cost. The government will finance taxes and duties of $23.59 million in cash from government resources.
[b] In mid-2017 prices.
[c] Physical contingencies computed at 5% for civil works. Price contingencies computed at average of 1.5% on foreign exchange costs and 2.3% on local currency costs; includes provision for potential exchange rate fluctuation under the assumption of a purchasing power parity exchange rate.
[d] Includes interest and commitment charges. Interest during construction for the OCR loan has been computed at the 5-year US dollar fixed swap rate plus an effective contractual spread of 0.5% and maturity premium of 0.1%. Commitment charges for the OCR loan are 0.15% per year to be charged on the undisbursed loan amount.
Sources: Asian Development Bank and Government estimates.

F. Implementation Arrangements

87. The EA will be the JMG, which will be responsible for overall project implementation. JPTC, a state-owned company under the JMG, will be the IA responsible for day-to-day management during project preparation and implementation. Implementation arrangements are discussed in more detail in the EMP (**Appendix A**).

IV. DESCRIPTION OF THE ENVIRONMENT

A. Location

88. The project is situated within Jinan City, the capital of Shandong Province.

89. **Shandong Province.** Shandong Province lies on the east coast of the PRC and at the lower reaches of the Yellow River (**Figure I-1**). In 2016, its population was 98.47 million, making it the second most populous province in the PRC. The province has a land area of 157,100 km^2 and a coastline length of 3,100 km. The province is comprised of 17 municipalities and 140 counties (including county level cities and districts).

90. Shandong is an economic powerhouse in the PRC. The province's gross domestic product (GDP) grew by 8% to CNY6.3 trillion in 2015, ranking the third in the country after Guangdong and Jiangsu provinces. As one of the PRC's major agricultural production bases, Shandong is known for the production of grains, fruits and vegetables, oil crops, aquatic products, and animal by-products. The total value of Shandong agriculture has been in the top place in the PRC for over a decade consecutively. Shandong is also an important energy base in the PRC. The Shengli Oilfield, discovered in 1955, is the second largest of its kind in the country and lies in the north of Shandong.[20]

[20] Economic Overview and Opportunities of Shandong Province. Netherlands Economic Network in China, December 2016.

91. Shandong has a temperate climate, with hot, rainy summers and dry, cold winters. Mean annual temperature is 10.5 to 13.5 ^{0}C; the average temperature in July is 24 to 27 ^{0}C, while the temperature in January is -4 to 1 ^{0}C. Mean annual precipitation is 550 to 950 mm, increasing from northwest to southeast. The province is divided into four topographical zones: (i) Northwestern Shandong Plain, formed by deposits of the Yellow River (and where the project will be sited); (ii) Jiaolai Plain between central-south Shandong and the Jiaodong hilly regions, bounded by bays in the north and south and traversed by the Jiaolai, Weihe and Dagu rivers; (iii) Central-South Shandong hilly area, with elevations >1,000 masl; and (iv) Jiaodong Hilly Area, the main part of the Shandong Peninsula. The Yellow River passes through the province's western region, entering the Bohai Sea along Shandong's northern coast.

92. **Jinan City.** Jinan City is located in the middle part of Shandong Province between longitude 116°11′ - 117°44′ E and latitude 36°02′ - 37°31′ N, approximately 400 km south of the national capital of Beijing. It is bordered by Liaocheng to the southwest, Dezhou to the northwest, Binzhou to the northeast, Zibo to the east, Laiwu to the southeast, and Tai'an to the south.

93. The city is comprised of 6 districts (Lixia, Shizhong, Huaiyin, Tianqiao, Licheng and Changqing); 3 counties (Pingyin, Jiyang, and Shanghe); and a county level city (Zhangqiu) (**Figure IV-1**). The city has a total area of 8,177 km^2, while the urbanized area where the project is to be sited has an area of approximately 1,022 km^2. The 111.2 km of project trolley BRT corridors are spread over an area of approximately 250 km^2 (**Figure IV-2**).

Figure IV-1: Districts and Counties of Jinan City
(the four urban districts are circled)

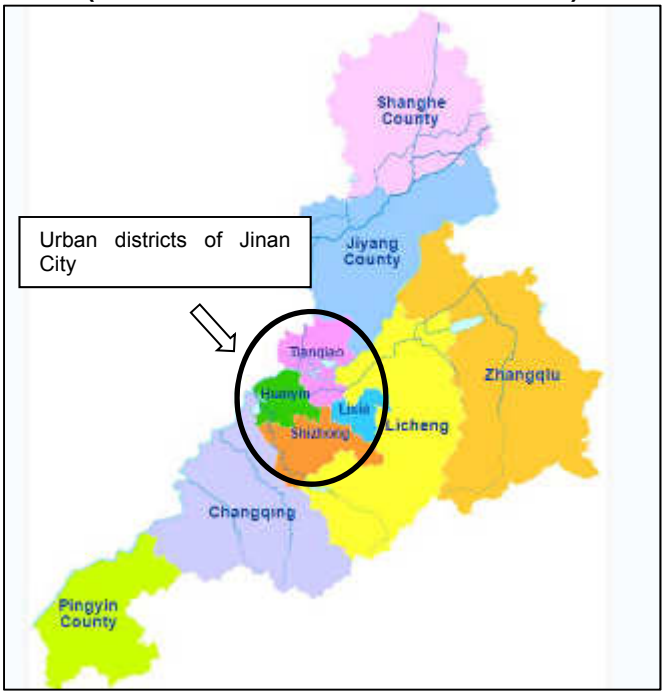
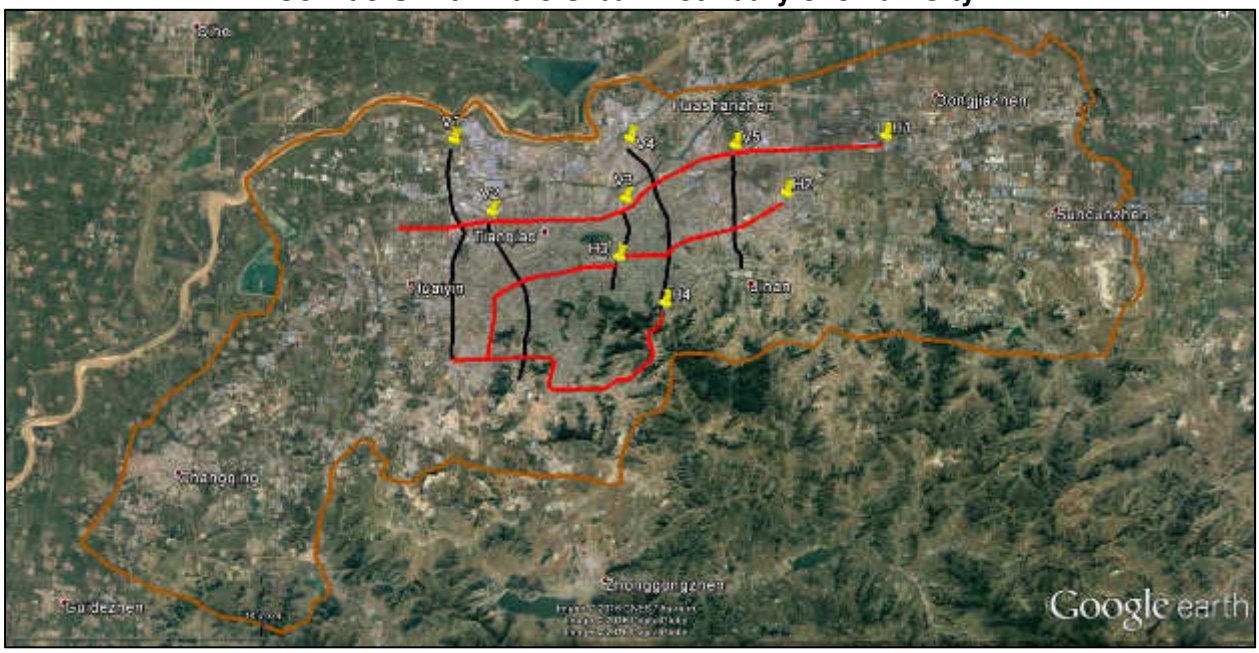


Figure IV-2: Location of Proposed Zero-Emission High Quality Rapid Transit Trolley Bus Corridors within the Urban Boundary of Jinan City

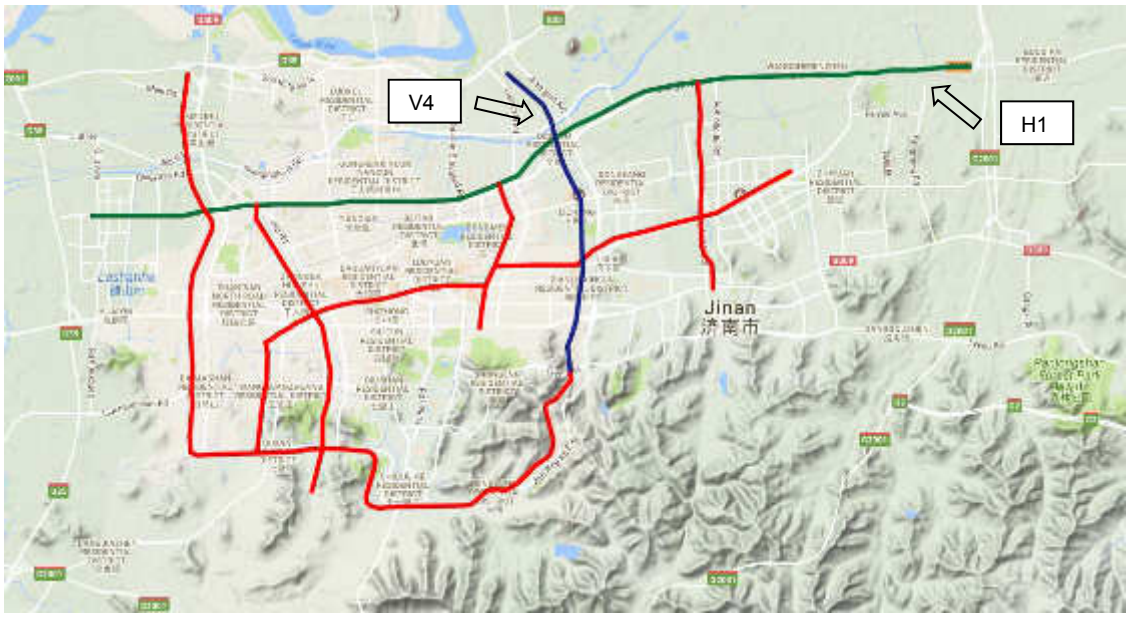


Sources: Project FSR (2017) and Google Earth (2017).

B. Physical Resources

94. **Topography.** Jinan City occupies a transition zone between the northern foothills of the Taishan Massif to the south-southeast of the city and the Yellow River Valley to the north and northwest. Within the project area the topography is generally flat, sloping slightly downwards from the east to the west, and from the southern foothills north to the Yellow River (**Figure IV-3**).

Figure IV-3: Topography of Jinan Urban Area, including East-West Elevation Profile along Corridor H5 and North-South Elevation Profile along Corridor V3



East west elevation profile along trolley bus rapid transit corridor H1

North-south elevation profile along trolley bus rapid transit corridor V4.

Sources: Project FSR (2017) and Google Earth (2017).

95. Elevations in the study area typically range from 25 to 150 masl, with the highest elevations of over 250 masl occurring in corridor H3 as it passes through low foothills in the southeast of the urban area. As the river bed of the Yellow River sits higher than the surrounding surface, the urban area is in somewhat of a basin shape.

96. **Geology and seismicity.** According to EIT, the stratigraphic structure of the project area is simple and stable, without unfavorable geological processes, and is therefore suitable for project construction.

97. The PRC classifies seismic intensity into 12 grades under the *China Seismic Intensity Table* (GB/T 17742-2008), based on the severity of "shaking" of the earth surface and the extent of potential impact. According to the *China Seismic Ground Motion Parameters Zoning Map* (GB18306-2001, Amendment 1), the seismic intensity in the project area is Grade 6, with a design peak ground acceleration of 0.05 g, a 10% probability of exceedance in 50 years, and a return period of 475 years.

98. According to the domestic EIT, project sites are class II under the *Code for Seismic Design of Buildings* (GB50011-2010), applicable to medium dense and loose gravel, dense and medium dense coarse and sands, and clays with a bearing capacity >250 kPa. The project sites are thus considered as suitable for construction activities, and there are no significant risk of potential disasters like landslides, mud flows, land subsidence or geological faults.

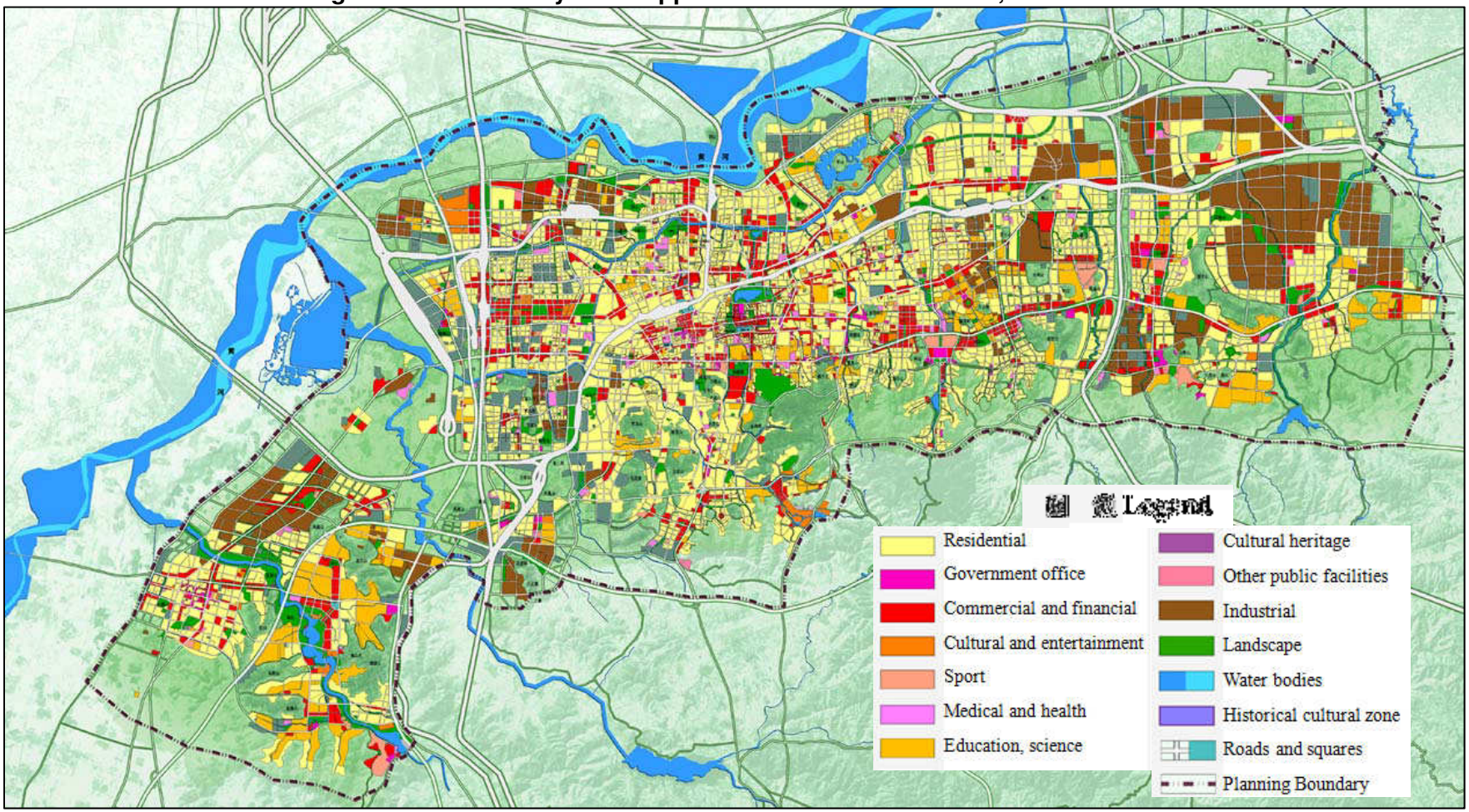
99. **Land use.** In August 2016, the State Council approved the Jinan City Master Plan 2011–2020. According to the plan, the spatial layout of the urban area will be structured as "One City, Two Regions" covering 1,022km^2 (**Figure IV-4**). The project sites are all in highly urbanized industrial, commercial, or residential areas, and are predominantly in existing road right-of-ways.

100. **Climate.** Jinan has a temperate continental climate with four distinct seasons. It is dry in the spring, hot and rainy in the summer, cool in the autumn, and dry and cold in the winter. The average annual temperature in Jinan is 16.6°C, the average summer average temperature is 26^{0}C and the maximum recorded summer temperature was 42.7^{0}C. The average temperature in the

coldest month of winter is below 0^0C, and the lowest maximum recorded temperature is -19.5^{0}C. (**Figure IV-5**).

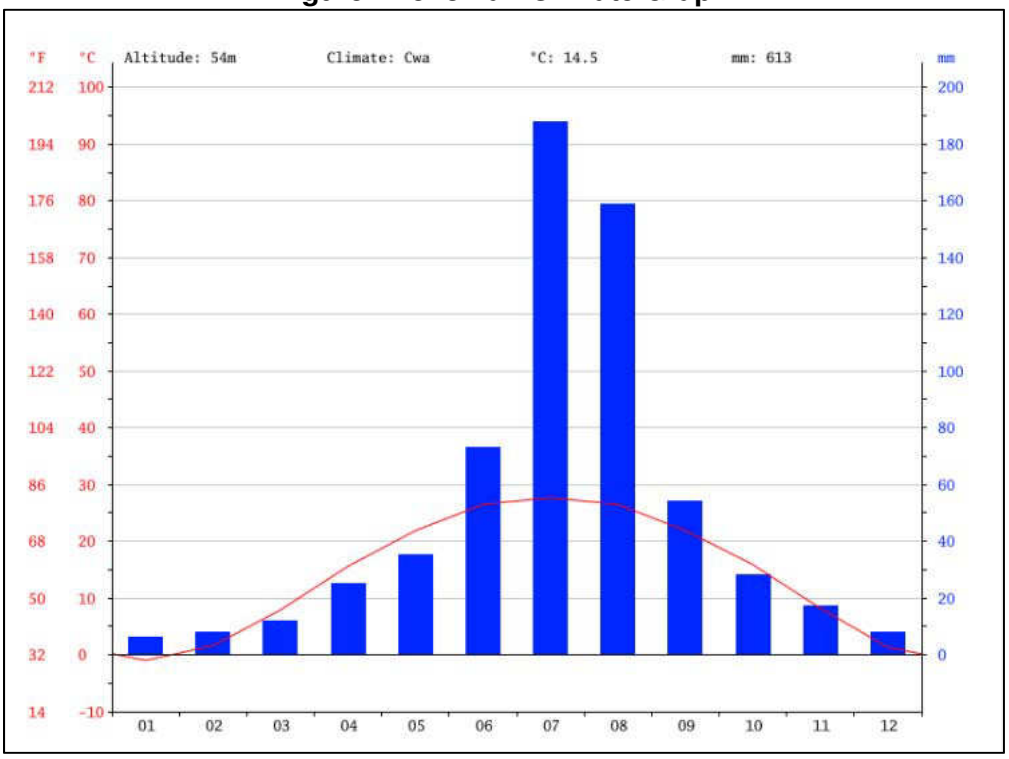
101. The average annual precipitation is 685 mm, with a recorded maximum of 1,160 mm and a minimum of 320.7 mm. In winter months, precipitation is low (20 mm–25 mm/month), and the majority of precipitation occurs during the summer months. Average annual average humidity is 58%. The dominate wind direction is from the SE (**Figure IV-6**).

Figure IV-4: Jinan City State Approved Urban Landuse Plan, 2011–2020



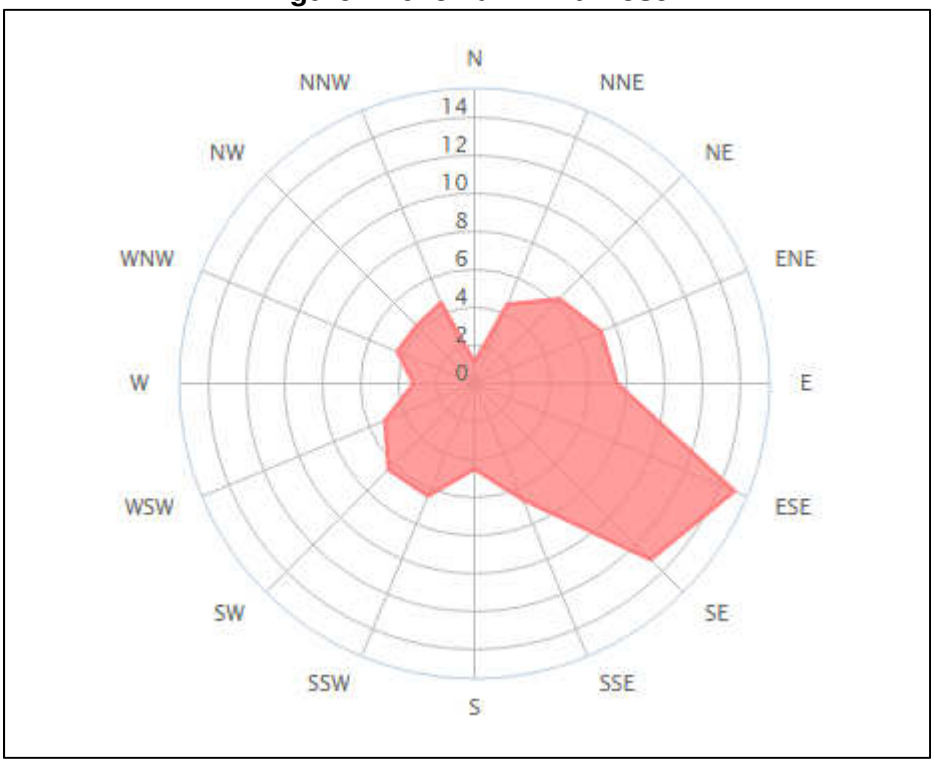
Source: Jinan Municipal Government.

Figure IV-5: Jinan Climate Graph



Source: https://en.climate-data.org/location/2382/

Figure IV-6: Jinan Wind Rose



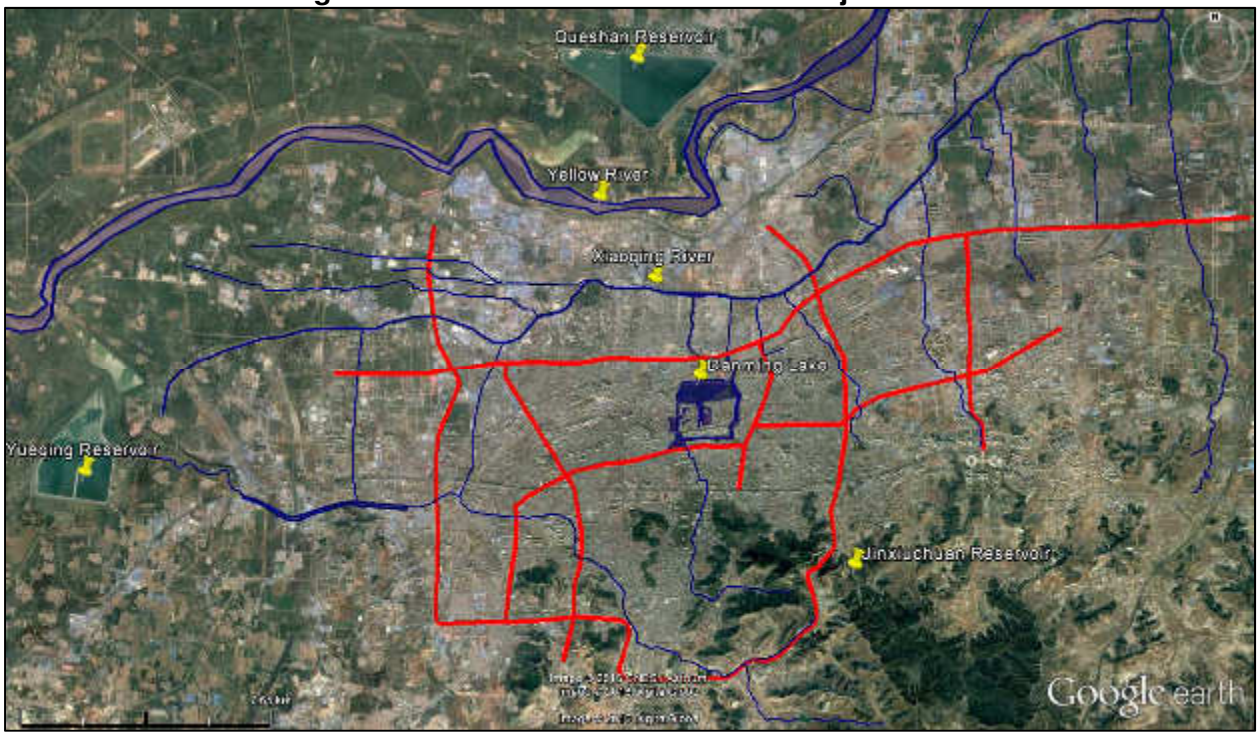
Source: https://www.windfinder.com/windstatistics/jinan

102. **Surface water rivers and reservoirs.** Surface water resources in the project area are presented in **Figure IV-7**. Jinan lies on the south shore of the Yellow River, and it is the main river in the project general area, although it is north of the project impact zone. With an estimated length of 5,464 km, the Yellow River is the second-longest river in Asia, and the sixth-longest river system in the world. It originates in the Bayan Har Mountains in Qinghai province of western China, it flows through nine provinces, and it empties into the Bohai Sea near Dongying in Shandong province. It has a watershed area of 742,443 km^2.

103. The Xiaoqing River is the other main river in Jinan. Originating west of Jinan, it is 220 km long and has a watershed area of 10,336 km^2. It flows south of, and roughly parallel to, the Yellow River, in Jinan passing through Huaiyin, Tianqiao, and Licheng Districts, and also empties into the Bohai Sea. It is fed by a series of tributaries flowing north through the urban areas of Jinan and in recent years has become contaminated as a result of large amount of industrial and domestic wastewater.

104. Water reservoirs in Jinan include the Queshan, Yeuqing, and Jinxiuchuan. There are no reservoirs in the project impact zone.

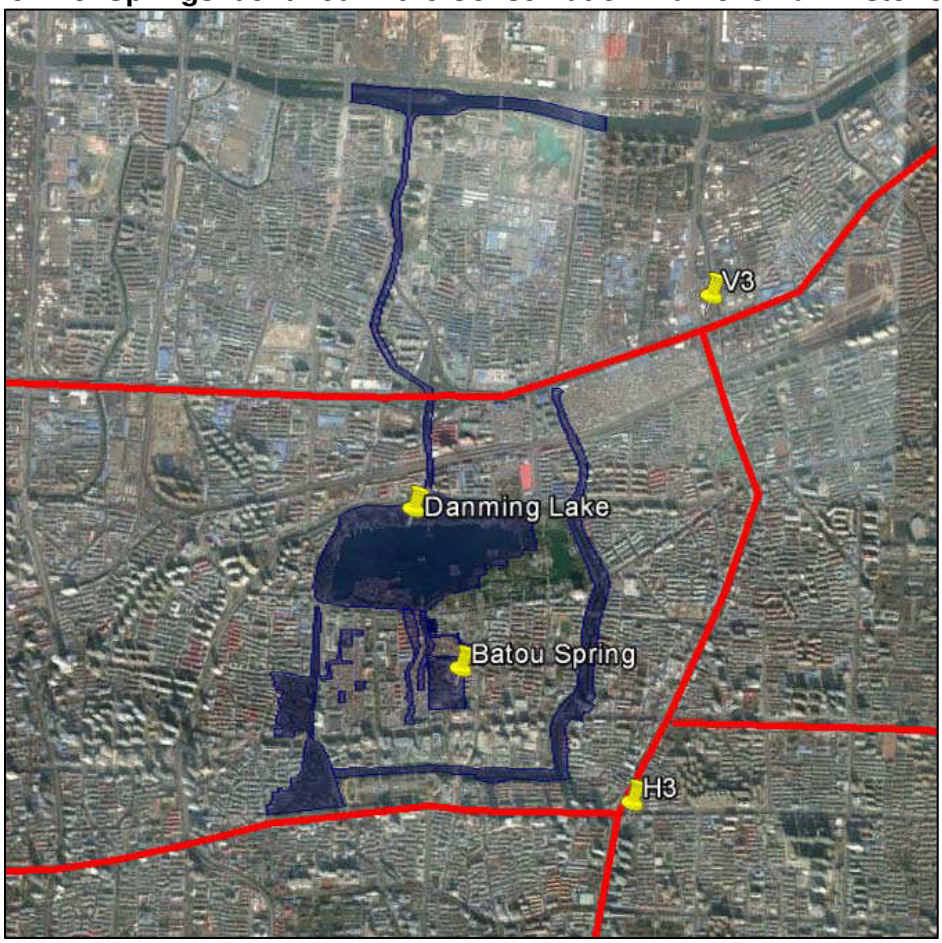
Figure IV-7: Water Resources in the Project Area



Source: JEPB (2016).

105. **Groundwater and springs.** Jinan is well known for its artesian karst springs and lakes, and is referred to as the Spring City. Daming Lake, located in the historical city center, is the largest lake in Jinan, and one of the city's main natural and cultural landmarks. Fed by the artesian karst springs, the lake maintains a fairly constant water level and temperature through the entire year. Other key karst fed artesian spring include Batou, Heihu, Wulong and Zhenzhu, and in total there are more than 70 named springs in Jinan. **Figure IV-8** shows springs in the historic center of Jinan identified in the Jinan Historic City Conservation Plan.

Figure IV-8: Springs Identified in the Conservation Plan of Jinan Historic City

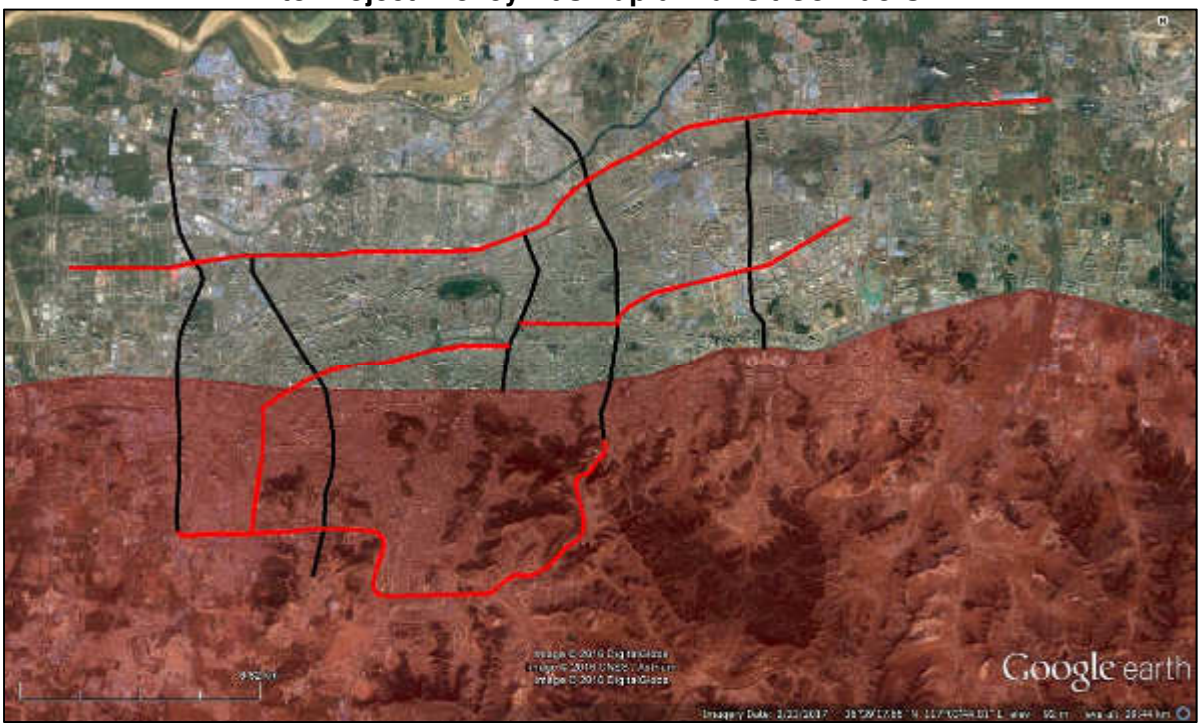


Source: Conservation Plan of Jinan Historic City, Jinan Urban Planning Department (October 28, 2015), and Google Earth (2017).

106. The springs are fed by a catchment area of approximately 1,500 km^2 to the south of the city. The main aquifer systems consist of Ordovician and Cambrian limestone with karst fractures. Metamorphic rock is distributed in the southern water divide area and igneous rock in the north of the city. In the northern discharge area, Quaternary sediments overlie karst aquifers. In the middle area, outcrops of karst aquifers are distributed. Groundwater flow is generally from the southern recharge area to the northern discharge area.[21] The recharge area is classified as a "quasi groundwater drinking water source protection zone"[22] by JMG (**Figure IV-9**). In addition, the Jinan Landscape Bureau has developed a spring protection zone map, which covers much of the urban area of Jinan including a significant portion of the project trolley bus rapid transit corridors (**Figure IV-10**).

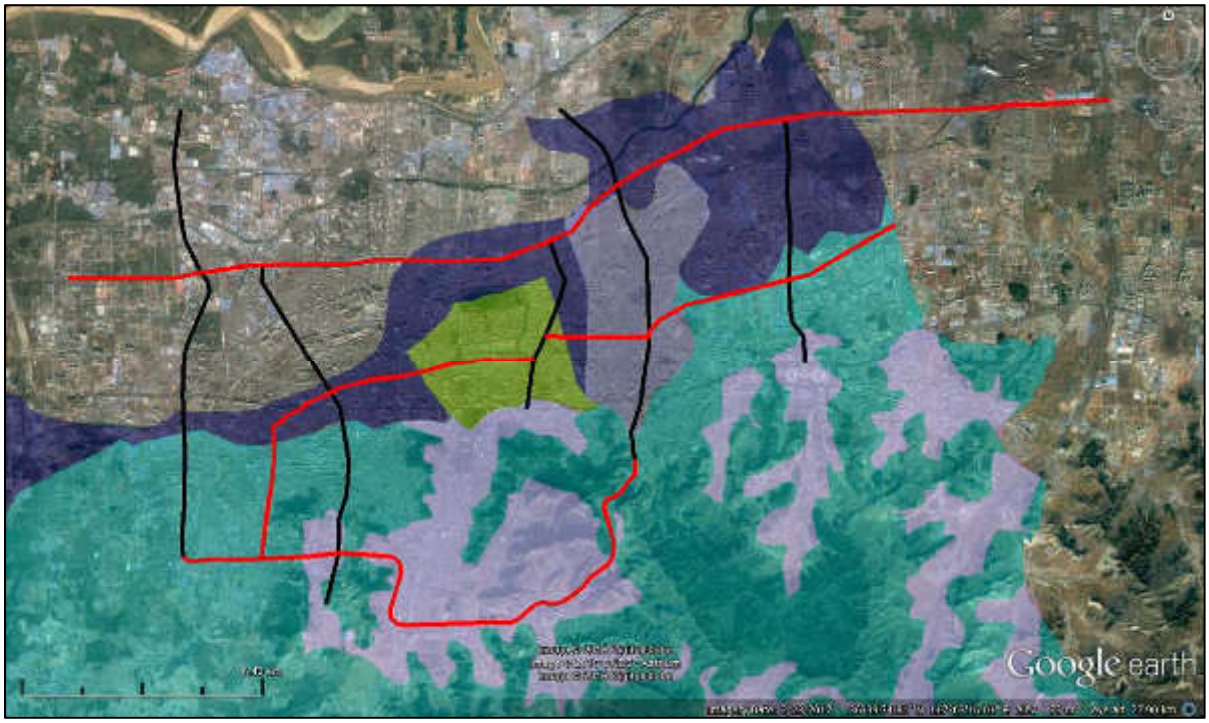
[21] Yangxiao Zhou and Zhandong Gao. Groundwater quality monitoring network for Jinan Karst spring catchment. PRC.
[22] Zones established as a precautionary measure to protect ground water.

Figure IV-9: JMG Quasi Groundwater Drinking Water Source Protection Zone in relation to Project Trolley Bus Rapid Transit Corridors



Sources: JMG (2016) and Google Earth (2017).

Figure IV-10: Jinan Spring Protection Zones in relation to Project Trolley Bus Rapid Transit Corridors



Sources: Jinan Landscape Bureau (2017) and Google Earth (2017).

107. **Baseline data.** According to Jinan's Environmental Quality Bulletin (2016), urban air quality in Jinan has improved compared with 2015, but pollution levels remain severe; the quality of drinking water sources is good while surface water quality has not improved; and the acoustic environmental quality is relatively good.

Air Quality

108. **Air quality index.** MEP monitors air pollution in cities throughout the PRC and presents the results in an Air Quality Index (AQI) based on the level of 6 pollutants **(Figure IV-11**).

109. **Air quality in Jinan City.** There are 21 automated air quality monitoring stations in the Jinan City, 14 of which are in the urban area (**Figure IV-12**). Monitoring in the stations includes in PM_{10}, $PM_{2.5}$, sulfur dioxide, nitrogen dioxide, carbon monoxide, and ozone. Summary data on stations and monitoring results for 2016 are presented in **Table IV-1.**

Figure IV-11: The PRC's Air Quality Index

The Air Quality Index (AQI) was introduced in 2012 and replaces the old Air Pollution Index (API). The AQI is based on the concentration levels of six major atmospheric pollutants: sulphur dioxide (SO_2), nitrogen dioxide (NO_2), suspended particulates smaller than 10 microns in diameter (PM_{10}), carbon monoxide (CO), ozone (O_3), and suspended particulates smaller than 2.5 microns in diameter ($PM_{2.5}$). The index is employed at monitoring stations in more than 350 cities across the nation.

The MEP measures and assigns an individual air quality score (IAQI) to each of the six pollutants over a period of one, eight, or 24 hours, or annual average. A city's final AQI is the highest of those six scores with that particular pollutant being the city's major pollutant. When the index is lower than 50, the ministry does not name the major pollutant. The AQI ranges from zero to over 300:

AQI	Air Pollution Level	Health Implications
0–50	Excellent	No health implications.
51–100	Good	Few hypersensitive individuals should reduce outdoor exercise.
101–150	Lightly Polluted	Slight irritation may occur, individuals with breathing or heart problems should reduce outdoor exercise.
151–200	Moderately Polluted	Slight irritation may occur, individuals with breathing or heart problems should reduce outdoor exercise.
201–300	Heavily Polluted	Healthy people will be noticeably affected. People with breathing or heart problems will experience reduced endurance in activities. These individuals and elders should remain indoors and restrict activities.
300+	Severely Polluted	Healthy people will experience reduced endurance in activities. There may be strong irritations and symptoms and may trigger other illnesses. Elders and the sick should remain indoors and avoid exercise. Healthy individuals should avoid out door activities.

Source: Li Li and Dong-Jun Liu (2014) and http://multimedia.scmp.com/china-air-pollution-in-2014/

110. The following discussion on Jinan air quality is based on summary data from 18 of the stations (data from three municipal stations was not available).

Figure IV-12: Air Quality Monitoring Stations in Jinan City Urban Area

Source: Jinan EPB (2017).

Table IV-1: Air Quality Index and 24-hour Mean Ambient Air Quality at Monitoring Stations in the Project Area, Jinan City, 2016. Shading denotes exceedance of the relevant Class II standard (*Ambient Air Quality Standard* GB3095-2012).

(unit: μg/m^3, excluding CO)

#	Name of Station	District	# of Good AQI Days	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO 95per[23] (mg/m$_3$)	O_3 (8 hour)
1	Agricultural Science Institute	Huaiyin	144	165	82	40	45	2.7	186
2	The 2nd machine tool factory								
3	Jinan Chemical Factory	Tianqiao	170	147	74	38	59	2.4	178
4	Provincial seed warehouse	Licheng	136	144	79	46	54	2.7	208
5	Development area	Lixia	176	148	67	38	52	2.2	160
6	Municipal monitoring station	Lixia	140	156	84	54	61	2.5	187
7	Cadre's Sanitarium	Shizhong	186	128	68	30	45	2.2	164
8	Lanxiang Vocational School	Tianqiao	122	171	91	50	63	2.4	194
9	Shangdong Luneng	Shizhong	175	138	67	32	39	1.9	186
10	Quancheng square	Lixia	186	129	68	50	52	2.7	182
11	Economic college	Lixia	149	139	73	38	37	1.6	202
12	Jinan Baosheng	Licheng	104	198	89	40	57	2.4	177
13	Experimental school	Licheng	167	150	66	28	46	1.9	176
14	Building engineering school	Licheng	142	143	72	43	44	1.9	198
15	Aoto center	Not available							
16	Jinping middle school	Lixia	166	128	61	30	46	1.8	204
17	City Museum	Lixia	169	119	71	31	40	2.2	206
18	Paomaling	Changqing	194	88	51	38	17	1.5	213
19	Party school	Changqing	164	137	71	45	50	2.2	190
20	Business, Vocational & Technical College	Licheng	160	109	64	37	30	1.9	220
21	Changqing college town	Changqing	154	117	70	38	47	1.9	218
22	Western urban area	Huaiyin	145	139	72	38	46	2.4	208
	Jinan City	—	164	144	74	40	49	2.2	187

Source: Jinan Environmental Quality Bulletin (2016).

111. In 2016 average daily concentrations of PM_{10}, $PM_{2.5}$, sulfur dioxide, nitrogen dioxide, carbon monoxide and ozone in Jinan were 141 μg/m^3, 73 μg/m^3, 38 μg/m^3, 45 μg/m^3, 2.0 mg/m^3 and 188 μg/m^3, respectively (**Table IV-2**). Of these, the concentrations of PM_{10}, $PM_{2.5}$, nitrogen dioxide and ozone exceeded the National Ambient Air Quality Standard (GB3095-2012) by 1.01, 1.09, 0.13 and 0.18 times, while the concentrations of sulfur dioxide and carbon monoxide met the standard. The concentrations of ozone slightly increased compared to 2015, while concentrations of PM_{10}, $PM_{2.5}$, sulfur dioxide, nitrogen dioxide and carbon monoxide decreased by 10.2%, 16.1%, 24%, 6.3% and 20.0%, respectively.

[23] Note: CO standard applicable to 95th percentile of data.

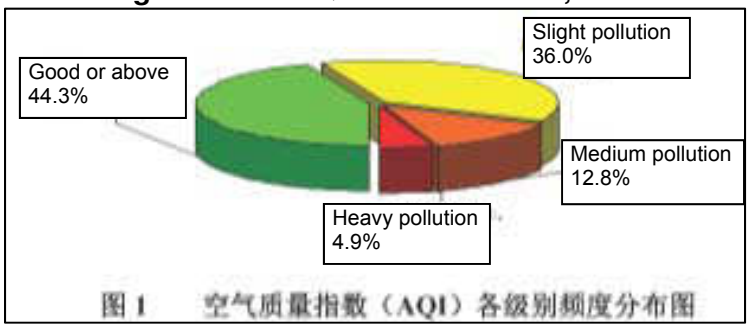
Table IV-2: 24-hour Mean Ambient Air Quality in 2016 Jinan City Urban Area
(unit :μg/m^3, excluding CO)

Item	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO 95per[24] (mg/m_3)	O_3 (8 hour)
Range of 24-hr mean concentrations	30-570	15-359	15-142	19-112	0.5-6.5	8-240
Samples exceeding the standard, %	37.4%	38.0%	0	5.5%	0.5%	19.1%
Average 24-hr concentration	141	73	38	45	2.0	188
Average 24-hr concentration exceedance of standard, %	101%	109%	In Compliance	13%	In Compliance	18%
Change compared to 2015, %	-10.2%	-16.1%	-24.0%	-6.3%	-20.0%	1.1%
24-hr mean standard (GB3095-2012)	70	35	60	40	—	—

Source: Jinan Environmental Quality Bulletin (2016). Based on 21 stations.

112. In 2016, Jinan had 162 days with a Good AQI level, an increase of 29 days over 2015. 18 days had a Heavily Polluted or Severely Polluted AQI level, a decrease of 16 days over 2015. The frequency distribution of all levels of AQI in 2016 is presented in **Figure IV-13.**

Figure IV-13: AQI Levels in Jinan, 2016

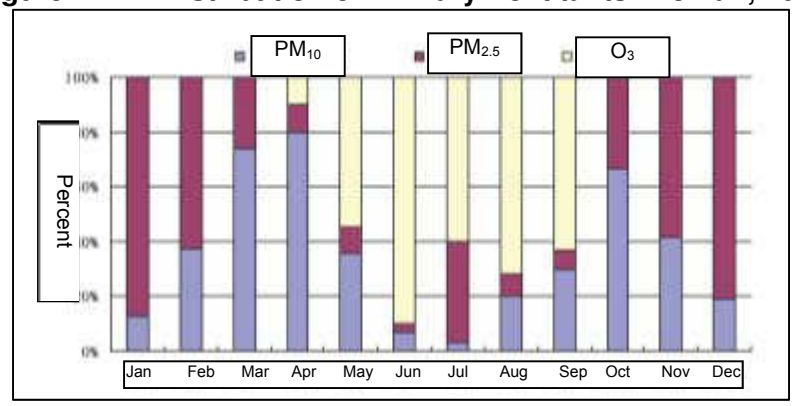


Source: Jinan Environmental Quality Bulletin (2016).

113. In 2016 PM_{10}, $PM_{2.5}$ and O_3 were identified as primary pollutants on 127, 126 and 102 days respectively. Fine particulates are more frequently primary pollutants in the heating season (November to February) due to coal based heating, and less so in the summer. O_3 is generally identified as the primary pollutant from May to September, with the highest level in June (**Figure IV-14)**.

[24] Note: CO standard applicable to 95th percentile of data.

Figure IV-14: Distribution of Primary Pollutants in Jinan, 2016



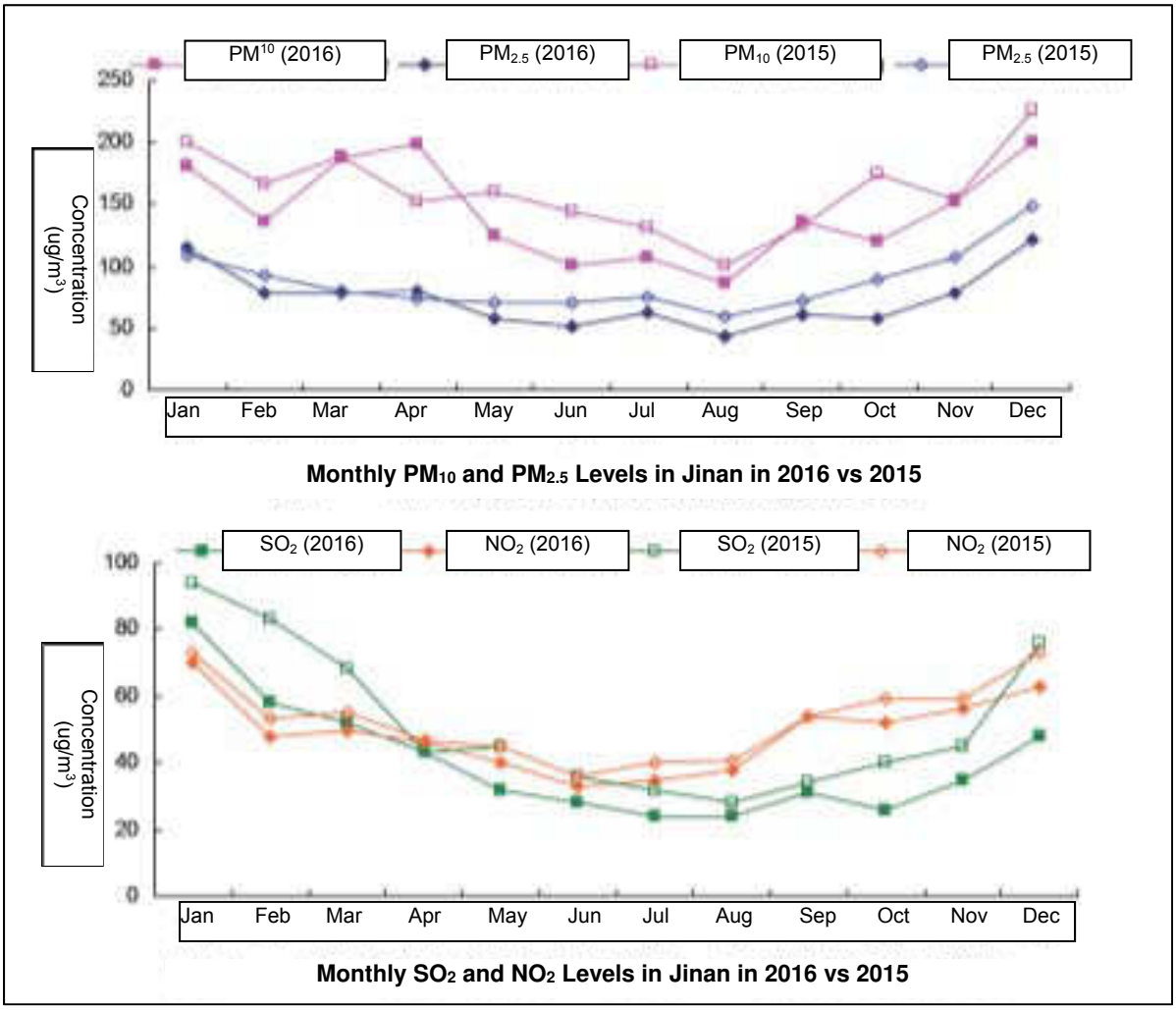
Source: Jinan Environmental Quality Bulletin (2016).

114. In 2016, MEP ranked Jinan's AQI ninth from the bottom of a list of 74 key environmental protection key cities.

115. **Monthly variation of pollutants.** Pollutant levels in Jinan vary substantially over a year, with concentrations typically being higher during the winter heating season and lower in the summer. In 2016 the monthly average concentration of PM_{10} in the worst month (December) was 2.3 times higher than in the lowest month (August). Similarly, the monthly average concentration of $PM_{2.5}$ in December was 2.84 times that of the month with lowest average concentration (August). The monthly average concentration of SO_2 in the worst month (January) was 3.42 times higher than in the lowest months (July, August), and the monthly average concentration of NO_2 in the worst month (January) was 2.12 times higher than in the lowest month (June).

116. Compared with 2015, PM_{10} concentrations in Jinan in 2016 were higher in April, consistent in March, September and November, and lower in the remaining months; $PM_{2.5}$ concentrations were higher in January and April and lower in the remaining months; SO_2 concentrations were consistent in April and lower in the remaining months; and NO_2 concentrations were consistent in December and lower in the remaining months (**Figure IV-15**).

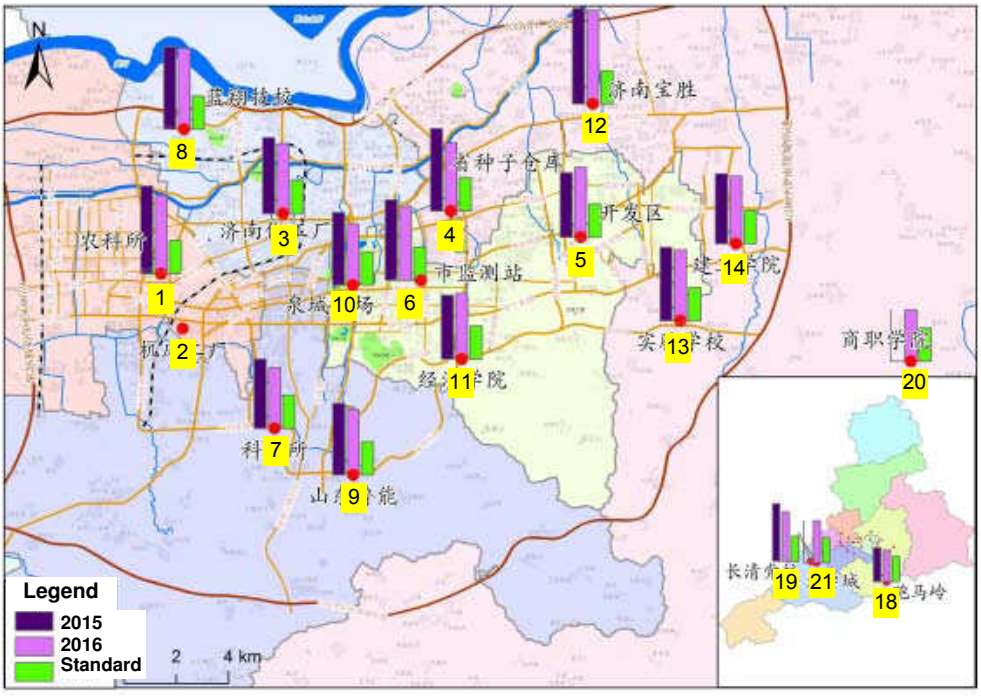
Figure IV-15: Average Monthly Concentration of $PM_{2.5}$, PM_{10}, SO_2 and NO_2 in 2015 and 2016



Source: Jinan Environmental Quality Bulletin (2016).

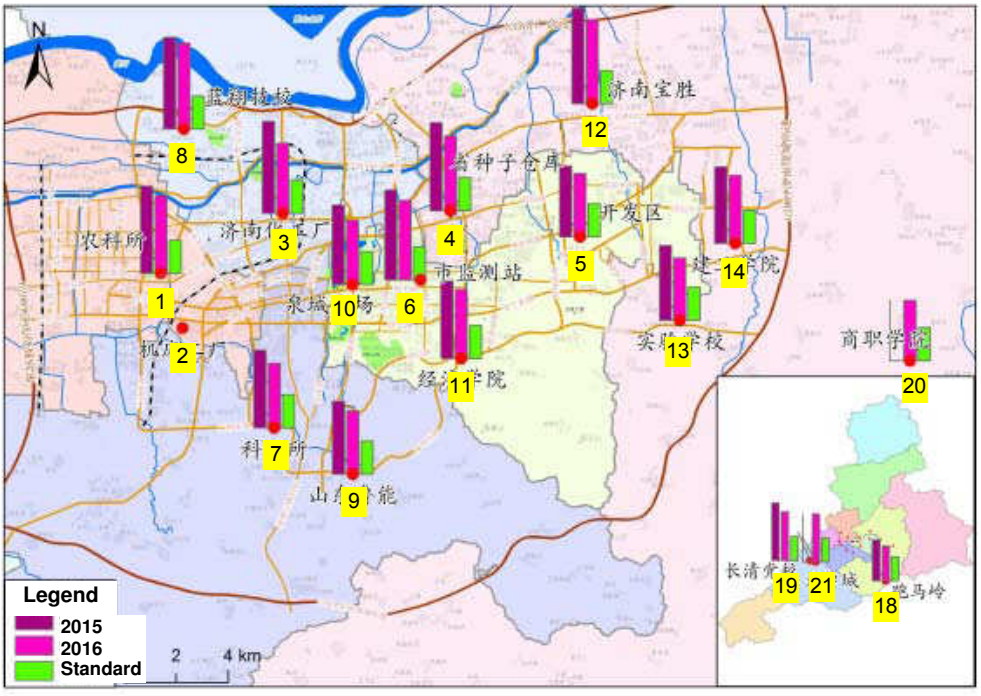
117. **Spatial variation of pollutants.** According the Jinan Environmental Bulletin, in 2016 the annual average concentration of PM_{10} exceeded the Class II annual standard (*Ambient Air Quality Standard* GB3095-2012) at all monitoring stations, and was highest in northeast, northwest and central core area and lowest in the south and southeast (**Figure IV-16**). The annual average concentration of $PM_{2.5}$ exceeded the Class II annual standard at all monitoring stations, and was also highest in northeast, northwest and central core area, and lowest in the south (**Figure IV-17**).

Figure IV-16: Average Annual Concentrations of PM_{10} at National, Provincial, and Municipal Monitoring Stations in Jinan City urban area, 2015 and 2016



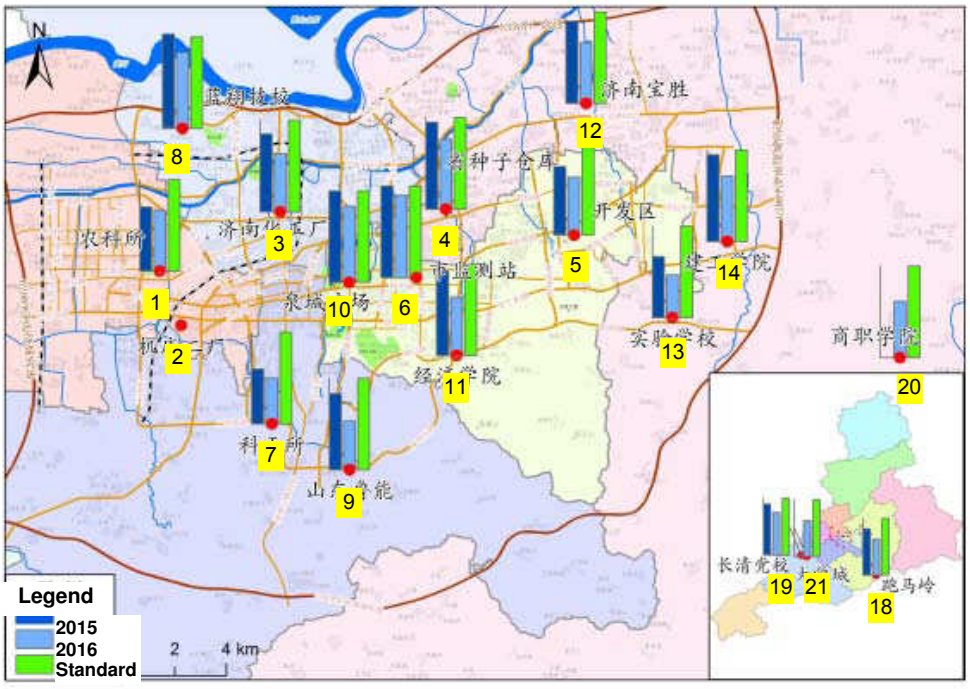
Source: Jinan Environmental Quality Bulletin (2016).

Figure IV-17: Average Annual Concentrations of $PM_{2.5}$ at National, Provincial, and Municipal Monitoring Stations in Jinan City Urban Area, 2015 and 2016



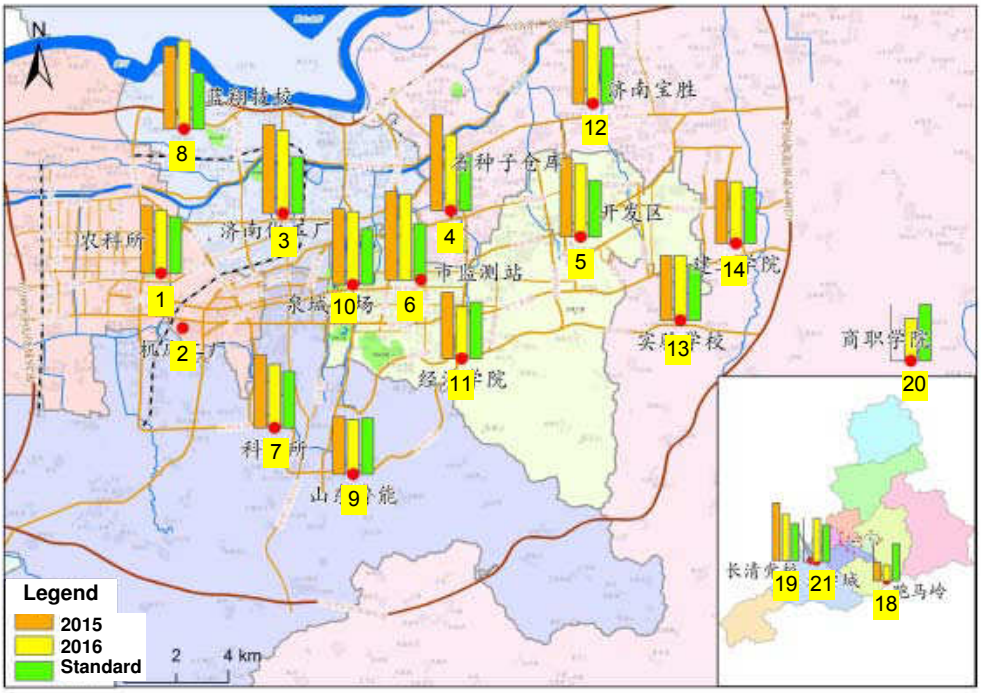
Source: Jinan Environmental Quality Bulletin (2016).

Figure IV-18: Average Annual Concentrations of SO_2 at National, Provincial, and Municipal Monitoring Stations in Jinan City Urban Area, 2015 and 2016



Source: Jinan Environmental Quality Bulletin (2016).

Figure IV-19: Average Annual Concentrations of NO_2 at National, Provincial, and Municipal Monitoring Stations in Jinan City Urban Area, 2015 and 2016



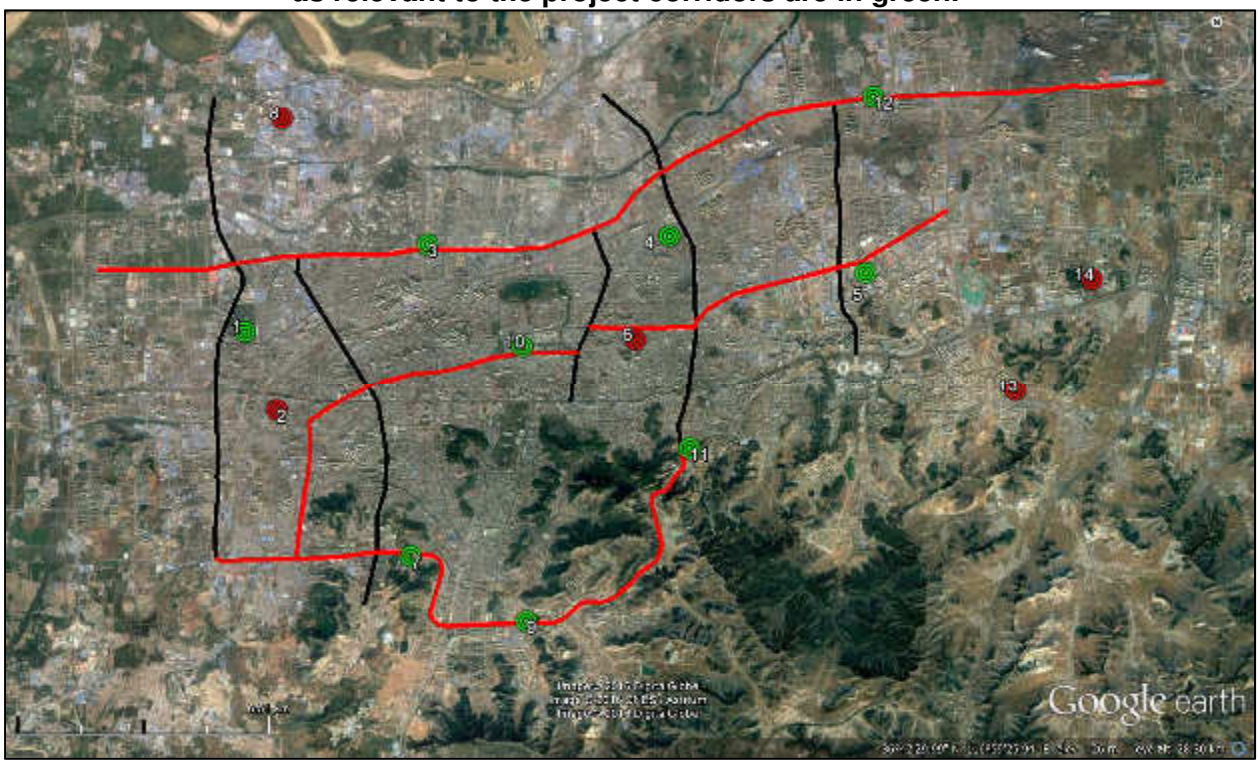
Source: Jinan Environmental Quality Bulletin (2016).

118. The annual average concentration of SO_2 met the Class II annual standard at all monitoring stations and was highest in the northwest and central core area, and lowest in the southeast (**Figure IV-18**). The annual average concentration of NO_2 exceeded the Class II annual standard at all monitoring stations, and was highest in the northwest and central core area, and lowest in the southeast (**Figure IV-19**).

119. **Haze.** In 2016, 180 days were considered to be hazy, of which 81.1% were slightly hazy, 15.0% were mildly hazy, 1.1% were medium hazy, and 2.8% were seriously hazy. During hazy days the average concentrations of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 were 181 μg/m^3, 99 μg/m^3, 44 μg/m^3, and 56 μg/m^3. SO_2 was in compliance with Class II annual standard (*Ambient Air Quality Standard* GB3095-2012), and the PM_{10}, $PM_{2.5}$ and NO_2 exceeded the standard by 1.59 times, 1.83 times and 0.4 times, respectively.

120. **Air quality - project area.** Of the 21 provincial and municipal automated air quality monitoring stations in the Jinan City proper area, 14 are in the main urban area, and 9 are in close enough proximity to the trolley bus rapid transit corridors as to be directly considered relevant to the project (within 400 or less of a project corridor) (**Figure IV-20**). Summary monitoring results for 2016 are presented in **Table IV-3**.

Figure IV-20: Air Quality Monitoring Stations in Jinan City Urban Area. Stations selected as relevant to the project corridors are in green.



Source: JEPB (2017).

Table IV-3: Ambient Air Quality Comprehensive Index and 24-hour Mean Ambient Air Quality at Monitoring Stations in Project Area, Jinan City, 2016. Shading denotes exceedance of the relevant Class II standard (*Ambient Air Quality Standard* GB3095-2012).

(unit: μg/m^3, excluding CO)

#	Name of Station	District	# of Good AQI Days	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO (mg/m$_3$)	O_3 (8 hour)
1	Agricultural Science Institute	Huaiyin	144	165	82	40	45	2.7	186
3	Jinan Chemical Factory	Tianqiao	170	147	74	38	59	2.4	178
4	Provincial seed warehouse	Licheng	136	144	79	46	54	2.7	208
5	Development area	Gaoxing	176	148	67	38	52	2.2	160
6	Municipal monitoring station	Lixia	140	156	84	54	61	2.5	187
7	Cadre's Sanitarium	Shizhong	186	128	68	30	45	2.2	164
9	Shangdong Luneng	Shizhong	175	138	67	32	39	1.9	186
10	Quancheng square	Lixia	186	129	68	50	52	2.7	182
11	Economic college	Lixia	149	139	73	38	37	1.6	202
12	Jinan Baosheng	Licheng	104	198	89	40	57	2.4	177

Source: JEPB (2017).

121. The results show that air quality in the project corridors is poor, with 24-hour mean concentrations of PM_{10}, $PM_{2.5}$ and NO_2 exceeding PRC standards.

122. **Water quality.** There are both groundwater and surface water sources of drinking water in Jinan.

123. **Groundwater.** In 2016, 39 parameters were monitored at the Dongjiao and Dongyuan Water Plants, both of which utilize groundwater as a source of drinking water. The Dongjiao Water Plant achieved the Class III standard of *Underground Water Quality Standard* (GB/T 14848－93), and compared with 2015 NH_3-N and fluoride concentrations decreased slightly while total hardness, sulfate, permanganate index, NO_3-N and electrical conductivity increased slightly. The Dongyuan Water Plant also achieved the Class III standard, and compared with 2015 the permanganate index decreased slightly while total hardness, sulfate, NH_3-N, NO_3-N, fluoride concentration and electric conductivity increased slightly (**Table IV-4**).

Table IV-4: Monitoring Results of Groundwater at Water Supply Plants

(Unit: μg/L)

Name	Year	pH	Total hardness	Sulfate	Permang-anate index (IMn)	Nitrate nitrogen NO_3-N	Nitrite nitrogen NO_2-N	Ammonia Nitrogen (NH_3-N)	Fluoride	Electrical Conductivity
1. Dongjiao water supply plant	2016	7.39	405	89.58	0.69	9.35	undetected	0.026	0.282	94.5
	2015	7.43	378	77.54	0.62	8.80	undetected	0.030	0.284	83.8
2. Dongyuan water supply plant	2016	7.40	387	90.00	0.64	10.80	undetected	0.028	0.255	84.7
	2015	7.47	382	89.26	0.65	10.39	undetected	0.027	0.251	82.3
Class III Standard, *Underground Quality Standard* (GB/T 14848－93)		6.5-8.5	≤450	≤250	≤3.0	≤20	≤0.02	≤0.2	≤1.0	—

Source: JEPB (2017).

124. **Main springs.** Monitoring of 24 parameters is undertaken for the four big spring groups (Baotu, Heihu, Wulong and Zhengzhu) in January and July. All parameters for 2015 and 2016 complied with the Class III standard of *Underground Water Quality Standard* (GB/T 14848－93) (**Table IV-5**).

Table IV-5: Water Quality Monitoring Results for the Four Main Spring Groups, Jinan City Urban Area, 2015 and 2016. (Unit: μg/L, except pH)

Name	Year	pH	Total hardness	Sulfate	Permang-anate index (IMn)	Nitrate nitrogen NO_3-N	Nitrite nitrogen NO_2-N	Ammonia Nitrogen (NH_3-N)	Fluoride
1. Baotu	2016	7.62	344	78.3	0.77	8.93	0.003	0.025	0.203
	2015	7.51	339	84.55	0.71	9.39	0.006	0.042	0.218
2. Heihu	2016	7.58	380	92.4	0.57	10.79	0.003	0.025	0.214
	2015	7.50	381	101.50	0.60	12.20	0.003	0.029	0.216
3. Wulong	2016	7.67	319	84.6	0.83	7.18	0.004	0.053	0.266
	2015	7.52	302	80.80	0.85	7.02	0.009	0.046	0.267
4. Zhenzhu	2016	7.71	306	84.9	1.00	6.54	0.005	0.030	0.312
	2015	7.73	295	86.65	0.90	6.14	0.005	0.052	0.305
Class III standard, Underground Water Quality Standard		6.5-8.5	≤450	≤250	≤3.0	≤20	≤0.02	≤0.2	≤1.0

Source: JEPB (2017).

125. **Surface water.** Key surface water bodies in Jinan City include the Yellow River (Jinan section), the Xiaoqing River (Jinan section) and its tributaries (including the Tuhai River located to the north of the Yellow River, outside the project assessment area), Daming Lake and a number of reservoirs. Both the Yellow River and the Xiaoqing River (at Mulizhuang, outside of the project assessment area) are drinking water sources, and both should comply with the Class III standard of the *Surface Water Environmental Quality Standard (GB3838－2002).*The urban sections of the Xiaoqing River and its tributaries are primarily used as a source of landscape water, while the Huanxiangdian section downstream as well as its tributary are agricultural water, all of which should comply with Class V standard of the *Surface Water Environmental Quality Standard (GB3838－2002).* Daming Lake is classified for non-contact entertainment water, and should with

the Class IV standard of the *Surface Water Environmental Quality Standard (GB3838—2002).* The reservoirs are drinking water sources, and should comply with the Class III standard.

126. **Table IV-6** presents a summary of water quality compliance with Surface Water Environmental Quality Standard (GB3838—2002), Jinan City, 2016.

(i) A total of 21 sections of Yellow, Xiaoqing and Tuhai rivers are monitored on a monthly basis for 26 parameters. Of these sections, 15 have reached class III standard. The water quality of Yellow River (Jinan Section) is in compliance with class III standard of the *Surface Water Environmental Quality Standard (GB3838—2002).* The annual average concentrations of COD and NH_3-N of the Mulizhuang section of the Xiaoqing River were respectively 12.3 μg/L and 0.51 μg/L, both of which complied with class III standard. The majority of Xiaoqing River tributaries in Jinan City in 2016 were not in compliance with relevant standards, primarily for COD and NH_3-N.

(ii) In 2016, a total of 109 parameters were monitored at the various reservoirs; Jinxiuchuan Reservoir reached class II standard except for total nitrogen, and Queshan, Yuqing Lake, Wohushan and Langmiaoshan reservoirs reached class II standard except for total phosphorus and total nitrogen. All reservoirs are suitable water sources with stable water quality.

(iii) In 2016, water quality in Daming Lake was in compliance with class IV standard, thus meeting the requirements of landscape and entertainment use. Compared with 2015, the concentration of total nitrogen increased 8.9%, and the lake is slightly to moderately eutrophic.

(iv) There are three monitoring sections in Lixiating, Wumingting, and Huiboqiao reservoirs, and 34 parameters are monitored each month. Of the main parameters, the annual average concentrations of DO, COD, NH_3-N, total phosphorus and total nitrogen were 8.12 μg/L, 11.2 μg/L, 0.153 μg/L, 0.042 μg/L, 7.04 μg/L respectively, and the annual average transparency was 82.5 cm. With the exception of total nitrogen, all parameters met Class IV standard of the *Surface Water Environmental Quality Standard (GB3838 — 2002)*. The Queshan, Yueqing, Jinxiuchuan, Wohushan and Langmaoshan reservoirs all met the Class III standard of the *Surface Water Environmental Quality Standard (GB3838—2002).*

127. Monitoring locations are presented in **Figure IV-21**.

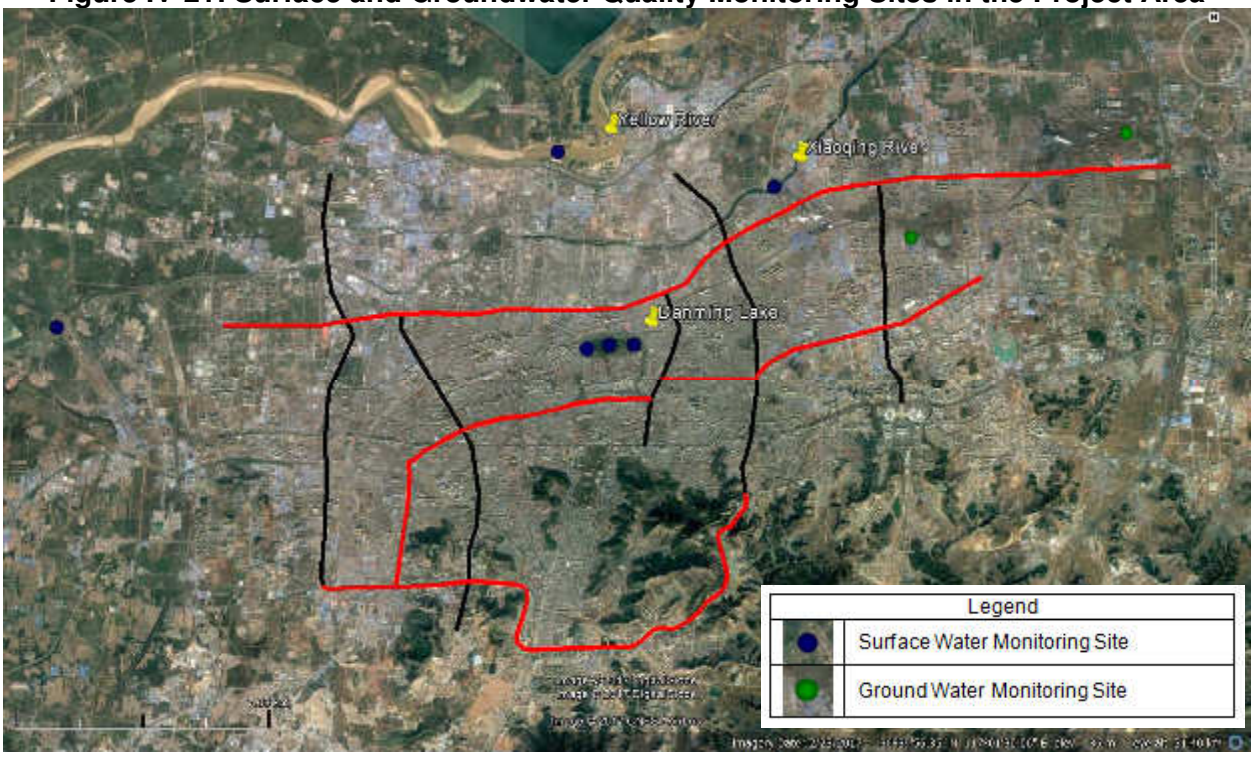
Table IV-6: Summary of Water Quality in Compliance with Functional Zoning for Surface Waters, *Surface Water Environmental Quality Standard (GB3838—2002)*, Jinan City, 2016

Water Body		Section	Applicable Standards	Compliance Status	Actual Water Quality Level	Exceedance Parameters
Yellow River		Luokou	Drinking water source protected area (Class III)	Yes	Class III	——
Xiaoqing River	Main stream	Mulizhuang	Water source protected area (Class III)	Yes	Class III	
		Huanxiangdian	Landscape (Class V)	No	worse than Class V	NH_3-N, TP
		Damatou	Landscape (Class V)	No	worse than Class V	NH_3-N, TP
		Xinfengzhuang	Agriculture (Class V)	No	worse than Class V	NH_3-N, TP
			Provincial control assessment section on transboundary rivers	No	——	NH_3-N
	Branches	Luohe Xiahouqiao	Class V	No	worse than Class V	TP
			Provincial control assessment section on transboundary rivers	Yes	——	
		Zhangqigou Wanghudong village	Class V	No	worse than Class V	TP
			Provincial control assessment section on transboundary rivers	Yes	——	
Daming Lake		Lixiating, Wumingting, Huiboqiao	Non- human body direct contact with recreational water area (Class IV)	Yes	Class III	——
Queshan Reservoir		Inlet, Outlet	Drinking water source protected area (Class III)	Yes	Class III	——
Yueqing Reservoir		Inlet, Outlet	Drinking water source protected area (Class III)	Yes	Class III	——
Jinxiuchuan Reservoir		Inlet, Outlet	Drinking water source protected area (Class III)	Yes	Class II	——
Wohushan Reservoir		Inlet, Outlet	Drinking water source protected area (Class III)	Yes	Class III	——
Langmaoshan Reservoir		Inlet	Drinking water source protected area (Class III)	Yes	Class II	——
		Outlet	Drinking water source protected area (Class III)	Yes	Class III	——

Source: JEPB (2017).

128. **Table V-7** and **Table V-8** present more detailed water quality data for the two key water bodies in the project area, Xiaoqing River and Daming Lake. The results show some standard exceedances likely due to untreated domestic wastewater and non-point source pollution.

Figure IV-21: Surface and Groundwater Quality Monitoring Sites in the Project Area



Source: Jinan Environmental Quality Bulletin (2016).

Table V-7: Monitoring Results of Xiaoqing River in 2016

Unit mg / L

Water body	Monitoring points	Coordinates	COD	Ammonia nitrogen (NH3-N)
Xiaoqing River	Mulizhuang section (Source section, Applicable to Class III)	116.8385 E, 36.6778 N	12.3 (In compliance)	0.51 (In compliance)
	Class III standards		20	1.0
	Huanxiangdian section (Applicable to Class V)	117.3981 E, 36.9468 N	Non-compliance	In compliance
	Class V standard		40	2.0

Note: There is no specific monitoring data for Huanxiangdian section.
Source: Jinan Environmental Quality Bulletin (2016).

Table V-8: Monitoring Results of Daming Lake in 2016

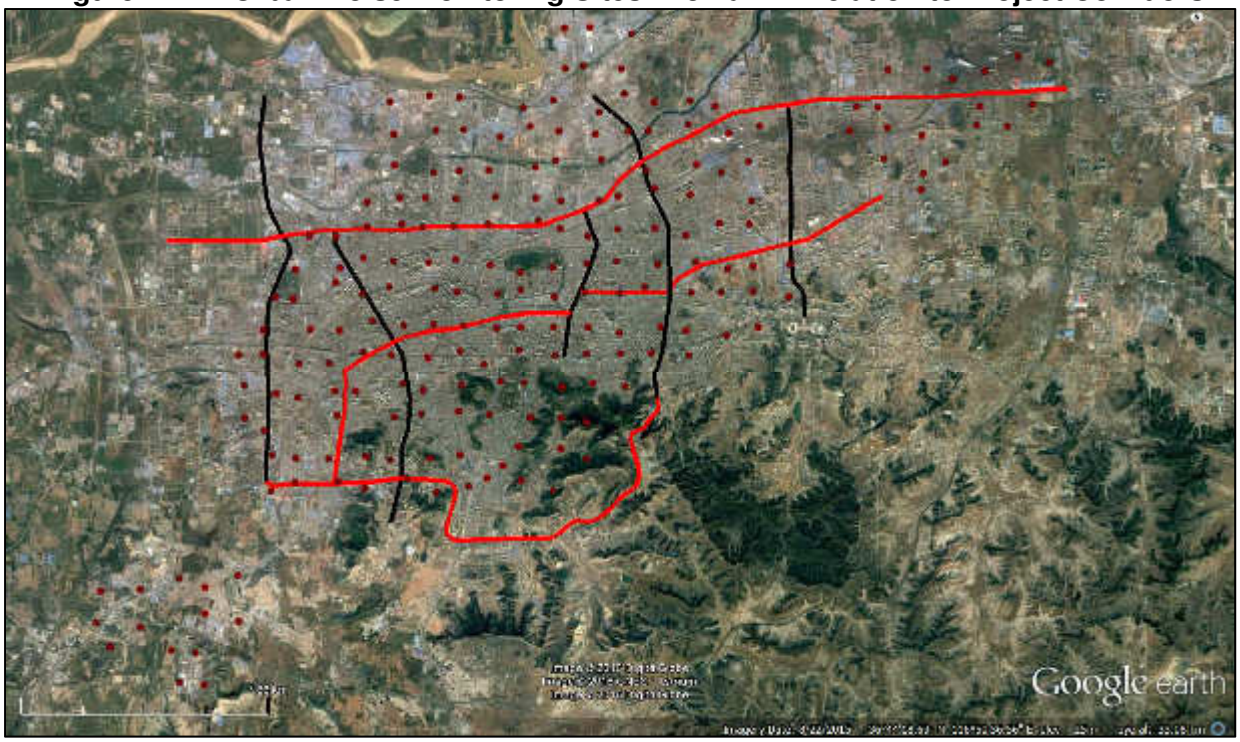
Unit mg / L

Water body	Section	DO	COD	Ammonia nitrogen (NH3-N)	Total phosphorus (TP)	Total nitrogen (TN)
Daming Lake	Lixiating, Wumingting, Huiboqiao (Applicable to Class IV)	8.12	11.2	0.153	0.042	7.04
Class IV standard		3	30	1.5	0.1	1.5
Compliance status		Non-compliance		In compliance		Non-compliance

Source: Jinan Environmental Quality Bulletin (2016).

129. **Urban noise.** There were 214 urban noise monitoring sites in Jinan in 2016 (**Figure IV-22**). The annual average 12-hour daytime noise level in 2016 was 53.1 dB(A), which complies with the Class I standard of *Environmental Quality Standard for Noise (GB3096—2008).*

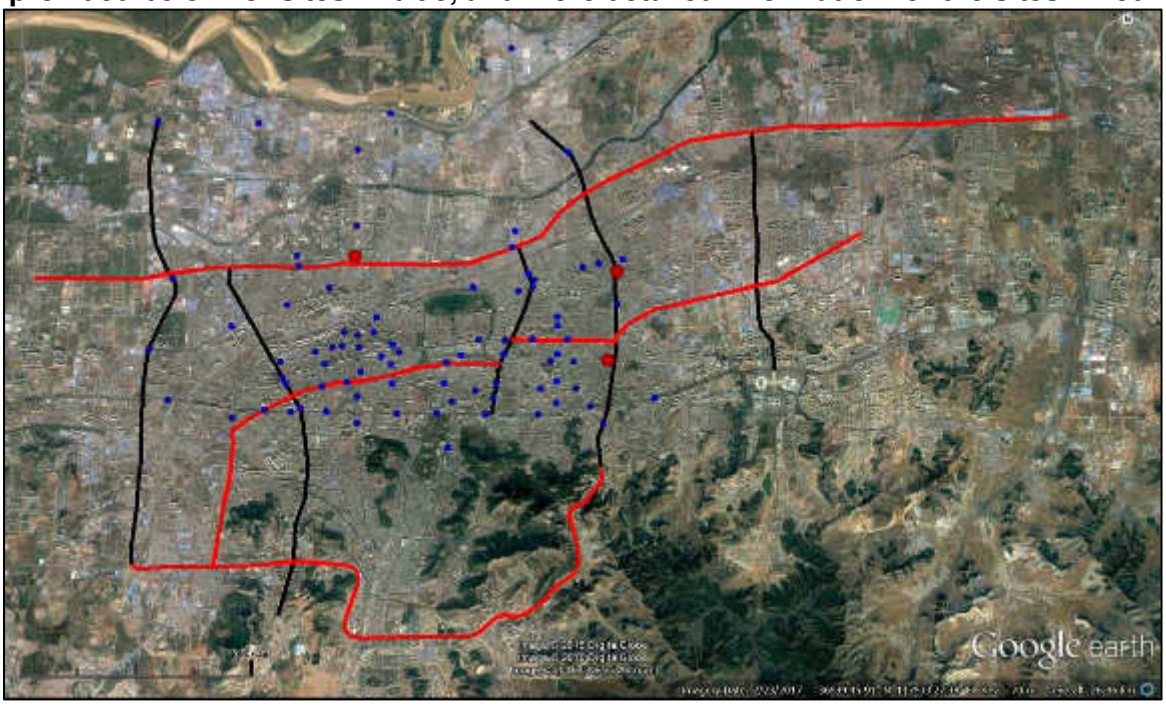
Figure IV-22: Urban Noise Monitoring Sites in Jinan in Relation to Project Corridors



Source: JEPB (2017).

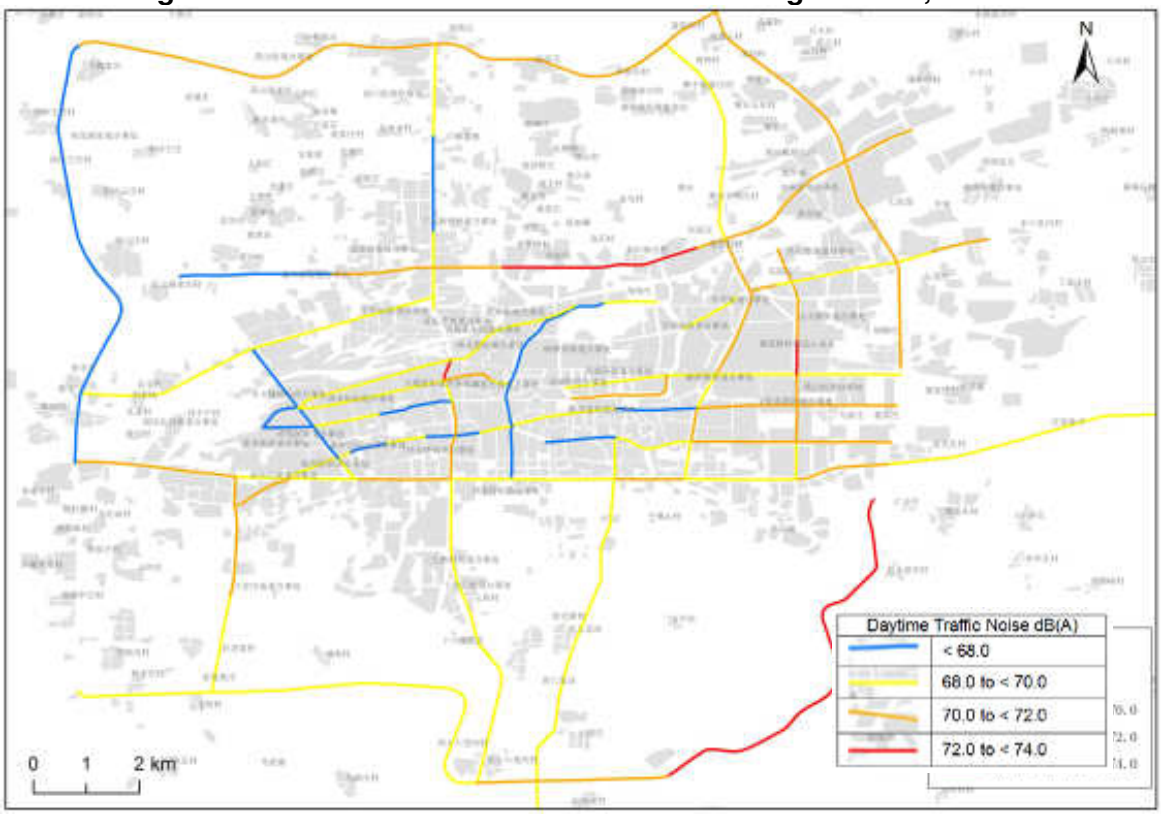
130. **Traffic noise.** Traffic noise in Jinan is monitored on 95 road sections of 39 urban trunk roads totaling 166.6 km in length (**Figure IV-23**). The results show that the overall average daytime traffic noise is 69.8 dB(A) which marginally complies with the Class 4a standard of *Environmental Quality Standard for Noise (GB3096—2008) of 70 dB(A),* applicable to urban trunk roads. *C*ompared with 2015 the traffic noise level has decreased 0.2 dB(A). Of the 39 urban trunk roads, 25 (64.1%) comply with the Class 4a standard (**Figure IV-24).**

Figure IV-23: Urban Core Traffic Noise Monitoring Sites in Jinan. Summary information is provided below for sites in blue, and more detailed information for the sites in red.



Source: JEPB (2017).

Figure IV-24: Results of Traffic Noise Monitoring in Jinan, 2016



Source: JEPB (2017).

131. **Figure IV-23** also shows the location of traffic noise monitoring conducted in 2016 at sensitive receptors at three sites on the project trolley BRT corridors (the stations are denoted in red). **Table V-9** presents the results, which show that noise levels at the sensitive receptors on both roadsides exceeded the Class 4a daytime noise standard of 70 dBA in *Sound Environmental Quality Standards* (GB3096-2008).

Table IV-9: Results of Noise Monitoring at Three Sites along Project Trolley Bus Rapid Transit Corridors

Trolley Bus Rapid Transit Corridor	Sensitive Receptors	Latitude and longitude	Date and Time	Leq	L10	L50	L90
V4-Second Ring East Road	Honglou Community	117.0801E 36.6877S	2016.5.16 daytime	71.0	73.2	69.0	66.2
V4-Second Ring East Road	Xunliu 1st Elementary School	117.0754E 36.6669S	2016.5.13 daytime	71.4	75.0	69.7	64.4
H1-Beiyuan Ave.	Qinnianjuyi Community	117.0143E 36.6907S	2016.5.16 daytime	72.9	75.6	71.4	68.0

Source: JEPB (2017).

C. Ecology and Sensitive Resources

132. **Ecology.** Jinan City (the full extent of the administrative boundary, including 6 districts and 4 counties or county level cities) is home to a reported 1,175 plant species in 149 families. This includes 12 families and 18 species of fern; 7 families and 21 species of gymnosperm; 106 families and 870 species of dicotyledon; and 24 families and 266 species of monocotyledon. There are 382 known species of wild plants, accounting for 33% of the total number of plant species; and 793 species of cultivated plants, accounting for 67% of the total. The fauna resources of Jinan include wild terrestrial and aquatic species typically associated with Yellow River watershed.

133. All project sites are within the Jinan urban core in highly developed and modified industrial, commercial and residential and urban environments. Project works for trolley bus corridor and stations will be undertaken within existing road right-of-ways. Trolley bus depot works will rehabilitate 8 existing sites and create 8 new depots on existing urban land, including the creation of a Command and Control center at one of the existing depots. Traction substations will be established on vacant state-owned land and road side landscaping, often within the road RoW.

134. Original vegetation cover at these sites has been previously removed, and existing site vegetation is either completely absent as they are developed industrial sites, disturbed dirt with little or no vegetation cover, or low value roadside landscaping with low grasses and bushes (**Appendix B, Tables 1** and **2**). A review of records by the Jinan Landscape Bureau indicates that there is one historic tree, an estimated 200-year-old Chinese scholar tree (*Sophora japonica)*, located at the southern end of corridor V5. No other historic trees were identified.

135. Based on the DEIA, site surveys and records review, other than the above noted historic tree there are no known rare or endangered flora or fauna, species with international, national or

provincial protection status, areas of natural or critical habitat,[25] parks, nature reserves, or areas with special national, regional or local ecological significance within or adjacent to any of the sites. There are also no known drinking water sources, scenic sites, or, based on both sites surveys and a review of relevant literature, sites with Physical Cultural Resources (PCRs).[26]

136. **Sensitive receptors.** The domestic EIT report identifies 335 sensitive receptors for air and noise impacts in the project trolley bus rapid transit corridors zone of influence, including 89 schools, 37 hospital, and 209 residential areas, as summarized in **Table IV-10**.[27]

137. The EIT also the following water resources as sensitive receptors: 100 m upstream to 1000 m downstream of the trolley bus corridors bridge crossings on the Xiaoqing River; and, Daming Lake, Batou Springs and other springs in the vicinity of the trolley bus rapid transit corridors designated for protection under the *Jinan Spring Protection Regulation* (2005, draft revision in 2016). It should be noted that there are no drinking water intakes at any of these rivers and springs within the project zone of influence.

138. Sensitive receptors are given special attention in the assessment of impacts (Section V) and the EMP (Appendix A).

D. Socioeconomic Conditions

139. **Jinan City.** The project is located in the central urban area of Jinan. Key features include:

(i) **Provincial capital.** Jinan is the political, economic, cultural, scientific, educational, and financial center of the province, and has been designated with sub-provincial administrative status since 1994.
(ii) **Famous historic and cultural city.** Jinan is an accredited “famous historic and cultural city” for its long-standing history and culture unique natural landscape. Historic sites include Chengziya Longshan Culture Site, Guo’s Ancestral Temple of Han Dynasty at Xiaotangshan, Four Gates Pagoda of Sui Dynasty, Dragon and Tiger Pagoda of Tang Dynasty, Nine Tops Tower and Luozhuang Han Tomb.
(iii) **Spring City.** Jinan is known as the “City of Springs”, and has a reputation for beautiful scenery. There are 733 known springs in Jinan, of which the most famous are the Baotu, Heihu, Zhengzhu, and Wulong spring clusters.
(iv) **Transportation hub.** Jinan has a well-developed railway, highway and aviation transportation network, and has become an important hub connecting with eastern China, northern China, and the central and western regions.

[25] Natural habitat is land and water areas where the biological communities are formed largely by native plant and animal species, and where human activity has not essentially modified the area’s primary ecological functions. Critical habitat are areas with high biodiversity value, including habitat required for the survival of critically endangered or endangered species; areas having special significance for endemic or restricted-range species; sites that are critical for the survival of migratory species; areas supporting globally significant concentrations or numbers of individuals of congregatory species; areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and areas having biodiversity of significant social, economic, or cultural importance to local communities (Environment Safeguards: A Good Practice Sourcebook, ADB, 2012).

[26] PCRs are broadly defined as covering all types of tangible cultural heritage, including movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic or other cultural significance. PCR are human-made objects, natural features, or a mix of the two. They may be located in urban or rural areas and may be above or below ground or underwater. They may be known and listed on official inventories, but often they are undiscovered (Environment Safeguards: A Good Practice Sourcebook, ADB, 2012).

[27] Project zone of influence is discussed in Section V.

(a) Jinan is one of the 45 national arterial hubs of the highway network. Jinan's own highway network is highly developed with multiple national highway (line 104, 305, 309, 220, Jiqing Expressway and Jingfu Expressway) and provincial highways running through it. Currently a half-day traffic circle is being established with Jinan in the center and connections to all cities within the province.
(b) Jinan is on the Beijing-Shanghai Railway and Jiaozhou-Jinan Railway; Jinan-Handan Railway is connected with Beijing-Kowloon Railway and Beijing-Guangzhou Railway (two major trunk railways). The Beijing-Shanghai high speed railway has already been put into operation.
(c) Jinan Airport's phase 2 extension has been completed.

140. **Population.** Jinan City as a whole has an area of 8,177 km^2 and a population of 7.132 million permanent residents in 2015, of which about 4.8 million live in urban areas, and over 2.8 million are in the main urban center. The urbanization rate is 67.96%, and 49.7% of the population is male and 50.3% female.

141. The project is being implemented in five urban districts: Licheng, Lixia, Tianqiao, Shizhong, and Huaiyin. These five districts have a combined land area of 2,094 km^2 and a combined population of 3.086 million, accounting for 43.3% of Jinan's population.[28]

[28] Jinan Statistical Year Book (2015) and PPTA Poverty and Social Analysis Report (2016).

Table IV-10: Air Quality and Noise Sensitive Receptors along the Trolley Bus Rapid Transit Corridors

No.	Trolley Bus Rapid Transit Corridor	No. of Schools	No. of Hospitals	No. of Residential areas	Key Sensitive Receptors	Direction and Estimated Distance to Corridor Boundary
1	V1. Erhuanxilu	8	5	21	Duandiangongyuan community	East, 20 m
					Jinan Chinese medicine dermatology hospital	West, 51 m
					Jinan City, Meilihu first primary school	East, 72 m
2	V2. Weishierlu-Yangguang-Jiuquzhuang	17	6	39	Lvdixingcheng community	West, 39 m
					People 's Hospital of Huaiyin District, Jinan City	East, 30 m
					Jinan thirty - seventh middle school	East, 18 m
3	V3. Lishan	17	3	10	Lingshan Mingjun phase II community	West, 35 m
					Shandong Province Chest Hospital	East, 39 m
					State Prosecutor College Shandong Branch	East, 24 m
4	V4. Erhuandonglu	15	3	37	Honglou Community	West, 13 m
					Shandong University of Finance and Economics Dormitory	East, 26 m
					Jinan Liuyi children hospital	West, 26 m
					Jinan City the eleventh middle school	West, 57 m
					Xunliu 1st Elementary School	West, 150 m
5	V5. Aoitizhonglu	2	3	10	Xianwen Garden Community North District	East, 43 m
					Shandong Provincial Hospital East District	East, 91 m
					Jinan City the second vocational school	East, 31 m
6	H1. Qingdaolu-Beiyuandajie-Gongyebeilu	15	8	42	Qinnianjuyi Community	North, 46 m
					Quancheng Garden Community	South, 62 m
					Second Hospital of Shandong University	North, 72 m
					Jinan City the sixth middle school	South, 30 m
7	H2. Nanxinzhuang-Gongyenanlu	10	6	34	New World Sunshine Garden Community	North, 35 m
					Jinan City Central Hospital	North, 45 m
					Jinan City seventh middle school	South, 28 m
8	H3. Erhuannanlu	5	3	16	Luneng Linxiucheng community E area	South, 56 m
					Santa Maria Maternity Hospital	North, 56 m
					Shandong Medical College	South, 40 m
Total (335)		**89**	**37**	**209**		

Notes: (i) Air Quality Relevant Standard: Class II, Ambient Air Quality Standard GB3095-2012; (ii) Noise Relevant Standard: WHO Class WHO Class I: Residential, institutional, educational: 55 day and 45 night. Source: EIT (2017), based on satellite imagery.

Table IV-11: Administrative Divisions and Population in the Project Area

Region	Area	Population (1000s)
	Km2	
Lixia	101	603
Shizhong	281	609
Huaiyin	152	403
Tianqiao	259	514
Licheng	1301	957
Total	**2094**	**3086**

Source: Jinan Statistical Yearbook (2016)

142. **Economy and GDP.** In 2015, Jinan's GDP was CNY610.02 billion, a year-on-year increase of 8.1%. Of this, the output value ratio of primary, secondary, tertiary industries was 5.0: 37.8: 57.2. In 2015, Jinan's per capita GDP was CNY85,919, higher than the provincial and national averages (**Table IV-12**) and a year-on-year increase of 7.0%. The five project districts show per capita GDP considerably higher than the provincial average. Tertiary industries dominate the five districts' GDP and show considerable year-on-year growth.

Table IV-12: Comparison of GDP in the Project Area to Shandong Province and PRC

Area	GDP (CNY billion)	Primary Industry		Secondary Industry		Tertiary Industry		Growth Rate	Per Capita GDP (CNY
		Output	%	Output	%	Output	%		
PRC	67,670.8	6,086.3	9.0%	27,427.8	40.5%	34,156.7	50.5%	6.9%	49,351
Shandong	6,300.2	497.9	7.9%	2,948.6	46.8%	2,853.7	45.3%	8.8%	64,168
Jinan City	610.0	30.5	5.0%	230.7	37.8%	348.8	57.2%	8.1%	85,919
Project Area									
Licheng	80.8	48.3	4.9%	330.1	38.8%	429.6	56.3%	8.0%	
Lixia	107.1	0.0	0.0%	15.0	14.0%	92.1	86.0%	8.5%	
Tianqiao	38.5	0.4	1.0%	9.6	24.9%	28.5	74.0%	9.1%	
Shizhong	75.1	0.4	0.4%	12.7	16.5%	62.1	83.1%	8.2%	
Huaiyin	38.7	0.4	1.0%	10.5	27.1%	27.8	71.8%	8.1%	

Source: 2015 Economic and Social Development Statistical Bulletins (National, Shandong, Jinan); Jinan Statistical Yearbook (2015).

143. Per capita disposable income of Jinan urban residents and rural residents was higher in 2015 than the provincial and national averages, and as with the rest of the PRC urban incomes were considerably higher than rural ones (**Table IV-13**).

Table IV-13: Comparison of Per Capita Disposable Income in 2015

	Per Capita Disposable Income (CNY)	
	Urban	Rural
PRC	31,195	11,422
Shandong	31,545	12,930
Jinan	39,889	14,232

Source: Jinan Statistical Yearbook (2015).

144. **Employment.** Jinan's employed population was 3.887 million in 2015, including 718,000 employees in primary industry, 1.247 million in secondary industry, and 1.922 million in tertiary industry, giving an employment ratio for the three industries of 18.5%: 32.1%: 49.5%. In 2015, the registered unemployment rate was 2.0%.

145. **Education**. Jinan had 43 institutions of higher education in 2015, and 536,000 thousand students. Of these, 11 institutions are privately operated with 100,000 students. There are 302,000 students in middle schools and 414,000 students in primary schools.

146. **Public transit and traffic conditions.** The number of vehicles on the roads of Jinan is increasing dramatically. In 2016, 258,000 new vehicles were added, and total vehicle ownership reached 1.824 million vehicles, of which car ownership was 1.742 million, an increase of 16.1%. Private cars were used an average of 2.9 times per day.

147. Currently, the Jinan public transit system includes BRT and regular buses, and Jinan was the first city in the PRC to operate a BRT network. Due to concerns regarding protection of the city's artesian springs, Jinan does not yet have an underground metro system, though work has now begun on three lines, the first of which will be operational in 2019. By the end of 2015, Jinan had a fleet of more than 6,340 buses operating on 247 routes, providing more than 2.4 million trips each day. However, since 2011, the percentage of total commuter trips being served by public transit is falling, and in 2013 it was only 18%, down by 4.8% from 2011. Although overall transit ridership is declining, daily BRT ridership increased from 170,000 in 2008 to 240,000 in 2012. However, the BRT network does not yet cover the major traffic corridors, and for a large belt shaped city, the existing transit system is not competitive enough to reduce traffic congestion.

148. Jinan's rapid urbanization and growth in the car ownership and inadequate public transportation network has led to traffic congestion and associated air pollution. In the first quarter of 2016, Jinan overtook Beijing to become the most congested city in the PRC. The ranking is based on a "delay index" calculated by analyzing data collected from devices installed on vehicles that can record their speed and location. The index reading for Jinan was 2.097, 1.979 for Beijing, and 1.789 for Shanghai. An index reading of 2.0 indicates that a commuter spends twice as much time on a trip as on a normal day.[29] The JEPB reports that 15% of $PM_{2.5}$ in Jinan's urban area comes for auto emissions.

149. **Wastewater treatment and solid waste management.** The Jinan urban area has five urban wastewater treatment plants (WWTPs) and 11 smaller domestic wastewater treatment stations, with a total capacity of 0.84 million m^3/d. They are served by a pipeline network including 1,300 km of sewers, 950 km of storm water lines, and 20 pump stations (Jinan Municipal Utilities Bureau, 2017). According to 2015 and 2016 JEPB monitoring data, the effluent of all the 16 WWTPs and stations is generally in compliance with applicable standards.

150. In 2015, the urban area of Jinan handled 1,858,000 tons of domestic solid waste, of which 844,500 tons was incinerated and 613,500 tons landfilled (Information on Environmental Pollution Prevention and Control of Solid Waste, JEPB).

[29] *An Analysis Report of Traffic in Major Chinese Cities in the First Quarter of 2016*, co-released by AutoNavi Software Co, and the Sustainable Transport Research Institute, Tsinghua University. 2016.

V. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Project Zone of Influence and Assessment of Impacts

151. The project zone of influence is defined as:

(i) 200 m to either side of the centerline of the 111.2 km of zero-emission high quality BRT trolley bus corridors (this includes all trolley bus stations);
(ii) 100 m upstream to 1,000 m downstream of the trolley bus corridors bridge crossings on the Xiaoqing River;
(iii) the 8 existing and 8 new trolley bus depot sites (one of which includes a Command and Control Center site); and
(iv) the 40 traction substation sites (if not already within the trolley bus corridor zone of influence).

152. The project zone of influence is presented in **Figure V-1**.

Figure V-1: Project Zone of Influence

Sources: FSR (2017), EIT (2017), Google Earth (2017), and PPTA consultants.

153. Potential negative and positive impacts within the project zone of influence were assessed. Pre-construction, construction phase, and operation phases were each considered separately.

B. Anticipated Impacts Associated with Project Location, Detailed Design and Pre-Construction Phase

154. **Siting and land acquisition.** Project construction will require some, albeit very limited, temporary and permanent land acquisition. Land will be used temporarily for staging construction works or for the storage and disposal of excavated spoil; however, these lands will be within the permanent land acquisition or occupation area and hence no compensation will be required for temporary land occupation. The BRT trolley bus corridors, BRT stations and power lines will be within the RoW of the existing roads, and will not require any land acquisition. The only project activities requiring land acquisition will be construction of traction substations and trolley bus depots.

155. The project will construct 40 traction substations on vacant state-owned land and road side landscaping. A total of 4.8 mu (0.32 ha) land will be permanently acquired, but no persons will be affected and no resettlement is required.

156. The project will upgrade 8 existing depots and construct 8 new ones. According to the FSR and confirmed by surveys, 398.7 mu (26.58 ha) of land will be required by the bus depots, of which, 374.1 mu (24.94 ha) are state-owned land and 24.6 (1.64 ha) mu are collective land. Of the state-owned land, land use certificates have been obtained or appropriated by the government for 213 mu (14.2 ha) for 9 depots, and for the remaining 161.1 mu (10.74) for 6 depots, land use certificate must be obtained and compensation payment completed to the pertinent district governments, although these lands are currently being used by the JPTC. No person will be affected by the state-owned land occupation and no resettlement is required.

157. The only depot requiring permanent acquisition of collectively owned land is the Hanyu depot in Nanhu Village, Gaoxin District. A total of 24.6 mu (1.64) will be required, affecting 4 households with 13 persons, including 7 females. The land has been abandoned and is not currently farmed.

158. The following mitigation measures will be implemented:

159. The project has been classified as resettlement category B and a resettlement plan (RP)[30] with time-bound actions has been prepared under a separate process, supported by a due diligence review by ADB social safeguard specialists. The RP includes CNY6.37 million in compensation, including CNY4.35 million (68.2%) for collective land acquisition, CNY0.74 million (11.6%) for young crop compensation; CNY0.7 million (11.1%) for other costs, and CNY0.58 million for contingencies.

160. **Measures to be implemented during detailed design.** The project detailed technical design will:

(i) Ensure land acquisition issue resolved for bus depots.
(ii) Minimize land acquisition for traction power substations on state owned land.
(iii) Ensure public health and safety, promote nonmotorized traffic, and ensure barrier-free access for the disabled.
(iv) Coordinate with Jinan Landscape Department (JLD) for relocation of landscaping trees on trolley bus rapid transit corridors.

[30] Resettlement Plan and Due Diligence Report for the Shandong Spring City Green Modern Trolley Bus Demonstration Project, 2017.

161. **Measures to be Implemented during pre-construction.** A number of environmental management measures will be implemented in the pre-construction phase to ensure the project's environment management readiness. These include:

(i) **Institutional strengthening:**
   a. Recruitment, including (a) appointment of a qualified Environmental and Social Officer (PMO ESO) within the PMO by the IA; (b) contracting of an external Loan Implementation Environmental Consultant (LIEC) by the IA; and (c) contracting of a qualified Environmental Monitoring Station (EMS) or consultant by the IA to conduct environmental quality monitoring.
   b. Prior to the start of construction, the institutional strengthening and training program will be delivered by the LIEC (**Table 6, Appendix A**). The training will focus on ADB's and PRC's relevant environmental, health and safety laws, regulations and policies; implementation of the EMP, environmental monitoring, chance find procedures for PCRs, and the GRM. Training will be provided to the IA, relevant PMO staff, and contractors.

(ii) **Grievance redress mechanism.** In accordance with the GRM (see Chapter VIII and Appendix I), the PMO ESO will assume overall responsibility for the GRM. GRM training will be provided for PMO members and GRM access points. A website will be developed to provide information on the project and the GRM, the PMO will coordinate with government "Hotline" to link to the project level GRM, the PMO will issue public notices to inform the public within the project area of the GRM, and contact information (GRM website address, PMO address and telephone number, PMO contact point email address) for the PMO and local entry points (e.g., contractors) will be disseminated at all major access points. Maintain and update a complaints register to document all complaints.

(iii) **Updating the EMP (if required).** Mitigation measures defined in this EMP and the EMoP will be updated based on final technical design. This will be the responsibility of the PMO Environmental Officer and the LIEC. Submit to ADB/PMO for approval and disclose updated EMP on project and ADB website.

(iv) **Disclosure and consultation.** Information disclosure and consultation activities will be continued with affected people and other interested stakeholders, including but not limited to the project implementation schedule, GRM and status of compensation (if relevant).

C. Anticipated Construction Phase Impacts and Mitigation Measures

162. **Impact screening.** Potential impacts during the construction phase could include air pollution, noise, water pollution, solid waste and poor occupational health and safety practices. Potential air quality impacts could occur due to fugitive dust generated at construction sites from stockpiles of uncovered earth materials, and vehicles hauling materials. The use of powered mechanical equipment (PME) during construction activities will generate noise. Construction activities will generate process wastewater and construction workers will produce wastewater. Wastewater generation is expected to be limited considering the nature and scale of construction. Construction works will produce construction and demolition (C&D) wastes. Workers will face occupational health and safety issues working on construction sites. Potential impacts are assessed and addressed below. Identified impacts can be readily addressed through the application of good construction site practices.

163. As this is an urban project, there will be no worker camps or on-site canteens.

1. Impact on Physical Resources

164. **Soil and spoil.** Construction activities during lane modification include removing and/or relocating the existing road-side landscaping. At new bus depots, leveling and landscaping works will involve earthwork. It migt involve excavation at one new bus depot where current conceptual design of depot building has one ground level. According to the design institute, excavation is expected to be shallow excavation (1.5 m depth or less around 500 square meter building area). For bus corridors, there will be no excavation needed. According to the EIT, approximately 22,143 m^3 of soil and spoil is estimated.

165. To minimize spoil production during construction, good construction soil and spoil management construction practices will be adopted:

(i) Strip and store topsoil in a stockpile for reuse in restoration.
(ii) Temporary spoil storage sites (and storage containers at lane modification and stations construction sites) will be identified, designed, and operated to minimize impacts. Spoil sites will be restored at the conclusion of storage activities.
(iii) Spoil will be reused on-site or other project sites to the maximum extent feasible as fill. Excess spoil that cannot be used on-site will be transported to an approved spoil disposal site.
(iv) Spoil and aggregate piles will be covered with landscape material and/or regularly watered.
(v) Waste construction material such as residual concrete, asphalt, etc., will be properly handled for reuse or disposal.
(vi) Construction and material handling activities will be limited or halted during periods of rains and high winds.
(vii) Any planned paving or vegetating of areas will be done as soon as practical after the materials are removed to protect and stabilize the soil.
(viii) Once construction is complete disturbed surfaces will be properly revegetated with native trees and grass.
(ix) Conduct project completion audit to confirm that spoil disposal site rehabilitation meets required standard, hold contractor liable in case of noncompliance.

166. **Air quality.** Fugitive emission of dust (measured as total suspended particulates [TSP]) during earth works and fumes from asphalting and concrete batching are expected to be the main air pollutants during the construction stage. The PRC *Air Pollutant Integrated Emission Standard* (GB16297-1996) controls the emission of air pollutants from these activities (**Table II-11**).

167. Fugitive dust will be generated on construction sites during earth works from construction activities, uncovered earth material stockpiles on construction sites and temporary spoil storage and disposal areas (and containers), and from vehicles hauling loads, especially if loads are uncovered. The EIT predicts unmitigated compliance with the *Ambient Air Quality Standard* (GB3095-1996) at 150 m downwind of TSP generating activities or locations. With mitigation measures such as frequent watering of unpaved areas and haul roads (7–8 times each day), the EIT estimates that the amount of dust could be reduced by 70% or more and the impact area be reduced to within 100 m downwind of earth work activities. Impacts will be short-term and localized, and in line with typical construction works that occur daily in cities throughout the PRC and the world.

168. Commercial asphalt will be procured negating the need for asphalt mixing on construction sites, and asphalt fumes will only be generated during road paving during lane modification works.

Fumes will contain small quantities of toxic and hazardous chemicals such as volatile organic compounds (VOCs) and poly-aromatic hydrocarbons (PAHs), and may have negative impacts along the trolley bus rapid transit corridors due to their urban nature and associated dense populations and sensitive receptors. Asphalt fumes generated during road paving with commercial asphalt will be considerably less than fumes generated during on site mixing, and according to the EIT, once the paved asphalt is cooled to <82^{o}C asphalt fumes will be reduced substantially and then totally eliminated when the asphalt is solidified. Impacts will thus be short-term in duration, localized in scale, low in magnitude, and in line with typical road works that occur daily in cities.

169. Construction of bus stations, depots, and traction will use ready-mix concrete. Concrete batching for depots, stations and substations structures will produce TSP. According to the EIT, TSP levels from similar construction projects have been found to be approximately 9 mg/m^3, 1.65 mg/m^3 and 0.3 mg/m^3 at distances of 50 m, 100 m and 150 m respectively downwind of concrete batching activities. Compliance with the *Ambient Air Quality Standard* (GB3095-1996) is thus expected to be achieved at 150 m downwind. Again, impacts are expected to be short-term, localized and low-magnitude.

170. The following mitigation measures to suppress dust and fumes at construction sites, backfill areas, storage sites, and haulage will be adopted:

(i) Construction works will be implemented in a phased manner along corridors so as to ensure activities in any one area are of limited duration.
(ii) Particular attention will be paid to dust suppression near sensitive receptors such as schools, hospitals, residential areas, and natural areas.
(iii) Water will be sprayed on sites with the potential to cause fugitive dust including unpaved areas, backfill areas, and unpaved haul roads, as necessary.
(iv) Temporary fencing will be erected around dusty activities.
(v) Construction spoil, aggregate other construction materials will be temporary stored using containers, but they maythe potential to generate dust. Thus, containers will be covered and/or watered if necessary. Powdered materials such as cement and lime will be stored in sealed bags or containers.
(vi) The time construction and demolition wastes are on site will be minimized by regularly removing them off site for disposal.
(vii) Construction and material handling activities will be limited or halted during periods of high winds if nuisance dusts are being generated.
(viii) Trucks transporting earth materials will be equipped with covers or tarpaulin, and will not be overloaded. Fine materials will be transported in fully contained trucks.
(ix) Muddy or dusty materials on public roads outside the exits of works areas will be cleaned immediately.
(x) Transport routes and delivery schedules will be planned to avoid densely populated and sensitive areas, and high traffic times.
(xi) Disturbed sites will be revegetated as soon as possible after the completion of works.

171. Overall, air quality impacts will be short-term (because of the phased construction approach), localized and low in magnitude, and are in line with typical construction or road works undertaken daily in cities throughout the PRC and around the world.

172. **Noise.** Noise will be emitted by powered mechanical equipment (PME) used during construction **Table V-1**. Predicted construction noise attenuation based on combined sound power levels of noise sources is presented in **Table V-2.**

Table V-1: Construction Phase Noise Sources

Construction Activity	Sound Source	Sound Level dB(A)	Nature of Sound Source	Directivity
Earthworks	Bulldozers	78-96	Intermittent	No
	Other vehicles	70-80	Intermittent	No
Pole foundation construction	Pile drivers	70-90	Intermittent	No
	Tampers	70-90	Intermittent	No
Structure fabrication	Concrete mixer trucks	70-85	Intermittent	No
	Vibrators	85-100	Intermittent	No
	Air compressors	85-95	Intermittent	No
	Electric welding machines	90-95	Intermittent	No
	Electric saws	100-110	Intermittent	No
Finishing and equipment installation	Electrodrills	100-110	Intermittent	No
	Electric hammers, hand tools	100-105	Intermittent	No

Source: Domestic EIT (2017).

Table V-2: Predicted Construction Noise Attenuation of Combined Sound Power Levels of Noise Sources

Construction Phase	Noise Levels [dB(A)] at Distances from the Noise Source								
	10m	20m	30m	40m	60m	80m	100m	150m	
Earth works	92	85	81	77	73	70	67	63	60
Pole foundation construction	96	88	85	81	77	74	71	69	64
Structural works	94	87	83	79	75	72	69	65	62
Noise standard at construction site boundary (GB12523-2011)	Day time: 70; Night time (22:00-06:00 hrs): 55								

Source: Domestic EIT (2017).

173. **Table V-2** shows that to comply with GB12523-2011 standards without mitigations, PMEs would have to be located at distances from the construction site boundary in the day time of 80 m during earth works, 100 m during super structural works and 150 m during foundation works. At night, PMEs would have to be located more than 200 m from the construction site boundary. The footprint of a trolley bus corridor construction site is long and narrow and such distance separation is unrealistic.

174. The following mitigation measures will be applied to reduce construction noise to acceptable levels:

(i) Construction activities will be planned in consultation with local authorities and communities so that activities with the greatest potential to generate noise and vibration are planned during periods of the day that will result in the least disturbance.

(ii) Construction will be avoided to the extent possible between the hours of 22:00 and 06:00. However, it is recognized that construction in the trolley bus rapid transit corridors will occasionally require some works to be conducted at night to take advantage of reduced road traffic and/or to avoid worsening day time traffic conditions. In such cases:
  (a) night time construction work should avoid using high sound level power equipment; and
  (b) nearby residents should be notified of such night time activities well in advance.
(iii) Low-noise equipment that conforms to the PRC noise standard GB12523-2011 will be selected as much as possible.
(iv) Equipment and machinery will be equipped with mufflers and will be properly maintained to minimize noise.
(v) Machines in intermittent use will be shut down in the intervening periods between work or throttled down to a minimum.
(vi) Noise personnel protective equipment (PPE) will be provided to workers.
(vii) Transportation routes and delivery schedules will be planned during detailed design to avoid densely populated and sensitive areas and high traffic times.
(viii) Vehicles transporting construction materials or wastes will slow down and not use their horn when passing through or nearby sensitive locations.

175. **Water quality.** Inappropriate disposal of construction wastewater (from construction site runoff, drainage of drilling, washing construction equipment and vehicles, pouring and curing concrete, and oil-containing wastewater from machinery repairs) could potentially pollute nearby water bodies and clog local drains. Workers will generate but limited amount of domestic wastewater.

176. Excavation for bus depots could also affect groundwater and springs if they are too deep. However, the project will only undertake shallow excavations (1.5 m depth or less). Consultations with the JEPB and the JLD confirmed that groundwater depths are typical 10 m or more, and that the shallow excavations to be undertaken by the project, which are considerably shallower than excavations undertaken throughout the city for buildings and municipal utilities, will not have a negative impact on groundwater or springs.

177. To prevent pollution of water resources, the following mitigation measures will be implemented:

(i) Sufficient portable toilets will be provided for the workers and will be cleaned and discharged to the municipal sewerage system on a regular basis.
(ii) Construction wastewater from each site will be directed to temporary detention and settling ponds (at bus depot sites) or tanks (at bus station sites), and then treated water may be recycled for use in dust control or discharged to the local storm drainage network. If needed, polyacrylamide flocculent will be used to facilitate particle settling. All discharged construction wastewater will to be treated to the appropriate PRC standard prior to discharge. Discharged water will then be treated in one of Jinan's 16 municipal WWTPs.
(iii) All necessary measures will be undertaken to prevent construction materials and waste from entering drains and water bodies.
(iv) Maintenance of construction equipment and vehicles will not be allowed on sites to reduce wastewater generation.

178. The above mitigations combined with other EMP mitigations with respect to management of solid and hazardous wastes will ensure protection of groundwater and springs, and are consistent with guidelines presented in the “Jinan Historical and Cultural City Protection Plan” and ”Jinan City Famous Spring Protection Regulations”.

179. **Solid waste.** Solid waste generated during construction will include construction and demolition (C&D) waste dominated by excavated spoil and pavement, and refuse generated by construction workers is 0.1 kg/worker/day. Inappropriate waste storage and disposal could affect soil, groundwater, and surface water resources, and hence, public health and sanitation.

180. The following solid waste management measure will be implemented:

(i) C&D wastes will be reused or recycled to the extent possible. The existing pavement on the zero emission trolley BRT corridors, estimated in the EIT at 103,000 m^3, will be recycled to the maximum extent possible for use as paving materials for the new road surfaces.
(ii) C&D waste dumpsters will be provided at all work sites. C&D waste will be collected on a regular basis by a licensed waste collection company and transported for recycling, reuse, or disposal at a licensed landfill, in accordance with relevant PRC regulations and requirements.
(iii) Littering by workers will be prohibited.
(iv) Domestic waste containers will be provided at all work sites. Domestic waste will be collected on a regular basis by the local sanitation departments and transported for recycling, reuse, or disposal at a licensed landfill, in accordance with relevant PRC regulations and requirements.
(v) Excavated soil will be backfilled onsite to the extent possible. Excess spoil that cannot be used on-site will be transported to an approved spoil disposal site.
(vi) There should be no final waste disposal on site. Waste incineration at or near the site is strictly prohibited.
(vii) Contractors will be held responsible for proper removal and disposal of any significant residual materials, wastes, and contaminated soils that remain on the site after construction.

181. **Hazardous materials.** Inappropriate transportation, storage, use and spills of petroleum products and hazardous materials that might be involved at new bus depot areas can cause soil, surface and groundwater contamination.

182. The following mitigation measures will be implemented:

(i) Some hazardous materials handling and disposal protocol that includes spill emergency response will be prepared and implemented by contractors.
(ii) A spill response plan will be developed, including:
    a. Maintain a stock of absorbent materials (e.g., sand, earth, or commercial products) on site to deal with spillages and training staff in their use.
    b. If there is a spill take immediate action to prevent entering drains, watercourses, unmade ground or porous surfaces. Do not hose the spillage down or use any detergents use oil absorbents and dispose of used absorbents at a waste management facility.
    c. Record any spill events and actions taken in environmental monitoring logs and report to PMO and LIEC.

(iii) Suppliers of chemicals and hazardous materials must hold proper licenses and follow all relevant protocols and PRC regulations and requirements.

2. Impact on Ecological Resources

183. **Flora and fauna, protected area.** All project sites are within the Jinan urban core in highly developed and modified industrial, commercial and residential and urban environments. Project works for trolley corridors and stations will be undertaken within existing road right-of-ways. Bus depot works will rehabilitate 8 existing sites and create 8 new depots on existing urban land, including the creation of a Command and Control center at one of the existing depots. Traction substations will be established on existing undeveloped land often within the road RoW on landscape strips. Original vegetation cover at these sites has been previously removed, and existing site vegetation is typically completely absent as they are developed industrial sites, or in the case of some of the traction substations, have typical grasses and low shrubs. Based on the DEIA and site surveys, there are no known rare or endangered flora or fauna, species with international, national or provincial protection status, areas of natural or critical habitat, parks, nature reserves, or areas with special national, regional or local ecological significance within or adjacent to any of the sites.

184. Construction of the zero emission trolley BRT corridors will require some existing landscape shrubs and small trees to be removed located on the landscape strips between the motor vehicle lanes and the bicycle lanes. Construction may also threaten the only known protected tree in the project zone of influence, a 200-year-old Chinese scholar tree (*Sophora japonica)*, located at the southern end of corridor V5. The site visit confirmed that the 200-year-old tree is located in landscaping area just off the project road corridor, which is well protected with a proper protection signage and fence to limit the access. Other than this tree, ecological impact during construction will be minimal.

185. The following mitigation measures will be implemented:

(i) Detailed design of the low emission trolley bus rapid transit corridors will maximize the retention of trees, and in particular trees with trunk diameters >40 cm.
(ii) Construction working areas will be demarcated to prevent encroachment and damage to adjacent areas.
(iii) Green landscaping will be implemented along trolley corridors and at bus depots and traction substations, including replacement trees and grasses appropriate to local ecological conditions. Locations and species selection to be decided in consultation with the JEPB and JLD.
(iv) No modification will be allowed in the landscaping area where the Chinese scholar tree (*Sophora japonica)*, located at the southern end of corridor V5 is fenced and protected.

186. The maximum retention of existing trees and planting of new trees will improve urban quality, provide shade and screening and is in line with the national vision for Jinan as a demonstration city for the environment.

3. Impact on Socioeconomic Resources

187. **Occupational health and safety.** Construction may cause physical hazards to workers from noise and vibration, dust, handling heavy materials and equipment, falling objects, work on

slippery surfaces, fire hazards, chemical hazards such as toxic fumes and vapors, and others risks.

188. The Contractor's Environment, Health and Safety Officer will develop and implement an Occupational Health and Safety Plan (OHSP), maintain records concerning health, safety and welfare and regularly report on accidents, incidents and near misses. The OHSP will provide adequate precautions to protect the health and safety of their workers, including but not necessarily limited to:

(i) **Construction site sanitation**:
   a. Sites will be effectively cleaned. During site preparation, phenolated water will be sprayed for disinfection if necessary.
   b. Wastes will be removed on a regular basis in accordance with waste management mitigation measures (above).
   c. A clean and sufficient supply of fresh, potable water will be supplied to all work sites. An adequate number of latrines and other sanitary arrangements will be provided at all work sites and cleaned and maintained in a hygienic state, in accordance with water quality mitigation measures (above).

(ii) **Occupational safety.** Workers will be provided with appropriate personal protective equipment (PPE) to workers to minimize risks, including:
   a. Safety hats and safety shoes to all construction workers;
   b. Safety goggles and respiratory masks to workers doing asphalt road paving;
   c. Ear plugs to workers working near noisy PME, especially during piling works.

(iii) **Electrical safety.** Electrical safety risks will be assessed and safety protocols developed.

(iv) **Traffic safety.** Provide appropriate safety barriers and warning signs to ensure safety of workers on roads.

(v) **Medical emergency response.** response procedures will be developed covering both workers and community members (when affected by project related activities), including communication systems and protocols for interaction with local and regional emergency response providers, first aid equipment on site, contact information for the nearest ambulance and medical facilities, training for workers on initial on-site emerge response, protocols for informing and transferring injured workers to local or provincial health centers, and record keeping. At least one trained first-aid worker will be available at each construction site.

(vi) **Emergency response.** response procedures will be developed, including communication systems and protocols for interaction with local and regional emergency response providers, protocols for shutting down power, firefighting response procedures, provision of appropriate firefighting equipment, training for workers on fire response, and record keeping.

(vii) **Training.** An OHS manual will be prepared and disseminated to workers, and training will be provided to workers in all aspects of the OHS plan prior to the start of construction and on a regular basis (e.g. monthly).

189. **Community health and safety.** Traffic congestion may worsen as construction traffic in the urban area increases during rush hours, causing temporary inconvenience to traffic, residents, commercial operations, and institutions and the risk of accidents. The project may also contribute

to road accidents through the use of heavy machinery on existing roads, temporarily blocking pavements for pedestrians etc.

190. Construction sites for the zero emission trolley bus rapid transit corridors will be located close to residential and commercial urban areas, presenting a threat to public health and safety. Assessments of dust and construction noise impacts indicate that with the implementation of mitigation measures described in this report, such impacts will not adversely affect nearby sensitive receptors and the public health of occupants at these sensitive receptors.

191. Construction may require relocation of municipal utilities such as power, water, communication cables, even though Jinan utility bureau confirmed that there will be no impact on most major utility cables and water piles buried under road sides since the project construction activities involves in the middle section of urban trunk roads.

192. To mitigate potential impacts on community health and safety contractors will implement the following measures:

(i) **Temporary traffic management.** A traffic control and operation plan will be prepared together with the local traffic management authority prior to commencement of construction. The plan shall include provisions for diverting or scheduling construction traffic to avoid morning and afternoon peak traffic hours, regulating traffic at road crossings with an emphasis on ensuring public safety through clear signs, controls and planning in advance.
(ii) **Information disclosure.** Residents, businesses, schools and hospitals will be informed in advance through media of construction activities, and be given the dates and duration of expected disruptions.
(iii) **Construction sites.** Signs will be placed at construction sites in clear view of the public, warning people of potential dangers such as moving. All sites will be made secure, discouraging access by members of the public through appropriate fencing whenever appropriate.

193. **Physical cultural resources.** Based on both sites surveys and a review of relevant literature, there are no known sites with Physical Cultural Resources (PCRs) within the project work site footprints. However, construction activities have the potential to disturb as yet unknown subsurface PCRs.

194. To address this issue, the following **Chance Find Procedure**, developed in in accordance with PRC's *Cultural Heritage Protection Law*, will be established and activated if any chance finds of PCRs are encountered at bus depots or other sites:

(i) Construction activities will be immediately suspended if any PCRs are encountered.
(ii) Destroying, damaging, defacing, or concealing PCRs will be strictly prohibited.
(iii) The local Cultural Heritage Bureau will be promptly informed and consulted.
(iv) Construction activities will resume only after thorough investigation and with the permission of the local Cultural Heritage Bureau.

D. Anticipated Operation Phase Impacts and Mitigation Measures

195. **Impact screening.** Potential operation phase impacts of a zero emission trolley bus network include GHGs, runoff from the corridors into drainage systems, and traffic accidents and threats to public safety. These potential impacts are assessed and addressed below.

196. Operation of the project will not affect or have any potential negative impacts on local air pollution due to tailgas emissions, vehicle noise, biological resources, ecology and biodiversity, and PCRs.

197. **Air quality.** Air pollutants in fossil-fuel combustion vehicle exhaust include NO_2, CO, HC, and PM. Of these, the critical air pollutant is NO_2, meaning that if NO_2 complies with the applicable standard, other pollutants such as CO, HC and PM typically also comply with their respective standards. Those vehicle exhaust emissions also contain GHGs which may have climate change implications.

198. The project will operate 735 modern electric "zero (tail-gas) emission" trolley buses, and depots will not be equipped with cafeterias. Thus, project operation is not expected to contribute any atmospheric pollutants emissions, and contribute substantially to emissions reductions. Operation of the project will result in substantial reductions in emissions compared to operation of a similar fossil fueled bus fleet, or the provision of equivalent transportation through private cars, as explained in **Section V.G**.

199. **Noise.** Unlike trams or gasoline and diesel buses, modern trolleybuses are almost silent, lacking the noise of an engine or wheels on rails. Most noise comes from auxiliary systems such as power steering pumps and air conditioning. Early trolleybuses without these systems were even quieter. But this also was taken as disadvantage and sometime it was referred to "silent death". When arriving and leaving stations or depots, bus speeds will be below 10 km/h, and expected noise levels from breaking and steering will be 69-70 dB(A). Electric trolley bus operational average noise level is 60 dB (A)[31], considerably lower than diesel buses which range from 80 to 85 dB(A).[32]

200. **Table V-3** presents noise attenuation results for trolley bus operation presented in the EIT.[33] According to the noise functional area classification in PRC's *Environmental Quality Standard for Noise* (GB3096-2008), areas within 35 m of the trolley bus corridors red line are classified as Class 4a with day time and night time noise limits of 70 dB(A) and 55 dB(A) respectively; while areas between 35 m to 200 m from the trolley bus corridor's red line are classified as Class 2, with day time and night time noise limits of 60 dB(A) and 50 dB(A) respectively. The results indicate that noise levels from trolley bus operation in the project corridors will comply with PRC and standards and EHS Guidelines.

Table V-3: Predicted Electric Trolley Bus Operation Noise Attenuation

Distance (m) from Corridor Red Line	**8**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**
Noise dB(A)	53.9	48.5	45.9	44.0	42.4	41.1	39.9	38.9	38.0	37.2
Environmental Quality Standards	Class 4a Nighttime<55	Class 3 Nighttime<50		Class 2 Nighttime<45				Class 1 Nighttime<40		

[31] C.A. Brebbia and J.L. Miralles I Garcis (ed). 2015. Urban Transort XXI, WIT press, Southhampton, Boston.

[32] *Development Prospects of Trolleybuses,* Zhang Xi; and adapted from Transport Action, Transport Canada 2000, October 2001; additional data from BC Transit, 1999 and Calgary Transit.

[33] Noise attenuation was calculated based on the following formula:

L2 = L1-20log r2/r1

Where L2 is the new sound level at the new distance

L1 is the sound level at the reference distance

r1 is the reference distance from the source

r2 is the new distance from the source

for Noise-GB3096-2008		
EHS Guidelines	Class I Daytime<55	Class 2 Nighttime<45

Source: EIT (2017).

201. **Table V-4** presents noise attenuation modelling undertaken at one of the sensitive receptors (Qinnianjuyi Community at Beiyuan Avenue) for the year 2030. The modelling assumed a peak ridership of between 9,000 and 10,000 passengers per hour and 105 busses in operation, for "with" and "without" project scenarios (the without project assumes traditional buses). The results indicate that the noise contribution from trolleybuses is lower than traditional buses by about 6 dB(A). Overall, project operation will help reduce traffic noise levels as a result of the trolley bus's quiet operation and improved traffic flows.

Table V-4: Predicted Trolley Bus Corridor Operation Noise Attenuation at the Qinnianjuyi Community Sensitive Receptor. Noise levels in dB(A).

Corridor	Distance to road centerline distance (m)									
	20	40	60	80	100	120	140	160	180	200
Beiyuan Ave. (traditional buses, without project)	64.0	56.2	53.4	51.7	50.4	49.3	48.4	47.6	46.9	46.3
Beiyuan Ave. (trolley buses, with project)	57.9	50.2	47.3	45.6	44.3	43.2	42.3	41.6	40.8	40.2
Noise reduction (with project)	-6.1	-6.0	-6.1	-6.1	-6.1	-6.1	-6.1	-6.0	-6.1	-6.1

Note: Assumes: urban trunk road, dual-way, ten lanes, 37 m wide, and a design speed of 60 km/h.
Source: EIT (2017).

202. **Traffic safety.** Operation of the zero-emission modern trolley bus network includes inherent risk of traffic accidents. This risk will be mitigated through:

(i) Regularly inspect and maintaining corridor roads and drains, and trolley bus supporting infrastructure (overhead cables, substations, etc.).
(ii) Appropriate training of trolley bus drivers and provision of PPE.
(iii) Strict enforcement of traffic laws and regulations, especially speed limits.
(iv) The provision of lanes for pedestrians and non-motorized vehicles.
(v) Improved designs of road junctions and pedestrian crossings.

203. **Domestic solid waste**. Solid waste generated during the operation phase will primarily consist of domestic garbage generated from passengers at bus stations and operational staff at bus depots, and will include plastic bags, paper, and other trash. The following solid waste management measure will be implemented:

(i) Bus stations and depots will be equipped with appropriate garbage and recycling containers.
(ii) Domestic garbage and recyclables will be collected on a regular basis. Recyclables will be collected by an appropriate recycling facility, and garbage by the local sanitation department for disposal at a municipal solid waste landfill.

204. **Hazardous materials and waste.** Toxic, hazardous, and harmful materials present in the operation of the project may include new and used batteries and used lubricating oil and grease (O&G) at bus repair workshop areas in a few bus depots. Trolley bus batteries have a design life

span of 15 years and the EIT estimates that waste about 5.3 t/a of O&G will be generated during vehicle and power traction substation maintenance and repair. Inappropriate waste storage and disposal could affect soil, groundwater, and surface water resources, and hence, public health and sanitation.

205. The following hazardous materials and waste management measure will be implemented:

(i) A hazardous materials handling and disposal protocol that includes spill emergency response will be prepared and implemented by depot operators.
(ii) Suppliers of chemicals and hazardous materials must hold proper licenses and follow all relevant protocols and PRC regulations and requirements.
(iii) Storage facilities will be established at each bus depot for fuels, oil, chemicals and other hazardous materials. Storage facilities will be established in accordance with *Hazardous Waste Storage Pollution Control Standards* (GB18597-2001) within secured areas on impermeable surfaces provided with dikes, and at least 300 m from drainage structures and important water bodies. A standalone site within each storage facility will be designated for hazardous wastes including scrap batteries.
(iv) Licensed companies will be hired to collect, transport, and dispose hazardous materials in accordance with relevant PRC regulations and requirements.
    a. Qualified waste battery recycling companies will collect and recycle used batteries on a regular basis.
    b. Qualified companies will collect and properly disposal waste O&G on a regular basis.

206. Some sections of the trolley bus corridors located south of the Jingshi Road pass through a quasi-groundwater drinking water source protection zone, and there are also two bridge crossings of the Xiaoqing River. There is a risk of battery or other leaks polluting these water resources.

207. To mitigate these risks:

(i) Regular vehicle maintenance will be undertaken to ensure safe battery operation.
(ii) Emergency spill response plan (noted above).

208. **Visual aesthetics.** The overall visual character of the project zone of influence is that of a mature developed urban center. Jinan already has 179 km of bus lanes including 47.9 km of rapid transit lanes, and the addition of the zero-emission trolley BRT network (priority lanes, stations, depots, traction substations and overhead power cables) is similar to that of existing conventional bus, trolley or BRT services, and therefore will not introduce new elements that will result in substantial negative visual effects in the highly urbanized areas along the zero emission trolley BRT corridors. With dual power supply technology, overhead line networks will no longer be needed at road intersections and landscape sections. Lighting and signage for the proposed zero emission trolley bus rapid transit corridors at stations and other locations will be compatible with the exiting surrounding urban facilities and infrastructure.

E. Cumulative, Indirect, and Induced Impacts

209. Cumulative impacts are defined as 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 cannot be expected in the case of a standalone project. With respect to the construction phase, the IA is not aware of any other transport construction

projects that might occur within close proximity of, and concurrently with, the construction of the zero emission trolley BRT corridors that might result in cumulative construction impacts.

210. Indirect impacts are adverse and/or beneficial environmental impacts which cannot be immediately traced to a project activity but can be causally linked. 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.

211. The upgrading of an existing road (such as zero emission trolley BRT corridor) has the potential to influence traffic volumes and developments on adjacent roads. The proposed corridors as well as future traffic volumes on these roads have been examined in the context of the appropriate master plans in the FSR. The proposed corridors will address weak links in the existing public transportation network. With their completion traffic function and public transport service provided for the adjacent areas will be improved and enhanced. The projects contributions to, and influence on the district and neighborhood traffic flows, have therefore been assessed within the context of the relevant plans and are considered appropriate. Significant indirect or induced negative impacts are not anticipated.

F. Associated Facilities

212. Associated facilities are facilities that are not funded as part of a project but whose viability and existence depend exclusively on the project, or whose goods or services are essential for successful operation of the project. There are no known project associated facilities.

G. Climate Change Impacts

213. Following ADB's climate risk management protocols, the project was screened using the AWARE tool, which provides more explicit and categorical information on the likely nature of climate and natural disaster risks. AWARE returned a risk rating of High, reflecting primarily high risks from wildfire, flood and water availability; and medium risks from temperature increase and solar radiation change. A full-scale climate risks and volunerability assessment was conducted by C. Rodgers, Senior Advisor of Climate Change Adaptation at SDCC/CCDRM. Taking into climate risks in Jinan, the nature of the project and the project locations, the flooding was considered as the climate risk of highest priority for the project.

214. Jinan has a several on going and planned flood control and drainage improvement activities as part of its efforts to manage flood-related risks. In 2012, Jinan developed its Urban Sewage Comprehemsive Management Strategies and Promotion Measures which includes the rehabilitation of three rivers and dredging 65 river courses which doubled the total over the previous four years. The city also completed rehabilitation of 24 waterlogging points, further improving its urban flood control and drainage capacity. The city's sewage pipe network was inspected and more than 800km of sewage pipelines were maintained. The institutional capacity of the city's flood control headquarters was strengthened, and its Urban Flood Emergency Plan revised. In 2016, Jinan promoted the sponge city concept which focuses in establishing a green and ecological spring city. In 2016, Jinan approved the Urban Special Planning on Sponge City Pilot and 27 other regulations which seeks to address flood water logging issues. Activities include, compeltion of nine bacthes of rainstorm and flood monitoring and observation projects, improvements in the urban sewage treatment facilities. A detailed discussion of Jinan's flood risk mitigation efforts is included in the CRVA report (Apendix C).

215. Projection on flood events and ongoing efforts to improve flood control meaures carried out by Jinan were taken into consideration. The CRVA provides recommendation to take a precautionary approach assuming that annual maximum daily rainfall events and/or similar high-intensity events that contribute to flood hazards will increase by 25% to 30% by 2050, and that the magnitude of flood quantiles will reflect such increases, at least approximately. It also concludes that such recommendations may not have direct implications for the Shandong Spring City Green Modern Trolley Bus Demonstration Project, as it is a transport sector project. Decisions concerning the location of facilities and good engineering designs and measures for potential flood events may be recommended at detail engineering design stage. Appendix C provides the full scale CRVA report.

H. Positive Impacts and Environmental Benefits

216. **Beneficiaries.** The project beneficiaries are the 3.086 million residents of Licheng, Lixia, Tianqiao, Shizhong and Huaiyin districts, both public transport users and residents in general. Users will benefit from the improved transit service provide the by the zero-emission prioritized trolley bus transport network, bus stations and depots. In addition, the 4.8 million urban residents will also benefit from reduced traffic congestion, improved road safety, and reduced air pollution.

217. **Positive impacts.** Project operation will have a number of significant positive and long lasting impacts, as described below.

218. First, an increased number of public transport users will benefit from an improved and more efficient service. Once operational, ridership on the trolley bus rapid transit network is expected to reach 804,000 passengers per day, and on-time performance will exceed 90%. By 2025 it is expected that the public transport mode share in the city center area will increase to 25%, compared to 18% in 2016.

219. Second, travelling on dedicated bus lanes will reduce stop-and-go in congested traffic, allowing the buses and other vehicles to travel at faster and more constant speeds (average public transport average speed in the city center is expected to increase to 19 km per hour compared to 14 km per hour in 2016), improving traffic flow, reducing traffic jams, and providing better road safety and faster travel times for passengers. This will also result in reduced carbon emissions per vehicle per mile travelled (see below).

220. Third, the provision of a BRT-trolley corridor will reduce traffic noise compared to the “no project” scenario, due to i) the low noise nature of electric trolley buses, and ii) trolley buses will be travelling more smoothly on dedicated lanes in the center of the carriageway, instead of the present in-and-out, stop-and-go conditions.

221. Fourth, universal access for vulnerable users including elderly, disabled, women, and children will be provided for at least 93 new BRT stations.

222. Fifth, an efficient public transport system will reduce the costs of transport in serving the major districts, industrial sites and transport hubs, and will provide better accessibility to employment and services in the city. It will enhance economic growth compared to the existing public transport system.

223. Sixth, project operation will reduce pollutant and GHG emissions compared to the non-project scenario as a result of zero-emission electric buses, reduced numbers of commuters in

private cars, and improved traffic flow.[34] A separate emission reductions analysis was carried out by the PPTA emissions specialist.[35] The analysis looked at two scenarios – with and without the project for the period 2022 to 2043. Both scenarios include the development of the underground metro system currently under construction and projected growth in vehicles and congestion. The "with project" scenario also includes emissions from thermal power plants associated with the production of electricity to power the electric trolley buses. Appendix D shows detailed emission reduction calculation and methodology used.

224. The analysis predicts that between the years 2023 to 2043, project operation will result in the reduction of pollutant emissions in Jinan City of 53,554 tons of carbon monoxide (CO), 5,830 tons of nitrogen oxides (NO_x), 3,157 tons of hydrocarbons (HC), and 169 tons of particulate matter (PM). The analysis predicts a very slight increase in sulpher dioxide (SO_2) of 15 tons due to coal fired production of the electricity used by the trolley bus fleet, but this is a very minor increase. Overall the results indicate that the project will result in reductions in transport sector pollutant emissions in the Jinan urban area, and associated benefits in terms of human health and well being.

225. The analysis also predicts a significant reduction in the urban transport related sector production of carbon dioxide (CO_2) by 5.2 million tons. Humans have increased atmospheric concentrations of CO_2, a GHG, by more than a third since the industrial revolution began, and reducing future emissions has a global benefit.

VI. ANALYSIS OF ALTERNATIVES

226. An analysis of project alternatives was undertaken during the feasibility phase to determine the most financially and technically feasible way of achieving the project objectives while minimizing environmental and social impacts.

A. No-Project Alternative

227. The consequences of the "no-project" alternative are a continuation of the current road congestion situation and other associated transport related air pollution and noise in Jinan City. Without the project, the urban residents of Jinan City will not benefit from a sustainable transport system with zero emission modern trolley buses, and will continue to suffer from traffic congestion, traffic noise, and poor air quality due to tail gas emissions from fossil fuel combustion buses. Jinan will not have an efficient, convenient public transport system that will reduce the use of passenger cars and reduce transportation. Jinan City will also lose the benefits of behavioral change with respect to road safety and traffic management.

228. The daily bus ridership is over 2.1 million in Jinan City, accounting for 32 % of transport mode share in terms of passenger travel distance. The number of passenger cars is growing and consequently so is congestion. Buses continue to fight for lanes with other motor vehicles when getting arriving and departing from stops in congested traffic, resulting in road safety risks and slower travel time for the passengers. In 2016 there were 250 bus lines running in Jinan City with

[34] According to Bai, Eisinger and Niemeier (MOVES vs. EMFAC: a comparison of greenhouse gas emissions using Los Angeles County. Transportation Research Board 2009 Annual Meeting. 15 pp. 2009), CO2 emission factors for both gasoline and diesel motor vehicles decrease from approximately 500 gm CO_2/mi to approximately 250 gm CO_2/mi when vehicle speeds increases from 25 mph to 75 mph, with diesel motors having a slightly lower emission factor than gasoline motors.

[35] Prof. Qingyu Zhang, Pollutant Emissions Reduction by Trolleybus Development, 2017.

a total of 5,640 buses in use, of which approximately 41% were diesel buses, contributing to poor local air quality. Without the project, transport related air pollution and traffic noise will continue to increase in future years.

229. With the project, Jinan City will have an extensive, cleaner and sustainable public transport system. The zero-emission prioritized trolley BRT network will provide a convenient, faster, and better public transport service so that bus users will increase shifting from passenger car to public transport. The combination of a reduction in the number of passenger cars, the use of buses with no tail pipe emission, and no noise modern trolley buses running along rapid bus routes, will enable residents in Jinan to enjoy a better air and noise environment compared to the existing situation. In addition, other existing conventional buses running the same corridors as the project network will benefit in terms of congestion ease, more passengers, and shorter stop-over time by using the prioritized bus lanes and median bus stations provided by the project. Overall, the benefits of the project are significant and long-term, and the no-project alternative was rejected.

B. Bus Type Options

230. A variety of bus types were considered. **Table VI-1** presents fuel efficiency data for various bus types, either based on actual operation data provided by JPTC or, for trolley buses, data provided by trolley bus suppliers in the PRC. The results show that modern trolley buses are the most fuel efficient.

Table VI-1: Fuel Consumption of Various Bus Types in Jinan and the PRC
(12 m long buses)

Bus type	Fleet no. in Jinan (2016 figures)	Fuel consumption (unit/100 km)	Fuel consumption (toe/100 km)
Electric bus	600	160 kWh electricity	0.0243
Existing trolley bus	121	160 kWh electricity	0.0243
Hybrid CNG bus	213	35 Nm^3 CNG	0.0342
Hybrid LNG bus	100	28 kg LNG	0.0370
Hybrid Diesel bus	400	20 L diesel	0.0169
Diesel bus	2200	28 L diesel	0.0237
CNG bus	1121	39 Nm3 CNG	0.0381
LNG bus	590	30 kg LNG	0.0397
Modern trolley bus (12 m)	0	89 kWh	0.0135

Source: JPTC and ADB PPTA consultant (2017).

231. With respect to carbon dioxide (CO_2) emissions and air pollutants, **Table VI-2** presents emission factors based on fuel (energy) and tail-gas measurement. If a comparison is made on vehicle travel km, a modern trolley bus shows higher CO_2 emission due to coal-based power generation in national grid of the PRC. However, it has zero tail gas emissions, thus significantly contributing to the improvement of local air quality.

Table VI-2: Emission Factors of Various Bus Types in Jinan and the PRC

Emissions	Modern Trolley Bus		Electric Bus		Diesel Bus	LNG Bus	CNG Bus
					Jinan		
Unit	**g/kwh**		**g/kwh**		**g/L Diesel**	**g/kg LNG**	**g/Nm3 CNG**
CO_2	1237.50		1237.50		2972.75	1270.15	1390.18
Air Pollutants	fuel based	tail gas	fuel based	tail gas			
PM	0.233	0	0.233	0	2.155	1.239	0.012
CO	1.475	0	1.475	0	25.010	543.220	19.232
NO_X	1.167	0	1.167	0	36.615	8.217	0.679
VOCs	0.093	0	0.093	0	5.814	11.839	0.256
SO_2	0.467	0	0.467	0	0.304	0.333	0.003
					PRC		
Unit	**g/km**		**g/km**		**g/km**	**g/km**	**g/km**
CO_2	1538.9		1980.0		832.4	381.0	542.2
Air Pollutants	fuel based	tail gas	fuel based	tail gas			
PM	0.290	0	0.373	0	0.603	0.372	0.005
CO	1.835	0	2.360	0	7.003	162.966	7.501
NO_X	1.451	0	1.867	0	10.252	2.465	0.265
VOCs	0.116	0	0.149	0	1.628	3.552	0.100
SO_2	0.581	0	0.747	0	0.085	0.100	0.001

Source: ADB PPTA team (2017).

232. Overall, modern electric trolley buses were selected as the best option for energy efficiency and low emissions.

VII. INFORMATION DISCLOSURE, CONSULTATION, AND PARTICIPATION

A. PRC and ADB Requirements for Disclosure and Public Consultation

233. Meaningful participation and consultation during project planning, feasibility study, design and implementation is an important environment safeguards requirement. It can directly reflect the public's perceptions of environmental quality in the project's area of influence.

234. **PRC requirements.** Public participation and environmental information disclosure provisions are among the most significant changes introduced in the amended *Environmental Protection Law* (2014). The legislative framework also includes decrees on the methods for public participation in environmental protection (**Table II-1,** item 20), information disclosure on construction project EIAs by government (item 22), preparation of EIA summaries for public disclosure (item 24), and technical guidelines for public participation in EIAs (**Table II-2,** item 9). The public disclosure and consultation process undertaken during the preparation of the domestic EIT was undertaken in compliance with the relevant PRC requirements.

235. **ADB requirements.** ADB's SPS (2009) has specific requirements for information disclosure and public consultation. Information disclosure involves delivering information about a proposed project to the general public and to affected communities and other stakeholders, beginning early in the project cycle and continuing throughout the life of the project. Information

disclosure is intended to facilitate constructive engagement with affected communities and stakeholders over the life of the project.

236. The SPS requires that borrowers take a proactive disclosure approach and provide relevant information from environmental assessment documentation directly to affected peoples and stakeholders. In addition, in order to make key documents widely available to the general public, the SPS requires submission to ADB for posting on the ADB website as follows:

(i) a draft full EIA (including the draft EMP) at least 120 days prior to ADB Board consideration, and/or environmental assessment and review frameworks before project appraisal, where applicable;
(ii) the final EIA/IEE;
(iii) a new or updated EIA/IEE and corrective action plan prepared during project implementation, if any; and
(iv) environmental monitoring reports.

237. The SPS also requires that the borrower carry out consultation with affected people and other concerned stakeholders, including civil society, and facilitate their informed participation. Consultations should include presentations on environmental impacts, benefits and mitigation measures, the project GRM, and ADB's Accountability Mechanism. For category A projects, such consultations should include consultations both at an early stage of EIA field work and when the draft EIA report is available.

B. Information Disclosure during Project Preparation

238. Two rounds of information disclosure for the project were conducted as summarized in **Table VII-1**.

Table VII-1: Summary of Project Information Disclosure

Information Disclosure	Date	Location	Information Posted
Round 1	20 January 2017	JPTC Bus Company website	Detailed project description Key contacts for more information
Round 2	7 April 2017	JEPB website	Formal JEPB acceptance of the EIT report on 7 April 2017 Links to EIT main report and annex Formal public comment period 07 to 13 April 2017 Contact to make comments

Source: PPTA consultant, JPTC and JEPB websites.

239. The first round was carried out in the early stages of the domestic EIT preparation, with information including a detailed project scope description and contact details of the PMO, the domestic environmental consultant and the JEPB released on the JPTC's Jinan Bus Company website (**Figure VII-1**).

240. The second occurred when JEPB formally accepted the revised EIT report. An announcement was posted on the JEPB website on April 7, 2017 with links to the EIT report, and a formal public comment period was announced from 07 to 13 April, 2017 (**Figure VII-2**). No comments were received.

C. Consultation and Participation during Project Preparation

241. Two rounds of consultation and participation were conducted during project preparation by means of a public consultation forum and a survey questionnaire.

242. The first round was conducted on 15 March 2017 in the form of a public consultation forum organized by the PMO, JPTC Bus Company and the PPTA consultant (**Figure VII-3**). Over 60 people attended, including representatives from the affected areas (mainly from communities, hospitals, schools, government departments, shops and enterprises nearby the proposed corridors and which might potentially be impacted by dust and noise). The forum discussed the scope of the project, EIT and IEE preparation, potential environmental impacts and mitigation measures during construction and operation and next steps. ADB's environmental safeguard requirements with an emphasis on the implementation of the EMP and GRM during project implementation were also discussed.

Figure VII-1: First Round of Information Disclosure on the JPTC Website

Source: http://www.jnbus.com.cn/websitenotice/17865.jhtml

Figure VII-2: Second Round of Information Disclosure on JEPB Website

Source: http://www.jnepb.gov.cn

Figure VII-3: Public Consultation Meeting, 16 March 2017

Source: PPTA consultant.

243. The second round was conducted in the form of a survey questionnaire administered on 16 March 2017 to residents or community committees along the proposed zero emission trolley BRT corridors and the proposed bus depot sites.

244. **Figure VII-4** presents a sample completed questionnaire, **Table VII-2** presents a translated version of the questionnaire, and **Table VII-3** summarizes the main questions and issues raised during the discussion forum and the questionnaire surveys, and the responses from the JPTC and the EIT domestic environmental consultant.

Figure VII-4: Sample Completed Project Public Consultation Questionnaire

山东泉城绿色现代无轨电车公交示范项目公众参与调查问卷

被调查人情况					
调查时间及地点：	2017年3月16日下午3：04				
姓名	李毅	性别	男	年龄	24
民族	汉	文化程度	高中	联系电话	1[illegible]7
地址	二环北路257号			职业	司机
单位	山东济南大地[illegible]车公司			职务	公交车司机

项目信息（项目简介、环评过程、可能产生的负面环境影响、缓解措施）

本项目为山东泉城绿色现代无轨电车公交示范项目，建设地点为济南市中心城区，建设单位为济南市公共交通总公司。项目规划建设"六横八纵"现代无轨电车网络，线网总长度228.64km。主要建设内容为：现代无轨电车网络建设工程、公交站台改造与新建工程、配套基础设施建设工程、车辆采购工程、公交智能系统升级改造工程、综合交通管理提升工程、机构能力建设与管理等。

济南市公共交通总公司已委托北京中环博宏环境资源科技有限公司承担该项目环境影响评价工作，目前项目环评报告初稿已经编制完成。

项目可能产生的环境影响主要是项目施工期施工扬尘、施工机械噪声、施工废水、施工固体废物等对周围环境的影响及项目运营期场站废水、噪声及固体废物对环境的影响。

拟采取的缓解措施为：

施工期：

（1）施工区域不设搅拌站，避免临时搅拌站对周围区域可能造成的粉尘影响。对于场区车辆运输和物料堆放过程产生的扬尘可以通过加强运输管理、增加覆盖、定期洒水等措施得到有效缓解，另外应避免在大风天气进行大范围土方施工。

（2）降低设备声级，采用低噪声的施工机械和先进的施工技术，以达到控制噪声的目的；合理安排施工时间；加强施工现场的噪声监测；加强人为噪声控制；建立公众参与的监督制度。

（3）施工期生活污水经现有设施，排入市政污水管网；施工废水通过设置沉淀池进行沉降后回用于洒水抑尘，不外排。

（4）施工期生活垃圾由环卫部门定期清运；建筑垃圾及渣土送到指定的垃圾渣土消纳点。

运营期：

（1）生活污水排入化粪池处理后，经市政管网排入市政污水处理厂处理后达标排放；车辆冲洗废水经沉淀池进行沉降后回用，不外排。

（2）制定严格管理制度，保持良好的交通秩序，在场站进出口设立明显的减速禁鸣标志，减少地面等偶然噪声的发生。

（3）生活垃圾由环卫部门统一清运；车辆报废电池、车辆维修产生废机油由有资质单位处理。

对项目了解程度	非常了解	✓	预计所建工程对发展当地经济	有利影响	✓
	一般了解			无影响	

Source: PPTA consultant.

Table VII-2: Translation of Project Public Consultation Questionnaire

Status of Participants					
Name		Sex		Age	
Nationality		Education level			
Contact number		Occupation			
Address					

Project information (a project summary is provided here, including descriptions of the project, briefly summarizing the environmental impact assessment process, most significant anticipated impacts, and proposed mitigation measures)

Understanding of the Project	Good understanding		**Project's anticipated effect on the local economy**	Positive effect	
	Moderate understanding			No effect	
	Low understanding			Negative effect	
Project's anticipated effect on the local living standards	Positive effect		**Attitude to the project**	Strongly Agree	
	No effect			Moderately Agree	
	Negative effect			Moderately Disagree	
				Strongly Disagree	
				No opinion	

What are the key current environmental issues in your home area?
○ Air pollution ○ Water pollution ○ Noise ○ Solid waste pollution ○ Don't know

What will be the project's main environment impacts during construction phase in your opinion?
○ Noise ○ Air ○ Solid waste ○ Water ○ Dust ○ Traffic Disruption ○ Other

Do you feel the proposed construction phase mitigation measures will be effective?
○ Highly Effective ○ Moderately Effective ○ Not Effective

What are the project's main environment impacts during operation phase in your opinion?
○ Noise ○ Air ○ Solid waste ○ Water ○ Dust ○ Traffic Disruption ○ Other

Do you feel the proposed operation phase mitigation measures will be effective?
○ Highly Effective ○ Moderately Effective ○ Not Effective

Project's anticipated effect on lifestyle, education and learning, work and entertainment

Effect	Lifestyle	Education and Learning	Work	Entertainment	Others
Positive effect					
Negative effect					
No effect					

Suggestions or requirements for the project:

Source: PPTA consultant.

245. In total, 51 survey questionnaires were distributed, and all (100%) were completed and returned. Of those surveyed, the male to female ratio was 49:51, 41% of participants were more than 30 years old, and 90% had a high school education or higher. 88% of participants had a good understanding of the project while the remaining 12% had a moderate understanding; 100% anticipated the project having a positive effect on the local economy; and 98% endorsed the project while the remaining 2% indicated that the project was acceptable. There were no participants who objected to the project.

246. In terms of Jinan's environmental status, 51% of participants considered air pollution to be Jinan's most significant environmental issue, 35% indicated noise, and 33% water pollution or solid waste. Almost 50% expressed concerns about traffic disturbance and 29% about dust and noise impacts during the project construction. Only 39% indicated concerns about adverse impacts such as traffic disruption or noise during operation. Almost all participants (98%) expected construction and operation phase mitigation measures proposed in the EIT (and this IEE) to be effective.

247. In total, 51 survey questionnaires were distributed, and all (100%) were completed and returned. Of those surveyed, the male to female ratio was 49:51, 41% of participants were more than 30 years old, and 90% had a high school education or higher. 88% of participants had a good understanding of the project while the remaining 12% had a moderate understanding; 100% anticipated the project having a positive effect on the local economy; and 98% endorsed the project while the remaining 2% indicated that the project was acceptable. There were no participants who objected to the project.

248. In terms of Jinan's environmental status, 51% of participants considered air pollution to be Jinan's most significant environmental issue, 35% indicated noise, and 33% water pollution or solid waste. Almost 50% expressed concerns about traffic disturbance and 29% about dust and noise impacts during the project construction. Only 39% indicated concerns about adverse impacts such as traffic disruption or noise during operation. Almost all participants (98%) expected construction and operation phase mitigation measures proposed in the EIT (and this IEE) to be effective.

Table VII-3: Issues Raised During Public Consultation and Project Proponent Responses

Project Phase	Issues Raised	Proponent Responses
Construction	Pedestrian and traffic disruptions	Shorten construction period by speeding up construction activities without compromising quality. Ensure road and pedestrian safety and smooth traffic flow during construction
	Noise from PME	On construction sites noise impacts will be controlled through measures such as selecting equipment with low noise, adopting sound insulation and absorption material to set up soundproof sheds, and strictly prohibiting noise construction activities during noontime (12:00-14:30) and nighttime (22:00-6:00), so as to ensure the normal life of nearby residents. If night time construction is needed, the use of noisy PME will be prohibited, and public notices will be issued to nearby residents to obtain their consent before works begin.
	Construction dust	During the construction phase the spatial extent and severity of dust impacts will be reduced through a series of construction dust and spoil transportation mitigations, such as the spraying of water, establishing fences and barriers, and requiring transport vehicles to cover loads.
	Wastewater discharge	The FSR Design Institute has designed a rainwater collection system for construction site to collect the surface runoff containing sediment during the rainy season, and to discharge after processing in a sedimentation tank, which can prevent sediment-contained waste water from flowing into nearby villages or shrimp ponds through drainage ditch or surface runoff,

Project Phase	Issues Raised	Proponent Responses
		and thereby negatively affecting residents' living environment and water quality of shrimp ponds. Settling tanks will also be used for the treatment of construction waste water, and attention will be paid to water resource protection of nearby wells.
Operation	Vehicle exhaust	The project will reduce urban vehicle emissions through the operation of zero-emission modern electric trolley buses. In addition, the project will ensure good environmental management by conducting regular ambient air quality monitoring.

Source: PPTA consultant.

D. Future Plans for Public Participation

249. Meaningful consultation to safeguard the environment and local residents will continue throughout detailed design, construction and operation phases, consisting of information disclosure by the project proponent and posting of project information on community notice boards and discussion forums. The IA and the PMO will be responsible for organizing the public consultations, with the support of the LIEC. Consultation will focus on public complaints about public nuisances from construction and operation activities, such as noise, asphalt fume nuisance, dust, traffic disturbance, as well as public concerns about the environment and resettlement.

250. The contractors will be required to communicate and consult with the communities in the project area of influence, especially those near the proposed zero emission trolley rapid transit corridors. Eye-catching public notice boards will be setup at each work site to provide information on the purpose of the project activity, the duration of disturbance, the responsible entities on-site (contractors, IA), and the project level GRM. Contact information of all GRM entry points and the PMO will be disclosed on the construction site information boards. The GRM is presented in summary in Chapter VIII and in detail in the EMP in Appendix 1.

251. Future consultation and participation will also include (i) involvement of affected people during inspection and monitoring of EMP implementation during construction and operation phases; (ii) participatory evaluation on the environmental and social-economic benefits and impacts; and (iii) consultation with the public after the project completion.

252. Project environmental information has, or will be, disclosed as follows: (i) this IEE will be available for review at www.adb.org; (ii) the domestic EIT (in Chinese) is available on request at the PMO and at JEPB's website http://www.jnepb.gov.cn/; and, (iii) environment progress will be reported in quarterly project progress reports and annual environmental monitoring reports, which will be disclosed on the ADB's project website (www.adb.org).

VIII. GRIEVANCE REDRESS MECHANISM

A. Introduction

253. A project grievance is an actual or perceived project-related problem that gives ground for complaint by an affected person (AP). As a general policy, the PMO will work proactively toward preventing grievances through the implementation of impact mitigation measures and community liaison activities that anticipate and address potential issues before they become grievances. In addition, as the project has strong public support and will not involve any involuntary land or

property acquisition or resettlement, significant grievance are unlikely. Nonetheless, during construction and operation it is possible that unanticipated impacts may occur if mitigation measures are not properly implemented, or unforeseen issues arise. To address complaints if or when they arise, a project GRM has been developed in accordance with ADB requirements and government practices. A GRM is a systematic process for receiving, recording, evaluating and addressing AP's project-related grievances transparently and in a reasonable period.

B. ADB Requirements

254. The ADB's SPS 2009 requires a project to establish a GRM to receive and facilitate resolution of AP's concerns and complaints about the project's environmental performance during construction as well as operation phase of the project. The GRM should be scaled to the risks and adverse impacts of the project; should address affected people's concerns and complaints promptly, using an understandable and transparent process; should be readily accessible to all sections of the community at no cost and without retribution; and, should not impede access to the PRC's judicial or administrative remedies.

C. Current GRM Practices in the PRC

255. At the national level a framework to address grievance has been established. State Council Decree No. 431 "Regulations on Letters and Visits" (January 2005) codifies a complaint mechanism at all levels of government, and safeguards the complainants from any retaliation. MEP "Decree No. 34 Environmental Letters and Visits System" provides specific guidelines to establish a system and address environmental complaints. When APs are negatively affected by project activities, they may complain to the contractors and the project company by themselves or through their community organizations, or complain directly to local environmental protection bureaus (EPBs). If the issue is not resolved they may take legal action, though that is typically considered as a last option.

D. Project GRM

256. The objective of the project GRM is to prevent and address community concerns, reduce risks, and assist the project to maximize environmental and social benefits. In addition to serving as a platform to resolve grievances, the GRM has been designed to (i) open channels for effective communication, including the identification of new environmental issues of concern arising from the project; (ii) demonstrate concern about community members and their environmental well-being; and (iii) prevent and mitigate any adverse environmental impacts on communities caused by project implementation and operations. The GRM will be accessible to all members of the community.

257. The GRM approach is to deal with grievances at a local level first in an efficient manner, and escalate to higher level of authority if the grievance cannot be resolved. The PMO Environment and Social Officers will be responsible for implementation of the GRM. The PMO will be the key contact point for residents, businesses, government departments and other stakeholders who may require information about the project or who have an issue they would like to discuss. The details of the GRM, including a time-bound flow chart of procedures, are included in the project EMP (Appendix I).

IX. CONCLUSIONS AND RECOMMENDATIONS

A. Expected Project Benefits

258. The project will benefit the 3.086 million residents of Licheng, Lixia, Tianqiao, Shizhong and Huaiyin districts, including both public transport users and residents in general.

(i) Once operational, ridership on the trolley bus rapid transit network is expected to reach 804,000 passengers per day. Users will benefit from an improved and more efficient service, with on-time performance expected to exceed 90%.
(ii) Travelling on dedicated bus lanes will reduce stop-and-go in congested traffic, allowing the buses and other vehicles to travel at faster and more constant speeds, improving traffic flow, reducing traffic jams, and providing better road safety and faster travel times for passengers. This will also result in reduced carbon emissions per vehicle per mile travelled (see below).
(iii) The provision of a BRT-trolley corridor will reduce traffic noise compared to the "no project" scenario, due to i) the low noise nature of electric trolley buses, and ii) trolley buses will be travelling more smoothly on dedicated lanes in the center of the carriageway, instead of the present in-and-out, stop-and-go conditions.
(iv) Universal access for vulnerable users including elderly, disabled, women, and children will be provided for at least 93 new BRT stations.
(v) An efficient public transport system will reduce the costs of transport in serving the major districts, industrial sites and transport hubs, and will provide better accessibility to employment and services in the city. It will enhance economic growth compared to the existing public transport system.
(vi) Project operation between the years 2023 to 2043 will result in the reduction of carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbon, particulate matter (PM), and carbon dioxide (CO_2) are predicted to be 53,554 tons, 5,830 tons, 3,157 tons, 169 tons, and 5.2 million tons respectively. The project will result in significant and long term reductions in transport sector emissions and GHGs, and associated benefits in terms of human health and well-being.

B. Adverse Impacts and Mitigation Measures

259. The project will permanently acquire 26.9 ha of land, most of which is state owned though there will be 1.64 ha acquisition of collectively owned land. Compensation and resettlement will be implemented which will fully meet applicable PRC and ADB applicable policies and requirements. The project is not expected to impact any rare or endangered flora or fauna, species with international, national or provincial protection status, areas of natural or critical habitat, parks, nature reserves, or areas with special national, regional or local ecological significance within or adjacent to any of the sites. The project is not expected to impact any physical cultural resources.

260. During construction, dust from construction sites, noise from power mechanical equipment, wastewater and solid wastes generated on construction sites, and traffic disruptions will be primary adverse impacts. Good housekeeping and effective mitigation measures will be implemented to reduce these impacts to acceptable levels.

261. Impacts during operation include waste generation and traffic safety, and can be mitigated effectively. Operation of the project will bring overwhelming significant and long term positive benefits, as described above.

C. Risks and Assurances

262. **Risks.** The project has no unusual technical risks and conventional engineering designs with proven reliability and performance will be adopted for all the components. From an environment safeguards point of view, the main risk relates to the failure of the PMO, IA and IA O&M units to monitor environmental impacts and implement the EMP during the construction and operation phases. This risk will be mitigated by (i) providing training in environmental management; (ii) appointing qualified project implementation consultants, (iii) following appropriate project implementation monitoring and mitigation arrangements, (iv) ADB conducting regular project reviews; and (v) project assurances covenanted in the loan and project agreement with ADB.

263. **Environmental assurances.** The following assurances will be included in the loan and project agreements.

1. General

264. JMG shall ensure that the preparation, design, construction, implementation, operation and decommissioning of the project comply with (a) all applicable laws and regulations of the Borrower relating to environment, health and safety; (b) the environmental safeguards; and (c) all measures and requirements set forth in the IEE, the EMP, and any corrective or preventative actions (i) set forth in a safeguards monitoring report, or (ii) which are subsequently agreed between ADB and JMG.

2. Provisions in Bidding Documents and Works Contracts

265. JMG shall ensure that all bidding documents and contracts for works contain provisions that (a) require contractors to comply with the measures relevant to the contractor set forth in the IEE, the EMP and the RP (to the extent they concern impacts on the respective affected people under the environmental safeguards and the involuntary resettlement safeguards), and any corrective or preventative actions set forth in (i) a safeguards monitoring report, or (ii) subsequently agreed between ADB and JMG; (b) make available a budget for all such environmental and social measures; and (c) provide JMG with a written notice of any unanticipated environmental, resettlement or indigenous peoples risks or impacts that arise during construction, implementation or operation of the project that were not considered in the IEE, the EMP and the RP.

3. Safeguards Monitoring and Reporting

266. JMG shall (a) submit annual safeguards monitoring reports to ADB in respect of implementation of and compliance with environmental safeguards, the GRM, the EMP, and the EMoP during the implementation of the project and the EMP until the issuance of ADB's project completion report unless a longer period is agreed, and disclose relevant information from such reports to the respective affected people under the environmental wsafeguards promptly upon submission; (b) if any unanticipated environmental risks and impacts arise during construction, implementation or operation of the project that were not considered in the IEE, and the EMP promptly inform ADB of the occurrence of such risks or impacts, with detailed description of the event and proposed corrective action plan; and report any actual or potential breach of compliance with the measures and requirements set forth in the EMP promptly after becoming aware of the breach.

4. Labor Standards, Health, and Safety

267. JMG shall ensure that the core labor standards and the borrower's applicable laws and regulations are complied with during project implementation. JMG shall include specific provisions in the bidding documents and contracts financed by ADB under the project requiring that the contractors, among other things: (a) comply with the borrower's applicable labor law and regulations and incorporate applicable workplace occupational safety norms; (b) do not use child labor; (c) do not discriminate workers in respect of employment and occupation; (d) do not use forced labor; and (e) disseminate, or engage appropriate service providers to disseminate, information on the risks of sexually transmitted diseases, including HIV/AIDS, to the employees of contractors engaged under the project and to members of the local communities surrounding the project area, particularly women. JMG shall strictly monitor compliance with the requirements and provide ADB with regular reports.

5. Prohibited List of Investments

268. JMG will ensure that no proceeds of the Loan are used to finance any activity included in the list of prohibited investment activities provided in Appendix 5 of the Safeguards Policy Statement.

6. Equipment Quality and Safety

269. JMG will ensure that all works, goods, and equipment are procured and used in accordance with the government's national technical standards, and that supervision, quality control and contract management area carried out in a periodic and satisfactory manner. JMG will further ensure that the safety standard of the project equipment strictly follow the relevant Government laws and regulations.

7. Capacity Building

270. JMG will ensure that all capacity expansion activities in the project area are completed in a timely manner.

D. Overall Conclusion

271. The project IEE has (i) identified potential negative environment impacts and established mitigation measures; (ii) assessed public support from the project beneficiaries and affected people; (iii) established a project GRM; and (iv) prepared a project EMP, including environmental management and supervision structure, environmental mitigation and monitoring plans, and capacity building and training.

272. It is concluded that the project will not result in adverse environmental impacts that are irreversible, diverse, or unprecedented. Any minimal adverse environmental impacts associated with the project will be prevented, reduced, or minimized through the implementation of the project EMP.

APPENDIXES

Appendix A: Project Environmental Management Plan

Appendix B: Site Details of Bus Depots and Traction Substations

Appendix C: Methodology and approach used for the Project Emissions Reduction Benefits

Appendix D: Climate Risks and Vulnerability Assessement Report

APPENDIX A - EMP

ENVIRONMENTAL MANAGEMENT PLAN

June 2017

PRC: Shandong Spring City Green Modern Trolley Bus Demonstration Project

Prepared by the Jinan Municipal Government for the Asian Development Bank (ADB)

ENVIRONMENTAL MANAGEMENT PLAN

A. Introduction

1. This is the environmental management plan (EMP) for the Shandong Spring City Green Modern Trolley Bus Demonstration Project. The project will be implemented through three outputs:

(i) **Output 1:** Zero-emission bus rapid transit (BRT) network constructed;
(ii) **Output 2:** Modern trolley bus and service standards implemented; and
(iii) **Output 3**: Travel demand management (TDM) measures for Jinan prepared.

2. The EMP was developed on the basis of on an approved domestic project feasibility study report (FSR) prepared by a domestic design institute (DI);[1] an approved domestic environmental impact table (EIT) report prepared by the Zhonghuanbohong Environmental Source Company, Jinan Division (the domestic EIT consultant);[2] additional analyses undertaken by the domestic EIT consultant under the direction of the Asian Development Bank (ADB) project preparatory technical assistance (PPTA) team;[3] site visits conducted by the PPTA team; ADB review mission discussions and agreements with relevant government agencies; and consultations with affected persons and stakeholders.

3. The objectives of the EMP are to ensure (i) implementation of identified mitigation and management measures to avoid, reduce, mitigate, and compensate for anticipated adverse environment impacts; (ii) implementation of monitoring and reporting; and (iii) project compliance with the People's Republic of China's (PRC) relevant environmental laws, standards and regulations, and ADB's Safeguard Policy Statement (SPS, 2009). Organizational responsibilities and budgets are identified for EMP execution, monitoring, and reporting.

4. The EMP is to be implemented in all phases of the project—detailed design, pre-construction, construction, and operation. In the detailed design stage, the EMP will be used by the DI for incorporating mitigation measures into the detailed designs. The EMP will be updated at the end of the detailed design, as needed. The final EMP will be disclosed on the ADB public website (www.adb.org) and included in the project administration manual (PAM).

5. The EMP will be included as a separate annex in all bidding and contract documents. The contractors will be informed of their obligations to implement the EMP and to provide for EMP implementation costs in their bids for project works.

B. EMP Implementation Arrangements

6. The Jinan Municipal Government (JMG) will be the executing agency (EA), responsible for the overall implementation and compliance with loan assurances and the EMP. The JMG has established a project steering committee.

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[1] ADB Shandong Spring City Green Modern Trolley Bus Demonstration Project Feasibility Report. Prepared by Shandong Engineering Consultancy Institute, March 2017.
[2] Construction Project Environmental Impact Statement, Shandong Green Modern Trolley Bus Demonstration Project. Construction unit: Jinan City Public Transport Corporation. April 2017.
[3] TA 9208-PRC: Shandong Spring City Green Modern Trolley Bus Demonstration Project.

7. The Jinan Public Transportation Company (JPTC) will be the implementing agency (IA). The IA will implement project components, administer and monitor contractors and suppliers, and be responsible for construction supervision and quality control. The IA will ensure that the EMP is implemented proactively and responds to any adverse impact beyond those foreseen in the IEE. The IA will also attend to requests from relevant agencies and ADB regarding the mitigation measures and monitoring program. It will nominate dedicated, trained, and qualified environment specialists to (i) supervise contractors and ensure compliance with the EMP; (ii) conduct regular site inspections; (iii) coordinate periodic environmental quality monitoring in compliance with the approved monitoring plan;[4] (iv) act as local entry point for the project grievance redress mechanism (GRM); and (v) submit quarterly monitoring results to the EA and ADB. The IA will also appoint a Project Management Office Environment and Safety Officer (PMO ESO) and engage a local environmental monitoring station (EMS) for environmental monitoring.

8. The EA will establish a project management office (PMO), which will be responsible for day-to-day management of the project. The PMO will designate a qualified PMO ESO, who will take overall responsibility for supervising the implementation of environmental mitigation measures, coordinating the project level GRM and preparing monitoring reports for submission by the IA to ADB. The PMO ESO with support of the LIEC will (i) provide overall coordination and support on environmental aspects; (ii) supervise contractors and construction supervision companies (CSCs) and their compliance with the EMP; (iii) conduct regular site compliance inspections; (iv) act as PMO entry point for the project GRM; (v) collect and submit environmental monitoring data provided by (a) contractors and/or CSCs to the PMO, and (b) the EMS to the PMO; and (vi) support PMO with preparation of EMP progress section as a part of quarterly project progress reports and semiannual environmental monitoring reports (EMRs).

9. The PMO will engage a Loan Implementation Environmental Consultant (LIEC), a part-time national environmental, health, and safety specialist prior to the engagement of construction contractors and the project construction, who will support the PMO in mitigation implementation, environmental monitoring, reporting, and addressing any environment-related issues that arise including grievances. The LIEC will also support contractors in developing construction site-specific environmental management plans (CEMPs) prior to construction and operation.

10. A local environmental monitoring station (EMS) will be engaged by the IA to undertake construction and operation phase ambient environmental monitoring, as per the requirements of the environmental monitoring plan (EMoP) presented in this EMP.

11. Construction contractors will be responsible for implementing the mitigation measures during construction under supervision of the IA and the PMO. In their bids, the contractors will prepare CEMPs which detail how the contractors will comply with the EMP. Each contractor will identify a lead focal point for environmental issues (e.g., Environment, Health and Safety Officer), who will oversee CEMP implementation, take all reasonable measures to minimize the impact of construction activities on the environment, develop and prepare monthly reports for submission to the IA. Contractors are also required to report any spills, accidents, and grievances received, and take appropriate action. The Environment, Health and Safety Officer will also be responsible for developing CEMPs and an Occupational Health and Safety Plan (OHSP).

[4] The Jinan EMS (under the Jinan Environmental Protection Bureau) will be contracted by the IA to conduct internal environment monitoring.

12. CSCs will be responsible for supervising and guiding construction contractors during project construction phase. CSCs will have a qualified Environment, Health and Safety Officer who will be responsible for supervising construction contractors to ensure proper the implementation of EMP and CEMPs; and preparing and submitting consolidated quarterly EMRs to the PMO based on the CEMPs implementation.

13. ADB will conduct due diligence of environment issues during project review missions. ADB will also review the semiannual EMRs submitted by the PMO and will disclose the reports on its website. If the PMO fails to meet safeguards requirements described in the EMP, ADB will seek corrective measures and advise the IA on items in need of follow-up actions.

14. The project IAs and their roles and responsibilities for the EMP are presented in **Table 1**. The project implementation arrangement chart is presented in **Figure 1**. Terms of reference for the PMO ESO and LIEC are presented in **Annex 1**.

Table 1: Agencies Involved in Implementation of the Project EMP

Organization	Role and Responsibility for the EMP
Shandong Provincial Government (SPG)	- Coordinating and overseeing project preparation and implementation. - Coordination of strategic issues at regional or national level. - Providing policy guidance and facilitation during implementation. - Facilitating interagency coordination with other involved parties at the regional level (and facilitate issues and decision making at the national level, if required).
SPG Finance Bureau (SPG-FB)	- Monitoring the use of ADB loan. - Monitoring the implementation of the onlending agreements under the project. - Coordinating with the executing and implementing agencies to ensure budget availability for the contracts to be awarded under the project.

Jinan Municipal Government (JMG)	- The EA and project contact point for ADB. Responsible for:
	  - Overall implementation and compliance with loan assurances and the EMP, including EMoP, environmental monitoring reporting, and GRM.
	  - Coordinating project implementation activities among government agencies such as finance bureau, development and reform commission, environmental protection bureau, and others.

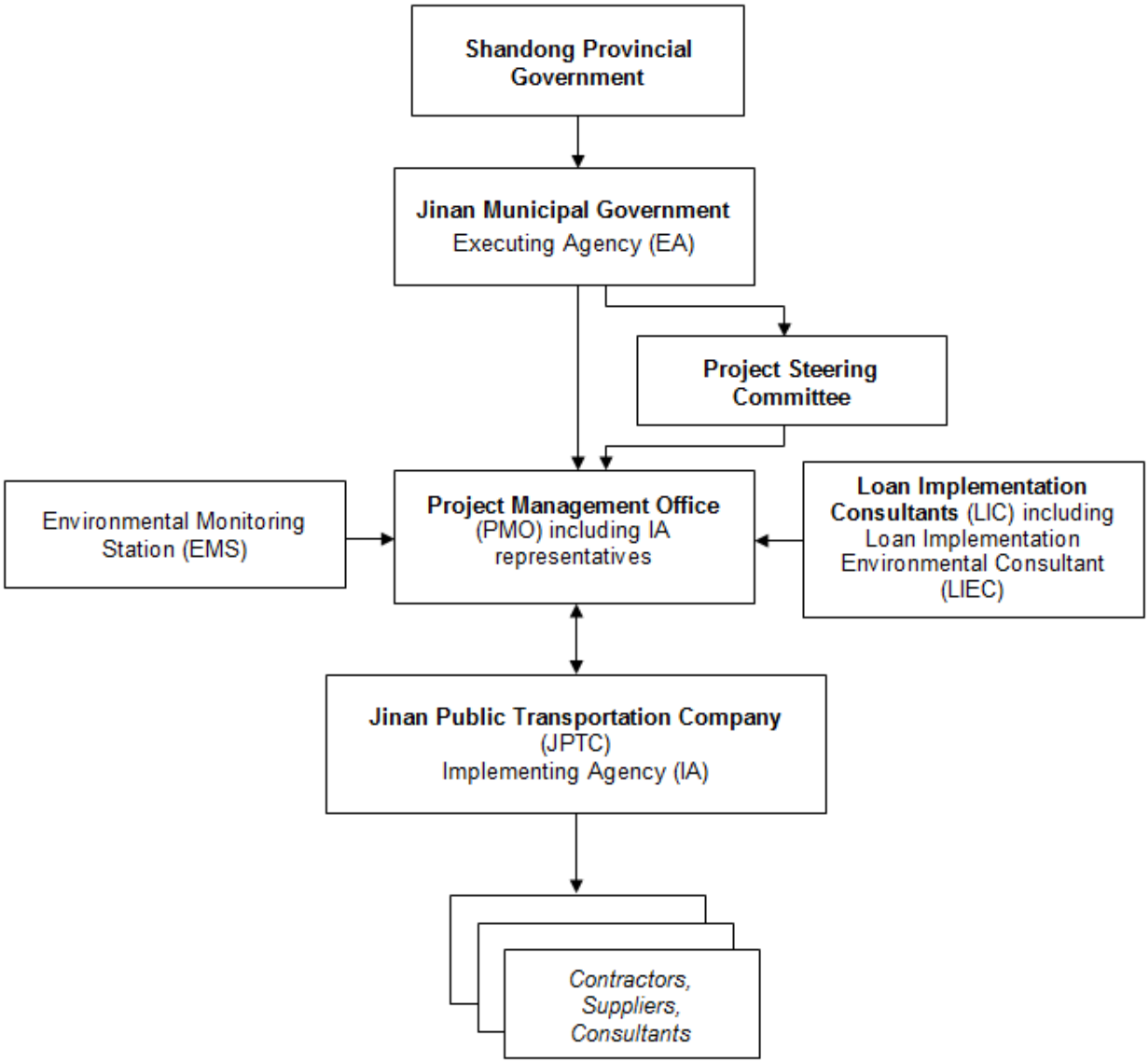
Jinan Public Transportation Company (JPTC)	- The project IA. Main responsibilities include:
	  - Contracting and administering contractors and suppliers.
	  - Supervising construction and monitoring quality control.
	  - Appointing a PMO ESO.
	  - Engaging local environmental monitoring station (EMS) for environmental monitoring.
	  - Engaging a LIC including a LIEC.
	  - Ensuring compliance with EMP and RP.
	  - Responding to any adverse impact beyond those foreseen in the IEE and ensuring that if there are any changes in scope, the IEE/EMP will be updated as needed.
	  - Responding to requests from relevant agencies and ADB regarding the mitigation measures and environmental monitoring program.
	  - Identifying and implementing O&M arrangements.

Project Management Office (PMO)	- On behalf of the EA, the PMO will be responsible for all project organization and implementation activities, including the following:
	  - Updating IEE/EMP, including EMoP, EMR reporting and GRM.
	  - Ensuring that mitigation measures are included in engineering detailed design.
	  - Ensuring project's compliance with loan and project agreements and safeguards requirements.
	  - Managing the activities of the design institutes, procurement agents, and consultants in accordance with government and ADB regulations.
	  - Coordination with concerned offices, including SPG, and with external contacts.
	  - Taking part in capacity development and training.
	  - Establishing and operating the project complaint center with hotline.
	  - Overseeing the project program and activities of the IA in the implementation of the project outputs.

Organization	Role and Responsibility for the EMP
	- Monitoring the project's physical and financial progress and compliance with project's reporting requirements, ensuring project progress reports are prepared and submitted to ADB on time. - Preparing progress reports for submission to the IA and/or PMO. - Coordinating the activities of and meeting the requirements of ADB visiting missions.
Loan Implementation Consultant (LIC)	- The LIC will assist the PMO in day-to-day activities of the project including: - Detailed engineering design. - Bid preparation, evaluation, and contract awarding. - Provision of technical advice and expertise. - Monitoring and reporting.
Loan Implementation Environmental Consultant (LIEC)	- The LIEC will: - Review the updated IEE and EMP. - Confirm that mitigation measures have been included in detailed engineering design. - Review bidding documents to ensure that the EMP clauses are incorporated. - Review CEMPs to ensure compliance with the EMP. - Provide technical assistance and support to the PMO and contractors on mitigation measures and EMP implementation. - Deliver the construction and operation phase capacity building programs to the staff of the IA, PMO, and contractors. - Conduct site inspections in compliance with the environmental monitoring plan. - Review reports prepared by contractors and the EM, and assist the PMO in preparing semiannual environmental monitoring reports.
EMS	- A qualified local EMS recruited to implement the ambient monitoring portion of the EMoP.
Contractors	- Ensure sufficient funding and human resources for proper and timely implementation of required mitigation and monitoring measures in the EMP throughout the construction phase. - Prepare CEMP(s) prior to the construction commencement. - Appoint an environment, health and safety (EHS) officer to oversee EMP implementation related to environment, occupational health and safety on construction site. - Ensure health and safety. - Implement mitigation measures. - Act as a local entry point for the project GRM.
Construction supervision company(ies) (CSCs)	- Ensure sufficient funding and human resources for supervising and instructing contractors for proper and timely implementation of required mitigation and monitoring measures in the EMP and CEMPs throughout the construction phase. - Appoint an EHS officer to supervise and instruct contractors and their EHS officers for EMP and CEMPs implementation related to environment, occupational health and safety on construction site. - Prepare and submit quarterly EMP and CEMP monitoring reports to the PMO.
Jinan EPB	- Review and approve EIT. - Review project monitoring results. - Conduct periodic monitoring and inspections. - Conduct acceptance inspections on completion of the project.
ADB	- Review and approve the IEE and EMP and disclose on ADB website. - Approve updated IEE/EMP if appropriate and disclose on ADB website - Provide guidance to the executing and implementing agencies. - Conducting review missions. - Monitoring status of compliance with loan and project covenants, including safeguards. - Regularly updating the project performance review reports with the assistance of executing and implementing agencies. - Regularly updating the project information documents for public disclosure at ADB website, including the safeguards documents.

ADB = Asian Development Bank, CSC = Construction Supervision Company, EA = executing agency, EMP = environmental management plan, EMoP = environmental monitoring plan, EMS = environmental monitoring station, EPB = Environmental Protection Bureau, GRM = grievance redress mechanism, IA = implementing agency, JMG = Jinan Municipal Government, LIC = loan implementation consultant, LIEC = Loan Implementation Environmental Consultant, O&M = operation and maintenance, PMO = Project Management Office, PMO ESO = Project Management Office Environment and Safety Officer, RP = resettlement plan, SPG = Shandong Provincial Government, SPG FB= Shandong Provincial Government Finance Bureau.

Figure 1: Project Implementation Arrangements



C. Potential Impacts and Mitigation Measures

15. Potential impacts of the project during each phase have been identified and appropriate mitigation measures developed (Section V of the project IEE). Potential impacts and the mitigation measures are presented in **Table 2**.

Table 2: Potential Impacts and Mitigation Measures

Item	Impact Factor	Potential Impact and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity
Detailed Design Stage					
Siting	Land Acquisition	Loss of land and assets	- Ensure land acquisition issue resolved for bus depots - Minimize land acquisition for traction power substations on state owned land.	Design Institute	PMO, IA
Design of corridor modification and stations design	Health and Safety	Promotion of nonmotorized transport, protection of vulnerable road users	Design must: - Ensure public health and safety. - Promote nonmotorized traffic. - Ensure barrier-free design for disabled people.	Design Institute	PMO, IA
	Landscape	Preservation of trees	- Coordinate with Jinan Landscaping Department (JLD) for relocation of landscaping trees on trolley bus rapid transit corridors.	Design Institute	PMO, IA
Pre-Construction Phase					
Institutional strengthening	Human Resources	Lack of environment management capacity within PMO and IA	Recruitment, including: - appointment of a qualified Environment and Social Officer (PMO ESO) within the PMO by the IA; - contracting of an external Loan Implementation Environmental Consultant (LIEC) by the IA; and - contracting of a qualified Environmental Monitoring Station (EMS) or consultant by the IA to conduct environmental quality monitoring.	IA, PMO	EA
			Capacity Building: - Prior to the start of construction, the institutional strengthening and training program will be delivered by the LIEC (Table 6).	LIEC, IA, PMO	EA
GRM	Project Affected Persons (APs)	Inadequate complaint mechanisms	- The PMO ESO will assume overall responsibility for the GRM. - GRM training will be provided for PMO members and GRM access points. - A website will be developed to provide information on the project and the GRM, the PMO will coordinate with government “Hotline” to link to the project level GRM, the PMO will issue public notices to inform the public within the project area of the GRM, and contact information (GRM website address, PMO address and telephone number, PMO contact point email address) for the PMO and local entry points (e.g., contractors) will be disseminated at all major access points. - Maintain and update a complaints register to document all complaints.	LIEC, IA, PMO	EA

Item	Impact Factor	Potential Impact and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity
EMP update	Revised project detailed design, if needed	Out of date EMP	- Review mitigation measures defined in this EMP and the EMoP, and update as required to reflect detailed design. - Submit to ADB/PMO for approval and disclose updated EMP on project and ADB website.	EIA Institute, PMO, LIEC,	IA, ADB
Tender documents	Various	Various	- All EMP obligations will be included in tender documents and will explicitly reference the EMP and EMoP.	PMO, LIEC	IA, ADB
			Estimated cost for Design and Pre-construction stage: costs are included in the detail design budget		
Construction Phase					
Good construction site practices	Soil resources	Spoil erosion and spoil management	- At each construction site the potential for storm water runoff will be assessed and appropriate storm water drainage systems to minimize soil erosion will be implemented, - Soil removal and filling will be balanced so as minimize the requirement for fill transportation. - During earthworks the area of soil exposed to potential erosion at any one time will be minimized through good project and construction management. - Strip and store topsoil in a stockpile for reuse in restoration. - Temporary spoil storage sites at new depot area if needed will be identified, designed, and operated to minimize impacts. Spoil sites will be restored after storage activities. - Spoil will be reused on-site to the maximum extent feasible as fill. - Excess spoil that cannot be used on-site will be transported to an approved spoil disposal site. - Spoil and aggregate piles will be covered with landscape material and/or regularly watered. - Waste construction material such as residual concrete, asphalt, etc. will be properly handled for re-use or disposal. - Construction and material handling activities will be limited or halted during periods of rains and high winds. - Any planned paving or vegetating of areas will be done as soon as practical after the materials are removed to protect and stabilize the soil. - Once construction is complete disturbed surfaces will be properly revegetated with native trees and grass. - Conduct project completion audit to confirm that spoil disposal site rehabilitation meets required standard, hold contractor liable in case of noncompliance.	Contractors	PMO, LIEC

Item	Impact Factor	Potential Impact and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity
	Air quality	Dust (TSP) during construction	- Construction works will be implemented in a phased manner along corridors to ensure activities in any one area are of limited duration. - Attention will be paid to dust suppression near sensitive receptors such as schools, hospitals, residential areas and natural areas. - Water will be sprayed on sites with the potential to cause fugitive dust including unpaved areas, backfill areas and unpaved haul roads, as necessary. - Temporary fencing will be erected around dusty activities. - Construction piles (spoil, aggregate other construction materials) with the potential to generate dust will be covered and/or watered if necessary. Powdered materials such as cement and lime will be stored in sealed bags or containers. - The time construction and demolition wastes are on site will be minimized by regularly removing them off site for disposal. - Construction and material handling activities will be limited or halted during periods of high winds if nuisance dusts are being generated. - Trucks transporting earth materials will be equipped with covers or tarpaulin, and will not be overloaded. Fine materials will be transported in fully contained trucks. - Muddy or dusty materials on public roads outside the exits of works areas will be cleaned immediately. - Transport routes and delivery schedules will be planned to avoid densely populated and sensitive areas, and high traffic times. - Disturbed sites will be revegetated as soon as possible after the completion of works.	Contractors	PMO, LIEC

	Noise	Noise from construction activities and vehicles	- Construction activities will be planned in consultation with local authorities and local communities so that activities with the greatest potential to generate noise and vibration are planned during periods of the day that will result in the least disturbance.
			- Construction will be avoided to the extent possible between 22:00 and 06:00 hours. However, it is recognized that construction in the trolley bus rapid transit corridors will occasionally require some works to be conducted at night to take advantage of reduced road traffic and/or to avoid worsening day time traffic conditions. In such cases:
			  - night time construction work should avoid using high sound level power equipment; and,
			  - nearby residents should be notified of such night
				Contractors	PMO, LIEC

Item	Impact Factor	Potential Impact and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity
			time activities well in advance. - Low-noise equipment that conforms to PRC noise standard GB12523-2011 will be selected as much as possible. - Equipment and machinery will be equipped with mufflers and will be properly maintained to minimize noise. - Temporary noise barriers will be used, as necessary - Machines in intermittent use will be shut down in the intervening periods between work or throttled down to a minimum. - Noise personnel protective equipment (PPE) will be provided to workers. - Transportation routes and delivery schedules will be planned during detailed design to avoid densely populated and sensitive areas and high traffic times. - Vehicles transporting construction materials or wastes will slow down and not use their horn when passing through or nearby sensitive locations.		
	Water quality	Pollution of adjacent water resources	- Excavations for foundations or any other purpose will be limited to 1.5 m below ground level. - Sufficient portable toilets will be provided for the workers and will be cleaned and discharged to the municipal sewerage system on a regular basis. - Construction wastewater from each site will be directed to temporary detention and settling ponds or tanks, and then treated water may be recycled for use in dust control or discharged to the local storm drainage network. If needed, polyacrylamide flocculent will be used to facilitate particle settling. All discharged construction wastewater will to be treated to the appropriate PRC standard prior to discharge. Discharged water will then be treated in one of Jinan's 16 municipal WWTPs. - All necessary measures will be undertaken to prevent construction materials and waste from entering drains and water bodies. - Maintenance of construction equipment and vehicles will not be allowed on sites to reduce wastewater generation.		
	Solid waste	Construction and demolition (C&D) waste and domestic refuse	- C&D wastes will be reused or recycled to the extent possible. The existing pavement on the low emission trolley bus rapid transit corridors will be recycled for use as paving materials for the new road surfaces. - C&D waste dumpsters will be provided at all work sites. C&D waste will be collected on a regular basis by a licensed waste collection company and transported for recycling, reuse, or disposal at a licensed landfill, in	Contractors	PMO, LIEC

Item	Impact Factor	Potential Impact and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity
			accordance with relevant PRC regulations and requirements. - Littering by workers will be prohibited. - Domestic waste containers will be provided at all work sites. Domestic waste will be collected on a regular basis by the local sanitation departments and transported for recycling, reuse, or disposal at a licensed landfill, in accordance with relevant PRC regulations and requirements. - Excavated soil will be backfilled onsite to the extent possible. Excess spoil that cannot be used on-site will be transported to an approved spoil disposal site. - There should be no final waste disposal on site. Waste incineration at or near the site is strictly prohibited. - Contractors will be held responsible for proper removal and disposal of any significant residual materials, wastes, and contaminated soils that remain on the site after construction.		

	Hazardous materials	Soil, surface and groundwater contamination	- Hazardous materials handling and disposal protocol that includes spill emergency response will be prepared and implemented by contractors.
			- A spill response plan will be developed, including:
			  - Maintaining a stock of absorbent materials (e.g. sand, earth or commercial products) on site to deal with spillages and training staff in their use.
			  - If there is a spill take immediate action to prevent entering drains, watercourses, unmade ground or porous surfaces. Do not hose the spillage down or use any detergents use oil absorbents and dispose of used absorbents at a waste management facility.
			  - Record any spill events and actions taken in environmental monitoring logs and report to PMO and LIEC.
			- Suppliers of chemicals and hazardous materials must hold proper licenses and follow all relevant protocols and PRC regulations and requirements.
				Contractors	PMO, LIEC

	Ecology	Protection of vegetation and restoration of disturbed areas	- Construction working areas will be demarcated to prevent encroachment and damage to adjacent areas. - Green landscaping will be implemented along trolley corridors and at bus depots and traction substations, including replacement trees and grasses appropriate to local ecological conditions. Locations and species selection to be decided in consultation with the JEPB and JLD.	Contractors	PMO, LIEC

Item	Impact Factor	Potential Impact and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity
			- No modification is allowed where the Chinese scholar tree (*Sophora japonica)*, located at the southern end of corridor V5, is fenced and protected.		
	Physical cultural resources (PCRs)	Destruction of cultural relics	- Chance find procedure will be established and activated at bus depots with consultation and permission of the local Cultural Heritage Bureau.	Contractor	PMO, LIEC, Cultural Heritage Bureau
Health and Safety	Occupational health and safety (OHS)	OHS Planning	The contractor's Environment, Health and Safety Officer will develop and implement an Occupational Health and Safety Plan (OHSP), maintain records concerning health, safety and welfare and regularly report on accidents, incidents and near misses. The OHSP will provide adequate precautions to protect the health and safety of their workers, including but not necessarily limited to the items below.	Contractors,	CSC, PMO, LIEC, IA
		Construction site sanitation	- Sites will be effectively cleaned. During site preparation, phenolated water will be sprayed for disinfection if necessary. - Wastes will be removed on a regular basis in accordance with waste management mitigation measures (above). - A clean and sufficient supply of fresh, potable water will be supplied to all work sites. An adequate number of latrines and other sanitary arrangements will be provided at all work sites and cleaned and maintained in a hygienic state, in accordance with water quality mitigation measures (above).	Contractor	PMO, LIEC, IA

		Occupational safety	- Workers will be provided with appropriate PPE to workers to minimize risks, including:
			  - Safety hats and safety shoes to all construction workers;
			  - Safety goggles and respiratory masks to workers doing asphalt road paving;
			  - Ear plugs to workers working near noisy PME, especially during piling works.
				Contractor	PMO, LIEC, IA

		Electrical safety	- Electrical safety risks will be assessed and safety protocols developed	Contractor	PMO, LIEC, IA
		Traffic safety	- Provide appropriate safety barriers and warning signs to ensure safety of workers on roads.	Contractor	PMO, LIEC, IA
		Medical emergency response	- Response procedures will be developed covering both workers and community members (when affected by project related activities), including communication systems and protocols for interaction with local and regional emergency response providers, first aid equipment on site, contact information for the nearest ambulance and medical facilities, training for workers on	Contractor	PMO, LIEC, IA, Health Agencies

Item	Impact Factor	Potential Impact and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity
			initial on-site emerge response, protocols for informing and transferring injured workers to local or provincial health centers, and record keeping. - At least one trained first-aid worker will be available at each construction site.		
		Emergency response	- Response procedures will be developed, including communication systems and protocols for interaction with local and regional emergency response providers, protocols for shutting down power, firefighting response procedures, provision of appropriate firefighting equipment, training for workers on fire response, and record keeping.	Contractor	PMO, LIEC, IA, EA, Emergency Response Providers
		Training	- An OHS manual will be prepared and disseminated to workers, and training will be provided to workers in all aspects of the OHS plan prior to the start of construction and on a regular basis (e.g. monthly).	LIEC, CSCs	PMO, IA,
	Community health and safety	Temporary traffic management	- A traffic control and operation plan will be prepared together with the local traffic management authority prior to any construction. The plan shall include provisions for diverting or scheduling construction traffic to avoid morning and afternoon peak traffic hours, regulating traffic at road crossings with an emphasis on ensuring public safety through clear signs, controls and planning in advance.	Contractor, local traffic police, PMO	LIEC, IA
		Information disclosure	- Residents and businesses will be informed in advance through publicity about the construction activities and provided with the dates and duration of expected disruption.	Contractor	PMO, LIEC, IA
		Access to construction sites	- Clear signs will be placed at construction sites in view of the public, warning people of potential dangers such as moving vehicles, hazardous materials, excavations etc., and raising awareness on safety issues. - All sites will be made secure, discouraging access by members of the public through fencing or security personnel, as appropriate.	Contractor	PMO, LIEC, IA
				Estimated cost for the Construction Stage:	$1.479 million
Operational Phase					
Trolley bus rapid transit corridors	Traffic Safety	Road condition	- Regularly inspect and maintaining corridor roads and drains, and trolley bus supporting infrastructure (overhead cables, substations, etc.).	O&M units	IA, Municipal Roads Department
		Road safety and traffic accidents	- Appropriate training of trolley bus drivers, including on existing emergency response plans/protocols, and provision of PPE. - Strict enforcement of traffic laws and regulations,	O&M units, Jinan Traffic Police	JMG

Item	Impact Factor	Potential Impact and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity
			especially speed limits. - The provision of lanes for pedestrians and non-motorized vehicles. - Improved designs of road junctions and pedestrian crossings		
	Domestic solid waste	Inappropriate disposal	- Bus stations and depots will be equipped with appropriate garbage and recycling containers. - Domestic garbage and recyclables will be collected on a regular basis. Recyclables will be collected by an appropriate recycling facility and garbage by the local sanitation department for disposal at a municipal solid waste landfill.	O&M units, Jinan Sanitation Department, Recycling companies	IA, JEPB

	Hazardous materials and waste at bus depots	New and waste batteries, lubricating oil and grease (O&G)	- hazardous materials handling and disposal protocol that includes spill emergency response will be prepared and implemented by depot operators.
			- Suppliers of chemicals and hazardous materials must hold proper licenses and follow all relevant protocols and the PRC regulations and requirements.
			- Storage facilities will be established at each bus depot for fuels, oil, chemicals and other hazardous materials. Storage facilities will be established in accordance with *Hazardous Waste Storage Pollution Control Standards* (GB18597-2001) within secured areas on impermeable surfaces provided with dikes, and at least 300 m from drainage structures and important water bodies. A standalone site within each storage facility will be designated for hazardous wastes including scrap batteries.
			- Licensed companies will be hired to collect, transport, and dispose hazardous materials in accordance with relevant PRC regulations and requirements.
			  - Qualified waste battery recycling companies will collect and recycle used batteries on a regular basis.
			  - Qualified companies will collect and properly disposal waste O&G on a regular basis.
				O&M units, qualified waste battery and lubricating oil recycling companies	IA, JEPB

	Quasi-groundwater protection zone	Pollution prevention	- Emergency spill response plan (noted above). - Regular vehicle maintenance will be undertaken to ensure safe battery operation.	O&M units, Emergency Response Providers	IA, JEPB
				Estimated cost for the Operational Stage: $0.360 million	

ADB = Asian Development Bank; EA = Executing Agency; EHS = environment, health & safety; EIT = Environmental Impact Table; IA = Implementing Agency; JEPB = Jinan Environmental Protection Bureau; JMG = Jinan Municipal Government; O&M = operation & maintenance; PMO = Project Management Office.

16. The mitigation measures defined in the EMP will be (i) checked and, where necessary, updated during detailed design and other project implementation stages (see Section J. Mechanisms for Feedback and Adjustment); (ii) incorporated into tender documents (where appropriate), construction contracts, and O&M manuals; and (iii) implemented by contractors and PMO under supervision of the IA. The effectiveness of these measures will be evaluated based on the results of the compliance inspections undertaken by the PMO ESO and LIEC and environmental quality monitoring conducted by the EMS.

D. Environmental Monitoring Plan

17. An EMoP will be implemented to monitor (i) the extent and severity of actual environmental impacts against the predicted impacts, (ii) the performance of the environmental protection measures and compliance with regulations, (iii) overall effectiveness of the project EMP; and (iv) need for adjustment of the project EMP. The project monitoring program focuses on the environment within the project's area of influence.

18. Two types of project monitoring will be conducted under the EMoP: [5]

(i) **EMP implementation monitoring.** To be conducted by the PMO ESO with support from the LIEC.
(ii) **Environmental quality monitoring.** To be conducted by the local EMS (contracted by the IA) involving the collection and analyses of water and air quality and noise data at designated monitoring locations to assess compliance with applicable environmental quality and emission standards.

19. In addition, environmental monitoring may also be periodically conducted by the local environmental authorities.

20. ADB will oversee EMP compliance based on (i) the EMP implementation section of quarterly project progress reports; (ii) semiannual EMRs provided by PMO; and, (iii) site visits during ADB review missions (generally once a year).

21. **EMP implementation monitoring.** EMP implementation monitoring will be undertaken on an ongoing basis by the PMO ESO with support from the LIEC, and will involve weekly or, when necessary, daily inspections of active work sites to ensure compliance with relevant EMP requirements. Findings of compliance inspections will be reported to the CSCs and contractor's Environment, Health and Safety Officer and the PMO, and measures to address any noncompliance will be implemented as soon as possible by the contractors.

22. **Environmental quality monitoring. Table 3** presents the project environmental quality monitoring program (air and noise), including, scope, location, parameters, duration and frequency of monitoring during the construction and operational stages. Environmental monitoring during construction and operation (first year) will be conducted by a qualified EMS or consultant, contracted by the IA. At the outset of project implementation, the PMO ESO with support from the LIEC will update the environmental monitoring program if necessary. The monitoring program and budgets will be included in the project tendering documents and budgets, as well as the construction and operation contracts.

[5] In addition to project-specific monitoring, the JEPB may conduct independent ambient and/or enforcement monitoring as per national requirements. This is separate to, and not funded by, the project.

23. The environmental monitoring results will be compared with relevant PRC performance standards (**Table 4**), and noncompliance with these standards will be highlighted in the monitoring reports. Monitoring results will be submitted by the EMS to the PMO and the IA on a quarterly basis. Any noncompliance will be reported in the EMP progress section under the quarterly project progress reports. Detailed monitoring results will be reported in semiannual EMRs by the PMO with the support of the LIEC (see reporting plan in **Table 5**).

Table 3: Environmental Monitoring Plan

Item	Monitoring Parameter	Monitoring Location	Monitoring Frequency and Duration	Implement-ing Entity	Supervising Entity
Construction Stage					
Air quality	TSP, $PM_{2.5}$, NO_2	10 existing air quality stations along BRT-trolley bus corridors:	24-hr continuous sampling, compiled monthly	EMS	PMO, JEPB
Noise	Leq dB(A)	10 locations along BRT-trolley bus corridors: - monitor only when road section has construction activities - no need to do night time monitoring at school locations	2 times per day per site (day time and night time) bi-monthly	EMS	PMO, JEPB
Operational Stage (first year)					
Air quality	TSP; $PM_{2.5}$ CO, NO_2	10 existing air quality stations along BRT-trolley bus corridors	24-hr continuous sampling, compiled semi-annually	EMS	IA Implementing Units, JEPB
Noise	Leq dB(A)	10 locations along BRT-trolley bus corridors (same locations as construction stage, no need to do night time monitoring at school locations)	2 times per day per site (day time and night time) semi-annually	EMS	IA Implementing Units, JEPB
					Total estimated cost: $ **10,000**

EMS = Environmental Monitoring Station; IA = Implementing Agency; JEPB = Jinan Environmental Protection Bureau; PMO = Project Management Office.

Table 4: Monitoring Indicators and Applicable PRC Standards

Period	Indicator	Standard
Construction	Air quality	Class II Ambient Air Quality Standard (GB 3095-2012)
	Noise limits of PME at boundary of construction site	Emission Standard of Environmental Noise for Boundary of Construction Site (GB 12523-2011)
	Noise at sensitive receptor within 35 m of road red line	WHO Class I: Residential, institutional, educational: 55 day and 45 night
	Discharge of wastewater from construction sites	Class I standard of Integrated Wastewater Discharge Standard (GB 8978-1996)
Operation	Air quality	Class II Ambient Air Quality Standard (GB 3095-2012)
	Traffic noise	Noise standard for Category 4a Functional Area in Environmental Quality Standard for Noise (GB 3096-2008)

E. Reporting

24. **Environmental reporting.** The contractors will submit monthly reports to the PMO on implementation and compliance with the EMP and CEMPs, including information on all spills, accidents, grievance received, and appropriate actions taken.

25. Based on the contractors' monthly reports and the compliance inspection and ambient monitoring results, the CSC will prepare quarterly environmental progress reports including EMP implementation and monitoring results for submission to the PMO, IA, EA, and ADB. The PMO ESO with support from the LIEC will prepare annual EMRs for onward submission to the IA and the EA, and then to ADB. The reports should assess the project's compliance with the EMP and PRC environmental standards, identify any environment-related implementation issues and necessary corrective actions, and reflect these in a corrective action plan. The performance of the contractors in respect of environmental compliance will also be reported, as will the operation and performance of the project GRM, environmental institutional strengthening and training, and compliance with all project covenants.

26. **Review by ADB.** ADB will review the semiannual EMRs and ADB missions will inspect the project progress and implementation on site at least once a year. For environmental issues, inspections will focus mainly on (i) monitoring data; (ii) the implementation status of project performance indicators specified in the loan covenants on the environment, environmental compliance, implementation of the EMP, and environmental institutional strengthening and training; (iii) the environmental performance of contractors, CSCs and the PMO; and (iv) operation and performance of the project GRM.

27. **Environmental acceptance reporting.** Within 3 months after completion, or no later than 1 year with permission of the JEPB, an environmental acceptance report shall be prepared by a licensed institute in accordance with the PRC *Regulation on Project Completion Environmental Audit* (MEP, 2001), approved by the relevant environmental authority, and reported to ADB. The environmental acceptance report will indicate the timing, extent, effectiveness of completed mitigation and of maintenance, and the need for additional mitigation measures and monitoring (if any) during operation.

28. Reporting requirements are summarized in **Table 5**.

Table 5: Environmental Reporting Plan

Phase/ Reports		From	To	Reporting Frequency
Construction Phase				
EMP and CEMP progress reports	EMP and CEMP progress reports	Contractors	CSC, PMO	Monthly
EMP and CEMP compliance Inspections	EMP and CEMP compliance inspection reports with environmental quality monitoring results	EMS, CSCs	PMO, IA	Quarterly
Environmental monitoring reports to ADB	Environmental monitoring report, including EMP, EMoP, GRM implementation and monitoring results)	PMO via IA (with support of LIEC)	ADB	Semiannual
Environmental Acceptance report	Environmental acceptance monitoring and audit report	Licensed institute	JEPB, ADB	Within 3 months of completion of physical works
Operational Phase				
Environmental monitoring reports to ADB	EMP progress and monitoring report	PMO	IA, EA, ADB	Annually (until project completion)

ADB = Asian Development Bank, EMS = Environmental Monitoring Station, IA = implementing agency, JEPB = Jinan Environmental Protection Bureau, LIEC = Loan Implementation Environmental Consultant, PMO = Project Management Office.

F. EMP Institutional Capacity Building and Training

29. The capacity of the PMO, IA, CSCs, and contractors responsible for EMP (and CEMPs) implementation and supervision will be strengthened. All parties involved in implementing and supervising the EMP must have a good understanding of the ADB SPS (2009), the project relevant environmental objectives, methods, and good practices of project environmental management. The project will strengthen capacity and expertise in environmental management through (i) institutional capacity building, and (ii) training.

30. **Institutional strengthening.** The capacities of the PMO and IA to coordinate environmental management will be strengthened through:

(i) The appointment of qualified PMO ESO in charge of EMP coordination, including the GRM.
(ii) The recruitment of a Loan Implementation Environmental Consultant (LIEC), a part-time national environmental, health and safety specialist who will support the PMO in mitigation implementation, environmental monitoring, reporting, and addressing any environment related issues that arise including grievances. The LIEC will also support contractors in developing Construction site-specific Environmental Management Plans (CEMPs) prior to construction and operation.
(iii) The recruitment of a local EMS to collect and analyze air quality and noise data at designated monitoring locations to assess compliance with applicable environmental quality standards during construction.

31. **Training.** The PMO, IA (including O&M units for the operational phase), CSCs, and contractors will receive training on the ADB SPS (2009); PRC safeguard requirements; development and implementation of environment, health and safety (EHS) plans during

construction and operation; implementation of the EMP, the EMoP, and the GRM; and typical good construction EHS plans and practices (**Table 6**), which can be incorporated into the CEMP development. Training will be facilitated by the LIEC with support of other experts under the loan implementation consultant services.

G. Consultation, Participation, and Information Disclosure

32. **Consultation during project preparation.** Section VII of the IEE report has described the meaningful public participation and consultation implemented during project preparation.

33. **Future public consultation plan.** Plans for public involvement during construction and operation stages have been developed during project preparation. These plans include public participation in (i) monitoring impacts and mitigation measures during the construction and operation stages; (ii) evaluating environmental and economic benefits and social impacts; and (iii) interviewing the public after the project is completed. These plans will include several types of public involvement, such as site visits, surveys, investigation of specific issues, interviews, and public hearings, as indicated in **Table 7**.

Table 6: Training Program

Training	Attendees	Contents	Times	Period (days)	No. of persons	Cost ($/person /day)	Total Cost
Construction Phase							
ADB and PRC EHS laws, regulations and policies	PMO, IA, contractors	– ADB's safeguard policy statement – Project applicable PRC EHS laws, policies, standards and regulations – International environmental, health and safety management practice in civil construction – International environmental, health and safety management practice in civil construction	Twice - once prior to, and once after one year of project implementation	2	30	100	$6,000
Implementation of EMP and EMoP	PMO, IA, contractors	– Impacts and mitigation measures – Monitoring and auditing mechanism – Reporting requirements – Issue of non-compliance and corrective actions for EMP, EMoP and GRM.	Twice - once prior to, and once after one year of project implementation	2	30	100	$6,000
Grievance Redress Mechanism	PMO, IA, contractors, JEPB	– GRM structure, responsibilities, and timeframe – Types of grievances and eligibility assessment	Twice - once prior to, and once after one year of project implementation	2	30	100	$6,000
Implementation of construction EHS Plans	PMO, IA, contractors, JEPB	– Plan descriptions – Roles and responsibilities – Worker and community EHS concerns and actions	Twice - once prior to, and once after one year of project implementation	2	30	100	$6,000
Operation Phase							
Implementation of operation EHS Plans	IA, O&M units	– Plan descriptions – Roles and responsibilities – Worker and community EHS concerns and actions	Once prior to project implementation	1	30	100	$3,000
Roads and Traffic	IA, O&M units	– Traffic management and traffic safety	Once prior to project implementation	1	30	100	$3,000
						Total estimated cost:	**$30,000**

IA = implementing agency, JEPB = Jinan Environmental Protection Bureau, PMO = Project Management Office.

Table 7: Public Consultation Plan

Organizer	Format	No. of Times	Subject	Attendees	Budget
Construction Stage					
PMO	Public consultation & site visit	4 times: 1 time before construction commences and 1 time each year during construction	Adjusting of mitigation measures, if necessary; construction impact; comments and suggestions	Residents adjacent to project sites, representatives of social sectors	$5,000
PMO, IA	Expert workshop or press conference	As needed based on public consultation	Comments and suggestions on mitigation measures, public opinions	Experts of various sectors, media	$2,000
Operational Stage					
IA, O&M units	Public consultation and site visits	Once in the first year	Effectiveness of mitigation measures, impacts of operation, comments and suggestions	Residents adjacent to project sites, representatives of residents and representatives of social sectors	$1,500
IA, O&M units	Expert workshop or press conference	As needed based on public consultation	Comments and suggestions on operational impacts, public opinions	Experts of various sectors, media	$1,500
				Total budget:	**$10,000**

O&M = operation and maintenance, PMO = Jinan Project Management Office.

H. Grievance Redress Mechanism

34. **Project-specific GRM.** A project grievance can be defined as an actual or perceived project-related problem that gives ground for complaint by an affected person (AP). The PMO will work proactively toward preventing grievances through the implementation of impact mitigation measures and community liaison activities that anticipate and address potential issues before they become grievances. The project has strong public support; nonetheless, grievances related to the environment, land acquisition, and resettlement will need to be adequately handled. During construction and operation, it is possible that unanticipated impacts may occur if the mitigation measures are not properly implemented, or unforeseen issues arise. To address any complaints, a project-specific GRM has been developed in accordance with ADB requirements and government practices. The GRM is a systematic process for receiving, recording, evaluating, and addressing AP's project-related grievances transparently and in a reasonable period.

35. The objective of the project GRM is to prevent and address community concerns, reduce risks, and assist the project to maximize environmental and social benefits. In addition to serving as a platform to resolve grievances, the GRM has been designed to (i) open channels for effective communication, including the identification of new environmental issues of concern arising from the project; (ii) demonstrate concern about community members and their environmental well-being; and (iii) prevent and mitigate any adverse environmental impacts on communities caused by project implementation and operations. The GRM will be accessible to all members of the community.

36. The overall approach of the GRM is to deal with grievances at a local level first in an efficient manner, and escalate to higher level of authority if the grievance cannot be resolved.

37. The PMO ESO is responsible for coordinating the implementation of the GRM and will establish a GRM unit within the PMO which will be the key contact point for residents, businesses, government departments, and other stakeholders who may require information about the project or who have an issue they would like to discuss. Other GRM entry points will include (i) the contractors, (ii) the IA, and (iii) the JEPB for environment issues. As for land acquisition and resettlement issues, different steps of GRM have been established in the RP. The PMO will issue public notices to inform the public within the project area of the GRM, and the PMO and other entry points phone number, fax, address, email address will be disseminated at construction and other sites.

38. The PMO will maintain a complaints database and communicate with contractors, CSCs, JEPB, and other relevant local government departments. The PMO ESO will be supported on an as need basis by the LIEC and if applicable, a Loan Implementation Resettlement Consultant (LIRC).

39. **Types of environment-related grievances and eligibility.** Construction phase grievances might relate to issues such as traffic disruptions, access to businesses and residences, and construction dust or noise. Operation phase complaints may relate to service levels, delays or traffic disruptions. Once a complaint is received and filed, the PMO 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 safeguards. 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 environment GRM (such as allegations of fraud or corruption); and (iii) where other company or community procedures are more appropriate to address the issue. Complaints ineligible to the project or the GRM will be recorded and passed onto relevant authorities. If an eligible complaint is rejected, the complainant will be informed of the decision and the reasons for rejection.

40. **Environment-related GRM steps.** The GRM will be implemented through five escalating steps, advancing to the next level only if the grievance was unable to be redressed at the previous level. Note that: (i) at any stage in the GRM, an AP may submit their grievance to any agency they feel most comfortable with. If such agency is not listed in the steps below, they will also need to inform at least one of the listed individuals or agencies, to enable the GRM procedures to be implemented; and (ii) the GRM does replace the role of existing laws and legal procedures. In the event of any grievance, the PMO will immediately inform ADB, and then ensure that ADB is updated on the progress.

(i) **Step 1:** If a concern arises, the AP should try to resolve the issue of concern directly with the contractor or via the GRM access points (community leaders, neighborhood organizations, JEPB) during the construction phase, and/or the operator during the operation phase. If the concern is resolved successfully no further follow-up is required. The contractor (during construction) and/or the operator (during operation) shall record any complaint and actions taken to resolve the issues and report the results to the PMO. If no solution is found within 7 working days or if the complainant is not satisfied with the suggested solution under Step 1, proceed to Step 2.

(ii) **Step 2:** The AP will submit the grievance to the PMO, who will record the grievance, assess its eligibility and report back to the AP within 7 working days. If the grievance is eligible, proceed to step 3.

(iii) **Step 3:** The PMO will investigate the complaint, and consult with the IA, LIEC and other stakeholders as appropriate in an attempt to identify a solution. The PMO will give a clear reply to the AP within 5 working days with the suggested solution, and the IA will ensure that implementation of the agreed-upon redress solution begins within 7 working days. If no solution is found or if the complainant is not satisfied with the suggested solution under Step 3, proceed to Step 4.

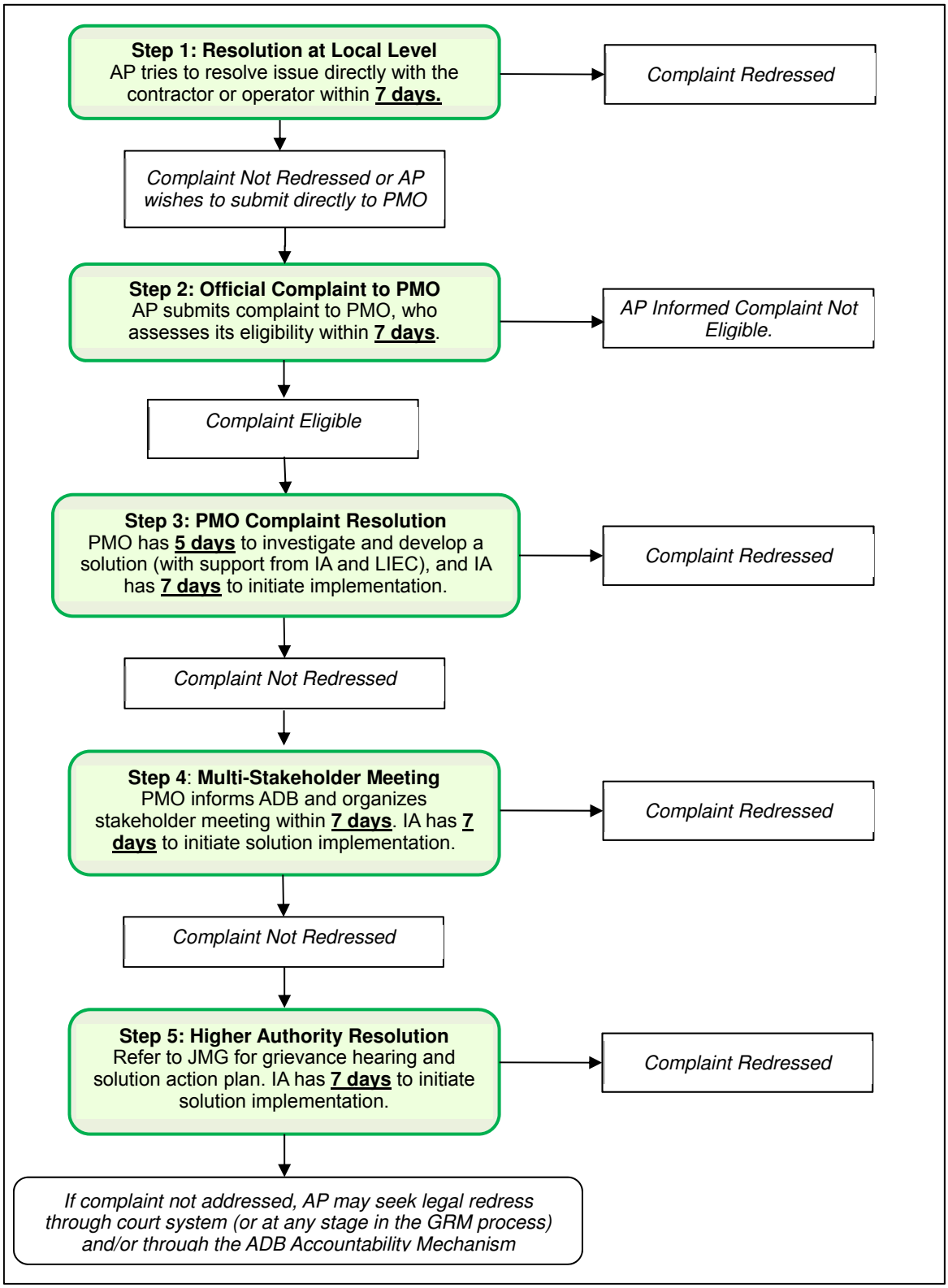
(iv) **Step 4:** The PMO will inform ADB as to the grievance, and will organize a multi-stakeholder meeting within 5 days, where all relevant stakeholders, including the complainant, the EA, IA, ADB and JEPB, can discuss the issue. The multi-stakeholder meeting will aim to find a solution acceptable to all, and identify responsibilities and an action plan. The IA will ensure that the implementation of agreed-upon redress solution begins within 7 working days of the completion of the multi-stakeholder meeting.

(v) **Step 5:** If the complainant is not satisfied with the suggested solution under Step 4, the grievance will be directed to JMG. The JMG will direct the EA to organize a hearing process and shall determine a solution acceptable to all. Based on the hearing results, an action plan shall be developed and the IA will ensure that the implementation of the agreed-upon redress solution begins within 7 working days of the completion of the hearing.

41. The five GRM steps are illustrated in **Figure 2**.

42. APs will not be charged any cost for submitting a grievance to the PMO. All costs for implementing an agreed solution will be paid by the party deemed responsible for causing the grievance. The grievance procedures will remain valid throughout the duration of the project construction and until project closure.

Figure 2: Five Step Project GRM



I. Cost Estimates

43. The estimated budgets for environmental monitoring, capacity building, training, and public consultation are summarized in **Table 8**. Construction phase costs are estimated at $148,000; operation phase mitigation and monitoring costs are estimated at $28,000 (first year). Costs for mitigation to be implemented by contractors are included within the main civil work contract costs, and are estimated at $1.664 million, equivalent to 0.45% of the total project cost (of this, 80% is allocated for the construction phase, and 20% for the operation phase). Total estimated cost for EMP implementation is $1.840 million.

44. Contractors will bear the costs for all mitigation measures during construction, including those specified in the tender and contract documents as well as those to mitigate unforeseen impacts due to their construction activities. The IA will bear all environmental monitoring costs during construction and the first year of operation and will ensure the necessary budgets are available for the EMS. The IA will also bear the costs for training and capacity building, and for coordinating the GRM. The O&M units will bear the costs related to mitigation measures during operation (e.g. provision of PPE to bus drivers).

J. Mechanisms for Feedback and Adjustment

45. The effectiveness of mitigation measures and monitoring plans will be evaluated through a feedback reporting system. If, during compliance inspections and monitoring, substantial deviation from the EMP is observed, then the PMO ESO and LIEC will consult with the PMO and JEPB and propose appropriate changes to the EMP monitoring and mitigation plan.

46. Any major EMP adjustments will be subject to ADB review and approval and ADB may pursue additional environmental assessment and, if necessary, further public consultation. The revised EMP with ADB confirmation is subject to reposting on the ADB's website as the ADB public communications policy requires. The revised EMP will be passed on to the contractor(s) for implementation.

Table 8: EMP Budget

Construction Phase					
1. Ambient Monitoring	**Unit**	**Unit Cost**	**# Times**	**Cost USD**	**Cost RMB**
Air - TSP, SO_2, NO_2	Daily from Jinan EPB stations	No Charge	Daily	No Charge	No Charge
Noise	Monthly, 10 Locations over 36 months	$ 25	360	$ 9,000	¥61,875
Subtotal				***$ 9,000***	***¥61,875***
2. Capacity Building	**Unit**	**Course Cost**	**# Times**	**Cost USD**	**Cost RMB**
Construction Phase EMP Training	Development and Delivery	$ 12,000	2	$ 24,000	¥165,000
Subtotal				***$ 24,000***	***¥165,000***
3. Public Consultation	**Unit**	**Total Cost**	**# Times**	**Cost USD**	**Cost RMB**
Construction Phase	Consultations, Site Visits and Workshops	$ 7,000	Various	$ 7,000	¥48,125
Subtotal				***$ 7,000***	***¥48,125***
4. Loan Implementation Env. Consultant	**Unit**	**Monthly Cost**	**# Months**	**Cost USD**	**Cost RMB**
Construction Phase LIEC	Person Months	$ 6,000	18	***$ 108,000***	***¥742,500***
TOTAL Construction Phase				***Cost USD***	***Cost RMB***
				$ 148,000	***¥1,017,500***
Operation Phase (first 2 years)					
1. Ambient Monitoring	**Unit**	**Unit Cost**	**# Times**	**Cost USD**	**Cost RMB**
Air - TSP, SO_2, NOx	Daily from Jinan EPB stations	No Charge	Daily	No Charge	No Charge
Noise	Semi-annual, 10 Locations over 24 months	$ 25	40	$ 1,000	¥6,875
Subtotal				***$ 1,000***	***¥6,875***
2. Capacity Building	**Unit**	**Course Cost**	**# Times**	**Cost USD**	**Cost RMB**
Operation Phase EMP Training	Development and Delivery	$ 3,000	2	$ 6,000	¥41,250
Subtotal				***$ 6,000***	¥41,250
3. Public Consultation	**Unit**	**Total Cost**	**# Times**	**Cost USD**	**Cost RMB**
Operation Phase	Consultations, Site Visits and Workshops	$ 3,000	Various	$ 3,000	¥20,625
Subtotal				***$ 3,000***	***¥20,625***
4. Loan Implementation Env. Consultant	**Unit**	**Monthly Cost**	**# Months**	**Cost USD**	**Cost RMB**
Operation Phase LIEC	Person Months	$ 6,000	3	***$ 18,000***	***¥123,750***
TOTAL Operation Phase				***Cost USD***	***Cost RMB***
				$ 28,000	***¥192,500***
GRAND TOTAL Construction + Operation				***Cost USD***	***Cost RMB***
				$ 176,000	***¥1,210,000***

Construction Phase Notes:

- Assumes 36 months of actual construction works over the 4-year construction period.
- Ambient monitoring based accessing on-line air quality data from existing air quality monitoring stations along the trolley routes, and a contract with an environmental monitoring station for monthly monitoring of noise at ten sites, to be selected by the PMO ESO and LIEC.
- Construction phase LIEC part time – 18 months over construction phase.
- Does not include costs for mitigations to be implemented by contractors.

Operation Phase Notes:

- Ambient monitoring based accessing on-line air quality data from existing air quality monitoring stations along the trolley routes, and a contract with an environmental monitoring station semi-annual monitoring of noise at ten sites, to be selected by the PMO ESO and LIEC.
- Operation phase LIEC part time – 3 months over first year of operation phase.

Annex 1: Draft Terms of Reference for Environmental Positions

1. PMO Environment and Social Officer

A. 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 include 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, the PMO Environment and Social Officer (PMO ESO). These terms of reference describe the requirements for this officer.

B. Scope and Duration of Work

2. The officer will work on behalf of the PMO to implement the project EMP and handle other land acquisition and resettlement issues. The officer will report directly to the PMO. The position is for the entire duration of project construction and at least the first year of project operation.

C. Qualifications

3. The officer will have (i) an undergraduate degree or higher in environmental management or related field; (ii) at least 5 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.

D. Detailed Tasks

4. The PMO ESO will have a detailed understanding of the project EMP and supporting documents, including the domestic environmental impact table (EIT) report and 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. This should occur at least 3 months before construction begins.
(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 responsible for the internal environment monitoring described in the EMP understand their tasks and will implement the monitoring in a timely fashion.

(vi) At least 2 months before construction begins, establish and implement the project grievance redress mechanism (GRM) described in the EMP. This will include: (a) preparation of 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) preparation of 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 the implementation agencies 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) Support contractors in developing construction site-specific EMPs (CEMPs), if needed, and approve CEMPs.

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

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

(xi) Compile, review, and store environmental progress reports from the implementation agencies, 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.

(xii) Prepare quarterly progress reports for submission to the PMO and IA, and semi-annual environment progress reports on behalf of the PMO, to be submitted by the IA to ADB.

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

E. Reporting Requirements

5. EMP implementation section under quarterly project progress reports, and semi-annual environment monitoring reports (EMRs), using a template reviewed and approved by ADB.

F. Logistical Support Provided by the PMO and PMO ESO to the LIEC

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

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

2. Loan Implementation Environmental Consultant (LIEC)

A. Background

6. The project will be coordinated by a PMO whose overall responsibility includes implementation of the project EMP. The loan implementation environmental consultant (LIEC) will support the PMO to implement the project EMP, including EMoP, EMR, and GRM.

B. Scope and Duration of Work

7. This position could be a firm or an individual engaged by the PMO. It is an independent position and is not part of the PMO government staff. The specialist will report directly to the PMO and consulting firm (if the individual has been engaged by a firm). The position is part-time over the entire duration of project construction and the first year of project operation. The LIEC should be recruited as soon as possible after loan effectiveness.

C. Qualifications

8. The specialist will have (i) an undergraduate degree or higher in environmental management or related field; (ii) at least eight (8) 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.

D. Tasks

9. Working closely with the PMO ESO, the LIEC will do the following.

Before construction:

(i) Ensure (a) all bid and tendering documents include, and will comply with, the EMP; and (b) relevant sections of the EMP are incorporated in contractor contracts.
(ii) Support contractors in developing construction site-specific environmental management plan (CEMPs), which needs to be confirmed by the PMO and implemented by contractors.
(iii) Assist the PMO to implement the GRM, including (a) establish and publicize the GRM; and (b) collate and evaluate grievances received.
(iv) Develop procedures to (a) monitor EMP and CEMPs implementation progress; (b) collate and evaluate data collected in the EMP environmental monitoring program; and (c) prepare and submit EMP implementation section under quarterly project progress reports, and semiannual environmental monitoring reports (until project completion report).

During project implementation:

(i) Support the PMO Environment and Social Officer (PMO ESO) in their tasks. The overall aim is to raise the PMO ESO's capacity as needed, so they can independently achieve

the tasks in their terms of reference.

(ii) Accompany the PMO ESO on visits to the project construction sites to assess progress and compliance with the EMP.
(iii) Assist in the ongoing public consultation process as described in the project EIA.
(iv) Conduct EMP compliance assessments, identify any environment-related implementation issues, and propose necessary responses in corrective action plans.
(v) Undertake training of project agencies as required by the EMP training plan.
(vi) Assist the PMO to prepare quarterly and semiannual environmental monitoring progress reports.

APPENDIX B - Site Details of Bus Depots and Traction Substations

Table 1: Site Conditions at Trolley Bus Depot Sites

#	Name	Aerial View	Site View	Ecology
ED1	Dawei Depot			Site is paved with no existing vegetation or critical habitat.
ED2	Quanfu Interchange			Site is paved with no existing vegetation or critical habitat.
ED3	West Railway Station			Site is paved with no existing vegetation or critical habitat.
ED4	Yaojiazhuang			Site is paved with no existing vegetation or critical habitat.
ED5	Jinan University			Site is paved with no existing vegetation or critical habitat.

#	Name	Aerial View	Site View	Ecology
ED6	Xinxilukoubei			Site is paved with no existing vegetation or critical habitat.
ED7	Public Transport Vocational High School			Site is paved with no existing vegetation or critical habitat.
ED8	Jiuqu			Site is paved with no existing vegetation or critical habitat.
ND1	Tang Ye Bus Station			Site is paved with no existing vegetation or critical habitat.
ND2	Huanggang Bus Parking Lot			Site is paved with no existing vegetation or critical habitat.

#	Name	Aerial View	Site View	Ecology
ND3	Shengli Provincial Hospital Station			Site is paved or bare land with no existing vegetation or critical habitat.
ND4	Jiangshuiquan Station			Site is paved or bare land with no existing vegetation or critical habitat.
ND5	Suncun Station			Site bare land with some recent grass, no critical habitat.
ND6	West Railway			Site is paved with no existing vegetation or critical habitat.
ND7	Jiluolo Road			Site is waste land with low value scrub vegetation and no critical habitat.

#	Name	Aerial View	Site View	Ecology
ND8	Hanyu Station			Site is waste land with low value scrub vegetation and no critical habitat.

Note: ED = Existing Depot, ND = New Depot

Table 2: Site Conditions at Traction Substation Sites

#	Location	Ownership Status	Area (m^2)	Site Photo	Ecology
	H1 - Qingdaolu-Beiyuandajie-Gongyebeilu				
1	400m southwards from Qizhou Road of Qingdao Road	state-owned land	80		Typical road corridor landscaping, some small trees
2	100m eastwards from Weifang intersection of Qingdao Road	state-owned land	80		Typical road corridor landscaping, some small trees
3	100m eastwards from Huanggang intersection	state-owned land	80		Underpass landscaping

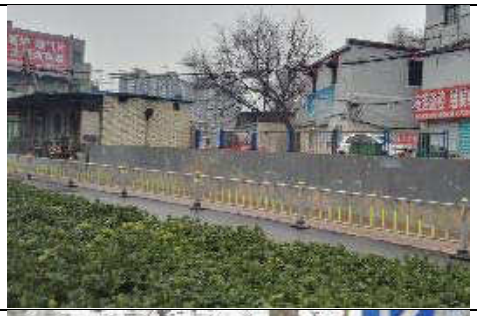
#	Location	Ownership Status	Area (m^2)	Site Photo	Ecology
4	80 m westwards from West Gongshang River Intersection	state-owned land	80		Underpass landscaping
5	140m from west of Shuitun Road	state-owned land	80		Underpass landscaping
6	340m from west of kiln ditch bridge	state-owned land	80		Underpass landscaping
7	Qilu Pharmaceutical Factory at Gongye North Road	state-owned land	80		Typical road corridor landscaping
8	300m from east of Xingfuliu Square	state-owned land	80		Typical road corridor landscaping

#	Location	Ownership Status	Area (m^2)	Site Photo	Ecology
9	East side of Ledong Exercise Center	state-owned land	80		Typical road corridor landscaping, currently disturbed
10	Jigang (#21, Gongye North Road)	state-owned land	80		Typical road corridor landscaping, currently disturbed
11	Guodian flyover	state-owned land	80		Abondoned Typical road corridor landscaping, grasses and shrubs
	H2 Nanxinzhuang-Jingqilu-Louyuan-Jiefanglu-Gongyenanlu				
12	Qinglongshan long-distance passenger station	state-owned land	80		Typical road corridor landscaping
13	Vicinity of Nanxinzhuang bus stop	state-owned land	80		
14	100m westwards from Jingqi Xiaowei 2nd Road	state-owned land	80		Typical road corridor landscaping

#	Location	Ownership Status	Area (m^2)	Site Photo	Ecology
15	Vicinity of Luowen Road of Quancheng Square	state-owned land	80		
16	200m westwards Shanda Intersection of Jiefang Road	state-owned land	80		Typical road corridor landscaping
17	Provincial prison dormitory	state-owned land	80		Typical road corridor landscaping
18	Blank land in vicinity of tobacco logistics center	state-owned land	80		Typical road corridor landscaping
	H3. Erhuannanlu				
19	300m southwards from Meili road of Erhuan West Road	state-owned land	80		Typical road corridor landscaping
20	Kuangshan Steel Market	state-owned land	80		Underpass landscaping

#	Location	Ownership Status	Area (m^2)	Site Photo	Ecology
21	200m northwards from Jingliu Road of Erhuan West Road	state-owned land	80		Underpass landscaping
22	Joint Logistics Department of military region of Erhuan West Road	state-owned land	80		Typical road corridor landscaping
23	1000m north of the intersection of south extension section of west ring 2 road and state way 104	state-owned land	80		
	V5. Aotizhonglu				
24	100m southwards from Yangliu Road of Aoti Middle Road	state-owned land	80		Typical road corridor landscaping
25	250m southwards from Tianchen Road of Aoti Middle Road	state-owned land	80		Typical road corridor landscaping
	V4. Erhuandonglu				

#	Location	Ownership Status	Area (m^2)	Site Photo	Ecology
26	Yangjiazhuang intersection	state-owned land	80		Baren land
27	CNPC 25 Gas Station (Jinan Red-cross Ophthalmic Hospital)	state-owned land	80		Typical road corridor landscaping
28	300m northwards from gate of Diequan mountain villa of open sea	state-owned land	80		Typical road corridor landscaping
29	Shandong Electric Power Research Institute	state-owned land	80		Typical road corridor landscaping
30	Vicinity of south campus zone of Shandong University	state-owned land	80		Typical road corridor landscaping

#	Location	Ownership Status	Area (m^2)	Site Photo	Ecology
31	South of Lvyou Road intersection of the Erhuan East Road	state-owned land	80		Typical road corridor landscaping
	V3. Lishan				
32	Vicinity of railway bridge of Lishan Road	state-owned land	80		Typical road corridor landscaping
33	Yizheng Mansion of Lishan Road	state-owned land	80		Typical road corridor landscaping
	V1. Erhuan East Road				
34	Central green land in opposite to Shimen gas station	state-owned land	80		
35	375m northwards of Park intersection	state-owned land	80		Typical road corridor landscaping

#	Location	Ownership Status	Area (m^2)	Site Photo	Ecology
36	125m northwards of Hepeingbeilu	state-owned land	80		Typical road corridor landscaping
	V2. Weishier Road				
37	Vicinity of fruit wholesale market of Dikou Road	state-owned land	80		Typical road corridor landscaping
38	East door of Harmony Square	state-owned land	80		Typical road corridor landscaping
39	Quanjin Wolong Park	state-owned land	80		Typical road corridor landscaping
40	Vicinity of Jiuqu parking lot	state-owned land	80		Typical road corridor landscaping

APPENDIX C - Climate Risk and Vulnerability Assessment

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

compared to 1971-2000
Figure 14c: Changes in the Simulated 100-Year Annual Maximum Daily Precipitation, 2036-2065 compared to 1971-2000

LIST OF ACRONYMS

ADB	Asian Development Bank
AR5	Fifth Assessment Report of the IPCC
CMIP5	Fifth Round of the Coupled Model Intercomparison Project
CRVA	Climate Risk and Vulnerability Assessment
DMC	ADB Developing Member Country
GCM	General Circulation Model (also Global Climate Model)
GEV	Generalized Extreme Value distribution
GDP	Gross Domestic Product
GDDP	Global Daily Downscaled Projections
IPCC	Intergovernmental Panel on Climate Change
JMG	Jinan Municipal Government
MASL	meters above sea level
OLS	ordinary least squares
PPTA	Project Preparatory Technical Assistance
PRC	Peoples' Republic of China
RCP	Representative Concentration Pathway
REA	Rapid Environmental Assessment
SLR	Sea Level Rise

1. INTRODUCTION AND OVERVIEW OF THE PROJECT AND CLIMATE RISKS TO THE PROJECT

1.1 Description of the Project:

1. From the Project Data Sheet: The Shandong Spring City Green Modern Trolley Bus Demonstration Project (the Project) is a $150 million loan-supported project (OCR) designed to improve the urban transport environment in Jinan, located in Shandong province. Introduction of a modern trolley system is intended to reduce emissions and road congestion. A project preparatory technical assistance (PPTA) is being conducted to verify the technical, financial, economic, social and environmental viability of the project and develop sustainable urban mobility strategies for the city, to be implemented together with the trolley bus system. The outcome of the project will be enhanced sustainable urban mobility with integrated public transport services and a zero emission trolleybus network.

1.2 Background (verbatim from Project Data Sheet):

2. Jinan is the capital of the Shandong province located in eastern China. It is 400 km south of Beijing and 200 km from the east coast. Jinan in recent years has evolved into a major administrative, economic and transportation center, with a population of 6.4 million and an average annual GDP per capita of USD 9,907 in 2014. The city has a monocentric and sprawl pattern to the southwest, east and north with direct jurisdiction over six urban districts, one county level city, and three counties. It has a special geological structure with underground streams from Taishan Mountain emerging in the form of numerous springs. The protection of springs is an important element to be considered in Jinan s urban development. The development of underground metro lines in the downtown area is restricted by the springs, thus making modern bus services more important.

3. Despite efforts by the government in reducing traffic congestion and pollution through improved public transport services with the seven Bus Rapid Transit routes, four trolley bus routes, suburban and exurban bus and special services for schools, supermarkets and businesses, Jinan overtook Beijing as the most congested city in the first quarter of 2016 in the PRC and tops the list in traffic congestion with a delay index of 2.1. Also according to the National Environmental Analysis released in January 2013, Jinan is one of the ten most polluted cities in the world. In Aug and Sep 2014, the Ministry of Environmental Protection Statistics ranked Jinan as the most polluted city in PRC. The major sources of pollution are coal-based power plants and industries in the Shandong province, rapidly increasing motor vehicles, and massive construction sites in the city.

4. Jinan has been nominated as one of the pilot cities in several different urban transport initiatives in the PRC. The Jinan Municipal Government (JMG) has developed a comprehensive urban public transport development plan for urban rail network development, a trolley bus network development plan, and a public transport infrastructure plan including stations, depots and low emission buses. With the visions and plans established, JMG has requested ADB to support upgrading and integrating its urban public transport infrastructure by developing a trolley bus network and sustainable urban mobility strategies built around urban public transport.

5. The outcome of the project has a huge potential for other cities in the PRC and DMCs where the trolley bus system can be considered suitable for the urban transport context.

1.3 Results of Screening: Climate Risks to the Project:

6. Pursuant to the request by ADB's Board of Directors communicated in 2013, all ADB-financed projects are now screened and, if necessary, assessed in detail for risks related to climate change, including climate-related disasters. The first stage of risk screening is a checklist appearing in the required Rapid Environmental Assessment (REA). The results of REA screening indicate that the Project is at ***Medium*** risk from the impacts of climate change. The accompanying remarks are as follows: *"Future increases in temperature may need to be taken into account in the planning of cooling requirements for trolley buses and stations. Design of stations should take account of passive design options to reduce mechanical cooling requirements. Materials specified for stations should be durable and low-maintenance. If there is an increase in extreme events and temperature there be a need for an increased frequency of maintenance of trolley bus infrastructure."*

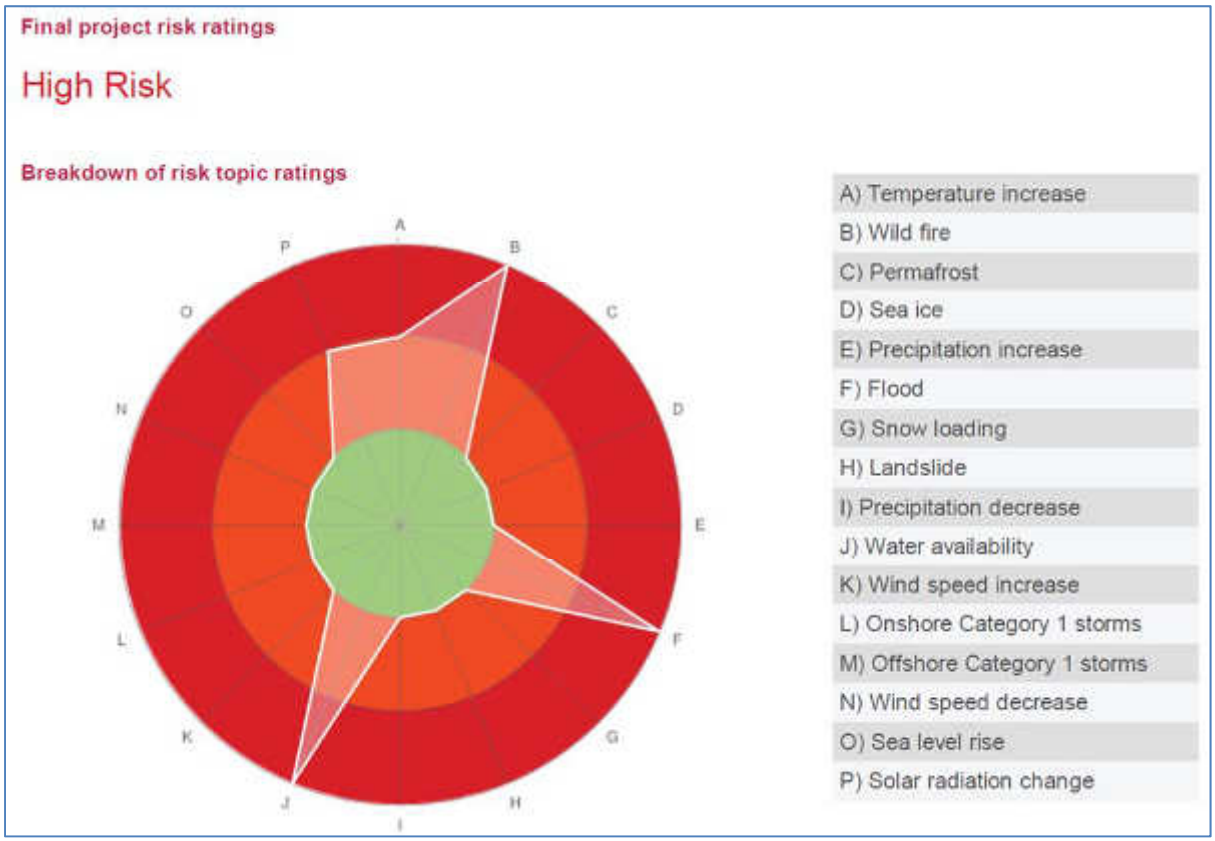
7. Following ADB's climate risk management protocols, on the basis of this rating the Project was subsequently screened using the AWARE tool, which provides more explicit and categorical information on the likely nature of climate and natural disaster risks. AWARE returned a risk rating of ***High***, reflecting primarily high risks from wildfire, flood and water availability; and medium risks from temperature increase and solar radiation change. AWARE results appear in Figure 1. These results do not contradict the results of checklist screening, but suggest that risks related to climate change must be taken seriously, and a strategy developed to manage them.

8. On the basis of preliminary documents describing the project and its location, it appears unlikely that wildfire presents itself as a major climate change-related risk, due primarily to the urban location of the Project. Decreasing water availability is a concern, although the impacts of reduced water availability on the project per se are likely to be indirect, as water is not a major input or component of the Project or its successful performance. By contrast, there is a history of destructive flooding in the Jinan region, most recently in 2015. Thus, this desk risk assessment will focus on flooding as the climate risk of highest priority for the project. Changes in the frequency and intensity of extreme temperature events will also be examined.

1.4 Objectives of This Report:

9. This study is a desk report, prepared without the opportunity to visit the Project site and assess risks on the basis of physical inspection. As such, it has more limited objectives than climate risk and vulnerability assessments (CRVA) as typically prepared for ADB projects at high risk from climate change impacts. The primary objective of this study is to examine the available evidence in order to make informed observations about the likelihood that flood and extreme temperature risks will increase over the next several decades, and if possible to present estimates of the potential magnitude of change. This information in turn can be used to inform and to design more detailed simulation-based risk assessment studies as required.

Figure 1: AWARE Climate Change Risk Rating for the Project



2. CLIMATE AND CLIMATE CHANGE IN JINAN IN THE OBSERVATIONAL PERIOD

2.1 Climate of Jinan

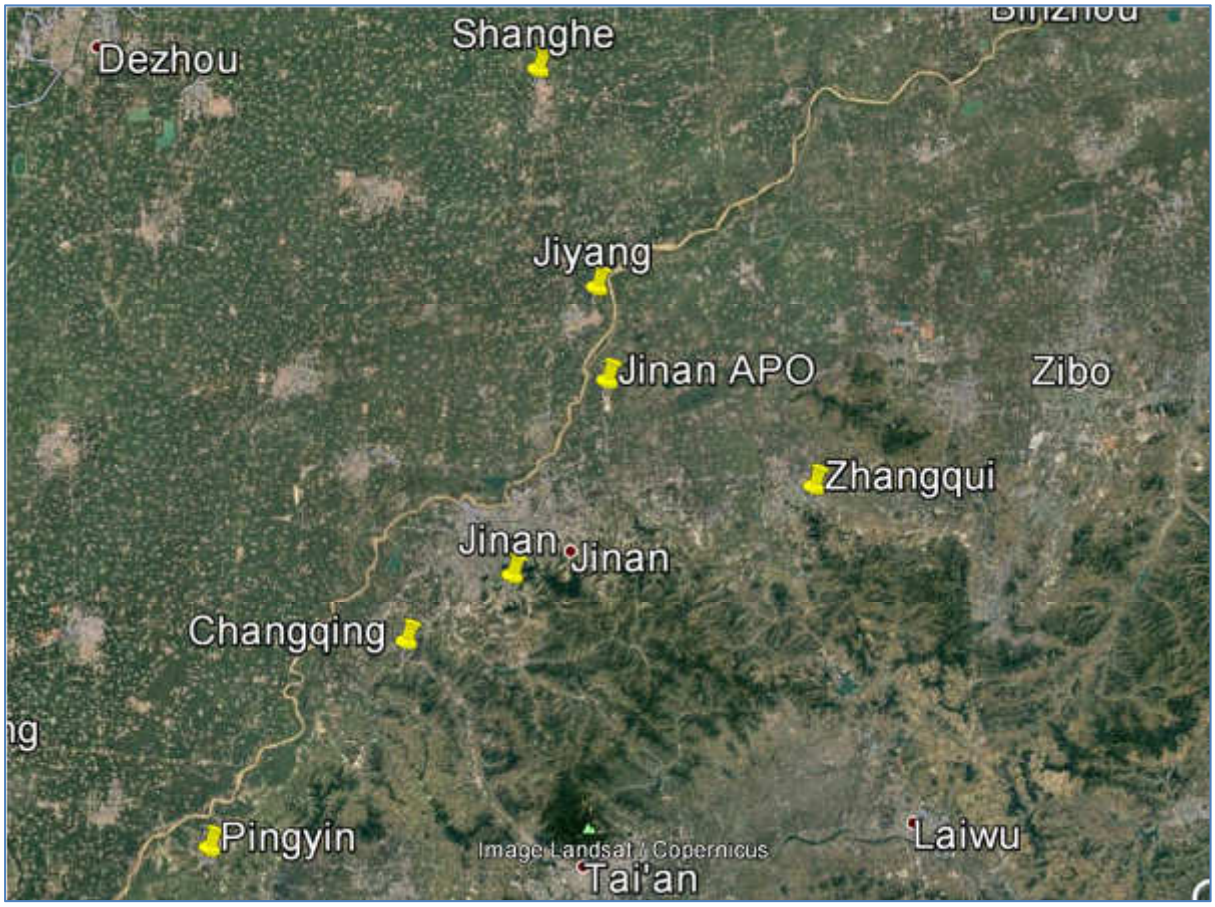
10. Jinan is located at roughly 37° N Latitude and 117° E Longitude, and elevation around 20 meters above sea level (MASL) in Shandong Province, PRC. Shandong Province itself has a temperate climate with four clearly defined seasons. Summers tend to be warm and humid, and winters cold and dry. Average temperatures in Shandong average around −5 to 1 ° C in January and roughly 24 to 28°C in July. Annual precipitation within Shandong exhibits considerable spatial variability, ranging from roughly 550 to 950 mm. The majority of precipitation occurs during the summer season and includes monsoon precipitation.

11. The Yellow River is a primary feature of Shandong's geography, flowing roughly west to east in Northern Shandong before discharging into the Bohai sea near Dongying. Historically, the river is prone to flooding and has been responsible for many of PR China's most severe flood episodes, some of which (e.g., 1332-33, 1887 and 1931) resulted in excess of 1 million fatalities. In Shandong, the Yellow River is contained behind levees and flows at an elevation above the surrounding floodplain, which exacerbates flood damages when levees are breached.

12. The following analysis of historical trends in precipitation and temperature is based on the relatively long (1951-2015) and continuous daily records for Jinan Meteorological Station (ID 54823; 36.6° N Lat, 117.0° E Lon). Daily records were also obtained for nearby Jinan Airport

(ZSTN; 36.86° N Lat, 117.2° E Lon) although these records only extend from Nov. 2012 to the present, making them unsuitable for historical trend analysis. At least five other meteorological stations exist in Shandong Province in the general vicinity of Jinan, but records were nor provided for these stations. Location of Jinan and surrounding stations is given in Figure 2.

Figure 2: Location of Meteorological Stations near Jinan in Shandong Province



2.2 Changes in Temperature

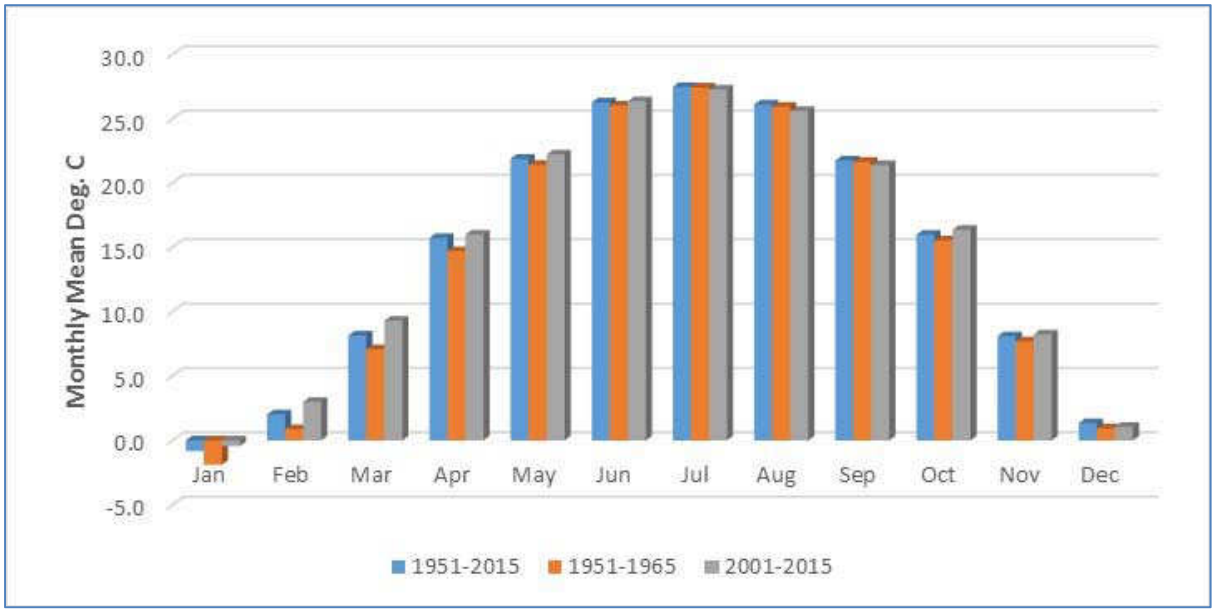
13. On the basis of 65 years of records at Jinan station (1951-2015)[6], mean annual temperature is 14.6°C, with a standard deviation of 0.6°C[7]. Interannual variation is relatively low, although trends in temperature are apparent over this period, as discussed subsequently. The coldest year within the 1951-2015 period averaged 13.1°C, occurring in 1952 near the beginning of recordings. The warmest year, at 16.0°C, occurred in 1998, likely influenced by the extreme *el nino* event occurring at that time. Over this period, mean temperatures during spring season (March, April, May) averaged 15.3°C, summer (June, July, August) temperatures averaged 26.6°C, autumn (September, October, November) temperatures averaged 15.3°C and winter (December, January,

[6] Although the record at Jinan is continuous over this period, data for 1972 were judged to contain errors and have been excluded from this analysis.

[7] The estimated standard deviation may not be accurate since it is based on a series with evident trend, thereby inflating the estimate.

February) temperatures averaged 0.9ºC, although below-freezing temperatures are common during the winter in Jinan, particularly in December and January. The average monthly temperatures at Jinan for the 1951-2015 period are displayed in Figure 3, along with average values for the earliest (1951-1965) and most recent (2001-2015) 15-year periods, respectively.

Figure 3: Monthly Average Temperatures (ºC) at Jinan Station (54823), 1951-2015; 1951-1965 and 2001-2015



14. The historical time series of mean annual temperatures at Jinan is displayed in Figure 4A, and spring, summer, fall and winter trends displayed as Figures 4B–4E respectively. It is immediately apparent that temperatures have increased over the 65-year period of record. In particular, annual temperatures have increased, reflecting primarily significant increases during winter (DJF, Figure 4E) and spring (MAM, Figure 4B). Very little trend (if any) is apparent in summer (JJA, Figure 4C) temperatures, and only relatively moderate increases in autumn (SON, Figure 4D) temperatures. Annual warming is apparently driven primarily by warming during the winter and spring seasons.

Figure 4A: Mean Annual Temperature (ºC) at Jinan Station (54823), 1951-2015

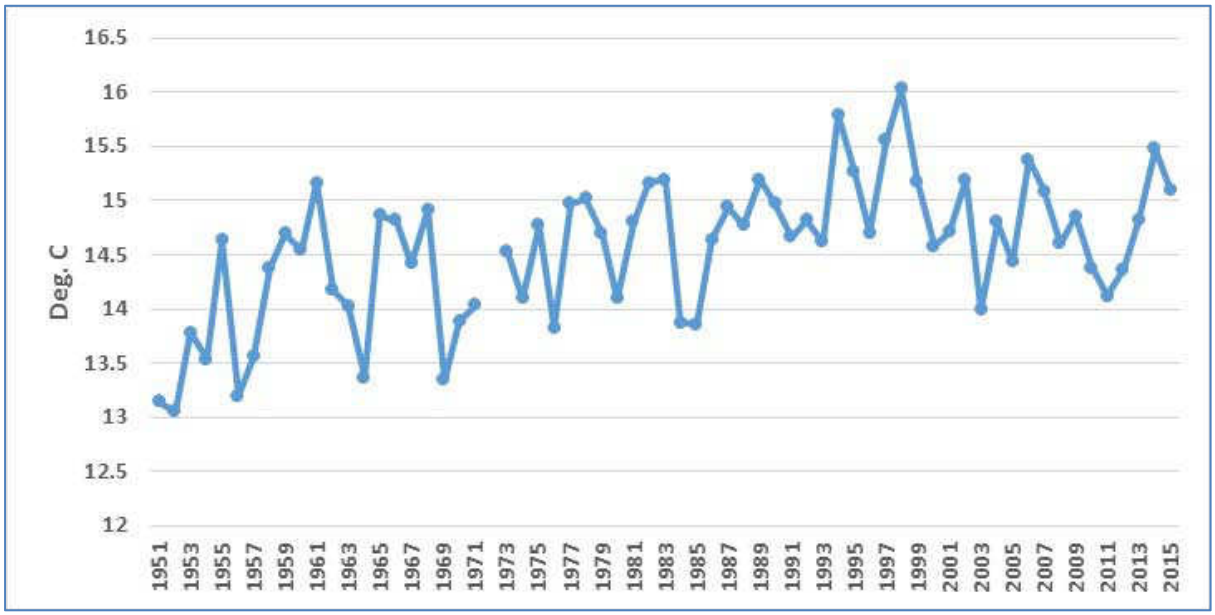


Figure 4B: Mean Spring (MAM) Temperature (ºC) at Jinan Station (54823), 1951-2015

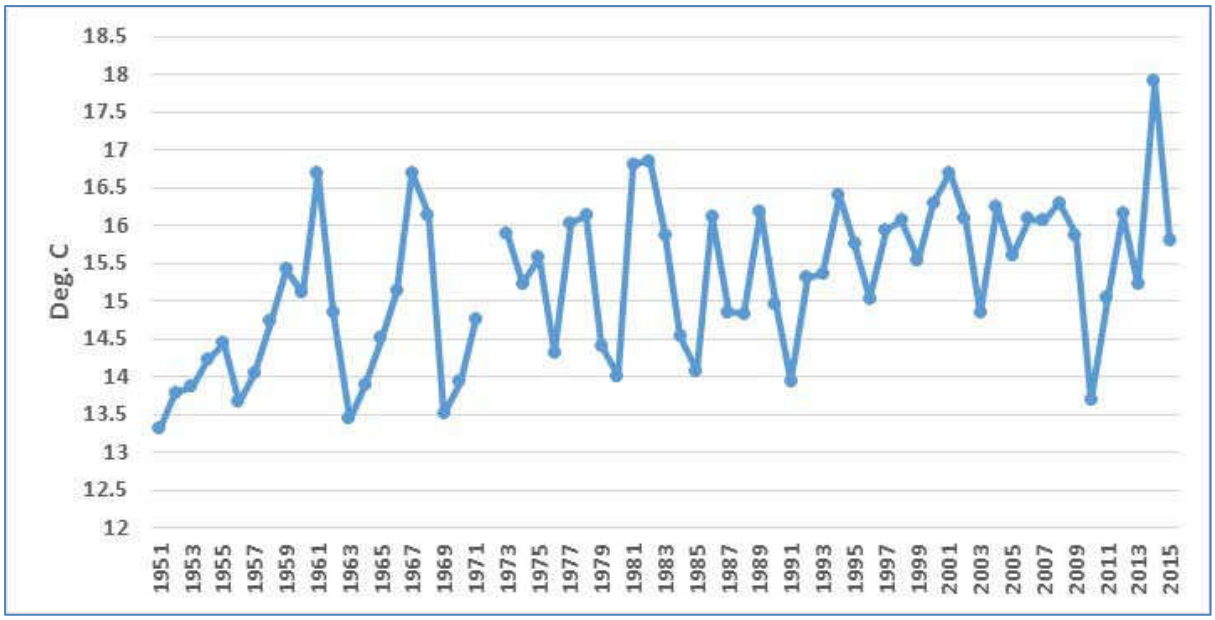


Figure 4C: Mean Summer (JJA) Temperature (°C) at Jinan Station (54823), 1951-2015

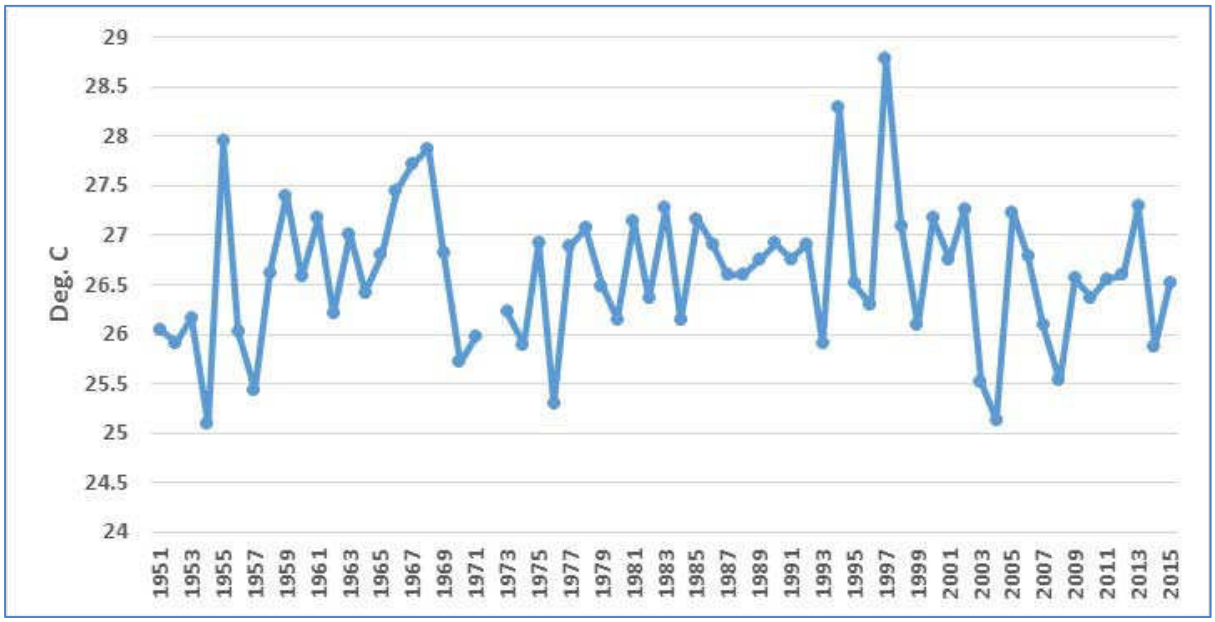


Figure 4d: Mean Autumn (SON) Temperature (°C) at Jinan Station (54823), 1951-2015

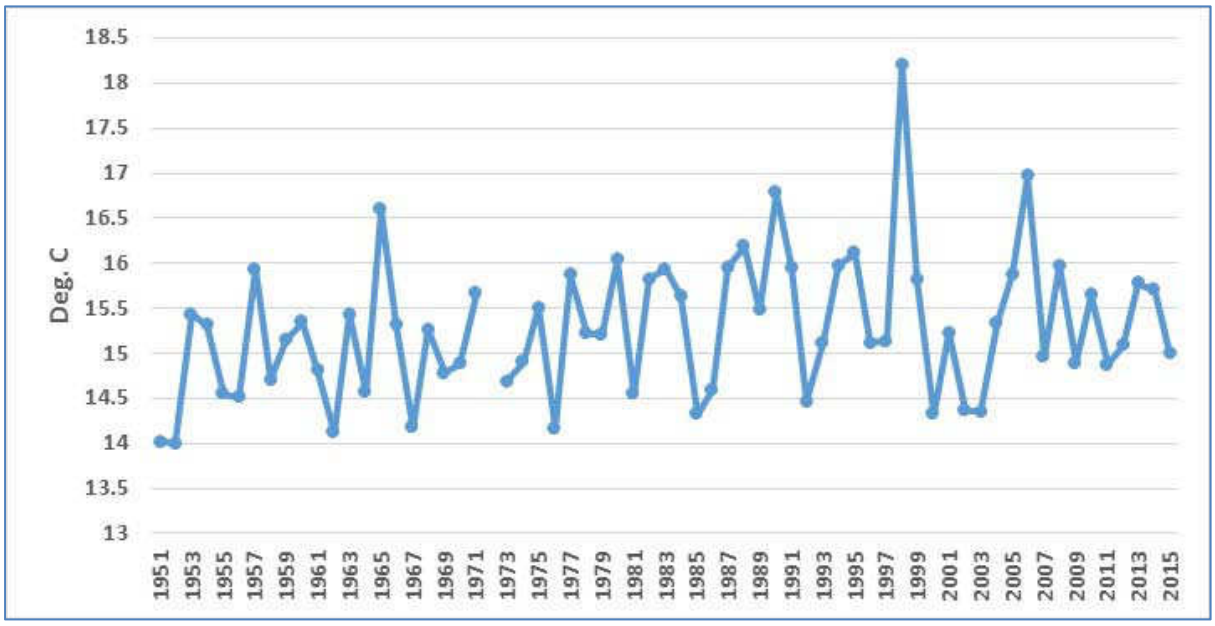
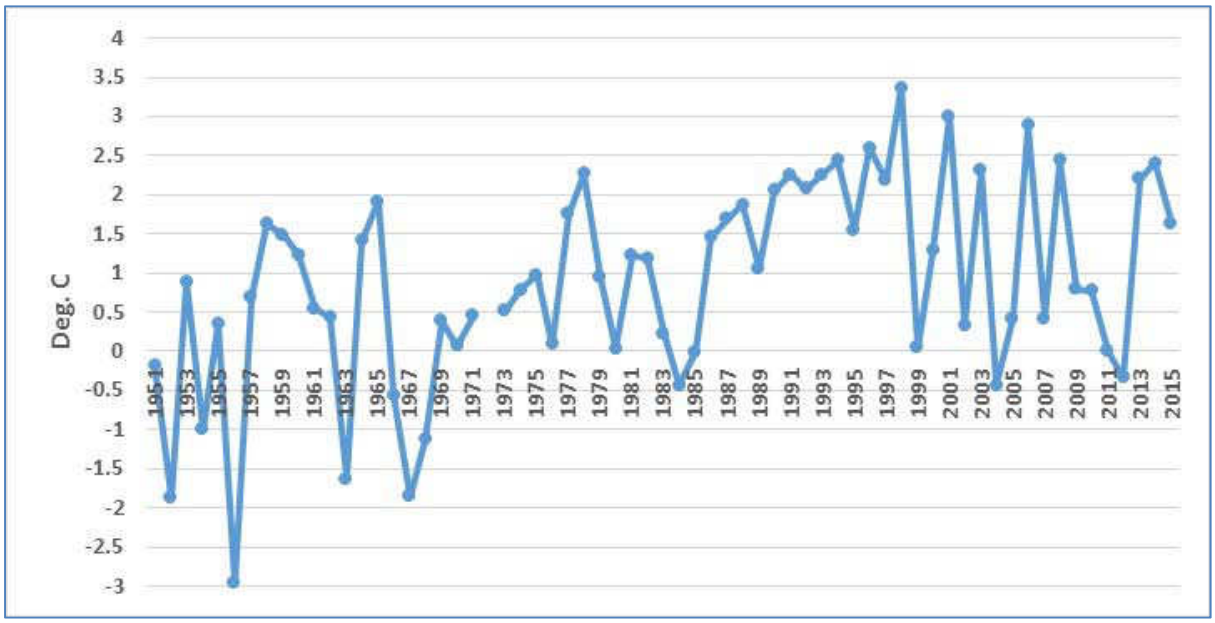


Figure 4e: Mean Winter (DJF) Temperature (°C) at Jinan Station (54823), 1951-2015



15. An approximate quantification of temperature change (warming) at Jinan was performed on the basis of linear trend analysis using ordinary least squares (OLS) regression.[8] Table 1 contains the results of OLS trend analysis for annual and seasonal mean temperatures. A first observation is that all annual and seasonal trends are statistically significant, defined here as t >= 2.0 (approximate 95% significance), with the exception of summer (JJA) for which t < 1.0. Mean annual temperatures have increased approximately 1.2°C over the 1951-2015 period, equivalent to around 0.18°C per decade. Estimated increases were greatest for the winter (DJF) period, equivalent to around 0.3°C per decade, implying that winters have become 2.0°C warmer over the period 1951-2015. Spring (MAM) increases are almost as dramatic, increasing 0.27°C per decade and 1.76°C over the period of record. Increases during autumn (SON) were not as dramatic, averaging slightly more than 0.1°C per decade and 0.75°C over the record period. Very little increase in average summer (JJA) temperature was observed, with estimated decadal increases of only 0.015°C and an increase of only 0.1°C over the 1951-2015 period. It should be noted that the increase in annual temperature at Jinan exceeds global mean warming over the same period.

[8] This should not be interpreted as evidence that the best fit trend is linear. No other functional form was tested.

Table 1: Results of Linear Trend Analysis, Annual and Seasonal Mean and Daily Maximum Temperature at Jinan, 1951-2015

Period	Coefficient (°C per year)	Std. error coefficient	Increase per decade (°C)	Increase period of record (°C)
Annual	0.0183	0.004	0.18	1.19
Spring (MAM)	0.0271	0.006	0.27	1.76
Summer (JJA)	0.0015	0.005	0.015	0.10
Autumn (SON)	0.0115	0.005	0.115	0.75
Winter (DJF)	0.0308	0.008	0.31	2.00
Annual Daily Max T (C)	-0.0022	0.008	-0.021	-0.14
Annual Maximum T (C)	-0.0115	0.010	-0.115	-0.75

16. The behaviour of extreme temperatures is also of interest, since periods of extreme high temperature may have impacts on e.g., demand for electricity and the performance of structural materials such as asphalt (tarmac) pavement, high-tension electrical transmission cable and bridge expansion joints. Temperature extremes can also pose direct and indirect risks to human health. Global warming is anticipated to influence the frequency and magnitude of extreme events as well as annual and seasonal averages. To examine the behaviour of extremes over the period of record, two series were defined. The first is the hottest day of each year, where daily temperature is defined as the average of maximum and minimum daily temperatures, respectively. The second is the maximum temperature recorded each year. The times series of warmest days at Jinan is presented in Figure 5a, and the series of maximum observed temperature in Figure 5B.

17. It is observed that neither series presents clear evidence of trend. Although the warming signal is clearly present in annual and seasonal averages, with the exception of summer, it is not apparent in the behaviour of extremes. This serves to reinforce the observation that warming in Jinan is driven primarily by increases in cold-season temperatures, and not extensively by increasing summer temperatures, noting that summer is the period during which temperature extremes typically occur. Formal analysis of trends (Table 1) indicates that neither the time series of annual warmest day (t=-0.26), or annual maximum temperature (t=-1.20) have statistically significant trends.

Figure 5A: Annual Maximum Daily Temperature (°C) at Jinan Station (54823), 1951-2015

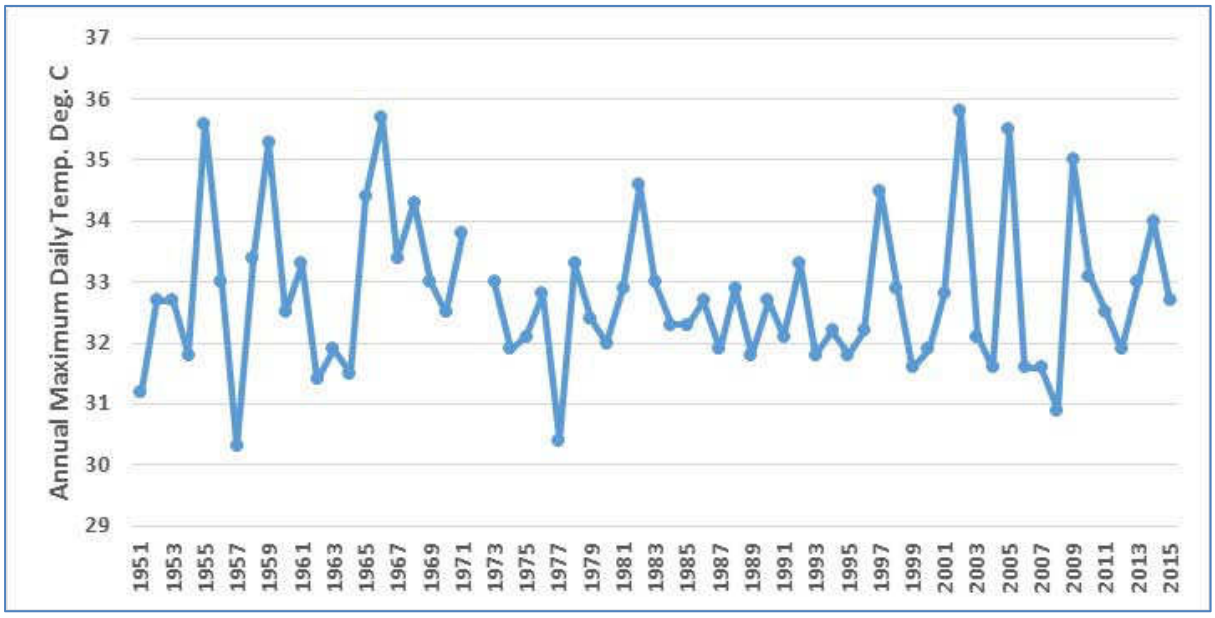
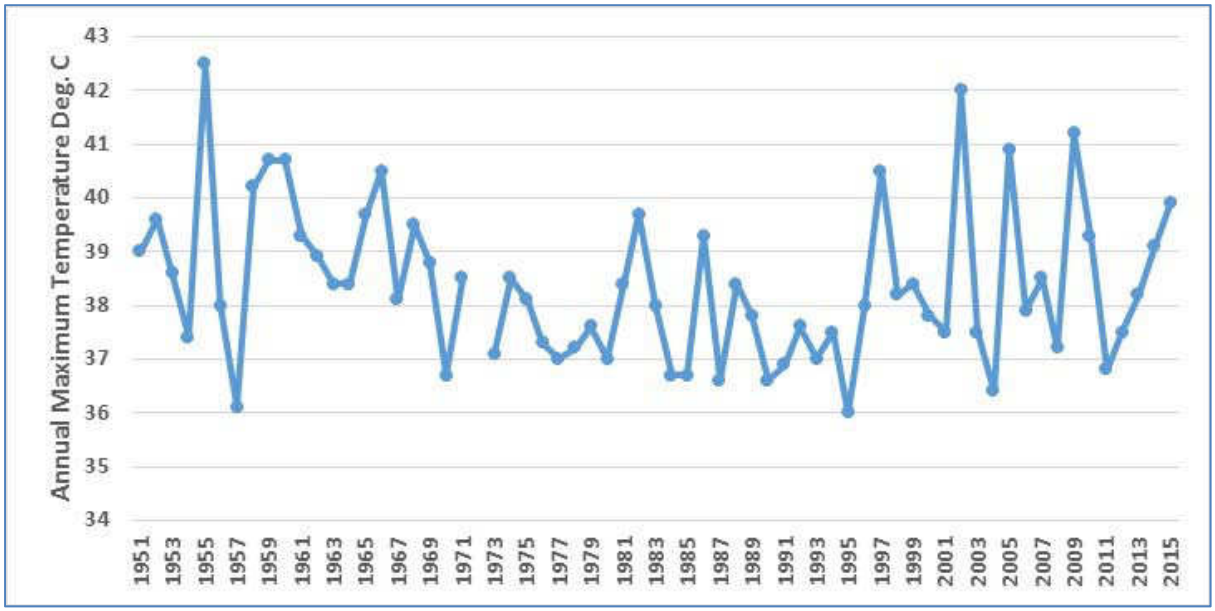


Figure 5B: Annual Maximum Temperature (°C) at Jinan Station (54823), 1951-2015



2.3 Changes in Precipitation

18. On the basis of Jinan records for the period 1951-2015, mean annual precipitation averages around 685 mm/year. The standard deviation is 190 mm per year, indicating a significant (but not extreme) degree of interannual variability. The driest year within the period of record is 1968, when Jinan received only 320 mm of precipitation. The wettest year is 1962, when precipitation totalled around 1,160 mm. The time series of precipitation at Jinan is presented in Figure 6. There is no obvious trend in annual precipitation at Jinan, although formal trend analysis summarized in

Table 2 indicates that precipitation appears to have increased at around 1 mm per year over the period of record, although this apparent trend is not statistically significant (t=0.57).

19. Precipitation is highly seasonal in Jinan, with the majority occurring as rainfall during the summer period (JJA), much of this reflecting occasionally heavy monsoon precipitation. Figure 7a displays the mean monthly precipitation accumulations over the period 1951-2015. Figure 7B displays the same data for 10-day periods to provide finer detail on the annual distribution of precipitation. It is observed that almost 50% (322 out of 685 mm) of annual precipitation falls within a 50-day period between Julian 190 and 240, corresponding to mid-summer.

Figure 6: Mean Annual Precipitation (mm) at Jinan Station (54823), 1951-2015

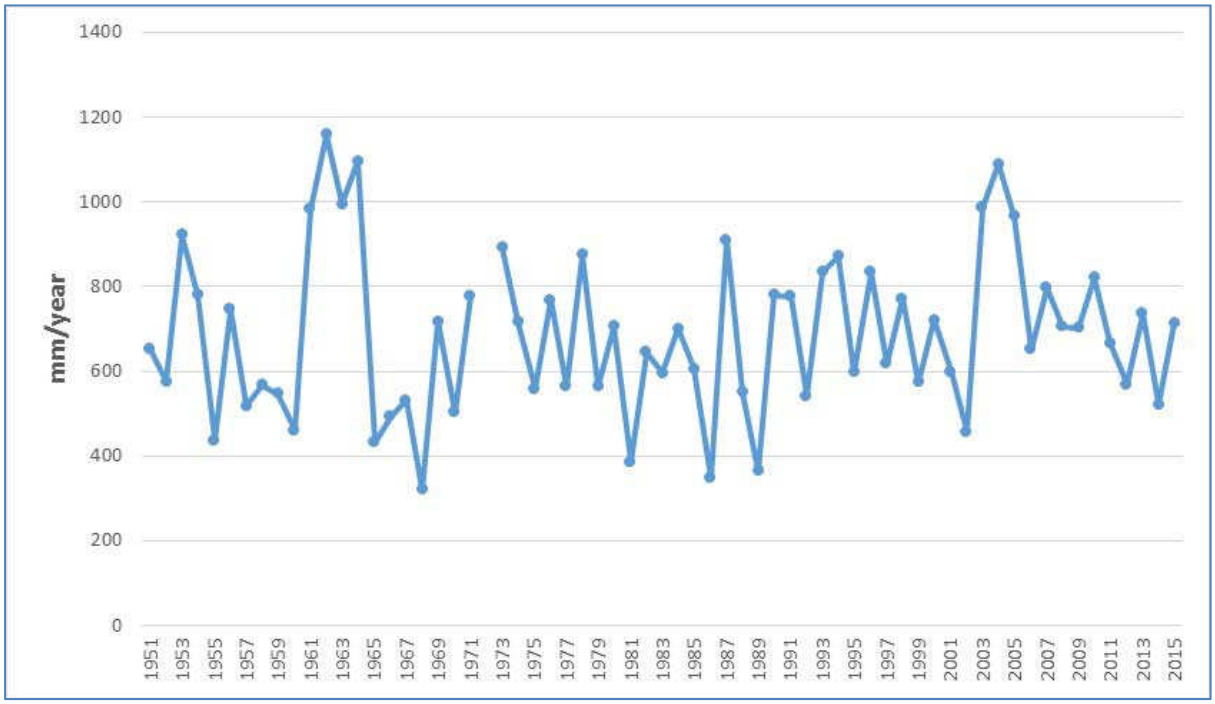


Figure 7a: Mean Monthly Precipitation (mm) at Jinan Station (54823), 1951-2015

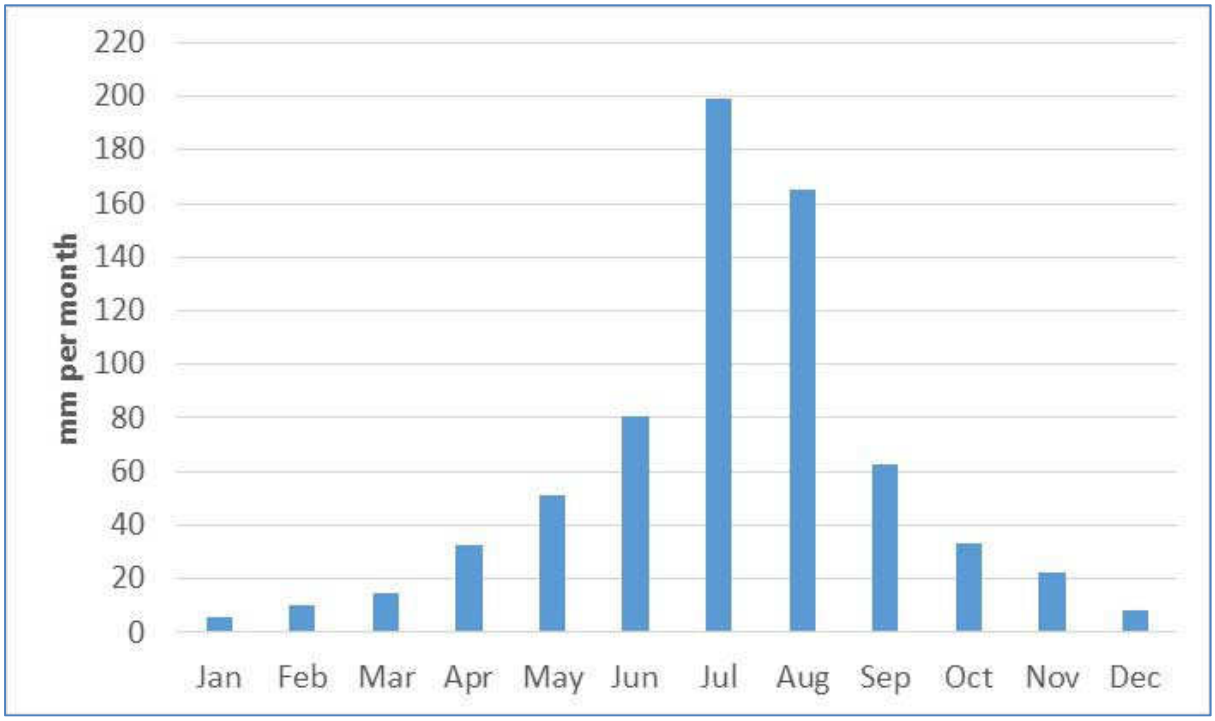
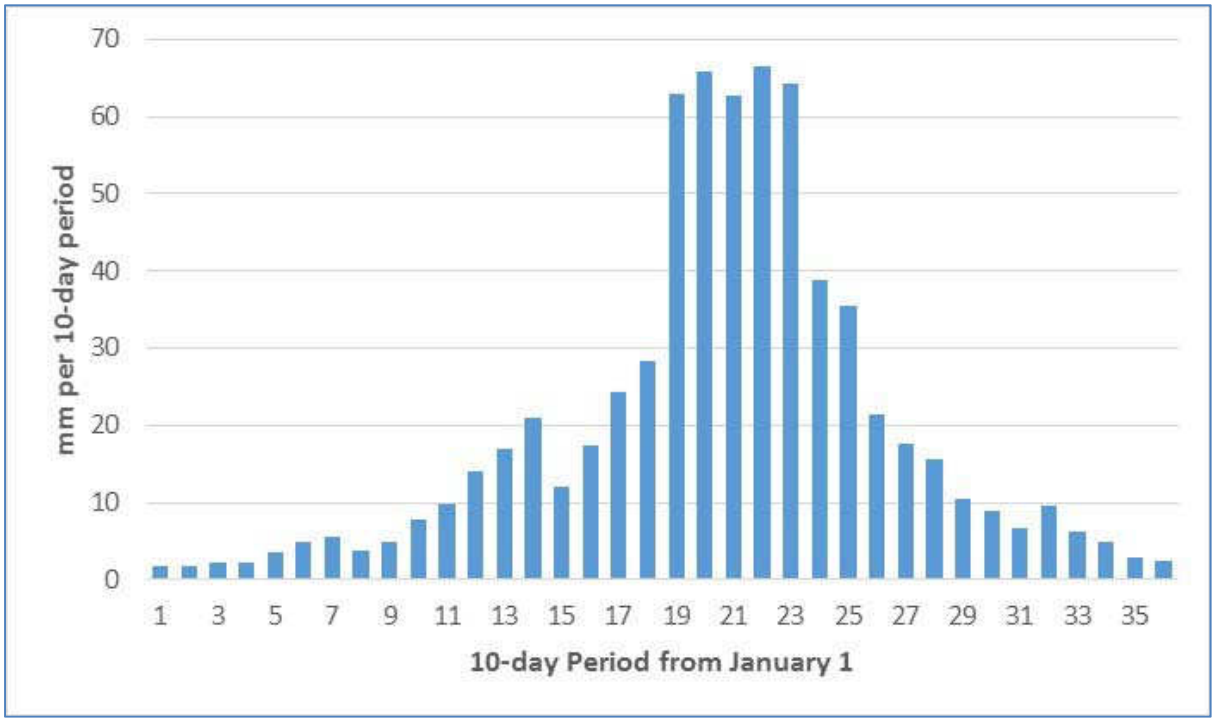
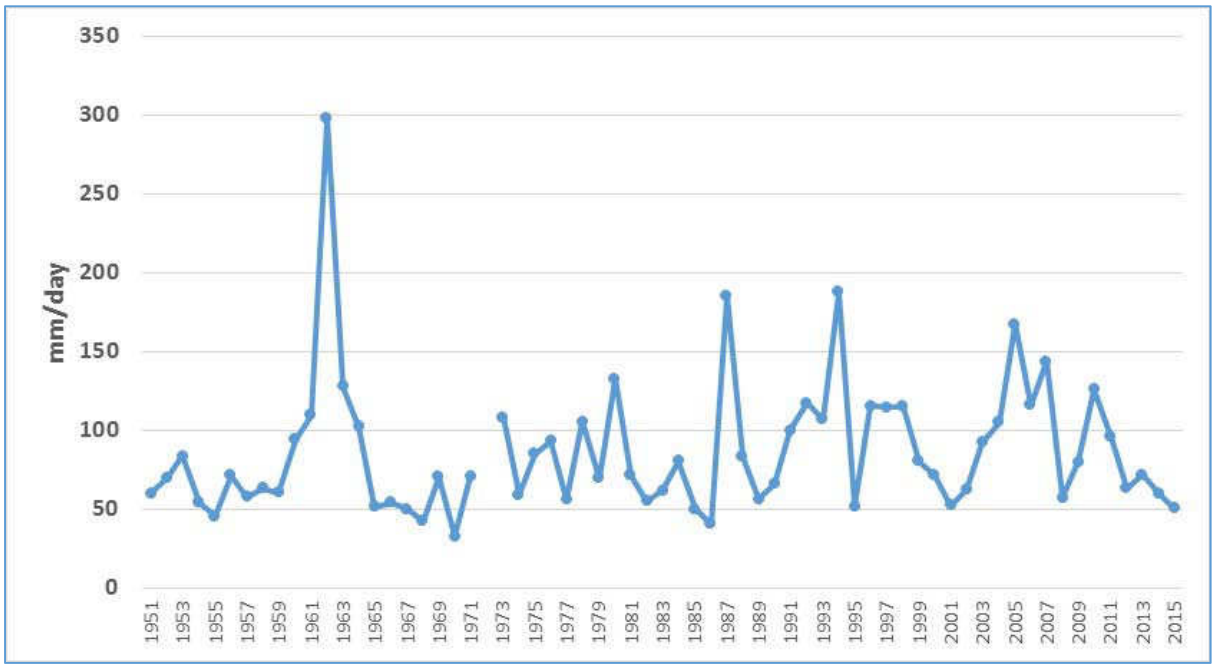


Figure 7b: Mean Precipitation by 10-day Period (mm) at Jinan Station (54823), 1951-2015



20. Another dimension of precipitation important in determining risks associated with climate change is the frequency and magnitude of extreme rainfall events, as these are often the precursors of flooding. The magnitude of the annual maximum 1-day precipitation (the largest one-day precipitation accumulation occurring in each year) is plotted in Figure 8. It is observed that the annual maximum typically varies between 50 mm/day and 150 mm/day, although there is at least one event that is large enough (1962, close to 300 mm/day) to be considered a statistical outlier. Note that 1962 was also the year of greatest precipitation accumulation, and this one-day event provided roughly one quarter of the annual total. Excluding 1962, it appears that there may be an increasing trend in the annual daily maximum event. Results of formal trend analysis on both total annual and maximum 1-day precipitation accumulation appear in Table 2. Analysis of 1-day maximum was performed both including and excluding 1962.

Figure 8: Annual Maximum Daily Precipitation (mm) at Jinan Station (54823) 1951-2015



21. An additional dimension of precipitation was examined for trend: the number of days each year receiving heavy precipitation. Both theory and empirical evidence point to an increase in heavy precipitation events due to atmospheric warming. For this analysis, heavy precipitation is defined as a daily total exceeding 10 mm. The results are plotted in Figure 9. Again, no clear evidence of trend is apparent. Linear trend analysis confirms this (Table 2): the observed trend is weakly negative and not statistically significant (t=-0.47).

22. To summarize, unlike temperature, trends in annual and maximum daily precipitation and number of heavy precipitation events are not statistically significant ($t < 2.0$). In the case of annual maximum 1-day precipitation, the trend is heavily influenced by the presence of the extreme value (almost 300 mm/day) early in the record (1962). When a linear trend is fit to the data after removing 1962, the trend is positive and border-line significant (t=2.10), providing weak evidence that precipitation extremes have been increasing over the 1951-2015 period, but only if the 1962 event is considered as an anomaly. However, this is not supported by changes in the annual frequency of heavy rainfall events, which does not change significantly over the period 1951-2015.

Figure 9: Annual Number of Heavy Precipitation Days (ppt > 10 mm) at Jinan Station (54823) 1951-2015

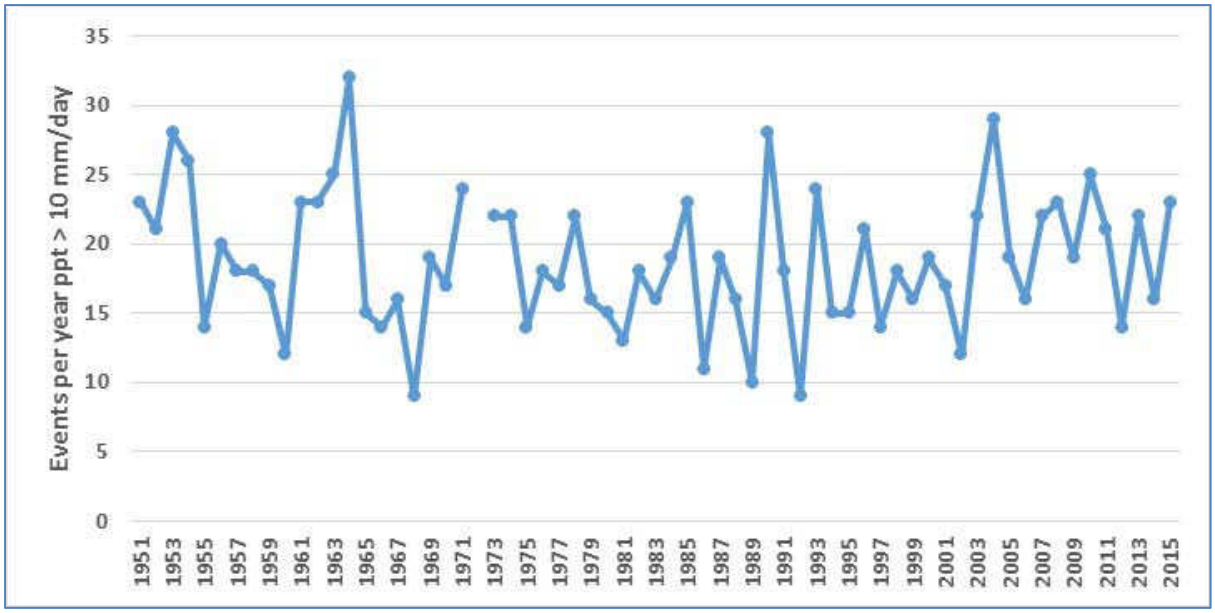


Table 2: Results of Linear Trend Analysis, Annual Total and Maximum 1-day Precipitation at Jinan, 1951-2015

Variable	Coefficient (mm per year)	Std. error coefficient	Increase per decade (mm)	Increase period of record (mm)
Annual Ppt.	**0.717**	**1.267**	**7.17**	**46.61**
Maximum 1-day Ppt.	**0.256**	**0.287**	**2.57**	**16.68**
Maximum 1-day Ppt excluding 1962	**0.466**	**0.222**	**4.66**	**30.29**
N days >= 10 mm	**-0.015**	**0.033**	**-0.15**	**-1.0**

2.4 History of Flooding in Jinan

23. Flooding is a recurring problem in Jinan, with damaging events occurring every two or three years on average over the last 100 years. There are many types of flood, and many flood-generating mechanisms (see Appendix 1). To assess the likely impacts of climate change on the frequency and severity of the flood hazard, it is important to understand the factors contributing to flooding in Jinan. Table 3 contains brief summaries of the most recent floods, listed in reverse

chronological order to 1980. The information is abstracted from the Dictionary of Meteorological Disasters in China, Shandong volume. The Dartmouth Flood Observatory archive was also consulted for cross-referencing, although only the 18 July 2007 and the 26 August 1987 events appear in the Dartmouth archive, as noted in Table 3.

Table 3: Flood Events in and around Jinan since 1980

Time (Place)	Description of Event
19:00 to 21:00, August 3, 2015	Jinan City suffered the strongest storm since the 18 July 2007 event (below). 73 mm of average precipitation, maximum 89.7 mm of precipitation,10-minute maximum precipitation 24.5 mm. Because of short duration, high intensity rainfall, most urban roads suffered serious flooding.
17:00 on 18 July 2007	Jinan City encountered strong torrential rains for short duration. 1-hour maximum precipitation up to 151 mm; 2-hour 167.5 mm,3-hour up to 180 mm. These are identified as historical maxima since meteorological records began. (Dartmouth: Strongest rainfall in Shandong this year. Jinan city received 18 cm of rain in three hours - worst rainstorm since 1916. 40 dead. 9 missing. 5,718 houses flooded. 1.5 billion yuan damages)
2:00 to 17:00 on August 4, 1998	4 counties/districts hit by storms. Maximum wind of force 8; maximum 193 mm rainfall. 13,300 hectares of crops were flooded, inundated area of 11,500 hectares, 305 houses collapsed, 1,234 houses damaged; 30,000m weirs and 7000 m highway washed away. 1 death, 15.36 million yuan of direct economic loss.
July, 1996	Continuous rainstorm in Jinan City; cumulative rainfall exceeded 300 mm in the urban area. Due to high rainfall concentration and poor drainage, low-lying areas of the northern and the western parts of residential areas in the urban area were flooded, with waterlogging under overpasses making them impassable to motor vehicles, causing serious traffic jams. Some sections were paralyzed. Licheng district received an average of 78.2 mm, maximum 131 mm of rainfall. 20 villages and towns affected to varying degrees, 22.4 million yuan of direct economic loss. Xiaoqing river suffered the severest floods occurred in recent 100 years.
1994 in Changqing district	Serious waterlogging, 861.8 mm of rainfall. 17,800 hectares of crops were affected, including 194 villages, 34,100 households or 121,000 people. 7 people died, and economic losses amounted to 200 million yuan.
July 13-14; August 7-8th in Jiyang county	20 towns of the county were affected. Affected area of 750,000 mu, 420,000 mu inundated, where cotton accounted for 48% of the disaster area.
July 27-29th, 1991	5 counties/districts experienced rainstorms of average 100 mm or more. Changqing had 154 mm of rainfall, resulting in a total of 32 towns including 1,397 villages; 159,200 households or 679,200 people affected. 18730 hectares of crops damaged, including 7,146 hectares inundated. 52 km roads washed out; 89 bridges and culverts, 27 dams, 170,600 m of weirs, 68,600 trees damaged; and 17 people injured, 3 people dead. Direct economic losses of 20 million yuan.
17:00 July 6 to 8:00 July 7, 1990	In Shanghe county, 3 episodes of heavy rain totalling 130 mm, with force 10 wind, and 208 mm at point of maximum rainfall. 21 townships were flooded, up to 20,000 hectares of farmland flooded, of which 6,666 hectares inundated. On July 15, from 23:30 to 1:00 of 16th, torrential rain in Jiyang county, with force 8 wind and 60 mm of average rainfall. Over July 6-15th, 16 towns received rainfall of 200 mm or more, of which 4 towns received more than 300 mm. In the county 20,000 hectares of crops were flooded, with cotton fields accounting for half. In Zhangqiu county, two townships suffered storm disasters, receiving 50 mm of rainfall, wind force 8. 2,333 hectares of crops flooded, causing total loss of 666 hectares. 200 houses collapsed, 1500 felled trees.
12:00 August 26 to 3:00	From west to east, heavy to torrential rain in Jinan, and a tornado in Pingyin county and Changqing districts. Over the 5,522 km^2 of total urban area, an average of

Time (Place)	Description of Event
August 27, 1987	124 mm was received, with Jinan urban area averaging 315 mm, the biggest rainstorm since recording began in 1916. The rainstorm, flood and tornado disasters caused direct losses of 370 million yuan to Jinan urban and rural areas. On August 26, from 5:30 to 6:30 pm, torrential rains averaging 110 mm fell on Changqing county, with maximum over 200 mm. (Dartmouth: "At least 51 people were killed, hundreds were injured and more than 2,000 homes were destroyed by storms that lashed the eastern provincial capital of Jinan, ... storms pounded Jinan from midday Wednesday to early Thursday, dumping up to 11 inches (280 mm) of rain and flooding most streets in the city")
July 24, 1985 in Changqing district	Rainstorms lasting for 3 hours produced an average of 160 mm rainfall, with centers receiving 200 mm. Rivers overflowed banks, 0.5 km of roads were washed away; 2 aqueducts, retaining weirs of 150 meters, 20 hectares of grain, 15 houses, and 16 factory buildings were damaged, resulting in 57,000 yuan of economic loss. On July 29, 1985 in Licheng County received sudden heavy deluge, with storm center maximum rainfall of 249.4 mm. Because of the convergence of three rivers, the maximum instantaneous flow into Wohushan reservoir was 639 m^3/s and water levels surged. On August 8, two embankments burst. In Changqing county, 50 villages were flooded and 835 houses destroyed, 3,400 hectares of land flooded and 228 wells inundated.
September 14-30 1981 in Changqing district	Two floods on the Yellow River. 4 communes along the Yellow river were flooded. 75 brigades and 11,683 households or 54,635 people affected, with flooded area of 121,283 mu. 808 houses collapsed.
July 27, 1980 in Pingyin county	Heavy rainfall. Hongfanchi area reported 185 mm of rainfall in two hours. More than 600 houses collapsed, and 2000 hectares of cropland waterlogged.

24. It is evident that the majority of flooding events in Jinan over the period documented have resulted from heavy local precipitation events. Changes in heavy precipitation cannot be interpreted directly as proportional changes in the flood hazard, since many factors mediate between precipitation and flooding. A partial list includes the location(s) of greatest precipitation intensity, associated topography, extent of impermeable surface, effectiveness of natural and engineered drainage, antecedent moisture conditions within the flood catchment, and potentially others as well. A rigorous assessment of climate change impacts on flood hazard in each setting requires the use of numerical simulation models of both hydrology and hydraulics, which is beyond the scope of this desk study. The subsequent analysis will accordingly focus on changes in the frequency and intensity of extreme rainfall events as indications of likely associated changes in flood hazard.[9]

3. PROJECTED CLIMATE AND CLIMATE CHANGE IN JINAN

3.1 Flood Hazards in a Changing Climate

25. Many mechanisms contribute to flood hazards, and their linkages to climate change can be numerous, uncertain and complex (Appendix 1). For this reason, the signature of climate change

[9] In this document, a distinction is made between *flood hazard* and *flood risk*. Flood hazard is associated with the magnitude and other characteristics of the climatic event, including precipitation totals, rate of runoff, peak flood discharge and discharge volume, and other physical dimensions of flooding. Flood risk refers to the potential for harm and damage, which in turn requires an understanding of the physical distribution of population and economic assets exposed to the flood hazard, the nature and effectiveness of flood risk mitigation infrastructure and practices (e.g., early warning systems) and the overall resilience of potentially affected populations.

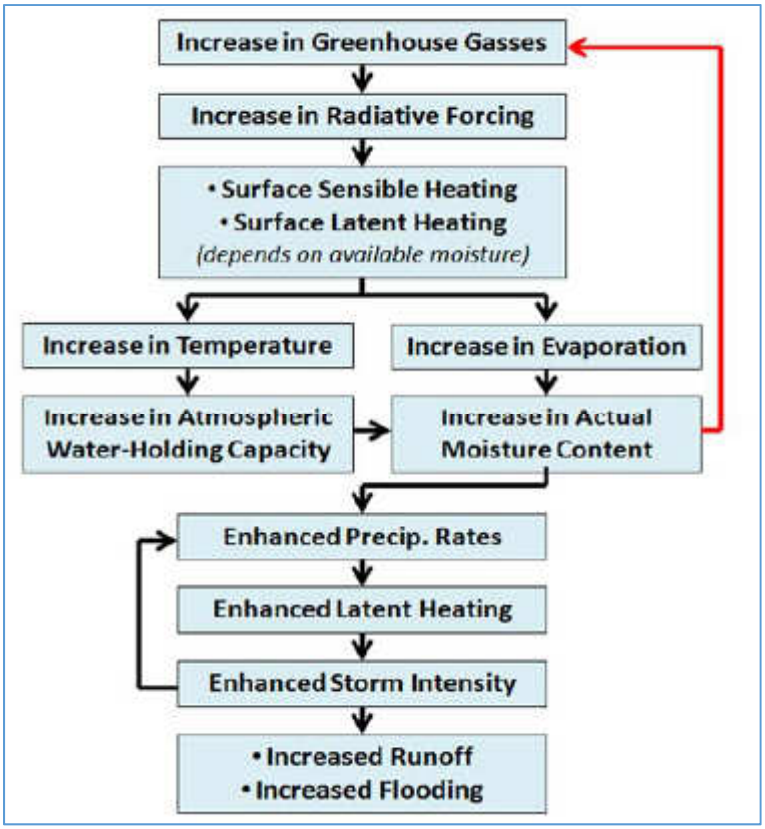
within historical flood events is often difficult to detect and to attribute, particularly since climate exhibits considerable variability over a range of timescales. Likewise, projections of future flooding behavior within the region are characterized by high levels of uncertainty. Climate-related floods also depend not only on precipitation intensity, volume, duration and timing, but also on antecedent conditions of rivers and their drainage basins. These factors must be acknowledged in assessing the changing risks of floods, and in designing appropriate responses. The hypothesis that atmospheric warming is likely to increase the frequency and intensity of flooding in certain settings (all other contributing factors assumed unchanged) reflects both fundamental physical principles and the views of many climate scientists. However, the synthesis presented in the SREX (2012) assesses the likelihood of such changes with low confidence, primarily due to the lack of high-quality empirical regional studies supporting such conclusions.

26. There is a basic link between atmospheric temperature and the intensity of the global water cycle. As the atmosphere warms, its moisture-holding capacity increases, leading in turn to increasing rainfall intensities and corresponding increases in the risk of floods (refer to Figure 10). At current global mean temperatures, an increase in atmospheric water holding capacity of around 7% for each °C of temperature increase is predicted.[10] When precipitation occurs, it will occur at higher intensity, and the increased condensation releases additional latent heat to drive the convective process, further amplifying the intensity of precipitation events. Increased precipitation intensity in turn leads to increased runoff, and in the extreme, to flooding. Runoff and flooding are also exacerbated by poor land use planning and practices in river basins (e.g. deforestation, reduction of wetlands) and expansion of urban areas. For example, expansion of impervious surfaces in urban areas increases the likelihood of flash floods, basement flooding and combined sewer overflow due to rapid runoff response following intense rainfall events.

27. Atmospheric warming also leads to a shift in cold-season precipitation from snow to rainfall, and to alterations in the seasonal timing of precipitation, and the frequency and magnitude of river basin flooding. Atmospheric warming also leads to increasing sea surface temperatures, a source of energy for tropical storms; and to sea level rise (SLR) via thermal expansion of ocean water and the melting of glaciers and continental ice masses. Coastal areas are particularly vulnerable to increases in flood risks due to SLR in combination with increased intensity of tropical storms. In river basins fed predominantly by glaciers and winter snowpack storage, increasing temperatures may initially lead to increased spring-summer flooding as glaciers melt, although these risks are likely to diminish in the longer term. Analysis of historical meteorological data provides ample evidence to support the physical theories linking increasing temperatures, increases in evaporation and atmospheric moisture, and precipitation intensity.

[10] This relationship is expressed as the Clausius-Clapeyron equation, which describes saturation vapor pressure as a function of air temperature.

Figure 10: Processes linking greenhouse gas emissions to increases in flooding and extreme weather events.[11]



3.2 General Features of Climate Change in the Jinan Region

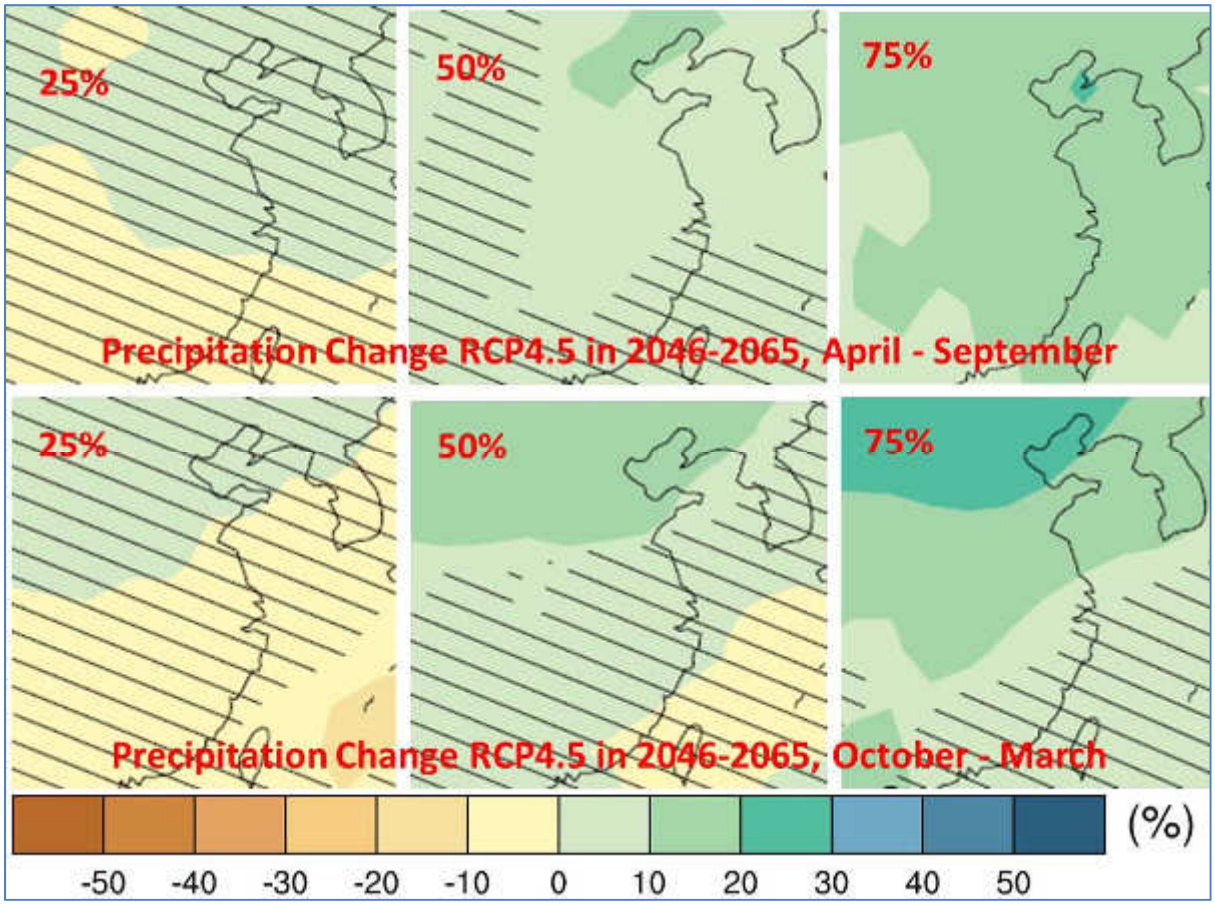
28. To assess the potential impacts of climate change on flood hazard and associated risks in Jinan, it is necessary to consider which meteorological variables, and at what length- and time-scales, are likely to influence the frequency and/or magnitude of damaging floods. As described above, global and regional temperature increases are drivers of change in the dynamics of water circulation through the atmosphere. Changes in precipitation are a more immediate concern, since precipitation is converted to runoff, which in the extreme results in flooding. Both overall increases in annual and seasonal precipitation, and increases in the most intense precipitation events are associated with increasing flood hazard. Note that the two are not necessarily correlated: intense precipitation events can increase as a result of climate change even in settings where annual and/or seasonal precipitation accumulations are unchanged, or decreasing. Evidence presented in Table 3 indicates that local high-intensity precipitation events from a few hours to a few days' duration are responsible for most of the recent damaging floods in Jinan and surrounding areas.

29. The most current and scientifically advanced climate modelling work currently available is the Coupled Model Inter-Comparison Project, Fifth Round (CMIP5), which informs the analysis

[11] Source: Trenberth, Kevin E. (1999). Conceptual Framework for Changes of Extremes of the Hydrologic Cycle with Climate Change. Climatic Change 42: 327-339.Figure 2, p. 335.

presented in the IPCC's Fifth Assessment Report (2013). Results from over 40 General Circulation (or Global Climate) Models (GCM) are represented in the Fifth Assessment Report. Annex I to Working Group I (Science) contains a composite of the results of CMIP5 models for one set of assumptions concerning greenhouse gas emissions, RCP4.5. RCP 4.5 (units watt m^2) is a relatively optimistic scenario with respect toward progress in GHG abatement in the 21st century. Figure 11 highlights the composite model results for the period 2046-2065.

Figure 11: Multi-Model Ensemble Projections for the Jinan Region, 2046-2065 (RCP4.5)



30. The upper panels in Figure 11 indicate changes in summer seasonal precipitation (April-September) as percentages relative to the historical baseline period 1986–2005. This is the period when most precipitation occurs in the region containing Jinan, and so projected changes in this season are most important. The lower panels indicate changes during the winter period (October-March). The panels on the left correspond to the 25th percentile of CMIP5 models, when sorted from dry to wet over the region in question. The middle panels correspond to the median (50th percentile) of projections, and the right-hand panel to the 75th percentile. Cross-hatching indicates that the projected changes fall within the 20-year envelope of current climate variability. It is seen that for the region surrounding Jinan there is a relatively high degree of concurrence across GCMs with respect to both the direction and likely magnitude of seasonal precipitation change. Specifically, most models (at least 75%) project a wetter future for the region, with increases most likely in the range of 0% to 10% relative to historical conditions, but possibly higher.

31. Results appearing in Figure 11 are based on the outputs of GCMs, which have characteristic horizontal resolutions of from 100 to several hundred kilometers. Due to this coarse spatial resolution, and due to the fact that GCMs do not resolve many important land surface and topographical features in detail (including mountain ranges and coastlines), unadjusted GCM outputs may not provide an adequate basis for decision support in situations where more local detail is required. A number of approaches to down-scaling GCM outputs have been developed to address this issue. The two most common approaches are dynamic down-scaling, which involves the use of higher-resolution regional climate models (RCM) which are similar to numerical weather forecasting models, and statistical down-scaling, which utilizes observed correlations between local weather patterns and broad features of climate.

3.3 NASA NEX Global Daily Downscaled Projections

32. In June 2015 the U.S. National Aeronautics and Space Administration (NASA) released the NASA Earth Exchange (NEX) Global Daily Downscaled Projections (GDDP) dataset. The dataset was produced in support of the IPCC AR5, and consists of daily projected values of three primary climatic variables – maximum and minimum temperature and precipitation– at 0.25 degree horizontal resolution (equivalent to approximately 25 km) for the entire globe. Projections are available for the historical period (1950-2005) and for 2006–2100 under two representative concentration pathways (RCP; corresponding to emissions scenarios): RCP4.5 and RCP8.5. The first is consistent with a relatively optimistic vision of progress in GHG mitigation[12], and the second (RCP8.5) is equivalent to a "business as usual" scenario and consistent with current global GHG emissions patterns.

33. Down-scaled projections are obtained using a statistical approach. The bias-correction spatial disaggregation (BCSD) approach (Maurer and Hidalgo., 2008) was applied to 21 of the CMIP5 models for which daily projections were made available by the global modeling centers.[13] The stated purpose of the GDDP is "… to provide a set of global, high resolution, bias-corrected climate change projections that can be used to evaluate climate change impacts on processes that are sensitive to finer-scale climate gradients and the effects of local topography on climate conditions" (Thrasher and Nemani, 2015).

34. GDDP projections at daily timestep were downloaded from the NASA NEX server for a set of six rasters corresponding to the locations of historical precipitation gauges, as indicated in Figure 2. Data from all 21 available GCMs was down-loaded, but preliminary analysis determined that projected values produced by one of these models (ACCESS1-0) were implausible, and were excluded from subsequent analysis. Estimates presented in this study therefore represent 20 GCMs, identified subsequently in Table 5. It should be further noted that many of these models share specification (e.g., MIROC-ESM and MIROC-ESM-CHEM) or represent two different resolutions (e.g., IPSL-CM5A-LR and IPSL-CM5A-MR).

35. The NASA NEX GDDP data are used for two purposes. The first is to better characterize projected climate change in the project region, and more specifically to provide insight into the range of uncertainty characterizing future climate. The second is to assess changes in extreme

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[12] Although relatively optimistic, RCP4.5 is nevertheless inconsistent with global temperature increases limited to 2.0 ^{o}C or less as targeted by the Paris Agreement (2015). Only RCP2.6, which includes removal of CO_2 from the atmosphere, is fully consistent with the Paris outcome.

[13] Although GCMs typically run at 3-hour or equivalent timesteps, not all modelling centers make daily outputs publicly available.

events, at daily time resolution. Two time periods were defined and used for both analyses. The historical period is defined as January 1971-December 2000, and the projection period as January 2036-December 2065 (both 30 years). It is important to stress that both periods are model-simulated, so that any projected changes in climatic variables are based on a comparison of model results with model results from different periods, rather than a comparison of model results with observation. For the projection period, RCP8.5 projections were used. RCP8.5 represents a future with more extreme climate change than RCP4.5, but was selected for this analysis consistent with a precautionary approach, since it is not possible to assign probabilities to the respective likelihoods of each of the RCPs.

36. Prior to performing analysis, the ability of the NEX GDDP projections to reproduce historical (observed) climate was evaluated. Comparisons were made for both temperature and precipitation at monthly resolution between (i) the 65 years (1951-2015) of historical observation at Jinan and (ii) the average of 20 down-scaled GCMs in the 25 km pixel containing Jinan, with centroid located at 117.125° E Lon; 36.875° N Lat. Results for temperature comparison appear in Figure 12a, and for precipitation in Figure 12b.

Figure 12A: Mean Monthly Temperature from Observations at Jinan (1951-2015) and Multi-model Average (1971-2000) in °C

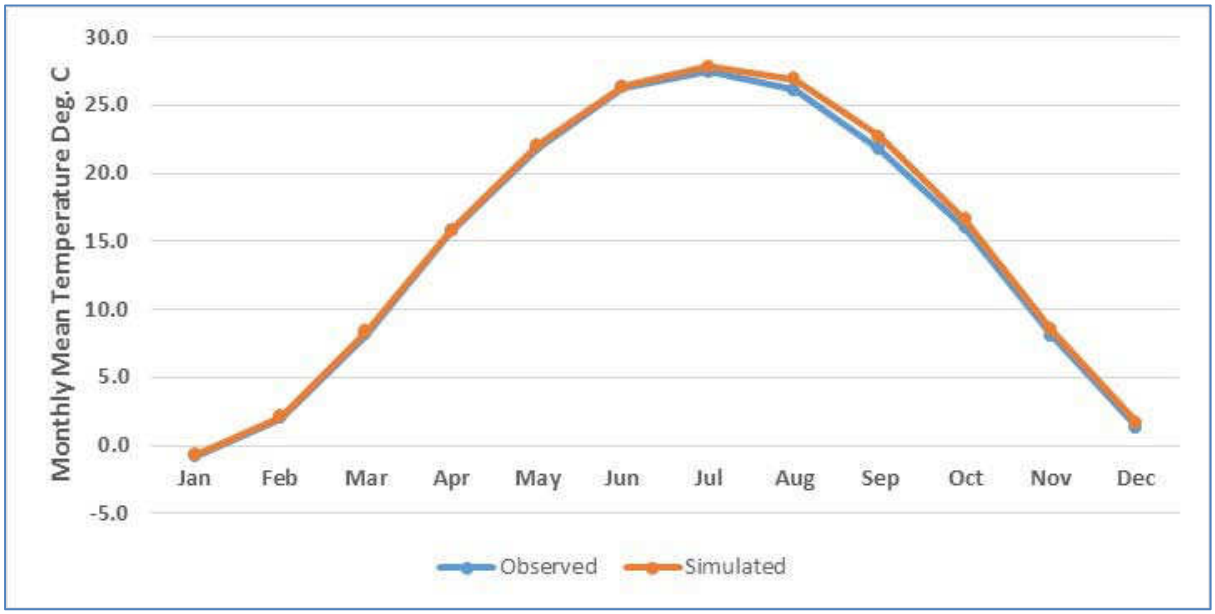
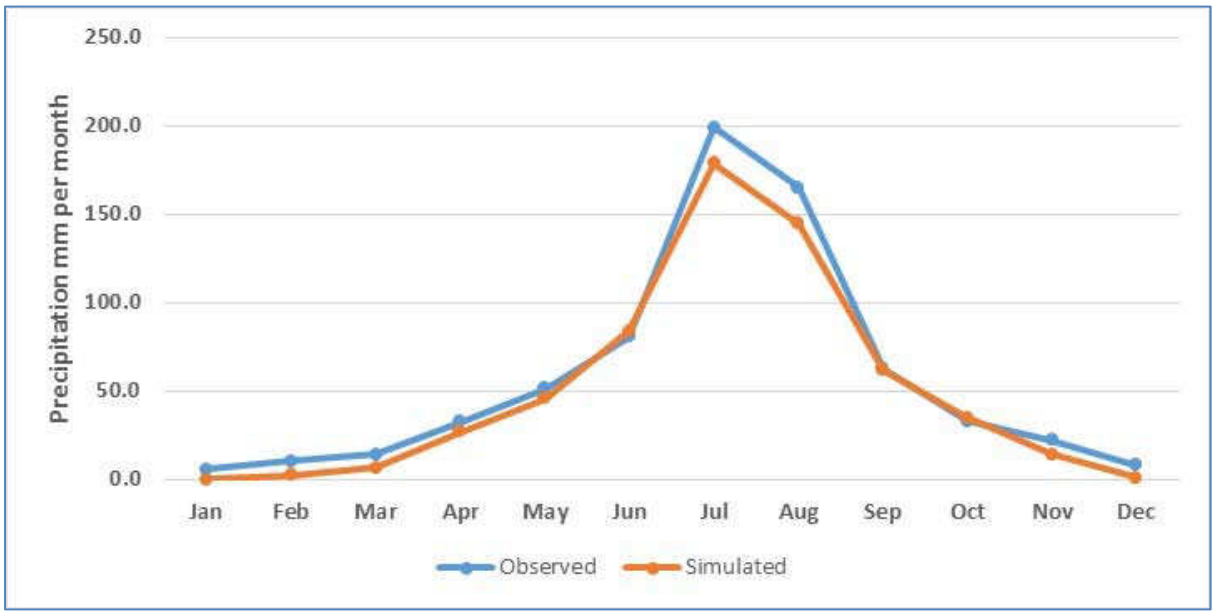


Figure 12B: Mean Monthly Precipitation from Observations at Jinan (1951-2015) and Multi-model Average (1971-2000) in ºC



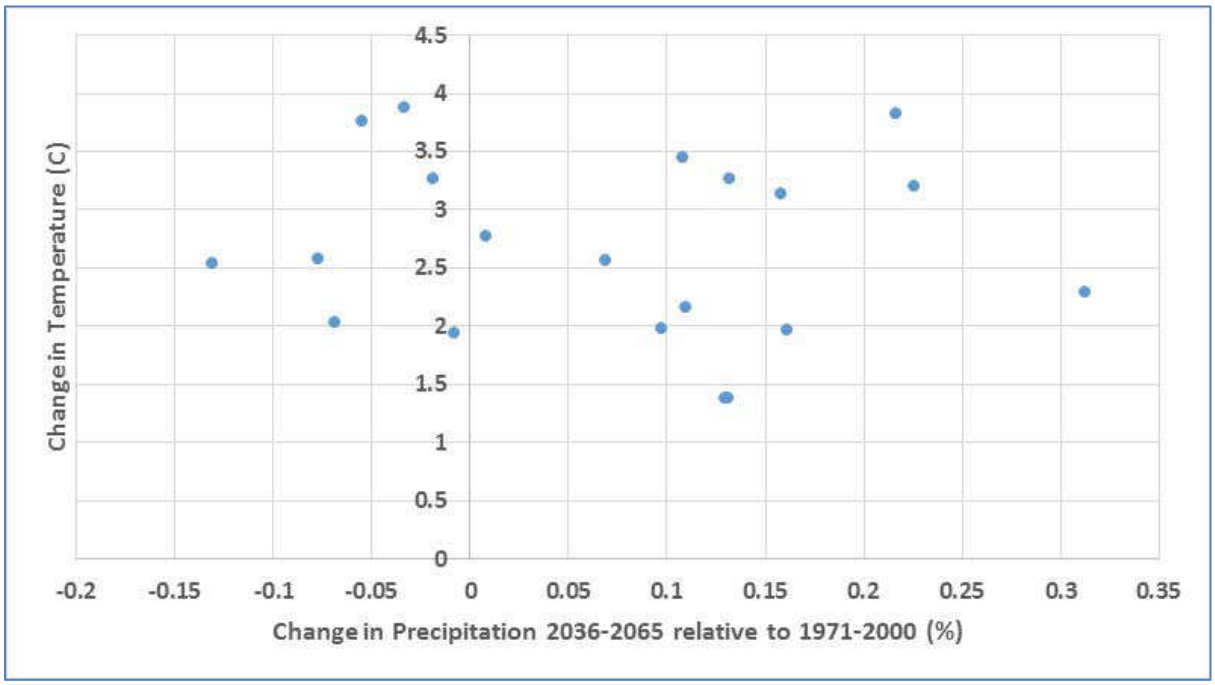
37. With respect to temperature, the multi-model ensemble average simulates historical observation well, with the caveat that the reference periods are not identical, but do overlap (the historical baseline for model simulations is contained within the period of observational record at Jinan). The NEX GDDP ensemble mean shows a small positive bias equal to approximately 0.34 ºC overall and reaching a maximum of 0.91 ºC in September. With respect to precipitation, overall pattern fit is good, although the bias is somewhat larger. The NEX GDDP ensemble mean precipitation for the baseline period 1971-2000 is 602 mm/year, as compared with 685 mm/year based on historical observation at Jinan. In particular, the model ensemble under-predicts precipitation during the peak rainfall months of July and August by roughly 10%. However, in both cases the observed seasonal patterns are well simulated by the model ensemble. To some degree this is anticipated since the NEX GDDP projections have been bias-corrected on the basis of historical data (although not necessarily on the basis of Jinan station data specifically).

38. The use of model ensemble mean results can disguise the extent of variability across individual model projections. Understanding this inter-model variation is important, since it is one way of visualizing the uncertainty attending future climatic conditions.[14] For each of the 20 models, mean annual conditions were calculated for both baseline (1971-2000) and projection (2036-2065) periods; and the changes with respect to simulated mean annual temperature and mean annual precipitation calculated. Figure 13 displays the results for the 20 individual models with respect to changes in annual precipitation (expressed as a percentage change relative to historical baseline) and changes in mean annual temperature (expressed in ºC). Results are for the 25 km x 25 km pixel containing Jinan meteorological station.

[14] Since inter-model variability captures just one of multiple sources of uncertainty in future climate, the dispersion displayed here should be understood as a type of lower bound on the potential (but unknown) range of uncertainty *given* assumptions concerning GHG emissions.

39. The following characteristics are noted. First, all models project increases in annual temperature, ranging from slightly above 1.0 °C to almost 4.0 °C, effectively applying to the period 1985 – 2050.[15] Second, while most models (13 out of 20) project increases in annual precipitation, a minority project decreases. However, the magnitude of the decreases is below 10% relative to historical baseline for all but one of the models projecting decreasing precipitation, while projected increases can exceed 30%. Across all 20 down-scaled models included in the analysis, changes in annual precipitation averaged around 7%, while changes in annual temperature averaged around 2.7°C. Recall that by mid-century (2036-2065) the various emissions scenarios begin to diverge, and RCP8.5 (used here) will be associated with the greatest increases in temperature from among the various RCP scenarios.

Figure 13: Individual Model Projections of Annual Changes in Precipitation and Temperature (pixel centroid 117.125 E Lon; 36.875 N Lat)



3.4 Changes in Extreme Precipitation Events

40. From the perspective of flood hazard and risk, changes in extreme precipitation are likely to be more important than changes in annual or seasonal precipitation accumulation, unless the latter are profound. One approach conventionally used to characterize extreme events is frequency, quantile or design event analysis. In this application, the annual maximum series of daily precipitation is used. The day of greatest precipitation accumulation in each calendar year is identified, and a statistical distribution is fitted to this series of annual maxima. On the basis of this parametric distribution, events having a specified probability of occurring in a given year (quantiles) can be estimated.

[15] Approximate mid-points of the baseline and projections periods, respectively.

41. The daily precipitation record for Jinan station (ID 54823) is relatively long and continuous, and thus supports a credible analysis based on fitted quantiles. The time series of annual maximum daily precipitation events is presented in Figure 8.

42. Daily maximum precipitation quantiles were estimated for this series assuming the generalized extreme value distribution (GEV) estimated using the method of L-moments (Hosking and Wallis, 2005). Due to the extreme influence of the large 1962 event on the statistical properties of the GEV distribution, estimates were made both with and without 1962. Results appear in Table 4.

Table 4: Estimated Quantiles of Annual Daily Maximum Precipitation in mm, Jinan

	All observations (n=64)	1962 event excluded (n=63)
Mean	**86.6**	**83.2**
Standard Deviation	**43.2**	**34.1**
5-year (p=0.2)	**108.6**	**105.3**
10-year (p=0.1)	**135.7**	**127.2**
20-year (p=0.05)	**166.2**	**150.1**
50-year (p=0.02)	**213.7**	**182.5**
100-year (p=0.01)	**256.2**	**209.1**

43. Observations at Jinan station are confined to the historical period, and quantile changes associated with future climate change must be based on the climate model outputs. Change in the annual daily maximum precipitation quantiles are estimated using a form of the *delta method*. The delta method involves estimating changes on the basis of climate simulation model results, and applying the estimated changes to the observed data. The delta method requires, among other assumptions, that any model bias relative to observation will not change significantly as the period of projection is extended. To apply the method, annual maximum daily precipitation quantiles are estimated for the annual maximum series extracted from projections for both the historical period (1971-2000) and the projection period (2036-2065). Any model biases are assumed to apply to both periods, noting that the NEX GDDP data are bias-corrected for the historical period.

44. It is well understood that GCMs in general tend to under-estimate the magnitude of extreme events due to constraints imposed by the physical representation of precipitation-generating conditions within the models. Quantiles were estimated on the basis of model projections using the same methodology (GEV distribution fitted by method of L-moments) as was used for the station observational data, and for each of the 20 elements of the NASA NEX GDDP ensemble (one model was eliminated based on evidence of extreme bias). The results indicate that the model-generated daily rainfall maxima are indeed considerably lesser in magnitude than observational records. The bias is assumed present in both historical and projection periods, and only changes are considered in subsequent analysis.

45. Results of the quantile estimation procedure are presented in Table 5, for 20-year, 50-year and 100-year events. It is seen that in almost all cases, quantiles estimated on the basis of climate model simulation outputs are significantly less than those estimated based on the observed station data, consistent with what is known about the performance of such models. It is also seen that not all models project that extreme events will increase in magnitude, although the majority do so: roughly 15 out of 20 models simulate increases in the low-frequency quantiles. Averaged over all models, the 20-year event increases by roughly 22%, the 50-year event by around 24%, and the 100-year event by around 26% relative to the (simulated) historical baseline.

46. It is anticipated that a widely dispersed range of results, including decreases, will be observed in a large ensemble. Each model-generated time series is understood as a sample trace, and the advantage of looking at the results of an ensemble of simulations is that some overall sense of the magnitude of change can be observed while the uncertainty range is also kept in view.

47. Results appearing in Table 5 are presented graphically in Figure 14a (20-year events), Figure 14b (50-year) and Figure 14c (100-year events). As consistent with projected changes in annual precipitation (Figure 13), the number of models projecting increases in one-day precipitation quantiles exceed the number projecting decreases (14 or 15 out of 20 project increases); and the typical magnitude of projected increases greatly exceeds the magnitude of projected decreases.

Table 5: Annual Maximum Daily Precipitation Quantiles Estimated from Down-Scaled Climate Simulation Models

	20-year Daily Ppt			50-year Daily Ppt			100-year Daily Ppt		
GCM	Historical	Projected	% Change	Historical	Projected	% Change	Historical	Projected	% Change
BNU-ESM	53.9	55.6	3.2%	63.358	60.547	-4.4%	71.1	63.7	-10.3%
CCSM4	75.4	101.9	35.2%	80.840	112.140	38.7%	84.1	118.8	41.3%
CESM1-BGC	84.3	100.8	19.6%	93.847	116.880	24.5%	100.3	128.7	28.3%
CNRM-CM5	85.2	103.3	21.3%	96.337	114.930	19.3%	104.3	122.6	17.6%
CSIRO-Mk3-6-0	72.2	93.2	29.0%	84.399	112.080	32.8%	93.5	127.3	36.2%
CanESM2	45.6	73.2	60.5%	53.153	88.615	66.7%	59.2	101.5	71.3%
GFDL-CM3	85.9	74.5	-13.3%	105.270	86.596	-17.7%	121.1	96.2	-20.6%
GFDL-ESM2G	63.5	76.8	21.0%	74.223	90.590	22.1%	82.6	101.6	23.1%
GFDL-ESM2M	59.6	55.9	-6.2%	65.101	59.598	-8.5%	68.7	61.8	-10.0%
IPSL-CM5A-LR	65.8	95.2	44.7%	82.850	124.460	50.2%	98.6	151.1	53.2%
IPSL-CM5A-MR	77.3	93.4	20.7%	98.846	114.540	15.9%	118.7	132.6	11.7%
MIROC-ESM-CHEM	55.6	76.4	37.4%	63.847	97.089	52.1%	70.0	115.5	64.9%
MIROC-ESM	55.3	54.4	-1.7%	62.933	62.607	-0.5%	68.6	68.9	0.5%
MIROC5	65.6	114.5	74.6%	72.787	131.620	80.8%	77.8	144.1	85.2%
MPI-ESM-LR	73.1	97.5	33.4%	84.221	110.830	31.6%	92.3	120.0	30.1%
MPI-ESM-MR	75.0	71.9	-4.1%	87.435	91.754	4.9%	96.9	110.1	13.6%
MRI-CGCM3	99.1	113.8	14.8%	110.700	131.240	18.6%	118.7	144.0	21.3%
NorESM1-M	59.1	86.6	46.5%	62.155	105.730	70.1%	63.9	121.9	90.9%
bcc-csm1-1	64.8	65.2	0.5%	78.075	72.896	-6.6%	88.8	78.1	-12.0%
inmcm4	83.9	81.7	-2.6%	98.661	90.275	-8.5%	109.9	95.8	-12.8%
Mean of Models			21.7%			24.1%			26.2%

Figure 14A: Changes in the Simulated 20-Year Annual Maximum Daily Precipitation, 2036-2065 compared to 1971-2000

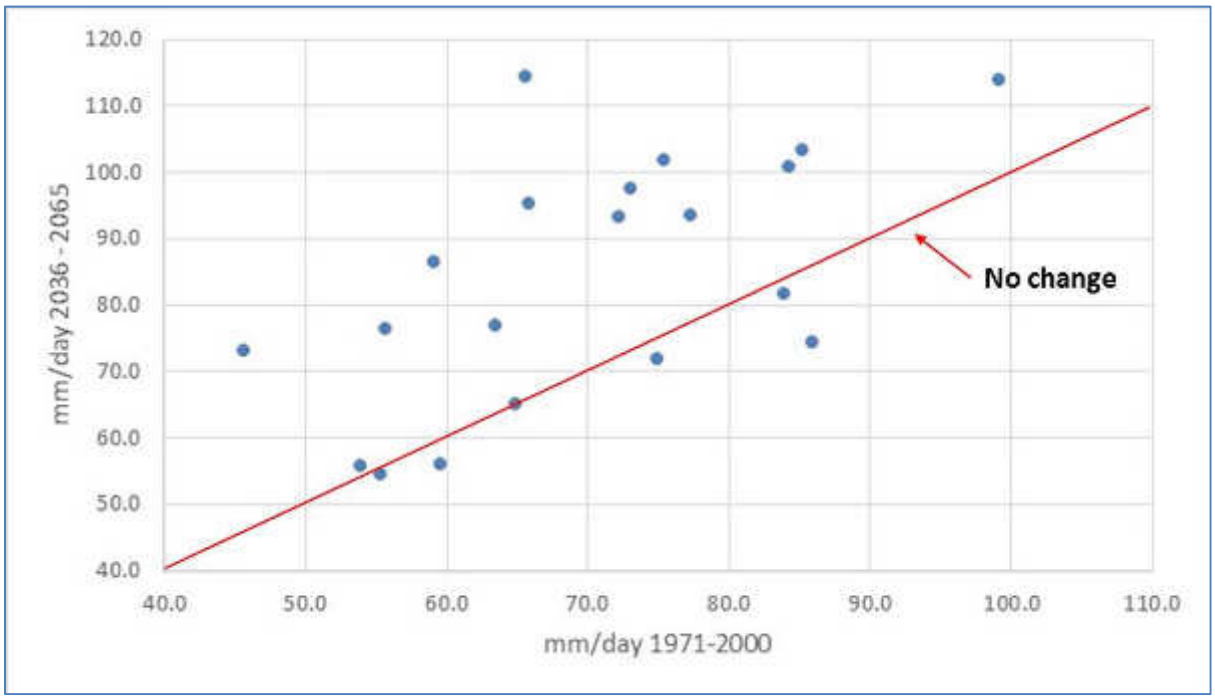


Figure 14B: Changes in the Simulated 50-Year Annual Maximum Daily Precipitation, 2036-2065 compared to 1971-2000

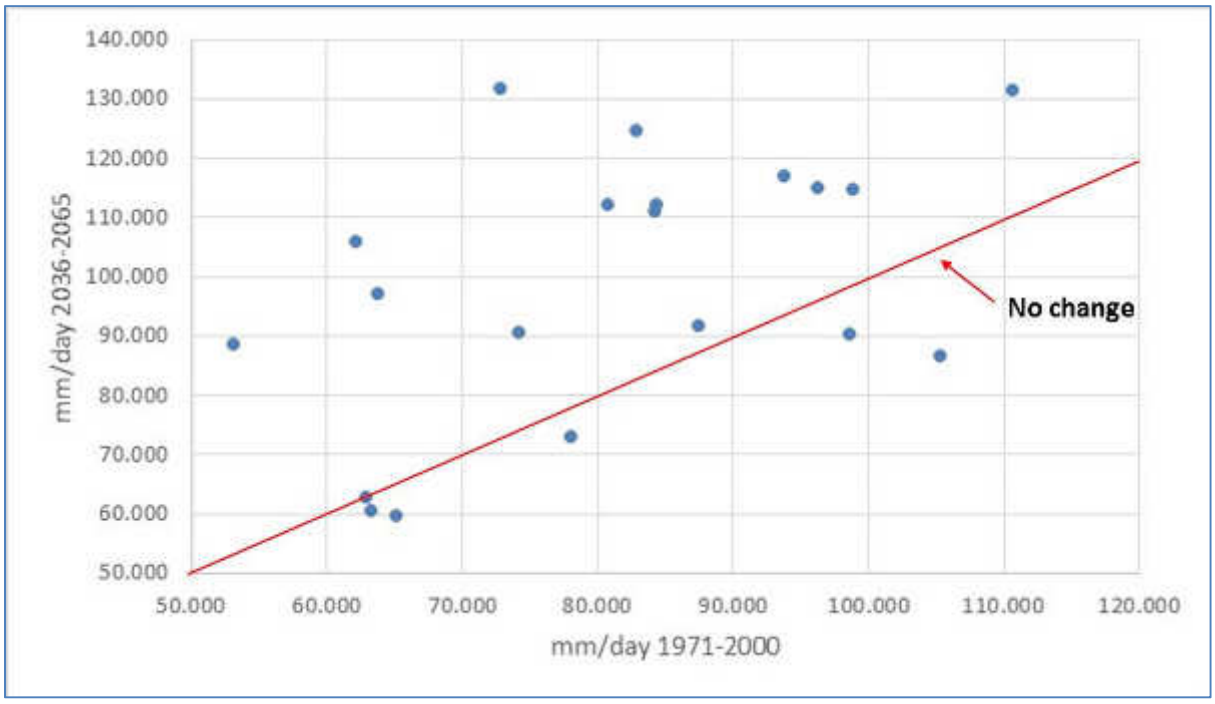
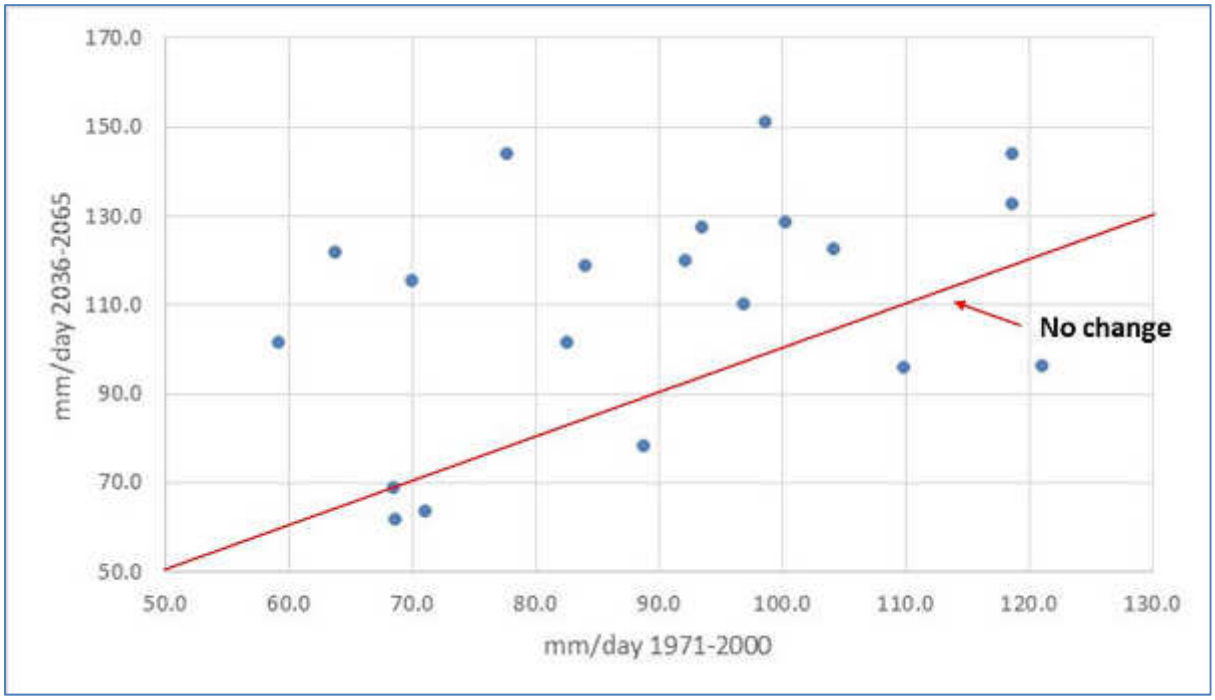


Figure 14C: Changes in the Simulated 100-Year Annual Maximum Daily Precipitation, 2036-2065 compared to 1971-2000



3.5 Impacts on Future Flooding

48. As noted in Section 3.1, while consideration of basic physical processes and observations on historical changes in precipitation intensity in many regions support the hypothesis that regional climate change will be accompanied by increases in the frequency and/or magnitude of flooding, the evidence to date is scarce and equivocal. Much of the available research literature is summarized in the IPCC's (2012) study "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" commonly referred to as the SREX. The relevant sections (p. 176) are quoted in full as follows (***emphasis added***):

49. "The number of projections of flood magnitude and frequency changes is still limited at regional and continental scales. Projections at the catchment/river-basin scale are also not abundant in the peer-reviewed scientific literature, especially for regions outside Europe and North America. In addition, considerable uncertainty remains in the projections of flood changes, especially regarding their magnitude and frequency. ***Therefore, our assessment is that there is low confidence (due to limited evidence) in future changes in flood magnitude and frequency derived from river discharge simulations.*** Nevertheless, as was argued by Kundzewicz et al. (2007) and Bates et al. (2008), physical reasoning suggests that projected increases in heavy rainfall in some catchments or regions would contribute to increases in rain-generated local floods (***medium confidence***). We note that heavy precipitation may be projected to increase despite a projected decrease of total precipitation depending on the regions considered, and that changes in several variables (e.g., precipitation totals, frequency, and intensity, snow cover and snowmelt, soil moisture) are relevant for changes in floods. Confidence in change in one of these components alone may thus not be sufficient to confidently project changes in flood occurrence. ***Hence, medium confidence is attached to the above statement***

based on physical reasoning, although the link between increases in heavy rainfall and increases in local flooding seems apparent."

50. "In summary, there is limited to medium evidence available to assess climate-driven observed changes in the magnitude and frequency of floods at a regional scale because the available instrumental records of floods at gauge stations are limited in space and time, and because of confounding effects of changes in land use and engineering. Furthermore, there is low agreement in this evidence, and thus overall low confidence at the global scale regarding even the sign of these changes. There is low confidence (due to limited evidence) that anthropogenic climate change has affected the magnitude or frequency of floods, though it has detectably influenced several components of the hydrological cycle such as precipitation and snowmelt (medium confidence to high confidence), which may impact flood trends. ***Projected precipitation and temperature changes imply possible changes in floods, although overall there is low confidence in projections of changes in fluvial floods***. Confidence is low due to limited evidence and because the causes of regional changes are complex, although there are exceptions to this statement. ***There is medium confidence (based on physical reasoning) that projected increases in heavy rainfall would contribute to increases in rain-generated local flooding, in some catchments or regions.*** Earlier spring peak flows in snowmelt- and glacier-fed rivers are very likely, but there is low confidence in their projected magnitude."

51. As a consequence, although analysis conducted for this study points to likely increases in the magnitude of large precipitation events (daily maximum precipitation with 20-, 50- and 100-year annual recurrence intervals) in the range of 20% to 30% by mid-21st century relative to historical conditions, it cannot be assumed that floods of comparable frequencies will increase by corresponding amounts, particularly in the absence of numerical flood simulation modeling. However, a precautionary approach seems appropriate, particularly under conditions of extensive and irreducible uncertainty. The consequences of failing to consider possible increases in flood hazard should they in fact occur likely exceed costs associated with preparing for such conditions when they subsequently fail to materialize; and possibly by a large margin. It is therefore the recommendation of this study that planners assume increases in flood design event magnitudes of between 20% and 30% relative to estimates based on the historical (observational) record when design decisions require explicit considerations of such events. Rigorous benefit-cost analysis should support any such decisions where adaptation costs are extensive; and monitoring and analysis of trends in both precipitation and flooding should be established practice.

4. Flood Risk Mitigation Efforts in Jinan

52. The Shandong Spring City Green Modern Trolley Bus Demonstration Project is a transport sector project, and it is unreasonable to consider that major flood risk management activities will be conducted in Jinan solely to address flood risks to this project alone. This section seeks to describe flood control activities in Jinan either completed, currently in implementation or planned that would act to manage flood-related risks to the Project. Many of these activities were undertaken following the severe 2007 and 2015 flood events. Others are being conducted through the Sponge Cities pilot program, described subsequently.

4.1 Description of Drainage Improvements in Jinan 2010-2016[16]

53. In 2010, the city's flood control and drainage capacities were improved. The Liuxing River, Huangtainan ditch and a total of seven rivers were rehabilitated, including dredging of 200 km of rainwater pipelines and 27 waterlogging points. The urban flood control measures and non-engineering measures were strengthened to ensure safety in flood season. In 2011, an additional 12 km of river was rehabilitated, consisting of dredging of 200 km rainwater pipelines and 27 waterlogging points. The city's flood emergency response plan was revised.

54. In 2012, Jinan developed its *Urban Sewage Comprehensive Management Strategies and Promotion Measures*. Urban municipal infrastructure construction completed the rehabilitation of three rivers, dredging 65 river courses which doubled the total over the previous four years. The city also completed rehabilitation of 24 waterlogging points, further improving its urban flood control and drainage capacity. The city's sewage pipe network was inspected and more than 800km of sewage pipelines were maintained. The institutional capacity of the city's flood control headquarters was strengthened, and its *Urban Flood Emergency Plan* revised. Jinan also developed a *Manual of Urban Flood Control Emergency Plan*, and *Guidelines of Urban Flood Control Command and Dispatch*. Some activities on rivers regulation, points prone to waterlogging and drainage network dredging were completed prior to flood season. River managers were made responsible for enhancing the effectiveness of drainage management so that it can withstanding a number of heavy rainfall events while ensuring the city's safety.

55. In 2013, Jinan's river flood prevention was further improved. Some river courses were widened and rehabilitated, and dangerous embankments and fence facilities were reinforced. A total of 800,000 m^3 of river silt was removed to improve river drainage capacity. Leakage sections management and rainwater utilization research were strengthened, and discharge of sewage or reclaimed water into rivers was strictly prohibited. Focusing on three major river-related functions - flood control, water retaining and ecological landscape - Jinan accelerated comprehensive improvement of rivers and channels, drainage pump stations and rainwater pipe networks, and dredging of waterlogging points. 30 detention ponds were built reflecting local conditions. Rainwater and flood control and utilization were improved. Some emergency drainage rescue projects were completed. Planning and design of the Longji River flood control project was completed and construction started.

56. In 2014, Jinan flood control, waterlogging and drainage capacity were further improved and enhanced. Longji River flood control project was completed with seven new large- and medium-sized bridges and 3 km of river regulation, effectively alleviating the flooding problem of Jinan City in rainfall season. Three drainage pumping stations and 18 waterlogging points were improved. Two old urban areas' drainage system were improved.

57. In 2015, Jinan was selected as a sponge city pilot, providing opportunities to make major changes in the city's development methodology and to promote the city's natural ecological improvement. As the second pilot city selected in the first batch of national sponge cities, five systems and 43 projects were completed in the pilot area at a total cost of CNY3.043 billion. Demonstration projects were finished, including Liyang Lake, Erhuan Road, and Sponge City Headquarters. Sewage treatment facilities were further improved. 'Six improvement strategies'

[16] This and the following section contain materials generously provided by Mingtao which have been lightly edited for inclusion in this report. Acknowledgements to Mingtao for his many contributions to this study.

were implemented to improve pollution control, river flood prevention, sanitation, water quality and landscaping. A project to convert surface water to groundwater achieved initial results.

58. In 2016, Jinan vigorously promoted the sponge city concept, focusing on establishing a green and ecological spring city. A comprehensive strategy to promote sponge city was actively implemented. The municipal government office issued *Opinions On the Implementation of Comprehensively Promoting the Sponge City* and *Stormwater Runoff Control and Management Regulations On Construction Projects in Jinan City*. Jinan approved the city's *Urban Special Planning On Sponge City Pilot* and other 27 regulations. In the 39 km^2 pilot area, the city water system, green space, traffic, community building and capacity building including 43 projects all started implementation. Among them, 24.7 km^2 or 63.33% of the total area were completed at an investment of CNY 5.09 billion, accounting for 65% of total investment. 35 roads at a total length of 39.7 km were upgraded. Via nine batches of rainstorm and flood monitoring and observation, the pilot area's flood waterlogging issues had been effectively alleviated. Twelve polluted rivers were comprehensively improved. Among 37 heavily water polluted points in the urban built-up area, 16 were improved, 5 are under construction, and for the remaining 16 engineering design and tender have been accelerated. Urban sewage treatment facilities continued to improve. The project to convert from surface- to groundwater project achieved impressive results, with total water transfer capacity of 780,000 m^3/day established to effectively utilize spring- and rain water and to ensure continual discharge of springs given reduced precipitation since 2013. A sponge city groundwater supply hydraulic model was developed to provide strong scientific support for accurately developing groundwater conversion.

4.2 Description of Drainage System Improvement Projects Post-2015

59. The following activities have been initiated post-2015 flood, and many were completed in 2016:

- Qianfoshan east road, about 1 km in length:1. sponge city rehabilitation. 2. new pipelines mainly including rainstorm, water supply, sewage, gas, heating and others. 3. pavement restoration (Sponge City pilot area - road associated rainwater runoff control and utilization project, initiated February 23, 2016)

- Qianfoshan west road, about 1.2 km in length: 1. sponge city rehabilitation. 2. new pipelines mainly including rainstorm, water supply, sewage, gas, communication, heating and others. 3. pavement restoration (Sponge City project)

- Jida road reconstruction project (initiated Feb. 23 and ending May 3, 2016): Yuhan-Shungeng road, 1074 m long, including sponge city rehabilitation, road maintenance and reconstruction, installation of rainwater, sewage, heating, gas, water supply and other pipelines, supporting transport infrastructure.

- Wanshou road reconstruction project (initiated February 23 and ending April 23, 2016): Shungeng-Yingxiongshan road, 778m long, including sponge city rehabilitation, road maintenance and reconstruction, installation of rainwater, sewage, heating, gas, water supply and other pipelines, supporting transport infrastructure.

- 2016 urban municipal facilities maintenance, emergency rescue and flood-control project (initiated April 1 and ending late 2016): routine maintenance of municipal roads in Jinan, drain pipelines dredging, check wells and septic dredging in accordance with daily maintenance plan of municipal facilities.

- Old urban area drainage improvement project (initiated May 2016): includes rainstorm and sewer pipelines rehabilitation at Jingliu road, intersection between Jingyi road and Weiliu road, and other activities.

- Jingliu road maintenance project (initiated September 2016: combines reconstruction of old urban area drainage facilities to upgrade road and build new traffic police facilities.

- Hongjialou north road separated drainage system project (initiated April and completed May 2016): built a rainwater pipeline of DN600-DN800 from south to north.

- Caishi area road rehabilitation project (initiated June 2016): improved rainwater and sewage drainage to completely solve the flood area's combined sewer systems and road waterlogging problems.

- Jinan City overall urban planning (2011-2020) approved August 28, 2016 by the State Council. Defines the future of Jinan urban planning, development and other important aspects. The city is divided into five areas including water conservation area in mountain areas in the south of the city, center city urban area, piedmont agricultural areas, coastal wetland conservation in the Yellow River area, and northern plains agricultural and forest ecological function area.

5. SUMMARY, OBSERVATIONS AND RECOMMENDATIONS

60. This rapid climate risk assessment for the Shandong Spring City Green Modern Trolley Bus Demonstration Project (the Project) has been conducted in response to the *high* climate risk rating assigned to the project by AWARE screening. On the basis of screening, and the well-documented history of severe flooding in Jinan over the last century, flooding is identified as the single greatest source of risk to the project associated with climate change. A primary consideration in focusing on flooding risk is that statistical analysis based on multiple down-scaled climate model projections suggests that the heavy one-day precipitation events associated with most of the recent serious flooding in Jinan may increase in intensity over the project design lifespan (practically, to 2050), implying, but not establishing, that urban rainfall flash flooding might increase in intensity as well. Other potential risks identified by AWARE screening, including high risks from wildfire and water availability and medium risks from temperature increase and solar radiation change, are assessed as unlikely to present substantial risks to the project, although increases in extreme temperature events require further analysis. A vulnerability analysis for the project was not possible to conduct at this point since documents describing the project in technical detail were not available at the time of writing.

61. The advantage of evaluating large ensembles of climate projections is that the uncertainty in future climate related to model specification, initial conditions and other factors is made visible. What is evident from this study is that there is considerable uncertainty around the extent to which extreme daily rainfall (and extreme events in particular) will change in the Jinan region as a consequence of climate change, although the preponderance of model-based analysis suggests that increases are more likely than decreases. As many factors in addition to rainfall accumulation and intensity contribute to the magnitude of flood hazard events, the uncertainty around climate change’s future impacts on flood magnitude should be assumed to be greater than the range associated with model diversity alone. It is also evident on the basis of established physical theory that increases in the intensity of daily events of a given recurrence interval (quantiles) are more

likely than decreases. In this study, a 30-year future time slice centered on 2050 has been compared to a 30-year simulated baseline centered on 1985. It is prudent to assume that daily rainfall quantiles commonly used in e.g., hydrologic design of drainage structures (10- or 20-year events) might increase by around 20% to 25% (the rough mean of increases at both sites as projected by 20 GCMs) over this interval.

62. Jinan's recent efforts to reduce risks associated with both water scarcity and overabundance (sponge city concept) provide evidence that the magnitude of flooding hazard and risk are being reduced relative to the pre-project era, assuming no change in climate. That is, Jinan's efforts appear to counter-balance many of the projected impacts of climate change, although a comparison of relative magnitudes is not possible based on the information available.

63. The recommendation of this study is to take a precautionary approach and assume that annual maximum daily rainfall events and/or similar high-intensity events that contribute to flood hazards will increase by 25% to 30% by 2050, and that the magnitude of flood quantiles will reflect such increases, at least approximately. These increments should be taken into account in all design decisions that require estimated magnitude of design (rainfall, flood) events. Such recommendations may not have direct implications for the Shandong Spring City Green Modern Trolley Bus Demonstration Project, as it is a transport sector project, although reasonable precautions consistent with increased heavy rainfall and/or flooding hazards should be observed. These include decisions concerning the location of facilities (trolley stops, electrical equipment) and the water-proofing of project components including electrical equipment. Further measures may be recommended when the project approaches final design.

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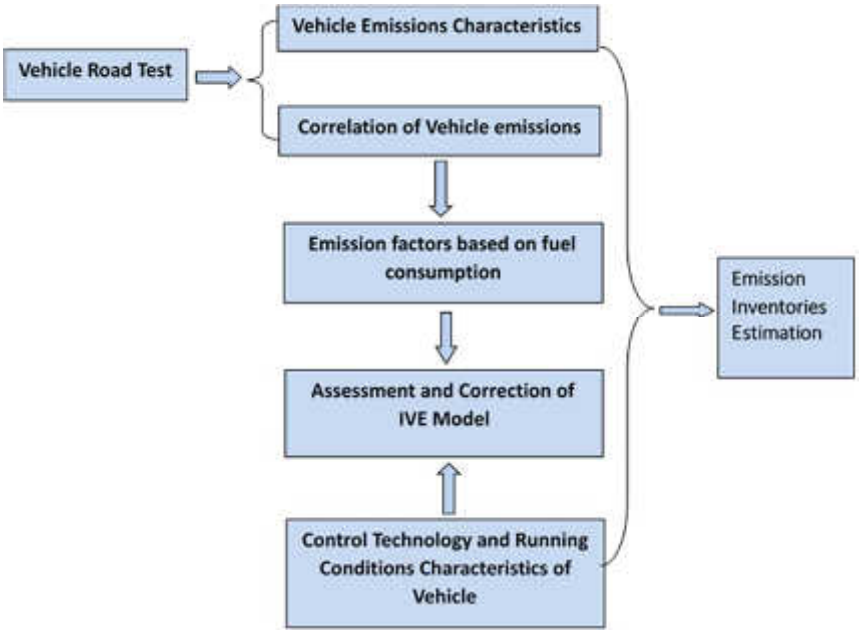
APPENDIX TABLE 1: FLOOD-GENERATING MECHANISMS AND LINKS TO CLIMATE CHANGE

Flood-Generating Mechanism	Likely Impacts of Climate Change	Other Contributing Factors
Heavy Seasonal Rainfall: river basin flooding	Regionally variable: some regions will experience increases while some will experience decreases	Siltation of channels from degraded watersheds and highly erosive rainfall; increased density of floodplain occupation
Tropical Cyclones: coastal flooding	Increased intensity of cyclones (although possibly lower frequency); sea level rise (SLR)	Increased density of settlement in coastal areas; poor quality housing
Monsoon Rainfall: river basin and coastal flooding	Intensity of monsoon rainfall likely to increase; changes in overall seasonal rainfall accumulation uncertain; changes in antecedent conditions uncertain; SLR in coastal areas	Urban areas: increase in impervious area; impaired drainage Rural areas: loss of soil structure and water-holding capacity
Torrential Rainfall: flash flooding in Rural Areas	Likely increase in rainfall intensity and frequency of high-intensity events, even in regions where annual rainfall is decreasing	Deforestation, degradation of watersheds; loss of soil structure and infiltration capacity
Torrential Rainfall: flash flooding in Urban Areas	Likely increase in rainfall intensity and frequency of high-intensity events, even in regions where annual rainfall is decreasing; SLR in coastal cities	Increase in impervious area; impaired drainage, reduced conveyance of floodways due to informal settlement
Storm and Tidal Surges: coastal flooding	Increased intensity of cyclones (although possibly lower frequency); sea level rise (SLR)	Land subsidence from over-extraction of groundwater
Dam and levee failures	Increases in rainfall intensity lead to steeper, less predictable flood hydrographs; flood quantiles likely to increase in many areas	Increases in rainfall intensity lead to upland erosion, reservoir sedimentation and loss of flood storage; channel aggradation
Glacial lake outburst flooding (GLOF)	Increased hazard throughout early decades of warming as glaciers recede; risks eventually diminish as glaciers ablate	Landslides

APPENDIX D - Methodology and approach used for the Project Emissions Reduction Benefits

1. This section shows the results of pollutant emissions reduction by Trolleybus development in the urban area of Jinan. Methodological structure for emission reduction calculation is shown below.



2. **Emission factors** are the basic of emission inventories estimation. The driving state, fuel type, accumulated mileage, control technology level, and curb weight are the factors which influence the emissions of pollutant a lot, According to these factors, vehicles types are classified into 588 types, as shown in table below. And because the emissions of vehicles are also influenced by oil quality, road conditions, temperature, humidity, etc. They have to be corrected in the emissions inventory model.

Vehicle	Driving state	Fuel type	Accumulated mileage	control technology	curb weight	Types
Passenger Cars (including taxis)	Start、Running	Gasoline、Diesel	≤80000km、80000-160000km、>160000km	Before National Ⅰ、National Ⅰ、National Ⅱ、National Ⅲ、National Ⅳ、National Ⅴ	Light、Medium、Heavy	216
Buses	Start、Running	Hybrid-LG、Hybrid-diesel、	≤80000km、80000-160000km、	Before National Ⅰ、National Ⅰ、National Ⅱ、	Heavy	120

		Diesel、CNG	>160000km	NationalⅢ、NationalⅣ		
Light trucks	Start、Running	Gasoline、Diesel	≤80000km、80000-160000km、>160000km	Before National Ⅰ、National Ⅰ、National Ⅱ、NationalⅢ、NationalⅣ	Light、Medium、Heavy	180
Motorcycles	Start、Running	Gasoline	≤80000km、80000-160000km、>160000km	Before National Ⅰ、National Ⅰ、National Ⅱ、NationalⅢ	Light、Medium、Heavy	72

3. In this work, emission factors are all come from our previous research work of on-road optical remote sensing and chassis dynamo meter testing method.

4. **Inventory emission estimation** was carried out using various factors: Forecast of vehicle number, emissions from various vehicle types, congestion, indirect energy use like electricity.

5. **Forecast of vehicle number.** Two scenarios were based on projections of vehicle numbers.

(i) Urban mobility without Trolley scenario: Metro grows rapidly from 2018, and trolleybus grows as usual. We forecast the number of vehicles from 2016 to 2043 according to the increase rate of public transport under UM without Trolley scenario.

(ii) Urban mobility with Trolley scenario: Metro grows as UM without Trolley scenario, and trolleybus grows rapidly. We forecast the number of vehicles from 2016 to 2043 according to the increasing rate of public transport under this scenario.

6. **Calculation of emissions**

$$E = E_{running} + E_{start} = EF_{running} \times Q + EF_{start} \times T$$

E is the pollutant emissions of vehicles, the types of which are shown in Table above. $E_{running}$ is the pollutant emissions in the vehicle running state, E_{start} is the pollutant emissions in the vehicle starting state; $EF_{running}$ is the emission factor in the vehicle running state, EF_{start} is the emission factor in the vehicle starting state; Q is the total driving distance per hour, T is the number of the starting times per hour.

7. **Emissions caused by congestion**

$$E = D \times T_v \times t$$

E is emissions of vehicles caused by congestion; D is number of vehicles in urban area, T_v is emission factor, t is rate of congestion.

8. **Emissions of Trolley by using electricity**

$$E = E_{coal} + E_{Ngas} = ET_{coal} \times Q_{coal} + ET_{Ngas} \times Q_{Ngas}$$

E is the emissions of trolleybus using electricity; E_{coal} is the emissions of coal power, E_{Ngas} is emissions of Natural gas power; ET_{coal} is generation of coal power, ET_{Ngas} is generation of Natural gas power; Q_{coal} is emission factor of coal power, Q_{Ngas} is emission factor of Natural power.

$$ET_{coal} = T/(1-r) \times a \times b_{coal}$$

ET_{coal} is generation of coal power; T is consumption of electricity using by trolley, r is the rate of loss from generation to consumption, a is rate of thermal power in all power, b_{coal} is rate of coal power in thermal power.

$$ET_{Ngas} = T/(1-r) \times a \times b_{Ngas}$$

ET_{Ngas} is generation of Natural gas power; T is consumption of electricity using by trolley, r is the rate of loss from generation to consumption, a is rate of thermal power in all power, b_{Ngas} is rate of Natural gas power in thermal power.

9. **Vehicle emission inventories model.** In this project, a vehicle emission inventories model (VEM) was developed (Fig.2). For VEM model, vehicle fleet technology distribution, vehicle driving pattern and VKT are the major inputs. Technology distribution and vehicle driving patterns of fleet. Vehicle age distributions are similar, indicating that the on-road tests captured a representative sample of vehicle model years operating. The VEM model includes a total of 588 different classes of vehicle. One technology class includes three vehicle use categories:<79,000, 80,000–161,000, and >161,000 km.

Vehicle emission inventories model

10. **Emissions reduction results.** Urban mobility without Trolley scenario and with Trolley scenario were compared for associated emissions in term of CO、NOx、HC、PM、and CO2 from 2023 to 2043, taking into account vehicle growth incorporating mode shift effects, emissions factors incorporating changes in vehicle technologies and fuel standards in the PRC, and congestion increase over time. Also, emissions from thermal power plants are included in calculation. Table below show yearly emissions reduction as well as the total emission reduction between 2023 and 2043.

All cars, buses and motor bicycle												
Year		2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	203
Emission abatement (tonne/annual)												
	CO	963	1,115	1,271	1,445	1,611	1,777	1,948	2,113	2,271	2,431	2,593
	NOx	81	101	122	148	170	191	212	231	249	267	286
	HC	48	57	67	78	88	98	109	120	131	141	152
	PM	(0)	1	2	3	4	5	6	7	7	8	8
	CO2	23,037	46,700	71,120	108,720	134,540	158,513	183,076	200,730	219,989	239,516	259,147

All cars, buses and motor bicycle												
Year		2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	**Total**
Emission abatement (tonne/annual)												
	CO	2,754	2,912	3,064	3,205	3,331	3,437	3,515	3,433	3,308	5,056	**53,554**
	NOx	304	322	339	355	369	381	390	381	367	562	**5,830**
	HC	163	174	184	194	202	210	215	211	203	313	**3,157**
	PM	9	10	10	11	12	12	12	12	11	18	**169**
	CO2	278,652	297,742	316,055	333,144	348,455	361,310	370,877	361,527	347,159	547,737	**5,207,745**