WATER REUSE AND ENVIRONMENTAL CONSERVATION PROJECT

CONTRACT NO. EDH–I–00–08–00024–00 ORDER NO. 04

Environmental Considerations Report for Zarqa Industrial Wastewater Treatment Plant

May 2015

IMPLEMENTED BY AECOM

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ENVIRONMENTAL CONSIDERATIONS REPORT FOR ZARQA INDUSTRIAL WASTEWATER TREATMENT PLANT MAY 2015

Submitted to:

USAID Jordan

Prepared by:

AECOM

DISCLAIMER:

The authors' views expressed in this document do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

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LIST OF ACRONYMS

ASL	Amman Silicified Limestone
AZB	Amman-Zarqa Basin
B	Boron
BOD	Biochemical Oxygen Demand
BOD_5	Biochemical Oxygen Demand Over a 5-Day Period
Cd	Cadmium
CEMP	Construction Environmental Management Plan
Cl	Chloride
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
°C	Degrees Celsius
DAF	Dissolved Air Flotation
dB A	Decibel
DFZC	Development and Free Zones Commission
DOA	Department of Antiquities
DOS	Department of Statistics
EC	Electrical Conductivity
ECR	Environmental Considerations Report
EIA	Environmental Impact Assessment
EMMP	Environmental Management and Monitoring Plan
FOG	Fat, Oil and Grease
H_2S	Hydrogen Sulfide
HASP	Health and Safety Plan
HERO	High Efficiency Reverse Osmosis
HMMP	Hazardous Materials Management Plan
IBA	Important Bird and Biodiversity Area
IEE	Initial Environmental Examination
IWRMP	Integrated Water Resources Management Plan
IWTP	Industrial Wastewater Treatment Plant
JEPCO	Jordan Electric Power Company
JIEC	Jordan Industrial Estates Company
JPRC	Jordan Petroleum Refinery Company
JS	Jordanian Standard
JSMO	Jordanian Standard and Metrology Organization
JVA	Jordan Valley Authority
KTD	King Talal Dam
m^3/d	Cubic Meters per Day
m^3/h	Cubic Meters per Hour
MBR	Membrane Bioreactor
MCM	Million Cubic Meters
mg/L	Milligrams Per Liter
$\mu g/m^3$	Microgram Per Cubic Meter
mg-N/L	Milligrams Nitrogen Per Liter
MOA	Ministry of Agriculture
MoEnv	Ministry of Environment
MOH	Ministry of Health
MOI	Ministry of Interior
MOL	Ministry of Labor
MOMA	Ministry of Municipal Affairs
MSL	Mean Sea Level
MWI	Ministry of Water and Irrigation
Na	Sodium
NH_3	Ammonia

NO_2	Nitrogen Dioxide
NRA	Natural Resources Authority
NTU	Nephelometric Turbidity Unit
O_3	Ozone
/100mL	Per 100 Milliliters
/L	Per Liter
P_2O_5	Phosphorus Pentoxide (used as an analog for available phosphate)
P2	Pollution Prevention
Pb	Lead
PM_{10}	Respirable Particulate Matter
$PM_{2.5}$	Fine Particulate Matter
PO_4-P	Phosphate Reported as Phosphorus
PPE	Personal Protective Equipment
PPM	Parts Per Million
RO	Reverse Osmosis
RSCN	Royal Society for the Conservation of Nature
SAR	Sodium Adsorption Ratio
SO_2	Sulfur Dioxide
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
UF	Ultrafiltration
USAID	United States Agency for International Development
WAJ	Water Authority of Jordan
WG	Wadi Umm Ghudran Formation
WRECP	Water Reuse and Environmental Conservation Project
WSL	Wadi As Sir Limestone Formation
WWTP	Wastewater Treatment Plant
ZCI	Zarqa Chamber of Industry

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1 INTRODUCTION

1.1 Project Background and Need for the Project

Water scarcity is one of the most important natural resource constraints on Jordan's economic growth. Rapid increases in population and industrial development have placed unprecedented demands on water resources. This situation has been exacerbated by the continuous depletion of Jordan's fresh water supply at an alarming rate.

Industries in Jordan, faced with critical water shortages, often resort to obtaining water from water tanker delivery at high cost and great inconvenience. The current situation cannot be sustainable for Jordanian industries.

In addition to improving water management to meet the needs of the growing population and the industrial and service sectors, there is an increasing need to build more treatment facilities to cope with the increasing wastewater generated from domestic and industrial uses. Untreated wastewater discharges can lead to pollution of valuable water bodies in a country that suffers from a critical shortage in potable and non-potable water supplies. Integrated water management is an immediate necessity in Jordan.

To address the need to protect and conserve water in Jordan, the United States Agency for International Development (USAID) and the Jordanian Government commenced the five-year Water Reuse and Environmental Conservation Project (WRECP), implemented by AECOM. This project has tackled water scarcity, quality and reuse issues through an industrial usage and pollution prevention perspective, seeking to deal with institutional and regulatory gaps, as well as furthering industry best practices.

The USAID WRECP works throughout Jordan in institutional capacity building, pollution prevention (P2) for industries, solid waste and wastewater management, and water reuse. The project is implemented by AECOM and a team of international and Jordanian partner firms. This five-year project has four primary tasks:

- Task 1 – Institutional and Regulatory Strengthening
- Task 2 – Pollution Prevention and Industrial Water Management
- Task 3 – Disposal Sites Rehabilitation and Feasibility Studies
- Task 4 – Water Reuse for Community Livelihood Enhancement

The overall objective of WRECP is to protect Jordan's water supply through the achievement of the following goals:

- Strengthen the ability of government agencies to monitor and regulate industrial wastewater handling and reuse
- Strengthen the ability of qualified laboratories to analyze industrial wastewater samples, to tell whether it is being treated properly
- Help industries gain access to technologies and expertise to reduce pollution and conserve water and energy
- Improve waste management practices at landfills and improve industrial wastewater treatment
- Help communities generate income through water reuse projects
- Increase public awareness of the benefits of water reuse and proper waste management

One of the main project components (Task 2) focuses on assisting industries to conserve water and energy and prevent pollution. This part of the project includes the following activities:

- Industrial pollution prevention and water management
- The design of up to three centralized Industrial Wastewater Treatment Plants (IWTPs)
- Developing an Integrated Water Resources Management Plan (IWRMP) in Aqaba and the King Abdullah II Industrial Estate

The key benefits of assisting industries and implementing these activities are:

- To reduce industrial operations costs through water and energy conservation and minimizing waste
- To improve environmental performance through cost-effective centralized IWTPs
- To enhance water resources utilization through IWRMPs

Zarqa is one of Jordan's major industrial centers and together with Amman contributes approximately 60% of industrial revenues in Jordan. Approximately 250 industrial facilities are contributing to wastewater generation in the Zarqa area, although collection and local treatment services for industrial wastewater are absent. Therefore, Zarqa was one of the locations chosen for the IWTP design task. A committee of representatives from the USAID, the Ministry of Environment (MoEnv), the Ministry of Water and Irrigation (MWI), and the Development and Free Zones Commission (DFZC) were involved in the selection.

1.2 Environmental Considerations Report Objectives

A screening process was conducted for the WRECP according to USAID's Environmental Compliance Procedures, Title 22, Code of Federal Regulations, Part 216. USAID conducted an Initial Environmental Examination (IEE) for the various components of the WRECP, including a threshold decision for the proposed Zarqa IWTP. As USAID's action is limited to the funding of a feasibility study and preparation of design documents, the IEE concluded that USAID's actions (i.e., studies/design) would not have the potential for significant adverse environmental impact. However, USAID recognized that implementation (e.g., construction/implementation) of recommendations made in the feasibility study and depicted in design documents could have potential adverse impacts if not implemented with appropriate controls, or if environmental monitoring is not incorporated into the project. The IEE noted that an Environmental Mitigation and Monitoring Plan, hereafter referred to as an Environmental Management and Monitoring Plan (EMMP) should be prepared, to minimize adverse impacts on human health and the environment for these activities. Further, the IEE determined that the environmental assessment process should be followed in accordance with USAID's Environmental Compliance Procedures.

The present report is an Environmental Considerations Report (ECR). This ECR was not prepared to be a formal Environmental Assessment; instead, it was prepared to demonstrate that potential environmental impacts are considered by the design team while making a decision on the recommended plan, and during development of the preliminary design. This ECR includes an EMMP to facilitate the implementation of the proposed action in a manner that enhances and sustains the natural and human environment. During implementation of the proposed IWTP final design and construction, an Environmental Impact Assessment (EIA) in compliance with MoEnv regulations and any other funding nation regulations, as appropriate, must be prepared and should include the major results, conclusions, and recommendations of this study.

This ECR plays a central role in assessing the social and environmental implications – including water resources implications – of the proposed project, identifying the measures

necessary to protect resources and related ecosystems. The ECR is concerned not only with impacts on the natural environment, but also with effects on the social environment.

The ECR describes various components of the environment of the area(s) to be affected by the alternative under consideration. Data and analyses in the ECR are commensurate with significance of the impact. The ECR includes discussions of direct and indirect effects and their significance, policies and controls for the areas concerned, the reuse and conservation potential of the recommended alternative, and mitigation measures. For each significant adverse impact, the mitigation discussions propose measure(s) that will minimize its magnitude and severity.

The main objectives of this ECR for Zarqa IWTP are summarized below:

1. Determine that the project will not have irreversible negative impacts on the natural and human environments
2. Identify and compare the potential environmental impacts, including the positive and negative, and direct and indirect impacts of the recommended alternative
3. Propose mitigation and monitoring measures for minimizing the potential adverse impacts of the project on the affected environment

"Project site" is routinely used in this document and refers to the site where construction and IWTP operations would occur; "project area" refers to the project site and its immediate vicinity.

2 REGULATORY FRAMEWORK

This chapter describes the applicable institutional and regulatory framework in Jordan, including relevant standards, laws, and regulations.

2.1 Laws

2.1.1 Environment Protection Law (No. 52 of 2006)

In 2006, the Jordanian Law for Protection of the Environment was decreed. Article 5 of this law states that the MoEnv, in cooperation and coordination with the authorities concerned with environmental affairs at the local, Arab and international levels, shall be responsible for the protection of the environment elements and components from pollution. A set of complementary regulations and instructions were issued pursuant to the Law.

According to Article 13 of the law, companies, establishments or entities that conduct activities which negatively impact the environment should prepare an EIA report for its projects and submit such report to the MoEnv to take the appropriate decision in its regard. The Environmental Protection Law is currently in the process of being reviewed and any modifications or additions to the law will be announced by the Ministry of Environment. Until such time, the requirements of the existing law should continue to be followed.

2.1.2 Public Health Law (No. 47 of 2008)

The Ministry of Health (MOH) is the entity responsible for applying the Public Health Law in Jordan. The Ministry is also authorized to take all necessary measures to protect public health. Article 47 considers activities that affect human health or cause a health nuisance by releasing solid or liquid waste or emitting gases. Article 48 states that entities responsible for creating health nuisance are given seven days' notice to apply corrective measures. If nothing is done, the ministry of health will carry out the required actions at the expense of the activity owner.

2.1.3 Archaeology Law (No. 21 of 1988)

Issued by the Ministry of Tourism / Department of Antiquities (DOA), the law details the main responsibilities of the DOA. These include but are not limited to determining the archaeological sites along with their importance, carrying out archaeological excavations, and maintenance, preservation and restoration of archaeological sites. Article 13 of this law bans construction of any structure within a distance of 5 to 25 meters from an archaeological site.

Article 15 states that any chance finds should be reported to DOA or the Public Security Directorate within 10 days. Article 27 sets the penalties for failing to report chance finds.

2.1.4 Water Authority Law (No. 19 of 1988)

The Water Authority Law and its amendments established the Water Authority of Jordan (WAJ) as an autonomous agency responsible for all water and wastewater issues in the country. WAJ's mandate includes connecting the public to the water and sewer networks, as well as maintaining, operating, and managing these networks.

WAJ's mandate also includes the management of wastewater treatment plants (WWTPs), and thus it is concluded that WAJ's mandate also encompasses any product of WWTPs.

2.1.5 Agriculture Law (No. 44 of 2002)

This law identifies the responsibilities of the Ministry of Agriculture (MOA) in regulating and developing the agricultural sector, in cooperation with the relevant authorities. In addition, Article 57 governs the protection of wild animals and birds and prevents the hunting, killing or capture of birds useful for agriculture as well as birds and animals of prey. The types and species subject to this regulation are specified by the Minister. The Law further governs the protection of agricultural land and pastures.

2.1.6 Law of Planning of Towns and Villages and Buildings (No. 79 of 1966)

By virtue of this law the Higher Planning Council is responsible for regional planning and planning zones. This law applies to all kinds of land uses including buildings and any construction works undertaken. It also applies to any reconstruction conducted by any governmental or local authority, public or private institution. The law provides many sections that regulate licensing, plans for land distribution, pollution prevention, solid waste disposal and sewage, as well as traffic control.

2.1.7 Labor Law (No. 8 of 2002)

The key component of this Law is stated by Article 56 paragraphs (A) and (B) regarding the right of the laborer to not work more than eight hours per day. Furthermore, Article 73 of this law bans the employment of individuals less than 16 years of age. The Law also outlines that projects shall comply with article 78 related to occupational health and safety, and provide essential precautions and arrangements to protect the workers from the risk of hazards, including the supply of Personal Protective Equipment (PPE).

2.2 Bylaws and Regulations

The following summarizes the bylaws and regulations that are relevant to remediation of Area 3. This summary includes, for some of the bylaws and regulations, a reference to specific language in the bylaws relevant to the proposed project.

2.2.1 Environmental Impact Assessment Regulations (No 37 of 2005)

The EIA regulations were issued to ensure that the anticipated impacts of any development project on the social, economic, and natural environment in Jordan are identified. Their aim is to limit these impacts in order to achieve sustainable development in the country. The regulations apply to all industrial, agricultural, commercial, construction, residential, and tourism projects. The level and type of EIA study is determined by the MoEnv consistent with the lists of Category 1 and Category 2 projects specified in Annex 2 and Annex 3 of the regulation. This regulation also states that the EIA review period for the MoEnv is 45 calendar days. The MoEnv is currently reviewing the EIA regulations, including the EIA classification system, and will issue any changes to the regulations or additional guidance as appropriate.

2.2.2 Regulation for the Prevention of Health Nuisances (No. 72 of 2009)

The provisions of this regulation prohibit anyone from causing any health nuisances within the municipal areas. It identifies the types of nuisances and the measures to be undertaken to prevent the occurrence of health nuisances.

2.2.3 Regulation for the Protection and Safety of Workers from Machineries and Workplaces (No. 43 of 1998)

The provisions of this regulation obligate any institution to take precautions and procedures to ensure prevention of occupational accidents. It identifies types of safety risks at work sites, including mechanical, chemical and electrical machinery and industrial equipment.

2.2.4 Regulation of Preventive and Therapeutic Medical Care for the Workers in Establishments (No. 42 of 1998)

The provisions of this regulation obligate any institution to ensure the medical capability of workers via preliminary and regular medical examinations.

2.2.5 Air Protection Bylaw (No. 28 of 2005)

This bylaw was issued in accordance with Article 23 of the Environmental Protection Law (No.1, 2003). The aim of the Air Protection Bylaw is to protect public health and the environment from pollution resulting from human activities by controlling air pollutants emitted from stationary and mobile sources. It states that for any facility the leak or emission of air pollutants should not exceed the maximum allowable limits. The MoEnv classifies establishments according to the quality and quantity of air pollutants and contaminants resulting from their activities, and their effects on the environment and public health; consequently, the appropriate location of the facility is determined. The MoEnv is responsible for detecting any excesses and monitoring the compliance with this bylaw.

2.2.6 Solid Waste Management Bylaw (No. 27 of 2005)

The MoEnv is responsible for applying this bylaw which aims to establish a solid waste management system that would protect the environment and the public health.

Under this bylaw, the MoEnv is responsible for designating appropriate dumping sites along with detailing the requirements of solid waste collection, transport, storage, recycling, treatment and disposal.

2.2.7 Soil Protection Bylaw (No. 25 of 2005)

Article 3-E of this bylaw states that the MoEnv, in coordination with the relevant authorities, is responsible for protecting soil from the harmful effects of industrial dust, solid waste, industrial waste and untreated wastewater. The regulation further states that the Ministry in cooperation with the MOA is responsible for studying the sites of development projects and project impacts on land and natural resources, as well as preparing the necessary programs for the rehabilitation of waste dumping sites and their cultivation with appropriate crops.

2.2.8 Environmental Monitoring and Inspection Regulation (No. 65 of 2009)

This regulation was issued pursuant to the Environmental Protection Law No. 52 of 2006. It categorizes three levels of operational facilities based on their risk to cause environmental pollution. This categorization is reflected in the frequency of environmental inspections stipulated in the regulation. In cases where environmental inspections carried out by the MoEnv reveal violation of stated environmental quality requirements, the MoEnv is authorized to request an environmental audit from the facility, which under Article 9 of the regulation is obliged to submit its audit reports to the MoEnv.

2.2.9 Regulation for Protecting the Environment from Pollution in Emergency Situations (No. 26 of 2005)

This regulation sets out the plan for "protecting the environment and controlling pollution in emergency situations and the methods of implementation thereof, subject to the specific international and regional protocols in this regard to which the Kingdom is party". In addition, MoEnv is responsible for managing the emergency plan and following up on its execution, as well as identifying the necessary resources and conducting the required surveys and studies.

2.2.10 Groundwater Control Regulation (No. 85 of 2002)

This regulation was issued pursuant to Articles 6 and 32 of the Water Authority Law No. 18 of 1988. It governs groundwater extraction and designates groundwater as exclusive government property. The regulation additionally controls the drilling of wells and the licensing thereof, as well as quality and pollution control and remediation. Furthermore, Criminal Law No. 16 of 1960 stipulates the protection of water resources and sets out the penalties in the case of violations.

2.2.11 Water Protection Regulation of 2004

This regulation aims at protecting water sources from pollution. It stipulates that the Ministry of Water and Irrigation (MWI) is to set the environmental conditions to be fulfilled if permission and authorization are to be given for the development projects covered by the environmental impact assessment regulation.

Additionally, Article 6 of the regulation states that no waste dump sites can be constructed without the MWI's authorization and states that MWI in coordination with the concerned entities should set the environmental criteria, conditions and requirements for such a facility. Article 11 further highlights the role of MWI and other concerned entities in setting the environmental conditions for the collection, storage and transportation of all liquid and solid waste in order to prevent the pollution of water sources.

2.2.12 Regulation of Land Use of 2007

This regulation, which applies to all land uses, including buildings and any construction works undertaken, makes the Higher Planning Council responsible for regional planning and planning of zones. It sets outs the different land use categories and defines the relevant allowable activities.

2.2.13 Sewerage System Regulation (No. 66 of 1994)

This regulation was issued pursuant to Article 32 of the Water Act No. 18 of 1988. It regulates the subscription in sewerage systems in Jordan, and specifies the fees of the service and the terms of participation. It prohibits any disposal of wastewater in public sewerage without permission. The regulation specifies the penalties that would be applied if the authority finds that wastewater disposed of in public sewerage contains any prohibited materials. The authority has the right to inspect wastewater of any institution at any time.

2.2.14 Hazardous Materials and Wastes Management, Transfer and Circulation Regulation (No. 24 of 2005)

This regulation prohibits dealing with hazardous waste or dangerous substances unless a permit is obtained from MoEnv. Per this regulation, the Ministry should form a committee that classifies hazardous waste or dangerous substances, and prepare instructions to determine the basis and conditions for the handling, collection, storage, treatment and disposal of hazardous waste and dangerous substances.

2.2.15 Regulation for the Formation of Committees and Moderators of Occupational Safety and Health (No. 7 of 1998)

The provisions of this regulation obligate any institution that has more than 20 employees to form a functionally specialized committee for the occupational safety and health of the employees. The size of the committee so formed should be commensurate with the size of the institution. The regulation also specifies the responsibilities of this committee.

2.3 Instructions and Decisions

2.3.1 Instructions for the Protection of Workers and Institutions from Workplace Risks and Hazards of 1998

These instructions specify mitigation measures that should be taken within trades, industries and crafts to ensure the occupational safety and health of workers and reduce risk factors in facilities.

2.3.2 Instructions for Preliminary Medical Testing of Workers of 1998

These instructions designate types of industries in which workers should be subject to a preliminary medical examination to check their capability to perform their assigned work.

2.3.3 Instructions for Regular Medical Testing of Workers of 1998

These instructions designate types of industries in which workers should be subject to certain medical examinations regularly.

2.3.4 Instructions for Wastewater and Treated Wastewater Use in Agriculture

These instructions identify all types of wastewater, treated wastewater and agricultural products. They also specify all the terms for reusing the treated wastewater in agricultural production.

2.3.5 Instruction for the Management and Handling of Consumed Oil of 2003

These instructions identify the oils that are refined from crude oil or synthetic oils and those that have been used and have become contaminated waste and therefore must be disposed of or treated to be reused. These instructions prohibit the discharge of these oils into sewage systems or septic tanks or surface water sources or groundwater or to the environment, and specify all the requirements for the proper handling and disposal of these oils.

2.3.6 Instruction for Management and Handling of Hazardous Waste of 2003

These instructions identify all types of hazardous wastes and prohibit the discharge of these wastes into sewage systems or surface water or groundwater or to the environment. They also specify all the requirements and steps for proper handling, storage, transportation and disposal of these wastes.

2.3.7 Instructions for Noise Prevention of 2003

These instructions address ambient noise and were issued by the MoEnv in 2003. Article 6 of the instructions specifies the maximum allowable level of noise for the different types of areas, both during the daytime and at night.

According to the Instructions for Controlling and Preventing Noise, construction works that use noisy equipment like mixers and shakers and any other similar equipment between 8 pm and 6 am is prohibited except for cases approved by the Ministry.

Table 2-1 below displays the allowable maximum limit of the equivalent volume level (dB A) per area.

Table 2-1: Maximum Allowable Noise Levels

Area	Maximum limit for equivalent sound level (decibel A)	
	Day	Night
Residential areas in cities	60	50
Residential areas in suburbs	55	45
Residential areas in villages	50	40
Residential areas that have some workshops or simple vocations or business and commercial and administrative areas and downtown	65	55
Industrial areas (heavy industrial)	75	65
Tuition, worshipping and treatment places and hospitals	45	35

2.3.8 Instructions for Discharge of Industrial and Commercial Wastewater in the Sewage Network of 1998

These instructions detail the detrimental characteristics of industrial and commercial wastewater that make it illegal to discharge into the sewage network. As shown in Table 2-2, they denote the maximum allowable limits for a number of wastewater pollutants. They also provide instructions on applying these limits for sewage connections and prohibit discharge to the sewerage network of wastewater that exceeds these limits.

Table 2-2: Pre-Treatment Standards for Industrial Wastewater Discharge to Domestic Wastewater Collection Systems

Parameter		Limit	
Hydrogen Ion Concentration	pH	5.5 to 9.5	Range
Temperature	T	65° C	Maximum
Fat, Oil, Grease, Wax	FOG	100 mg/L	Maximum
Hydrocyanic acid-forming compounds	HCN	1.0 mg/L	Maximum
Phenolic compounds (as Phenol)	Phenols	10 mg/L	Maximum
Sulfides (as hydrogen sulfide [H_2S])	Sulfides	10 mg/L	Maximum
Methylene Blue Active Substances	MBAS	40 mg/L	Maximum
Chromium*	Cr	5.0*mg/L	Maximum
Copper*	Cu	4.5*mg/L	Maximum
Tin	Sn	10 mg/L	Maximum
Beryllium	Be	5.0 mg/L	Maximum
Nickel*	Ni	4.0* mg/L	Maximum
Cadmium*	Cd	1.0* mg/L	Maximum

Parameter		Limit	
Arsenic	As	5.0 mg/L	Maximum
Barium	Ba	10 mg/L	Maximum
Lead*	Pb	0.6* mg/L	Maximum
Manganese	Mn	10 mg/L	Maximum
Silver*	Ag	1.0*mg/L	Maximum
Boron	B	5.0 mg/L	Maximum
Mercury*	Hg	0.5* mg/L	Maximum
Iron	Fe	50 mg/L	Maximum
Zinc	Zn	15 mg/L	Maximum
Cobalt*	Co	0.05* mg/L	Maximum
Selenium*	Se	0.05* mg/L	Maximum
Lithium	Li	5.0 mg/L	Maximum
Vanadium*	V	0.1* mg/L	Maximum
Aluminum	Al	5.0 mg/L	Maximum

Notes:* Provided the combined total of these elements together does not exceed 10 milligrams per liter.
°C indicates degrees Celsius;
mg/L indicates milligrams per liter;

2.3.9 Ordinance of the Administrative Board of WAJ, 1999

The Administrative Board of Water Authority issued decision No 3 on 20/6/1999 to allow the sale of treated water for irrigation at a much lower price than the current price for fresh water. Consequently, the price was set at 10 fils/m^3.

2.4 Standards

2.4.1 Ambient Air Quality Standards (Jordan Standard [JS] 1140 of 2006)

These standards designate ambient air pollutants and the maximum allowable concentration for each of those pollutants in the atmosphere, in addition to approved methods of measurement. Table 2-3 shows the maximum allowable limits for some of the ambient air pollutants listed in JS 1140/2006. The project should comply with these limits during construction and during operations.

Table 2-3: Allowable Limits of Ambient Air Pollutants

Pollutant	Averaging Period	Maximum Limit	Number of Times Limit is Allowed to be Exceeded
Sulfur Dioxide (SO_2)	1 hour	0.3 ppm*	3 times in any 12-month period
	24 hours	0.14 ppm	Once a year
	Annual	0.04 ppm	-
Carbon Monoxide (CO)	1 hour	26 ppm	3 times in any 12-month period
	8 hours	9 ppm	3 times in any 12-month period
Nitrogen Dioxide (NO_2)	1 hour	0.21 ppm	3 times in any 12-month period
	24 hours	0.08 ppm	3 times in any 12-month period
	Annual	0.05 ppm	-
Ozone (O_3)	1 hour	0.12 ppm	-
	8 hours	0.08 ppm	-

Pollutant	Averaging Period	Maximum Limit	Number of Times Limit is Allowed to be Exceeded
Particulate Matter 10 (PM_{10})	24 hours	120 µg/m^3 **	3 times in any 12-month period
	Annual	70 µg/m^3	-
Particulate Matter 2.5 ($PM_{2.5}$)	24 hours	65 µg/m3	3 times in any 12-month period
	Annual	15 µg/m3	-
Total Suspended Particulates (TSP)	24 hours	260 µg/m^3	3 times in any 12-month period
	Annual	75 µg/m^3 (geometric average)	-
Lead (Pb)	Seasonally	1 µg/m^3	-
	Annual	0.5 µg/m^3	-
Phosphates (P_2O_5)	24 Hours	100 µg/m^3	3 times in any 12–month period
	Annual	40 µg/m^3	-
Cadmium (Cd)	Annual	0.005 µg/m^3	-

Notes: *ppm: parts per million
**µg/m^3: microgram per cubic meter
Reference: Jordan Ambient Air Quality Standards (JS 1140/2006)

2.4.2 Water-Industrial Reclaimed Wastewater Standard (JS 202/2007)

This standard outlines maximum allowable concentrations of various chemical and biological parameters in treated industrial wastewater effluent. Criteria are established for various uses of the treated effluent, including wadi discharge and irrigation of certain crops. These criteria are shown in Table 2-4.

Table 2-4: JS 202/2007- Effluent Limits for Reclaimed Industrial Wastewater

Parameter	Unit	I. Cooked vegetables, parks, playgrounds sides of roads within city limits	II. Fruit trees, sides of roads outside city limits, and landscape	III. Field crops, industrial crops and forest trees	Cut Flowers	Wadi Discharge
Category A						
Biological Oxygen Demand (BOD)	mg/L	30	200	300	15	60
Chemical Oxygen Demand (COD)	mg/L	100	500	500	50	150
Dissolved Oxygen (DO)	mg/L	>2	-	-	>2	>2
Total Suspended Solids (TSS)	mg/L	50	200	300	15	60
pH	pH unit	6-9	6-9	6-9	6-9	6-9
Turbidity	NTU	10	N/A	N/A	5	15
Nitrate	mg/L	30	45	70	45	80
Ammonium	mg/L	-	-	-	-	5
TN	mg-N/L	45	70	100	70	70
E coli	/100mL	100	1000	-	<1.1	1000
Helminthes	/L	≤1	≤1	≤1	<1	<0.1
Fat Oil and Grease (FOG)	mg/L	8	8	8	2	8
Category B						
Phenol	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002
Total Dissolved Solids (TDS)	mg/L	2000	2000	2000	2000	2000
Methyl Blue Active Substances (detergents) (MBAS)	mg/L	100	100	100	100	25
Total Phosphate	mg/L	30	30	30	30	15
Chloride	mg/L	400	400	400	400	350
Sulfate	mg/L	500	500	500	500	300
Bicarbonate	mg/L	400	400	400	400	400
Sodium	mg/L	230	230	230	230	-
Magnesium	mg/L	100	100	100	100	-
Calcium	mg/L	230	230	230	230	-
Aluminum	mg/L	5	5	5	5	2

Parameter	Unit	I. Cooked vegetables, parks, playgrounds sides of roads within city limits	II. Fruit trees, sides of roads outside city limits, and landscape	III. Field crops, industrial crops and forest trees	Cut Flowers	Wadi Discharge
Arsenic	mg/L	0.1	0.1	0.1	0.1	0.05
Beryllium	mg/L	0.1	0.1	0.1	0.1	0.1
Copper	mg/L	0.2	0.2	0.2	0.2	1.5
Fluoride	mg/L	2	2	2	2	2
Iron	mg/L	5	5	5	5	5
Lithium	mg/L	0.075	0.075 (2.5 for citrus trees)	0.075	0.075	2.5
Manganese	mg/L	0.2	0.2	0.2	0.2	0.2
Molybdenum	mg/L	0.01	0.01	0.01	0.01	0.01
Nickel	mg/L	0.2	0.2	0.2	0.2	0.2
Lead	mg/L	0.2	0.2	0.2	0.2	0.2
Selenium	mg/L	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	5	5	5	5	5
Boron	mg/L	1	1	1	1	1
Chromium	mg/L	0.1	0.1	0.1	0.1	0.1
Mercury	mg/L	0.002	0.002	0.002	0.002	0.002
Vanadium	mg/L	0.1	0.1	0.1	0.1	0.1
Cobalt	mg/L	0.05	0.05	0.05	0.05	0.05
Cyanide	mg/L	0.1	0.1	0.1	0.1	0.05
Sodium Adsorption Ratio (SAR)	-	9	9	9	9	9
Color	cobalt unit	-	-	-	-	15
Temp change	°C	-	-	-	-	6

Notes: °C indicates degrees Celsius;
mg/L indicates milligrams per liter;
Mg-N/L indicates milligrams nitrogen per liter;
NTU indicates Nephelometric Turbidity Unit;
/100mL indicates per 100 milliliters;
/L indicates per liter.

Reference: Jordan Water-Industrial Reclaimed Wastewater Standard (JS 202/2007).

2.4.3 Uses of Treated Sludge and Sludge Disposal Standard (JS 1145/2006)

This standard outlines the maximum allowable concentrations of various chemical and biological parameters in treated sludge (Table 2-5). It also outlines the allowed uses and proper methods of disposal of treated sludge. Three classes of sludge quality are described depending on the content of heavy metals and level of treatment to reduce the pathogen content, as follows:

- Class I – may be used for agricultural purposes and soil improvement
- Class II – may be used for soil improvement purposes or disposed of at waste disposal sites
- Class III – may only be disposed of at waste disposal sites

Table 2-5: JS 1145/2006 - Sludge Characteristics by Class

Parameters	Concentration by Sludge Class (milligrams per kilogram, except as noted)		
	Class I	Class II	Class III
Arsenic, As	41	75	75
Cadmium, Cd	40	40	85
Chromium, Cr	900	900	3000
Copper, Cu	1500	3000	4300
Mercury, Hg	17	57	57
Molybdenum, Mo	75	75	75
Nickel, Ni	300	400	420
Selenium, Se	100	100	100
Lead, Pb	100	840	840
Zinc, Zn	2800	4000	7500
Moisture Content (max.)	10%	50%	97%
Fecal Coliform (total), MPN/g	1000	2,000,000	-
Salmonella	3/4 g dry	-	-
Nematode Eggs	1/4 g dry	-	-
Intestinal Virus	1/g dry	-	-

2.4.4 Jordanian Building Codes

In 1993, the Government of Jordan issued the Building Code Law No. 7 of 1993, which led to the creation of the Jordan Building Code Commission. The Commission, led by the Ministry of Public Works and Housing, was designated the responsibility of preparing building codes for the country. Since then, the Commission has published 32 building codes regarding the design and construction of buildings in Jordan. For any building design to obtain clearance in Jordan, it has to be approved by the Jordanian Engineers' Association, Civil Defense Directorate, and the Earthquake Commission. These agencies ensure that the design abides by these codes, many of which address environmental, health, and safety issues and are relevant to the building. They are as follows:

- Jordanian Code No. 3: Loads and Forces (Section 4: Earthquake Actions)
- Jordanian Code No. 15: Fire Protection
- Jordanian Code No. 16: Natural Ventilation
- Jordanian Code No. 17: Natural Lighting
- Jordanian Code No. 18: Water Supply for Buildings
- Jordanian Code No. 19: Wastewater for Buildings

- Jordanian Code No. 20: Beautification of the City
- Jordanian Code No. 21: Solid Waste
- Jordanian Code No. 22: Public Safety during Construction
- Jordanian Code No. 23: Electrical Installation
- Jordanian Code No. 27: Fire Alarm Systems
- Jordanian Code No. 32: Building Requirements for the Physically Challenged

2.4.5 Jordanian Code No. 22: Public Safety during Construction

The Code of Public Safety during Construction describes the required measures to be taken in order to safeguard the work environment during construction works. This includes sanitation, toilet facilities, drinking water, medical services, protection from fires, lighting, ventilation, noise, gasses, electrical wiring, openings and edges, transporting workers, solid waste collection and disposal, and insects and harmful animals. For example, noise levels and exposure periods permitted for workers are set forth under this code.

2.5 International Treaties

There are numerous international and regional treaties, to which Jordan is a signatory or upon which it has reached agreement with other entities, which are of some relevance to the ECR and this project. These are listed in Table 2-6.

Table 2-6: Relevant Treaties, Conventions and International Agreements Ratified by Jordan

Treaties, Conventions, and International Agreements	Year (in force)	Description
Convention on Wetlands of International Importance Especially as Waterfall Habitat (Ramsar Convention)	1971	- Protects all characteristic flora and fauna, with emphasis on protection of the waterfall habitats.
The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	1979	- Regulates export and import of listed Endangered species of fauna and flora. - Additionally allows Parties to give protection to selected species of flora and fauna within their jurisdiction.
The United Nations Convention on Biological Diversity (Bonn)	1993	- Calls for identification and monitoring of biodiversity components. - Calls for establishment of protected areas and emergency response plans.
Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa	1994	- Calls for combating desertification. - Calls for mitigating the effects of drought.
The United Nations Framework Convention on Climate Change	1994	- Calls for stabilization of greenhouse gas emissions, and requires Parties to prepare greenhouse gas inventories.

3 INSTITUTIONAL FRAMEWORK

Municipal administration is provided by Governorates and Municipalities. Governorates are the executive authority for the implementation of central government policies at the local level and are responsible to the Ministry of Interior (MOI) for the provision of services outside the municipality areas and some regional planning. Municipalities are responsible to the Ministry of Municipal Affairs (MOMA) for municipal administration and land use planning.

3.1 Zarqa Chamber of Industry (ZCI)

ZCI serves around 6,000 industries from 10 sectors in Zarqa and Mafraq Governorates, consisting of small and medium-size enterprises. ZCI also sets trade standards and studies industrial issues.

3.2 Ministry of Environment (MoEnv)

MoEnv is the entity accountable for protecting various environmental components across the Kingdom, in addition to being responsible for environmental compliance. It aims to improve the environment, conserve Jordan's natural resources and achieve sustainable development. MoEnv is the entity that would be responsible for reviewing EIA studies and granting the approval for the project, as well as being the entity ensuring and monitoring environmental compliance and protection of environmental components throughout the construction and operation of the Project. Furthermore, MoEnv is the entity responsible for handling environmental complaints. The relevant MoEnv laws, regulations and instructions to be complied with were discussed previously in Section 2.

3.3 Ministry of Water and Irrigation and Water Authority of Jordan (WAJ)

MWI and its respective authorities are specifically responsible for the protection of water resources. The main objective of MWI is to maintain sustainable water resources with the purpose of achieving national water security and meeting the Ministry's development objectives.

WAJ is the entity that assumes all authority pertaining to water and wastewater in Jordan, including the management of WWTPs. The Authority's role further involves the improvement of the relevant infrastructure for the purposes of preserving public health and the environment.

Relative to the Project at hand, biosolids and sludge production falls under WAJ's umbrella. Even though the operation of a number of WWTPs has been delegated to private water companies through Public Private Partnerships, the ultimate decision maker with regards to management of biosolids and sludge produced by WWTPs remains the mandate of WAJ. WAJ is responsible for the operation of WWTPs in Jordan; it thus controls the quality of biosolids and sludge produced and subsequently influences the appropriate final disposal method. WAJ is responsible for ensuring the proper disposal of biosolids and sludge.

3.4 Ministry of Health (MOH)

MOH is the entity accountable and responsible for public health and safety monitoring and control and assumes the responsibility for all health affairs across the Kingdom.

Of particular relevance to the Project are the Occupational Health Directorate and the Environmental Health Directorate. The Occupational Health Directorate is responsible for ensuring the safety of the work environment from pollutants and occupational hazards, in addition to the evaluation of the work environment. The Environmental Health Directorate is responsible for ensuring compliance with environmental health requirements and implementing the provisions of the Public Health Law through the relevant monitoring programs developed.

3.5 Ministry of Agriculture (MOA)

MOA is the entity responsible for regulating and permitting all agricultural activities in Jordan and has a particular mandate for regulating soil fertilizers and agricultural input material.

Part of MOA's role involves ensuring the sustainability of the agricultural use of natural resources without harming the environment, in addition to creating the suitable atmosphere for investment in the agricultural sector, as well as rural development and increasing the incomes of farmers and improving their lives. This is relevant to the project given the fact that the area surrounding the site includes seasonal crop cultivated lands that can use the Zarqa IWTP effluent.

3.6 Ministry of Municipal Affairs (MOMA)

MOMA's mandate includes a responsibility for public health and safety monitoring and control via the management and operation of solid waste collection and disposal. It carries out its duties through its implementing arms: the municipalities and the Joint Services Councils (JSCs). For this Project, the relevant municipality and implementing arm of MOMA would be Zarqa Municipality. Within its area of jurisdiction (which includes the project area), Zarqa Municipality is authorized to undertake the needed measures to prevent the occurrence of health nuisances.

3.7 Ministry of Labor (MOL)

MOL is the entity responsible for ensuring occupational health and safety, as well as providing the indoor air quality requirements that need to be complied with.

3.8 The General Directorate of Jordan Civil Defense

The general directorate of Civil Defense in Zarqa is the entity to be contacted in the case of fires or accidents.

3.9 Jordanian Standard and Metrology Organization (JSMO)

JSMO is the entity responsible for the issuance of specifications and technical regulations, their adoption and revision, and the monitoring of their implementation for all services and products. However, despite being legally authorized to oversee implementation of specifications and technical regulations, JSMO delegates the responsibility of overseeing their implementation to the relevant ministries. This includes the technical regulations and standard concerning biosolids and sludge disposal, as elaborated previously in Section 2.

3.10 The Royal Society for the Conservation of Nature (RSCN)

RSCN is a non-profit, non-governmental organization that aims to conserve the Kingdom's natural resources. It is of particular relevance to the Project given the fact that the Project site has been designated as an Important Bird and Biodiversity Area (IBA).

4 DESCRIPTION OF THE PROJECT RECOMMENDED ALTERNATIVE

This chapter describes the recommended design alternative and principles for Zarqa IWTP.

4.1 Project Background

Zarqa is one of Jordan's major industrial centers. There are approximately 250 manufacturing facilities using water and/or discharging wastewater in Zarqa. Most of them are small to medium sized and they cover a wide spectrum of sectors. Therefore, these industrial facilities have a significant impact on water consumption and wastewater generation. The two major industrial water consumers in Zarqa are the Jordan Petroleum Refinery and an electric power generating plant.

Industrial pollution abatement in Zarqa is considered a critical issue for the MoEnv, MWI, ZCI, and other entities. Contamination of surface and groundwater resources with industrial pollutants is one of the major environmental concerns in Zarqa, especially since surface water wadis and Zarqa River sediments suffer from increased concentrations of heavy metals; resulting in severe pollution of the Zarqa River.

The ZCI has designated a 500 Dunums (50 hectares) site for constructing the IWTP project. The site is located in Wadi Al Ghudran on the highway near Ad Dulail, Hallabat and Khalidia. The location of the site will enable the plant to serve several industrial facilities in Zarqa city, Zarqa Free Zone, Awajan, Wadi Al Ish, Al Sukhneh, Rusayfeh, Khalidia, Hashemiya, Dulail, and Hallabat.

The site is located in an undeveloped area. However, the Jordan Industrial Estates Company (JIEC) has plans for establishing an industrial estate adjacent to the IWTP site. The new IWTP would serve the Zarqa Industrial Area and not be restricted to a single industrial estate.

4.2 Project Objectives

The main objectives of the proposed Zarqa IWTP Project are:

- Develop a cost-effective treatment and disposal alternative.
- Design an efficient reuse system.

This will ultimately result in achieving the WRECP's primary goal of bringing a more integrated water resources management perspective to wastewater pollution abatement in the Jordanian industrial sector.

4.3 Existing Industrial Wastewater Collection and Treatment Practices

There is no centralized IWTP at Zarqa to collect and treat industrial discharges. Industrial facilities that are connected to the sewer network can dispose of their pre-treated or untreated wastewater into the sanitary sewer if it complies with the "Jordanian Regulations Governing the Discharge of Industrial and Commercial Wastewater into the Sanitary Sewer" published in 1988.

However, a large number Zarqa's industrial facilities discharge their wastewater directly into wadis, or at off-site disposal sites such as the Ein Ghazal and Al Ekeder facilities, as they are not connected to the sewer system or not located near a sewered area.

Furthermore, there are plans to close the Al Ekeder facility, which will pose a serious disposal problem for industrial facilities in Zarqa. Therefore, constructing an IWTP would provide a

greatly needed industrial wastewater disposal capacity and help reduce pollution in greater Zarqa.

4.4 Process Design Criteria and Considerations

The influent quality criteria for the proposed Zarqa area IWTP were developed based on the quality and quantity of anticipated industrial sector flows. To address the current minimum anticipated flow need, the initial design flow for the Zarqa IWTP will be 2,500 cubic meters per day (m^3/d). The plant will be designed with provisions to add parallel treatment modules, each with the capability to accommodate an additional anticipated 2,500 m^3/d, and ultimately address the anticipated future maximum flow rate 7,500m^3/d. These flows represent the typical daily flow during the normal work week. The daily flows on a 7-day basis are expected to be somewhat less.

The design hourly flow rate is based on the daily equalized flow assuming it occurs uniformly for the entire 24-hour day. As the IWTP will include facilities for flow equalization, the higher flows would only occur in the receiving station and headworks equipment prior to equalization.

The following table shows the final estimated wastewater quality and the recommended quality parameter design values. The actual IWTP influent quality will depend on many factors, such as types of industries that dispose of their wastewater at the Zarqa IWTP, and specific exclusions and/or pretreatment requirements that are imposed by the IWTP operator. Therefore, it will be necessary to monitor influent concentrations on a regular basis, and it may be necessary to make adjustments to the treatment process to accommodate any significant variations from the design conditions.

Table 4-1: Wastewater Quality and Design Parameter Values

Parameter	Unit	Minimum	Maximum	Average	Design Value
pH	N/A	6.4	7.4	7	7
5-day biochemical oxygen demand (BOD_5) total	mg/L	921	1,300	1,102	1,300
Biochemical oxygen demand (BOD) soluble	mg/L	514	698	637	698
Chemical oxygen demand (COD) total	mg/L	2,072	2,871	2515	2,871
COD soluble	mg/L	1,183	1,616	1,445	1,616
Total Suspended Solids (TSS)	mg/L	750	1,391	983	1,391
Fat, Oil and Grease (FOG)	mg/L	21	60	42	60
Ammonia (NH_3)	mg/L	14	23	20	23
Total Kjeldahl Nitrogen (TKN)	mg/L	44	60	53	60
Phosphate Reported as Phosphorus (PO_4-P)	mg/L	0.2	11.7	6	11.7
Total Dissolved Solids (TDS)	mg/L	2,799	3,489	3,018	3,489
Sodium (Na)	mg/L	430	527	490	527
Chloride (Cl)	mg/L	665	788	708	788

Notes: °C indicates degrees Celsius; N/A: not applicable
mg/L indicates milligrams per liter;

All the proposed structures and buildings are located within the boundary of the treatment plant site. The only expected offsite elements include provisions for effluent and biosolids reuse.

Fat, oil and grease (FOG) collected at the Zarqa IWTP will be either transported offsite via tanker truck to Ain Ghazal pretreatment facility or to an approved incineration facility. Zarqa IWTP screenings and grit are expected to be transported to the Al Ghabawi landfill for disposal as per current practice at other facilities such as the Sahab IWTP. However, the project proponent should confirm with the various authorities that such practices will continue to be acceptable without the imposition of additional requirements.

To reduce odors and improve the overall characteristics of the sludge, the sludge will be stabilized, and then dewatered to reduce the volume of material requiring further treatment, handling, transport and disposal. It is recommended that the project proponent conduct tests on the sludge immediately upon startup of the IWTP in order to classify generated sludge in accordance with JS 1145/2006 and determine whether it can be reused.

Several industrial wastewater treatment alternatives were considered and evaluated for the Zarqa IWTP. Each of the proposed treatment alternatives includes a similar concept for wastewater receiving and pretreatment, and for sludge management. The alternatives have been developed based on their unique wastewater treatment process and/or regulatory/economic considerations for effluent reuse/disposition.

The IWTP alternative selected by MoEnv provides primary (Chemical), secondary (Biological) and tertiary (Reverse Osmosis) treatment for Agricultural and/or Industrial Water Reuse. It includes chemical addition systems and Dissolved Air Flotation (DAF) to remove suspended solids and some dissolved metals, biological treatment to remove organic compounds including nitrogen, and tertiary treatment employing a high efficiency reverse osmosis (HERO) process to remove dissolved solids. The recommended IWTP alternative is the most robust of the alternatives evaluated and treated effluent will satisfy current regulatory requirements for Reclaimed Industrial Wastewater Used for Irrigation (JS 202/2007 Divisions II and III) and the effluent limits for Reclaimed Industrial Wastewater Discharges to Surface Waters (Wadi discharges). Therefore, the effluent will provide a year-round source of irrigation water, with the ability to discharge to surface water for storage if there is no demand for irrigation water. There is also a possibility that the effluent from the IWTP could be used for future industrial reuse (e.g., dust control at nearby quarries).

The selected Zarqa IWTP alternative involves full treatment and reuse of the flow for irrigation; therefore, the effluents must meet the Jordanian standard JS 202/2007 for reclaimed industrial wastewater used for irrigation.

Figure 4-1 provides a block flow diagram illustrating the recommended IWTP alternative, with flow information for major equipment items summarized. Flow rates are indicated in cubic meters per hour (m^3/h).

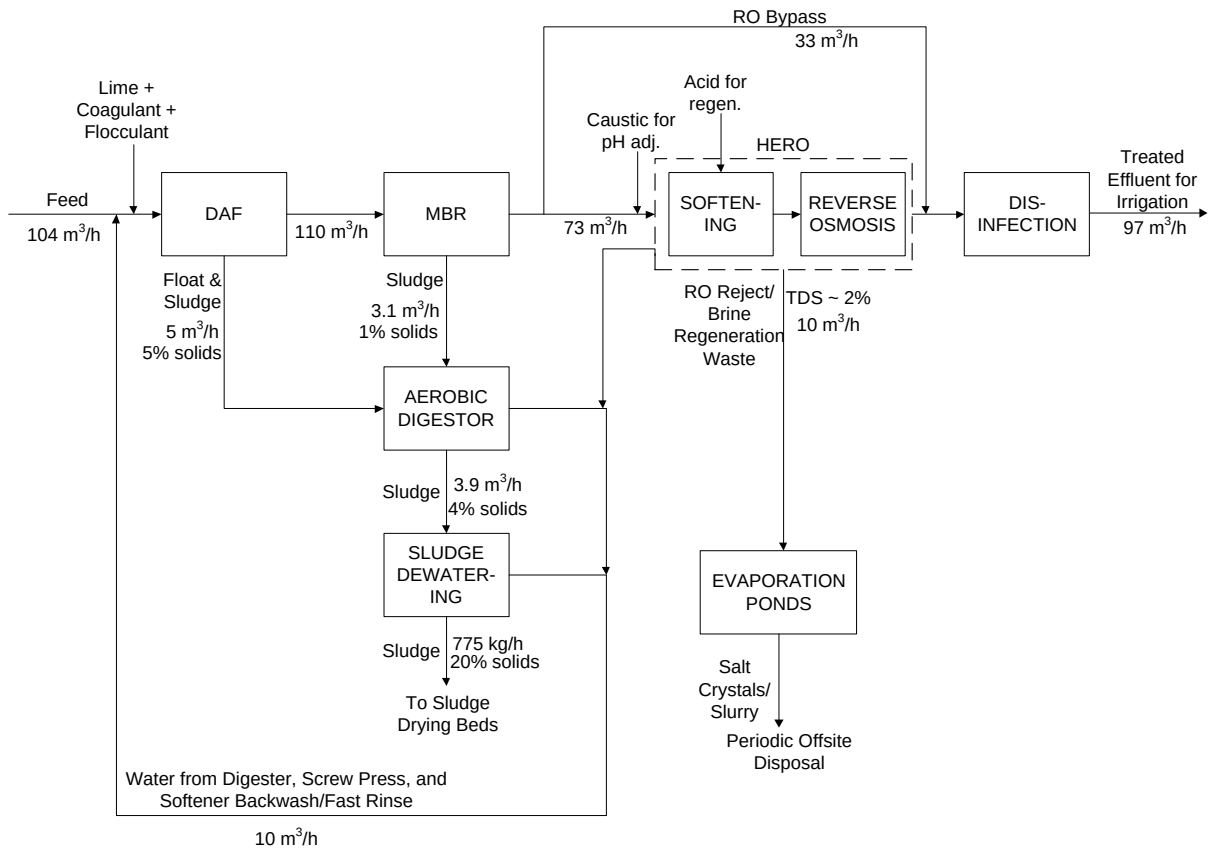


Figure 4-1: Block Flow Diagram for the Selected IWTP Alternative

4.4.1 Technology Selection

4.4.1.1 Receiving Station and Headworks

The plant's receiving station and preliminary treatment equipment has been selected to accommodate an average flow of 2,500 m^3/d delivered to the IWTP site by tanker truck. The receiving station has been designed assuming the trucks discharge during a 12-hour period, and that a maximum of 20 trucks will be offloading in any given hour. A packaged headworks system has been selected to provide preliminary treatment of the tanker discharge including fine screening, grit removal, and grease removal to protect the IWTP process pumps and other equipment.

4.4.1.2 Primary (Chemical/Physical) Treatment - Solids Removal

Primary treatment will be provided to remove suspended solids (both organic and inorganic) and allow some precipitation of dissolved solids from the screened wastewater. Chemically enhanced DAF has been selected mainly based on its tolerance for variations in influent wastewater composition which are anticipated for the Zarqa IWTP. In addition, the footprint for the DAF unit is significantly less than that of other flocculation/clarification equipment.

A key consideration in the removal of solids is optimization of pH. The addition of hydrated lime allows for pH adjustment, and is preferable to increase the ability to reuse the water for irrigation.

4.4.1.3 Secondary (Biological) Treatment-Organics Removal

To allow for reuse of the treated effluent, additional organics removal, and possibly the removal of nitrogen, will be required by the treatment system. Aerobic treatment has been selected based on the anticipated organic loadings to the treatment plant, which do not warrant anaerobic treatment. The aerobic membrane bioreactor (MBR), which includes ultrafiltration (UF) membranes to provide filtration of the biological system effluent, was selected for the Zarqa IWTP.

4.4.1.4 Tertiary Treatment – Dissolved Solids Removal

A reverse osmosis (RO) system is proposed to remove total dissolved solids. In order to maximize the recovery of treated water (and minimize the quantity of byproducts), the use of a HERO system was also evaluated and selected. RO efficiency is increased by removing hardness using ion exchange, then operating the RO at high pH. The RO system is intended to treat a portion (approximately 67%) of the wastewater flow stream, which can then be mixed with the biological treatment system effluent in order to provide water to meet the irrigation reuse requirements.

Based on climate data for the Zarqa IWTP location, solar evaporation is expected to be a reliable treatment technology for concentrating byproduct streams most of the year. For this reason, it is anticipated that the HERO reject streams will be evaporated using a solar evaporation process..

4.4.1.5 Disinfection

Disinfection is required to remove pathogens for reuse of the effluent. A chemical chlorination system (using sodium hypochlorite) was selected for the Zarqa IWTP treatment system.

4.4.1.6 Sludge Thickening and Dewatering

Several options for managing sludge were evaluated including allowing reuse of the biosolids. Aerobic digestion was considered to provide some sludge thickening and stabilization in a single step. The digested sludge can then be managed onsite without generating significant odors. The screw press was selected for dewatering since the equipment is designed for managing sludge with less supplemental thickening and odor generation than other sludge filtration/dewatering technologies. Once the sludge is digested and dewatered, it will be much easier to manage either for offsite disposition or in potential future subsequent biosolids processing operations.

4.4.2 **Site Development Considerations**

The Zarqa IWTP is located in an undeveloped area that is well away from any residential areas, and located directly on a main highway. The project site is in generally flat terrain, but with natural drainage features that contribute to a reservoir, created by a manmade dam and suitable for collecting storm water (Figure 4-2). The reservoir is used to collect surface water during the winter season to be utilized by the local people in the area.

The dam, called the Abu Sowanna Dam, was constructed in 1962 and rehabilitated approximately 10 years ago. The capacity of the reservoir is 25,000 cubic meters, and the water collected in the reservoir is mainly used for cattle and sometimes for irrigation. The water is being directly used from the reservoir and sometimes tankers transport water for use by the locals.

Figure 4-2: Earth Dam near to the Project Site

The reservoir is located north of (across the highway from) the IWTP site. Improvements to the site drainage will be needed in order to construct the IWTP; such improvements would include routings and diversions of the small ephemeral watercourses.

A box culvert exists in the project site (See Figure 4-3) and could convey the design runoff without overtopping the road, if it were maintained fully open.

Figure 4-3: Box Culvert that Exists in the Project Area

5 DESCRIPTION OF THE AFFECTED ENVIRONMENT

This section details the existing environmental conditions for the project area. The project is located in the Al-Hallabat area within Al-Dhulail District in Zarqa Governorate (See Figure 5-1).

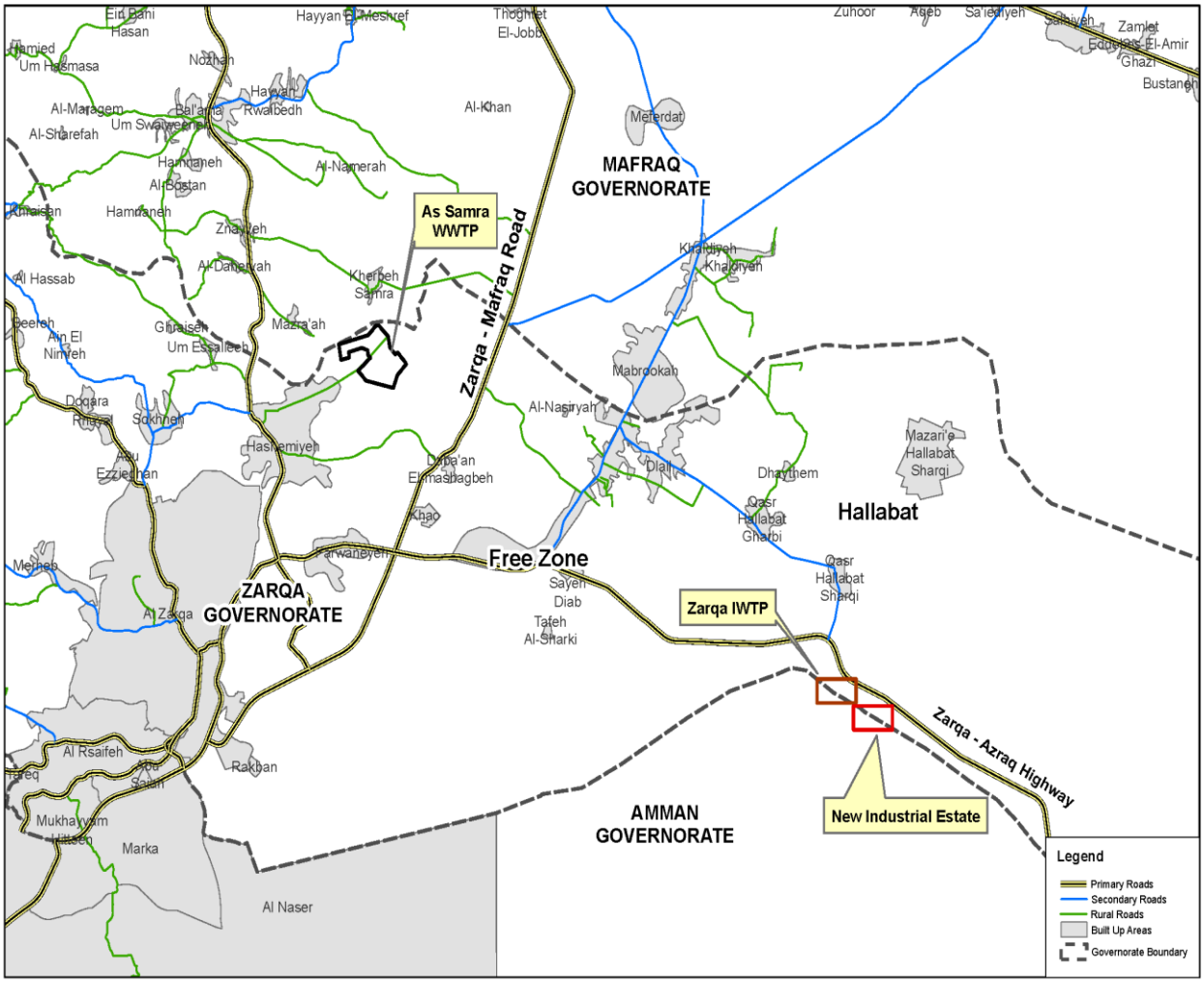


Figure 5-1: Proposed Zarqa IWTP

Desktop research and literature review were conducted in order to formulate a general description of the biophysical and socio-economic existing conditions. Site visits and baseline surveys were conducted when firsthand data was needed. All observations obtained from site visits are incorporated into this report. Where no specific data is available for the Zarqa IWTP project area, then data from Zarqa Governorate or of the Hashemite Kingdom of Jordan is presented instead.

5.1 Climate

The climate of Jordan in general is classified as “Eastern Mediterranean”, which is characterized by summers that are dry with high temperatures, while winters are rainy and cold. Average annual temperatures can typically range from a minimum of 13.6 degrees Celsius (°C) to a maximum of 25.5°C. Rainfall occurs in the months of October through May, with the most extensive rainfall being in the months of December, January and February. An

average annual rainfall of 123.4 millimeters was recorded at the Zarqa Meteorological Station in the period of 2009-2013, with the maximum rainfall (136.0 millimeters) being in 2013. Therefore, the region is classified as arid. Average annual humidity recorded for the period of 2009-2013 was 55.6% while average annual wind speed for that same period was 3.6 knots.

Tables 5-1 through 5-5 present the meteorological parameters obtained from the Zarqa Meteorological Station, which is the nearest station to the project area.

Table 5-1: Mean Maximum Air Temperatures for the years 2009-2013

Station: Zarqa													
Mean Maximum Air Temperature (°C)													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Average**
2009	15.3	16.3	17.9	24.8	28.8	34.0	33.7	34.1	31.0	30.4	20.7	17.2	**25.4**
2010	17.3	18.4	22.3	26.7	30.5	32.8	35.5	37.8	33.9	31.0	26.5	17.9	**27.6**
2011	15.3	15.6	20.1	23.8	28.3	31.4	35.8	33.9	32.2	27.2	18.1	16.3	**24.8**
2012	13.0	14.2	17.3	27.2	29.5	35.2	36.0	34.6	34.0	30.2	22.9	17.0	**25.9**
2013	14.8	17.7	22.8	24.4	31.0	32.3	33.4	34.2	31.7	26.9	23.5	13.7	**25.5**
Average	**15.1**	**16.4**	**20.1**	**25.4**	**29.6**	**33.1**	**34.9**	**34.9**	**32.6**	**29.1**	**22.3**	**16.4**	**25.8**

Source: Zarqa Meteorological Station

Table 5-2: Mean Minimum Air Temperatures for the years 2009-2013

Station: Zarqa													
Mean Minimum Air Temperature (°C)													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Average**
2009	4.4	6.2	7.7	11.9	15.7	19.9	21.6	20.4	18.6	18.1	10.1	8.2	**13.6**
2010	7.5	7.9	10.6	13.1	16.6	20.0	21.3	23.4	20.9	18.5	12.5	6.8	**14.9**
2011	6.3	7.4	8.3	11.7	15.5	18.4	22.1	20.8	19.2	15.3	8.1	5.2	**13.2**
2012	5.0	4.9	6.7	13.2	16.7	20.6	22.8	21.9	20.0	17.9	12.9	7.7	**14.2**
2013	5.6	7.9	10.6	12.0	17.3	18.9	20.2	20.9	19.1	13.7	12.3	4.7	**13.6**
Average	**5.8**	**6.9**	**8.8**	**12.4**	**16.4**	**19.6**	**21.6**	**21.5**	**19.6**	**16.7**	**11.2**	**6.5**	**13.9**

Source: Zarqa Meteorological Station

Table 5-3: Total Rainfall Amounts in the years 2009-2013

Station: Zarqa													
Total Rainfall Amount (millimeters)													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Total**
2009	4.3	48.0	17.3	0.6	0.0	0.0	0.0	0.0	0.0	8.3	13.7	26.6	**118.8**
2010	29.8	72.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	26.2	**131.5**
2011	25.8	40.6	5.0	10.9	2.3	0.0	0.0	0.0	0.0	0.0	19.5	9.4	**113.5**
2012	33.6	36.8	32.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0	10.1	14.7	**117.0**
2013	80.5	5.9	0.0	2.0	12.4	0.0	0.0	0.0	0.0	2.2	0.6	32.4	**136.0**
Average	**34.8**	**40.8**	**11.2**	**2.7**	**3.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.4**	**8.8**	**21.9**	**123.4**

Source: Zarqa Meteorological Station

Table 5-4: Mean Relative Humidity for the years 2009-2013

Station: Zarqa													
Mean Relative Humidity (%)													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Average**
2009	67.3	69.3	65.5	50.7	45.3	38.6	48.1	53.8	58.7	46.7	70.5	73.2	**57.3**
2010	70.6	68.8	60.7	50.4	47.9	46.1	50.5	49.2	56.7	49.4	40.1	58.4	**54.1**
2011	67.7	71.8	57.8	55.3	46.1	50.2	41.5	51.2	56.1	56.9	60.9	56.1	**56.0**
2012	71.7	65.7	61.1	45.1	42.9	39.2	44.2	46.5	48.7	51.0	62.0	70.4	**54.0**
2013	69.1	65.3	50.5	52.2	42.9	45.9	53.6	51.5	57.1	50.8	66.0	75.4	**56.7**
Average	**69.3**	**68.2**	**59.1**	**50.7**	**45.0**	**44.0**	**47.6**	**50.4**	**55.5**	**51.0**	**59.9**	**66.7**	**55.6**

Source: Zarqa Meteorological Station

Table 5-5: Mean Wind Speeds for the years 2009-2013

Station: Zarqa													
Mean Wind Speed (knot)													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Average**
2009	2.9	4.8	4.6	4.1	3.8	3.5	4.6	3.8	3.9	2.3	1.7	2.0	**3.5**
2010	2.2	3.1	2.8	4.3	5.1	6.6	5.3	3.3	3.7	2.3	1.1	2.2	**3.5**
2011	2.1	4.0	3.2	4.6	4.1	5.6	4.9	6.2	4.4	3.3	2.2	2.2	**3.9**
2012	3.9	5.7	4.8	3.4	5.2	3.8	4.5	4.8	2.6	2.3	2.8	2.8	**3.9**
2013	3.4	2.9	3.8	3.7	3.3	3.1	3.4	1.7	2.6	3.0	1.8	4.8	**3.1**
Average	**2.9**	**4.1**	**3.8**	**4.0**	**4.3**	**4.5**	**4.5**	**4.0**	**3.4**	**2.6**	**1.9**	**2.8**	**3.6**

Source: Zarqa Meteorological Station

5.2 Geology and Soil

The project team reviewed applicable geological reports concerning the project area and conducted a number of site visits to assess local conditions. Resources reviewed included: Handbook of the Geology of Jordan, Burden (1959); Geology of Jordan, Abed (2000); Geology of Jordan, Bender (1974); and the geological mapping performed by the National Resources Authority (NRA), reference – Geological Mapping Division – National Mapping Project – 2004. The team also reviewed the existing geotechnical data developed as part of the nearby Proposed Industrial Estate Project (International Center for Geotechnical Studies, Geotechnical Investigation Report for the Proposed Project at Zarqa Industrial State, June 2007).

A general geological overview map is shown in Figure 5-2. This map is based on the geological map of Qasr Al-Hallabat 3254 II, A.Hiari, NRA, 2004.

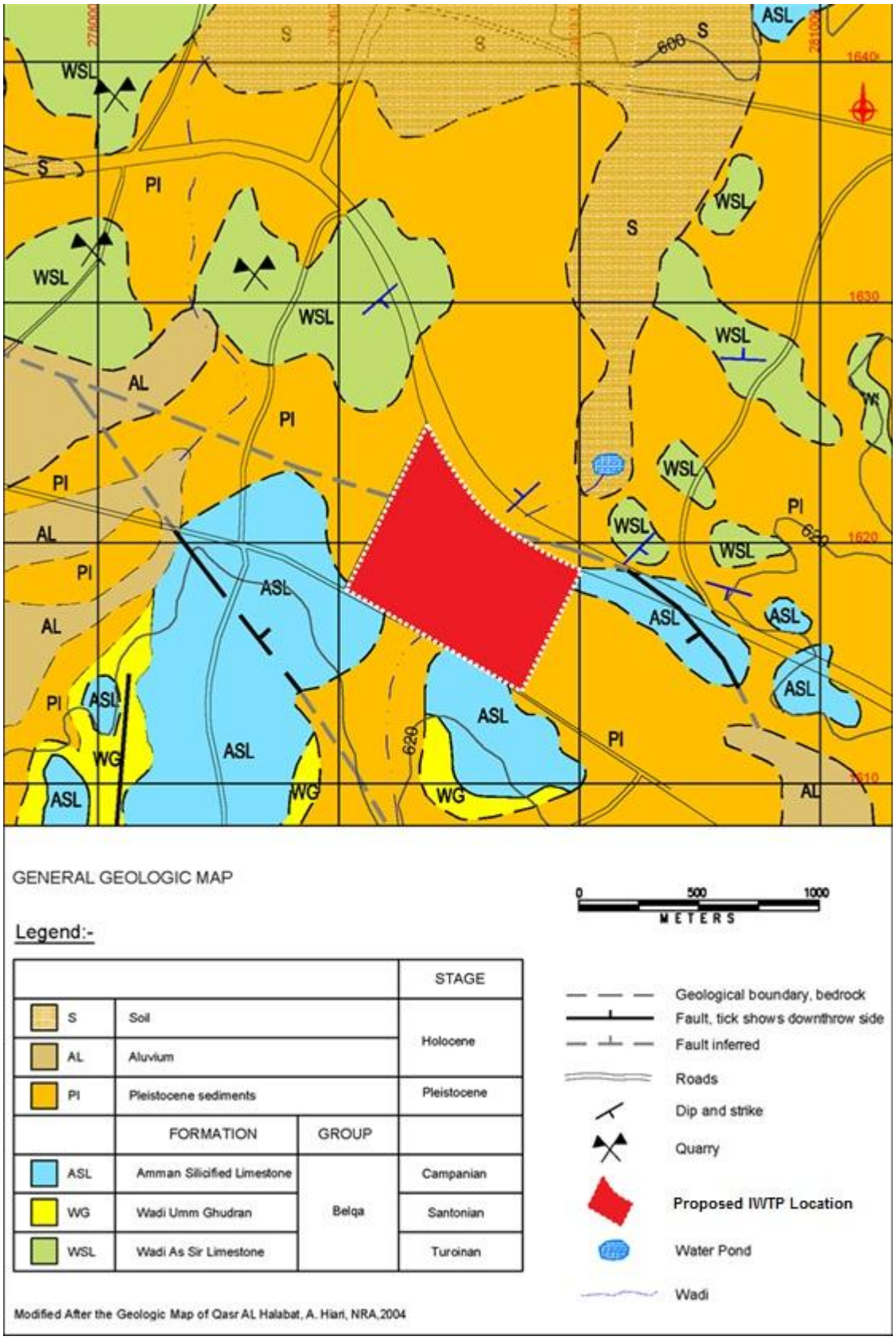


Figure 5-2: Geological Map of Qasr Al-Hallabat

The proposed project area is characterized by Pleistocene superficial deposits which cover most of the site. These deposits are composed of poorly sorted, sub rounded pebbles of basalt, limestone and fragments of chert. The Pleistocene deposits are covered with brown

and yellow brown soils consisting of silty clay, silt and clay. Alluvial fans are present, consisting of poorly sorted gravels, predominantly chert. Fill material is present at locations close to the main road. Soil depths in the area range between 30 and 70 centimeters. The soils are mostly crusted, which impedes water infiltration and large amounts of organic material would be needed to enhance soils properties.

The adjacent project area incorporates significant exposures of sedimentary rocks, including Wadi As Sir limestone formation, Amman silicified limestone, and Wadi Umm Ghudran formation of Cretaceous age. Many quarries are operating within the area adjacent to the project site; these are producing commercial building products of Wadi As Sir Limestone.

Another notable geologic feature of the site is a shallow water pond located approximately 350 meters northwest of the proposed IWTP. This pond is used for collecting surface water during the winter season for later use by the local population.

Stratigraphy
The rocks outcropping in the area range from Turonian to Campanian in age except the superficial deposits which are dated Pleistocene to recent.

In general the rock sequence described in the text follows the nomenclature used in the modified Geological Mapping.

The rock sequence in the project area is as follows:

- Amman Silicified Limestone (ASL): This formation consists of thick-bedded limestone and marly limestone inter-bedded with black, whitish grey, thin to medium bedded chert. It ranges in age from Santonian to Campanian. The formation was deposited in a shallow marine environment.

- Wadi Umm Ghudran Formation (WG): This formation overlies locally Wadi As Sir limestone formation. The formation consists of white to dirty white chalk in the lower part, with yellow, grey, thin to medium bedded limestone and coquina limestone in the upper part. This formation is Santonian in age and was deposited in a shallow to moderately-deep-water environment.

- Wadi As Sir Limestone Formation (WSL): This formation covers broad areas of the project area. It consists of yellowish to dirty yellow, grey limestone and dolomitic limestone in the lower part and yellowish, whitish grey, marly limestone and chalky limestone in the middle part, overlain by pale grey micritic massive bedded and fossilifereous limestone. The formation was deposited in a shallow open marine environment.

- Superficial Deposits: Pleistocene sediments covered by soil overlay the previous sequence of rocks and formations. The sediments are composed of poorly sorted, sub rounded pebbles of limestone and chert. Alluvium and wadi sediments consist of poorly sorted, sub rounded to angular formation of chert and limestone with silt and clay. Alluvial fans are present and consist of poorly sorted gravels. Red and yellow brown soils cover part of the project area.

5.3 Topography

The main characteristic feature of the area's topography is the Amman-Zarqa syncline, which is the cause for the pronounced topographic relief seen northwest and southeast of the Zarqa River and which has slopes of 20% to 30%. The Amman-Zarqa syncline starts southwest of Amman and ends northeast of Zarqa. This syncline is constituted of mountains on its northern and western sides with clear topographic relief and elevations reaching up to

1,000-1,085 meters above mean sea level (MSL). The Amman-Zarqa syncline also dictates the west-east flow direction of the groundwater. The east side of Zarqa Governorate is a wide flat land extended to the border with Iraq.

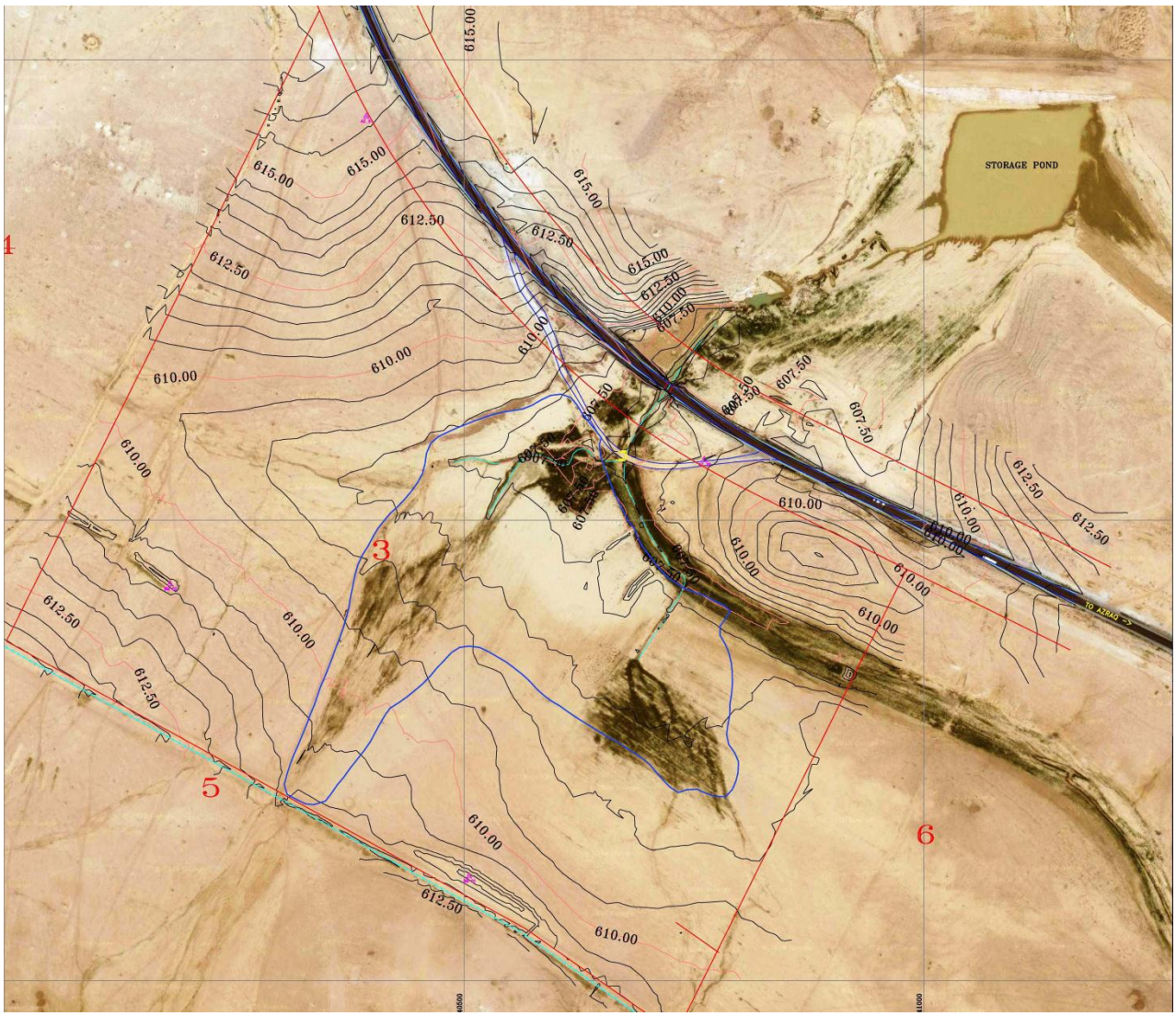


Figure 5-3: Zarqa IWTP Topographic Survey

The area of the site is approximately 500 dunums (50 hectares). As shown in Figure 5-3, the site is generally flat with elevations that range from about 607 meters to 617 meters above MSL. There is a natural wadi on the northern side of the site towards the highway, which facilitates the drainage of water to a reservoir located on the north side of the highway where the elevation is about 607 meters above MSL.

5.4 Water Resources

Surface Water

The main surface water resources in the project area are:

- Wadi Dhuleil. The stream rises in the desert that is northeast of the project area. Effluent from As Samra WWTP discharges to the Wadi Dhuleil and flows downstream towards the Zarqa River. Treated wastewater forms about 55% of the total inflow to King Talal Dam.
- Seil Al-Zarqa. This originates in the Amman urban area.

- Al-Zarqa River. This rises from a spring near Amman, called Ain Ghazal. Zarqa River consists of two tributary streams that join the river at Sukhna. The River flows about 50 kilometers downstream of As-Samra towards King Talal Dam.
- King Talal Dam. This dam was built as a reservoir with a total capacity of 86 million cubic meters (MCM). It is located on the Zarqa River, and it stores water from rain and treated wastewater from As Samra WWTP, to be used for irrigation in the Jordan Valley.

Groundwater

The Zarqa IWTP site is located within the Amman-Zarqa Basin (see Figure 5-4), one of the most important fresh groundwater sources in Jordan. The basin area is approximately 3,950 square kilometers and covers mainly Amman Zarqa and Mafraq cities. Annual average rainfall in Zarqa Governorate is 123.4 millimeters (2009-2013).

The basin is bordered by the Yarmouk Basin to the north, the Azraq Basin to the east and south, the Dead Sea Basin to the southwest, and by the Reft Sidis Basin to the west. The drainage course in Amman-Zarqa basin originates mainly from the Amman area towards the west into the Jordan Valley area.

The most important aquifer within the Amman-Zarqa Basin is the Amman-Wadi Sir (B2/A7) system.

The Amman-Zarqa basin is divided into two parts: an eastern part northeast of Wadi Zarqa that flows to the west; and a western part, extending to the west of Wadi Zarqa, that flows to the east. The direct recharge to the basin comes from precipitation, floodwater flows and infiltration resulting from irrigation activities. The groundwater quality in the basin is affected by various factors, such as over pumping, inflows of wastewater and leaching of solid wastes.

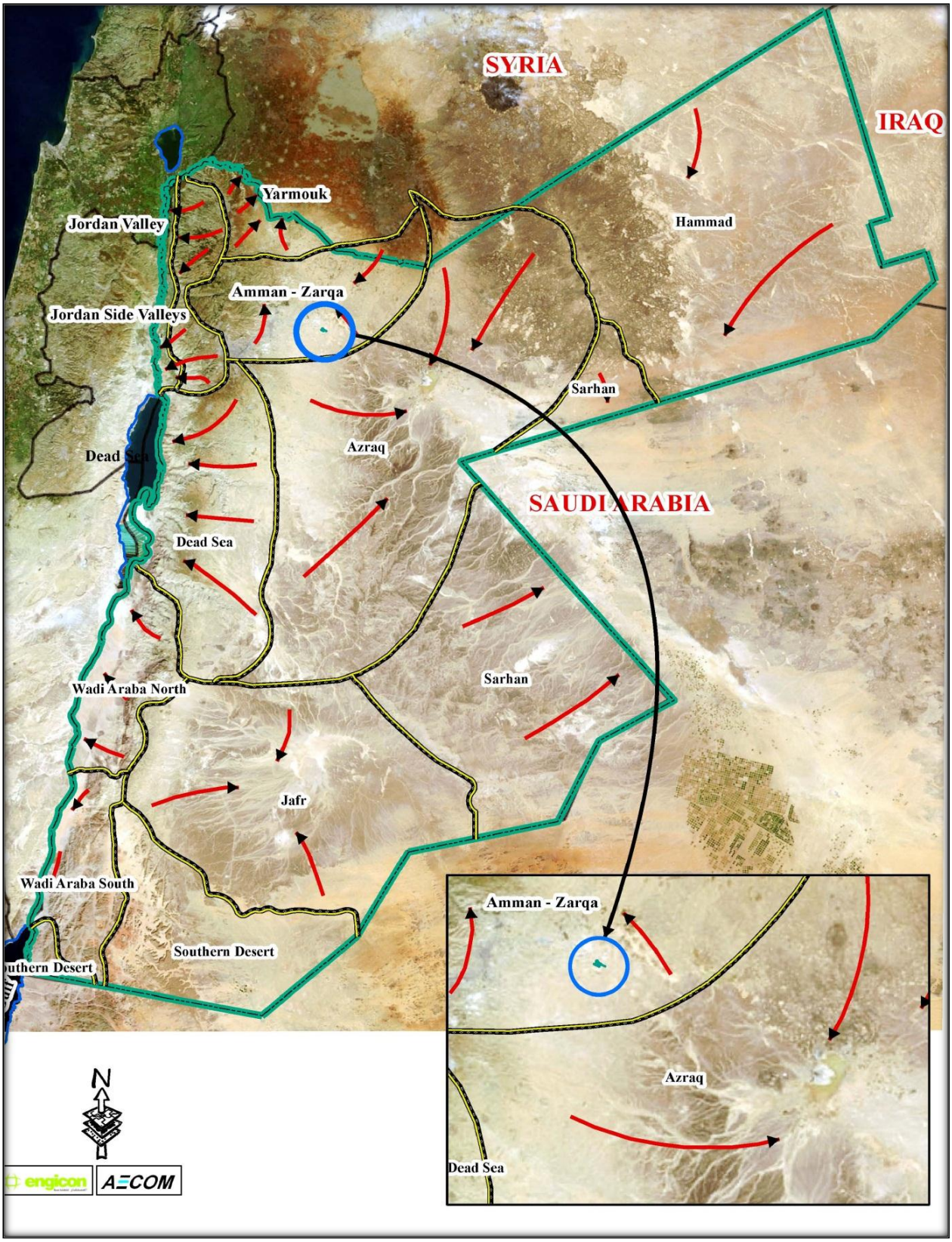


Figure 5-4: Zarqa IWTP Location within Amman-Zarqa Basin

There are three aquifer systems in the project area:

- **The Upper Aquifer System**. This consists of two sub-basins: Wadi Dhuleil basin and Zarqa basin.

Wadi Dhuleil basin is mostly covered with basalt and generally groundwater flows from northeast to southwest. Sub-surface recharge comes primarily from northwest (basalts). It also comes from the eastern and southeastern parts of the aquifer. Indirect recharge may also occur from floods along the stream channel of Wadi Dhuleil and in Qa' Khanna. Discharge occurs mostly as springs, seepage and underflow into the alluvial deposits along the Zarqa River.

Zarqa basin does not exist in the basaltic formation. It consists of two main aquifers: an upper, shallow aquifer system that is in hydraulic continuity with the Amman-Wadi Sir Formation, and a second lower aquifer that is in the Hummar Formation.

The Upper Aquifer System is characterized as an unconfined aquifer and natural recharge occurs easily through direct infiltration of rainfall and indirect stream flow infiltration. Therefore, this aquifer is susceptible to groundwater pollution in the event of water contamination on the surface.

- **The Middle Aquifer System.** This aquifer system is characterized as a confined aquifer. It consists of limestone inter-bedded with marl. It is around 250 meters thick and covered with wadi fill deposits. Discharge occurs only on a narrow strip in the northern part of the basin and in the Sukhna area. Natural recharge occurs mainly at the northwest part of Amman by direct rainfall infiltration. However, due to the extensive urban development in the Amman-Zarqa area and the consequent increase in impervious surfaces, infiltration of rainfall is decreasing continuously.

- **The Lower Aquifer System:** This aquifer appears only in the Baqa'a valley. It exists in sandstone formation, and it is being recharged through direct infiltration of rainfall, runoff and by flow of springs discharged from the middle aquifer system.

Abstraction from the basin was around 161 MCM in 2011; while the basin's annual safe yield is 88 MCM. Water abstracted from the Amman-Zarqa Basin (AZB) is used for municipal, agricultural, and industrial uses.

Figure 5-5 and Figure 5-6 show the quantities of water extracted for each sector, as well as the number of groundwater wells utilized for each sector, based on data obtained from the Department of Statistics (DOS).

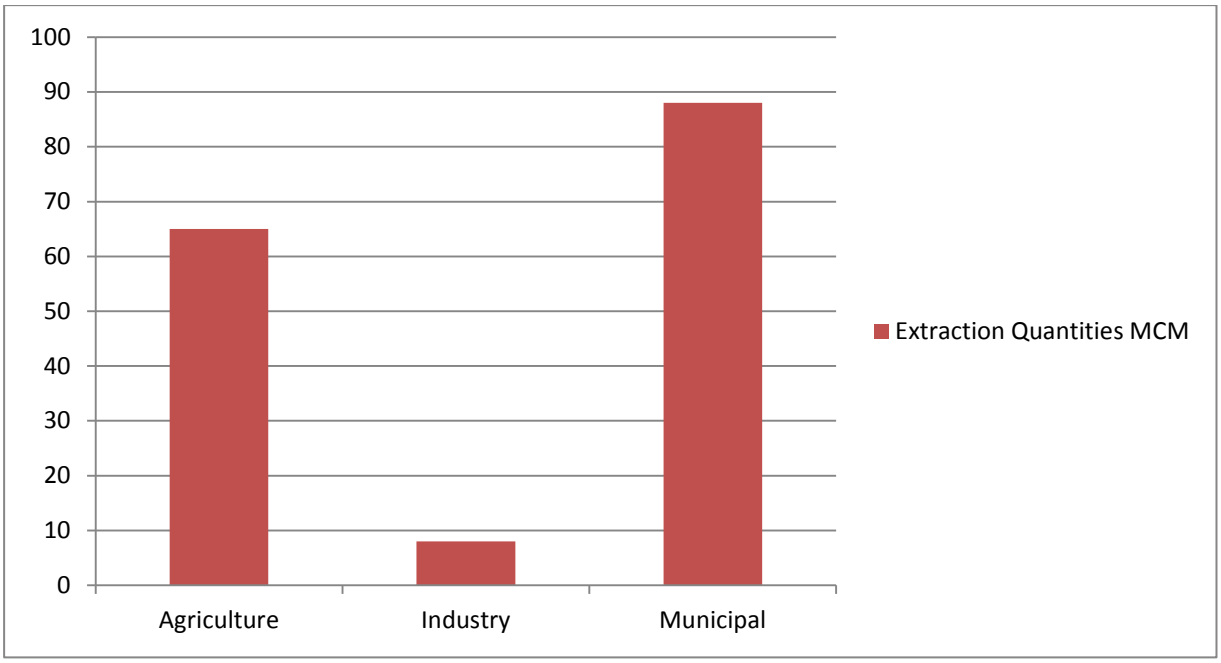


Figure 5-5: Extraction Quantities from AZB for Various Sectors, 2010

The number of registered wells in the AZB was 859 in 2011. There are some illegal wells in the basin, but the number is unknown.

All the wells designated for domestic use in the AZB are located in the Hallabat and Hashimyyah well fields (As per the environmental and social impact assessment for the expansion of As Samra WWTP, 2012).

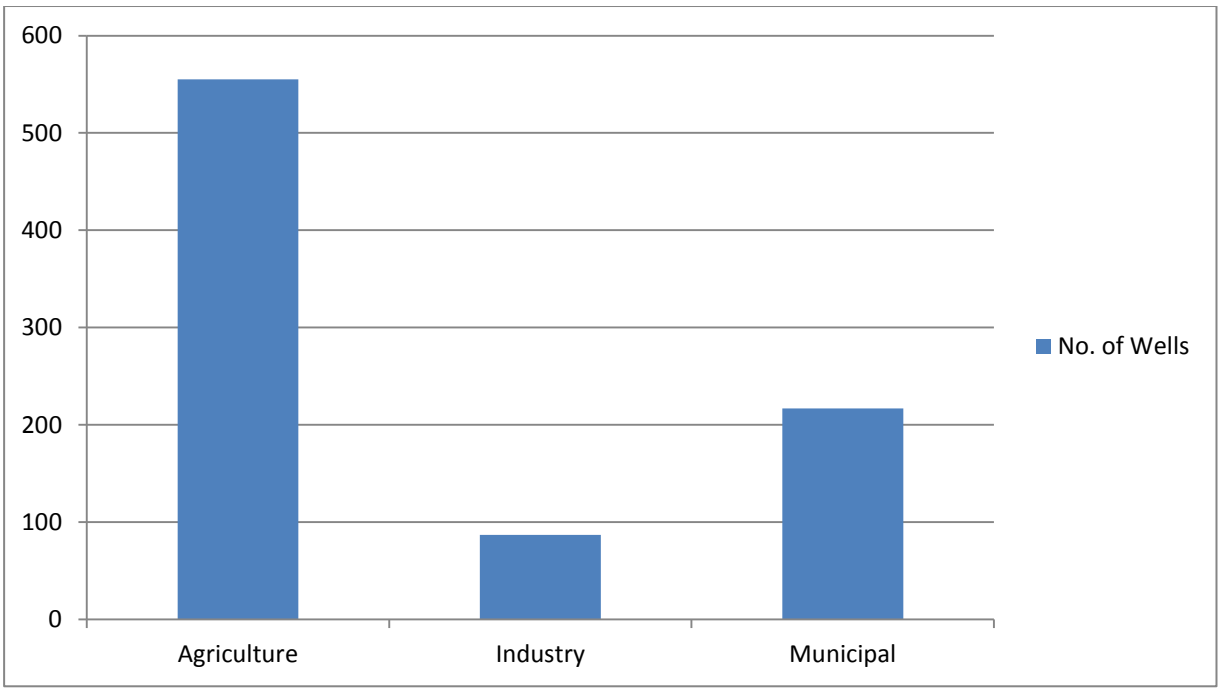


Figure 5-6: Number of Groundwater Wells in AZB Used for Various Sectors, 2010

No groundwater was encountered during the investigations for the nearby Industrial Estate, which included 72 borings completed to depths of 7 to 15 meters below surface grade.

According to a United States Geological survey unpublished report (2012), groundwater levels are declining in the heavily pumped central and northeastern part of the Zarqa groundwater basin. This area includes the Hallabat Corridor and Al'Aqeb wells. The report provided data for 106 wells within the AZB, including in the Dhuleil area, and the Hallabat and Corodor wellfields in the vicinity of the proposed IWTP Site.

Data from two monitoring wells (AL 2413 and AL 3283 HALLABAT 5 and 6, respectively), located within approximately 3-5 kilometers of the proposed IWTP site (beyond the limits of the map in Figure 5-7), indicate that the top of the aquifer in which they are located is at 77 meters below grade, and water levels are decreasing at a rate of greater than 1 meter per year. Reported water levels in these two wells vary from approximately 90 to 100 meters below grade.

According to the United States Geological Survey report, most wells with rapidly increasing electrical conductivity (EC), indicating increasing salinity and saltwater intrusion into the aquifer, are located at lower elevations in basins that represent discharge areas, away from freshwater recharge. The report cites studies which indicate that salinity increases in the Dhuleil area are due to over-pumping, and the salinity is derived from dissolution of native rocks, rather than from irrigation return flow. Groundwater EC levels from wells in the vicinity of the IWTP site range from 300 to more than 3,000 micro-Siemens per centimeter (µS/cm) which corresponds to total dissolved solids (TDS) concentrations up to approximately 2,000 milligrams per liter (mg/L). Figure 5-7 below shows the locations of the closest wells of Hallabat groundwater wells to the Zarqa IWTP.

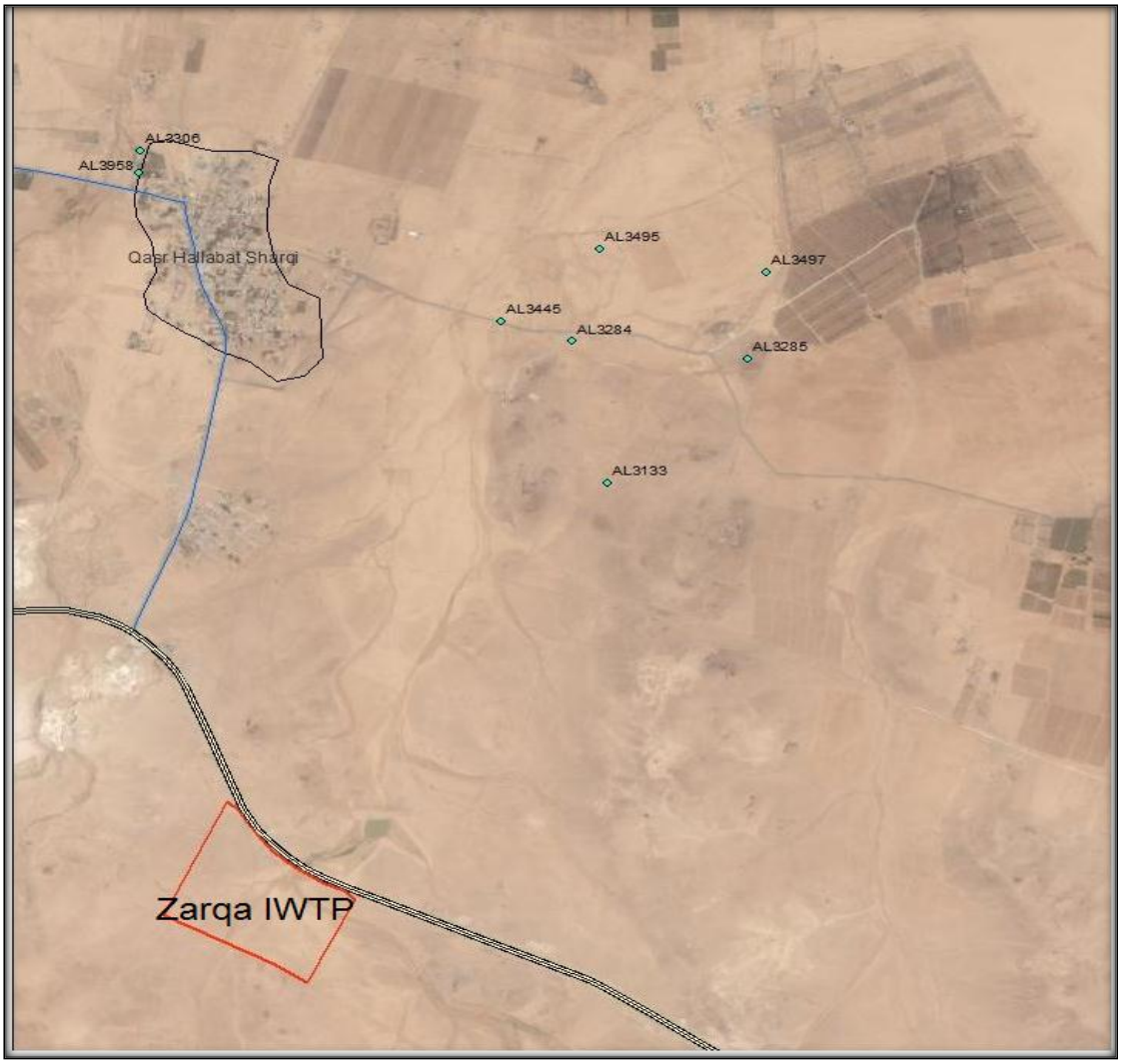


Figure 5-7: Locations of the closest Hallabat Groundwater Wells to Zarqa IWTP

5.5 Air Quality and Noise

There is no operating air quality monitoring station in the project area at the time of preparing this document. The closest air monitoring station is the MoEnv's station near to the Jordan Petroleum Refinery Company (JPRC) facility in Al Hashimyyah, which is about 25 kilometers from the project area.

During visits to the site, noise levels in the vicinity of the proposed IWTP were due to the construction activities of the new road and the movement of heavy vehicles and equipment.

5.6 Flora and Fauna

The project area falls within the Mediterranean realm (Figure 5-8), which is represented by the mountain ranges extending from the north near Irbid, to Ras an Naqb in the south. It consists of forested vegetation with an abundance of Juniper trees (*Juniperus phoenicea)*, White Weeping Brooms (*Retama raetam)*, Pistachio trees (*Pistacia atlantica)*, Pine trees (*Pinus halepensis)*, Palestine Oak (*Quercus calliprinos)*, Kermes Oak (*Quercus coccifera)* and Tabor Oak (*Quercus ithaburensis)*. Open areas are characterized by high cover of the Thorny Burnet (*Sarcopoterium spinosum*).

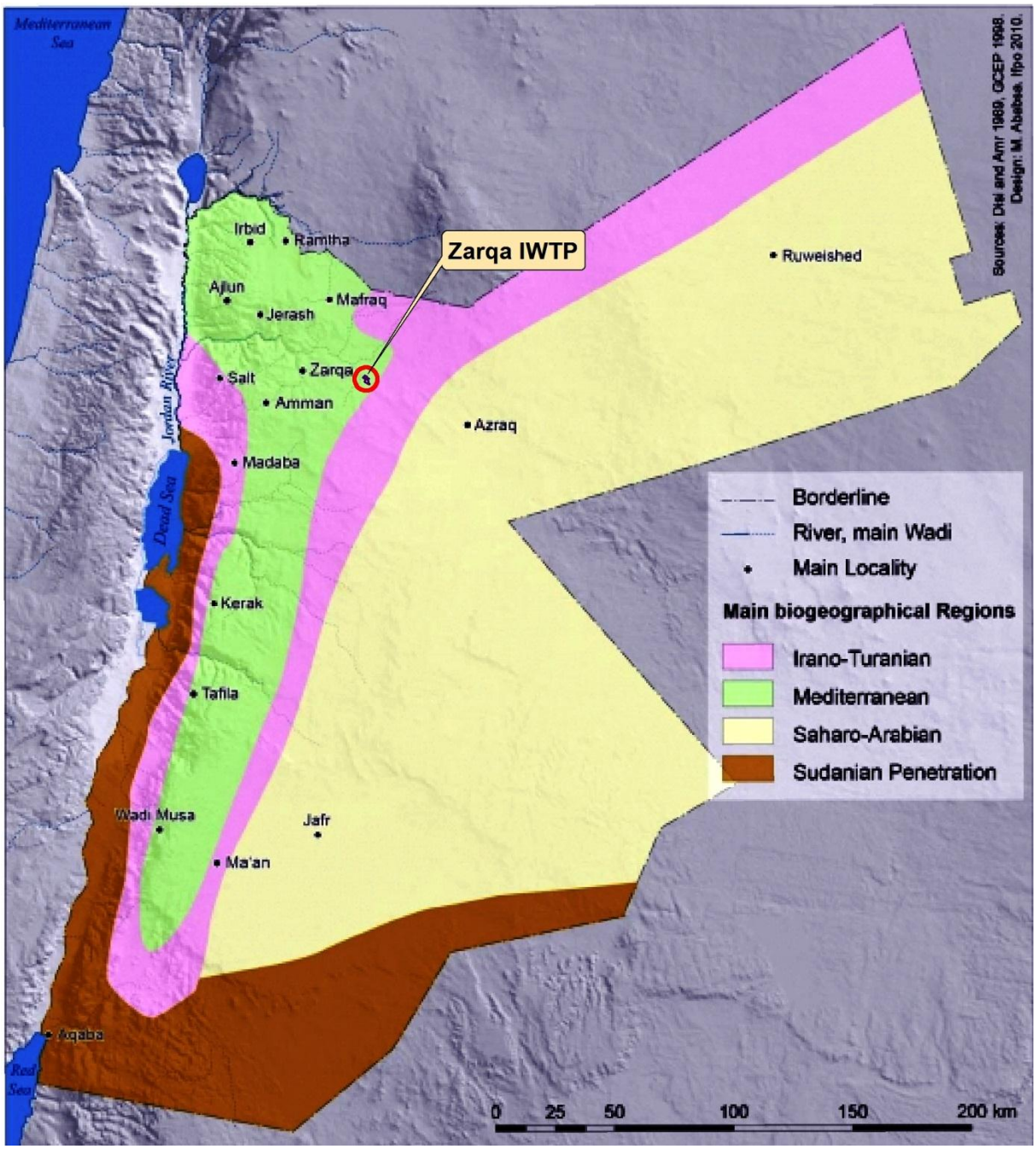


Figure 5-8: The Biogeographical Regions of Jordan Encompassing the Zarqa IWTP

The Zarqa area is characterized by a very sparse vegetative cover. The vegetation in the project area is mostly composed of shrubs and bushes that can resist hot conditions; the majority of plants are either small shrubs or annual or perennial herbs (See Figure 5-9). The vegetation is very poor and is usually found scattered around watersheds in small wadis.

Figure 5-9: Flora in the Project Area

The mammals of the project area represent most of the mammals found in the Mediterranean Zoogeographic Zone, including the striped hyena (*Hyaena hyaena*) and caracal (*Caracal caracal*).

As shown in Figure 5-10, the project is located within the bigger Qa Khanna area, which is considered an Important Bird and Biodiversity Area (IBA). The IBA program was developed by BirdLife International with the purpose of identifying and conserving sites that have a global significance for birds based on specific global criteria (The State of Jordan's Birds, 2013). As part of the bigger Zarqa River Basin, Qa Khanna was mainly chosen due to the migrating birds passing through it during spring and autumn migration. Birds that are known in the area include greater sandplover (*Charadrius leschenaultia)*, cream-colored courser (*Cursorius cursor*), *Pteroles alchata*, common crane (*Grus grus*), lesser short-toed lark (*Calandrella rufescens*), and Temminck's lark (*Eremophila bilopha*).

Figure 5-10: Zarqa IWTP Location within the IBA; Qa Khanna

5.7 Antiquities

Jordan has historically seen many different ancient civilizations and is home to numerous archaeological ruins. The Zarqa governorate is home to several archaeological sites, such as Qasr Amra, Qasr Azraq and Qasr Al Hallabat. Qasr al Hallabat is the closest residential village to the site and it is named after the Roman castle located there. Both Qasr Amra and Qasr Azraq are located around 50 kilometers east of the project area. The proposed IWTP site is close to some ancient trade routes and there was some concern whether the site's construction would encounter any historical remains.

A DOA inspection of the site found that there are no visible archaeological findings. This resulted in permission to go through with the first phase of the proposed IWTP. However, if any archaeological findings are encountered during the process, work is to be halted immediately and the project should contact the DOA in order to reassess the situation, without resuming work until further notice from the department.

Moreover, it is important to note that this permit is only given for the first phase of construction; once that is complete, additional authorization is required from the DOA to progress with future phases (Appendix1).

5.8 Land Use

The land use map in Figure 5-11 shows the classification of land uses in the area surrounding the proposed project. The area of the IWTP is bounded by the four black dots, indicating that the area is classified as a level 2 desert (D2) (MOMA 2015).

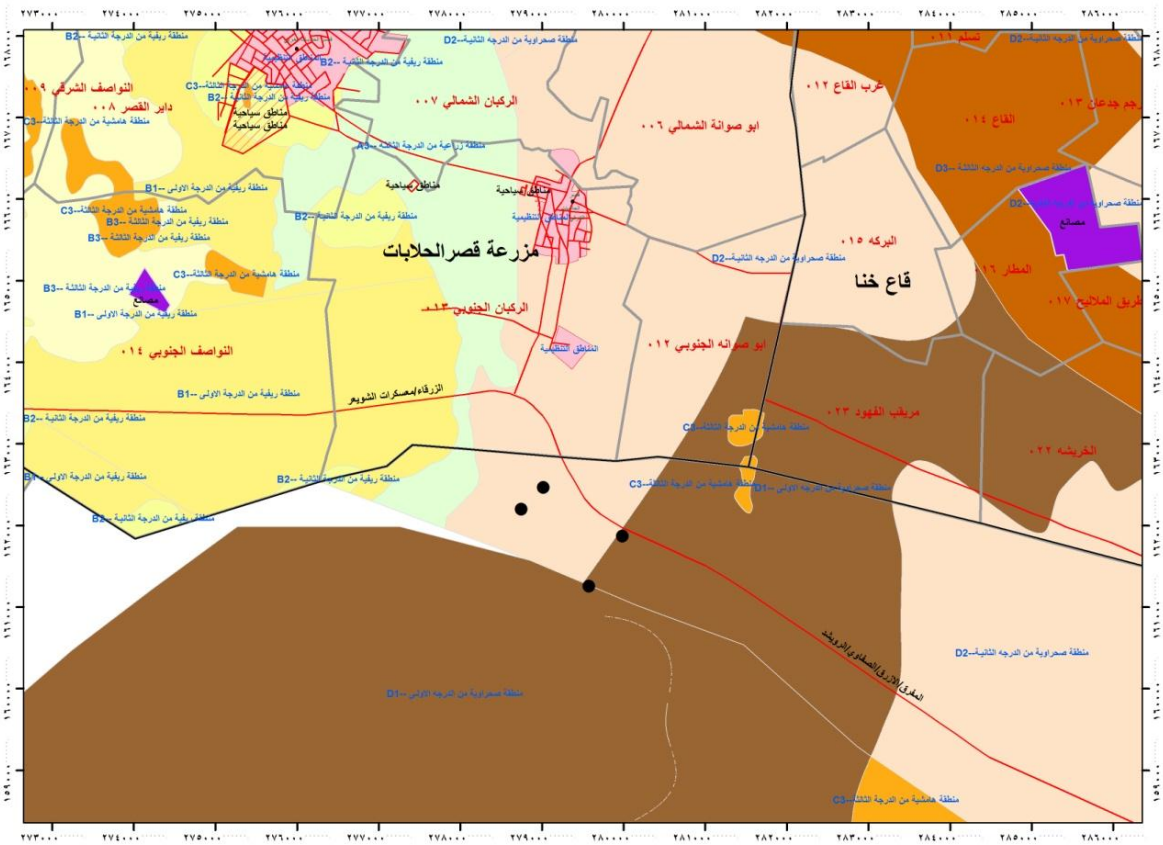


Figure 5-11: The Land Use Map for the Project Area

Under the Land Use Regulation of 2007, level 2 desert areas are classified as arid lands that allow seasonal crop cultivation as long as enough water is available. The construction of wastewater treatment plants is listed as one of the allowed uses on level 2 desert lands with a groundwater pollution prevention requirement. The surrounding area is mostly uninhabited and arid with the closest village being 2.5 kilometers northwest of the project site.

The project site is going to cover approximately 500 Dunums (50 hectares) and the proposed IWTP is projected to serve the needs of industrial facilities within greater Zarqa and adjoining areas. The land belongs to the Zarqa Chamber of Industry and the chamber is willing to use it for the purpose of an IWTP. The JIEC has also expressed interest in developing an industrial estate adjacent to the project site.

5.9 Population and Major Economic Activities

The Zarqa IWTP is proposed to be located in the Al-Hallabat area, which is in the Dleil district of Zarqa (Figure 5-12). The Zarqa Governorate has a population of approximately 972,900, which makes it the third most populous governorate in Jordan. The Dleil district has a population of 41,490 inhabitants. The Al-Zarqa area has an almost even distribution of males and females. The average unemployment rate in the Zarqa Governorate is 13.1%, with male unemployment standing at 12.0% and the female unemployment rate standing at 21.9% (Table 5-6, DOS 2013).

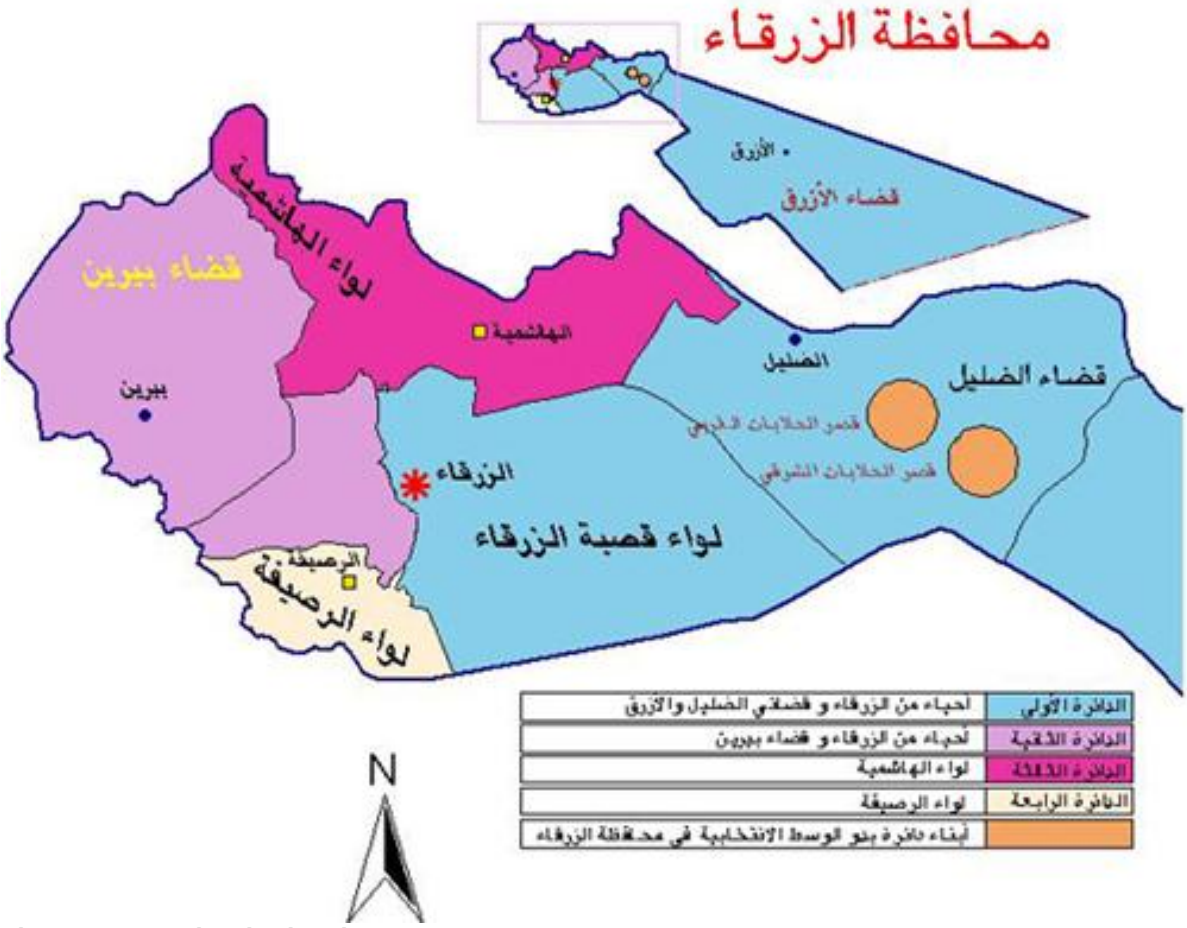


Figure 5-12 Main Districts in Amman Governorate

Table 5-6: Unemployment Rates by Sex & Governorate, 2013

Governorate	Total	Female	Male
Amman	10.5	19.0	8.7
Balqa	14.4	20.4	12.9
Zarqa	13.1	21.9	12.0
Madaba	16.2	23.2	14.2
Irbid	13.0	26.5	10.4
Mafraq	14.5	24.9	12.3
Jerash	12.3	22.3	10.4
Ajloun	13.5	27.2	9.7
Karak	15.8	25.0	12.5
Tafiela	17.1	28.9	13.0
Ma'an	15.0	19.1	14.1
Aqaba	15.2	21.3	14.1
The Kingdom	12.6	22.2	10.6

Source: DOS, 2013

The Zarqa IWTP aims to service the Zarqa Industrial area, as well as some sub-governorates which are either in Zarqa or in close proximity to the site. The industries that are likely to participate contain a variety of sectors, including food, chemical, construction, textiles, engineering, leather, paper and pharmaceuticals. It is estimated that approximately 250 manufacturing facilities contribute to wastewater generation. Many of these facilities dispose of their wastewater at distant disposal sites such as Ekeder and are likely to switch to the Zarqa IWTP if it is constructed.

The Zarqa governorate has a lot of industrial activity because of the availability of affordable land, resources, labor, infrastructure and utilities. It is also accessible and is in close proximity of two universities, which can be used as local recruiting sources and research support. Additionally, the site is very close to the Zarqa Free Zone district which hosts industrial, commercial and touristic economic activity (Jordan Investment Board).

The proposed IWTP will provide temporary and permanent jobs in the area and will service the surrounding industrial sector, which currently has to dispose of its wastewater in distant treatment plants that have spurred some environmental concerns because of surface and groundwater contamination.

5.10 Transportation

The proposed IWTP location lies on a major highway (road 40) that links the Zarqa region to Al-Azraq. This is a major highway that sees a large amount of local and international traffic. The need for an improved highway stretch along the Zarqa region has been recognized by the Jordanian government and a new highway is currently under construction, running parallel to road 40. The new highway should be able to cater to increased vehicle traffic and improve safety conditions as this road is notorious for having road safety issues. The following tables show the number of casualties as a result of road accidents in the Zarqa area, placing it at the third spot for most accidents/casualties in Jordan after Amman and Irbid (DOS 2013), and provide the lengths for each type of road.

Table 5-7: Number of Casualties from Road Accidents in Zarqa

	Number of Casualties
Total	1779
Deaths	101
Injured	1678

Source: DOS 2013

Table 5-8: Lengths of Road Networks by Type of Road in Zarqa, 2013 (kilometers)

Governorate	% of Jordan Roads	Total	Highways	Secondary Roads	Rural Roads
Zarqa	6.5	476	249	98	129

Source: DOS 2013

While Zarqa itself doesn't have a large number of vehicles, the area sees a fair share of traffic because of the presence of major trade routes, industries and three major universities (DOS 2013).

5.11 Water and Electricity Supply

Most of the electricity supply in Zarqa is used in the residential sector, followed by the industrial sector (see Table 5-9, JEPCO 2013). Electric service is provided by Jordanian Electric Power Company (JEPCO).

Table 5-9: Zarqa Electricity Consumption by Type

Consumption Type	2010	2011	2012
Residential	547.3	581.1	638.9
Commercial	115.0	115.5	128.6
Industrial	391.6	431.1	393.5
Water Pumps	68.8	67.2	70.0
Governments	71.1	72.2	78.6
Agricultural	13.3	14.4	14.8
Street Lighting	24.6	22.9	22.6
Others	6.7	7.0	7.5
Total	1238.4	1311.4	1354.4

Source: JEPCO 2013

It is well known that Jordan has water shortage problems. However, the government has successfully supplied the majority of cities with municipal water sources. The water supply to Zarqa for municipal and household purposes is the second largest in Jordan after Amman, as shown in Table 5-10. Moreover, Zarqa is among the top governorates when it comes to households connected to a public sewage system network, with 80.5% of its households connected (DOS 2010).

Table 5-10: Municipal Water Supply for Household & Municipal Purposes by Governorate (Million Cubic Meters)

Governorate	2012	2011	2010
Amman	136.0	132.2	134.2
Balqa	29.2	26.1	25.6
Zarqa	47.3	50.1	48.3
Madaba	7.3	6.7	7.5
Irbid	40.5	41.0	37.9
Mafraq	21.4	20.4	20.5
Jerash	6.0	5.2	4.7
Ajloun	4.4	3.6	3.9
Karak	15.4	15.2	15.4
Tafiela	4.3	3.5	5.0
Ma'an	11.9	10.5	10.4
Aqaba	15.7	15.3	14.6
Total	339.4	330.1	327.7

Source: Department of Statistics 2013

6 ENVIRONMENTAL IMPACTS AND MITIGATIONS

This section addresses the major anticipated environmental impacts of the implementation of the Zarqa IWTP. The analysis was qualitative in nature and included the most significant impacts based on professional judgment and experience. Environmental impacts were considered and detailed according to the two project phases:

- Construction phase
- Operation phase

The design team worked closely with the environmental specialists to minimize the environmental impacts on the project area. Mitigation measures for these environmental impacts were also proposed.

The design team took into consideration the projected capacity requirements, the limitations of the recommended siting area, the acts, codes and regulations of the Hashemite Kingdom of Jordan, and the intention of providing an environmentally sensitive and protective means for industrial wastewater treatment and management.

The initial design flow for the Zarqa IWTP will be 2,500 m^3/d, which addresses the current minimum anticipated flow need. Influent concentrations will be monitored on a regular basis, and necessary adjustments might be made to the treatment process to accommodate any significant variations from the design conditions.

The initial design for the Zarqa IWTP involves full treatment and reuse of the flow for irrigation; the effluent quality therefore needs to meet the Jordanian standard JS 202/2007.

The design recommends the disposal of FOG offsite via tankers to either an approved incineration facility, or to the Ain Ghazal pretreatment facility. Screenings and grit are expected to be transported to the Al Ghabawi landfill for disposal.

The initial design for the Zarqa IWTP also includes the stabilization of sludge in order to reduce odors and improve the overall characteristics of the sludge. Sludge will be dewatered to reduce its volume and then transported offsite for disposal.

The selected DAF primary treatment has a significantly lower footprint than that of other flocculation/clarification equipment.

In order to maximize the recovery of treated water and minimize the quantity of byproducts, the design evaluated the use of a HERO system. The HERO reject streams will be discharged to evaporation basins, constructed so that the water vapors can be evaporated using a solar evaporation process.

Utility water will be provided to the IWTP from the Treated Water Storage Pond. Emergency Eye Wash and Shower Stations will also be provided in the vicinity of the Lime Storage/Slurry locations, as well as in the vicinity of the Acid and Caustic Storage Tanks.

This utility water will also be used to provide dilution water for the DAF Flocculant and Polymer and Flocculant for Sludge Conditioning, and will also be used for washout water for the Screw Press.

A Potable Water Tank will be used to provide storage of the potable water supply required for the treatment facility restrooms and administrative facilities.

The design also involves improvements to the site drainage, including routings and diversions of the small ephemeral water courses. The existing box culvert will convey the design runoff. However, the sensitivity of the analysis to the conveyance capacity of the culvert should be given serious consideration; the calculations should be updated within the final design according to the new design of the road and culvert.

6.1 During Construction

The anticipated negative impacts that will occur during the construction phase vary in their nature and severity; however, some of these impacts are temporary and can be reduced with proper mitigation measures.

6.1.1 Geology and Soil

Anticipated Impacts

Soil erosion might happen as a result of construction activities such as drilling, excavation, and land leveling. These activities will mostly affect topsoil. Movement of heavy machinery on unpaved surfaces might cause soil compaction, which may affect drainage and increase flooding risk.

Additionally, soil pollution might occur as a result of oil and fuel leakage or spills from vehicles or machines, improper disposal of excess asphalt or concrete generated, as well as waste from workers.

Proposed Mitigation Measures

The contractor should develop and abide by a Soil Erosion Prevention Plan and Spill Management Plan. These plans should include all the necessary measures, main concerns, actions, as well as responsibilities to prevent soil erosion and pollution.

Soil contamination can be avoided by isolating fuelling and maintenance areas as well as vehicle parking areas on a sealed floor or paved impermeable surface. Any leakage or spill incidents should be dealt with immediately by using spill kits and cleaning up and removing the top contaminated soil. Such accidents should be reported.

Solid and liquid wastes should be collected regularly, and disposed of to the closest available disposal site to prevent soil contamination.

6.1.2 Surface Water and Groundwater

Anticipated Impacts

Although the proposed site grading maintains the natural course of the wadi to the extent possible, there might be temporary alterations during the construction of the new IWTP. If the temporary alterations were not addressed, it could present a risk of flooding and thus surface water contamination. However, the risk of surface water contamination from discharges of construction activities and used hazardous chemicals is considered insignificant.

The risk of ground water contamination from discharges of construction activities and used hazardous chemicals is considered insignificant.

Proposed Mitigation Measures

Engineered drainage channels will be incorporated into the design of the construction activities and final site grading to convey runoff and to avoid risk of flooding. Construction workers should be banned from washing their equipment and tools in the wadi course.

A Hazardous Materials Management Plan should be developed and abided by. Hazardous materials should be stored within double-skinned tanks to prevent any spills / leaks to the environment.

The Contractor should develop and abide by a HMMP. Hazardous materials should be stored within double-skinned tanks to prevent any spills or leaks to the environment. Hazardous materials should be labeled, used and disposed of properly and according to the HMMP.

6.1.3 Air Quality

Anticipated Impacts

The main impact on air quality during construction is caused by dust generated from excavation, vehicular movement, and uncovered construction materials. Emissions from heavy construction machinery are another source of air pollution during construction.

Despite the fact that these impacts are temporary, they can cause nuisance and health problems for workers and the surrounding communities.

Proposed Mitigation Measures

The Contractor should develop and abide by a Dust Management Plan. All necessary dust abatement measures should be identified in the plan, including but not limited to:

- Minimizing dust generation during dry and dusty weather, and scheduling dust-generating activities according to the weather conditions
- Suppressing dust using water spraying and moistening of excavation areas and exposed surfaces, or using a non-water dependent dust control product given the scarcity of water in the region.
- Covering all stockpiles and trucks transporting sand and other construction materials
- Controlling vehicles movement on unpaved roads, and paving unsmoothed roads as soon as practicable
- Following good housekeeping within the site and its perimeters
- Providing workers with dust protection equipment
- Undertaking and recording visual on-site and off-site inspections on a daily basis, especially during periods of high activity or prolonged dry, windy weather

Heavy machinery should be maintained regularly to minimize released emissions. Spill cleaning equipment should be available at all times. All air quality complaints should be kept and recorded, as well as the identified causes.

6.1.4 Noise

Anticipated Impacts

Noise levels are anticipated to increase during the construction phase, due to excavation activities and operation of heavy machinery. Nevertheless, since there are no neighborhoods in close proximity to the site, construction workers are the most affected from noise.

Proposed Mitigation Measures

Noise protection equipment should be provided to workers. Multiple noise-generating activities should be conducted simultaneously so as to prevent prolonged periods of noise. Heavy machinery should be maintained and greased regularly to minimize unnecessary noise.

6.1.5 Flora and Fauna

Anticipated Impacts

Except for some shrubs and bushes, there is no significant vegetation in the vicinity of the project. Parts of this vegetation cover would be removed during the construction phase to enable construction activities. Construction activities might also pose some pollution and damage risk to the natural vegetation of the area.

Construction works might have minimal negative impacts on the fauna species that exist in the project area. No fauna species is anticipated to be affected.

The Qa Khanna area is recognized as an IBA for various migratory water birds. Therefore, these water birds might be at risk of disturbance due to construction noise, traffic, and presence of people.

Proposed Mitigation Measures

Increasing the vegetation cover inside the Zarqa IWTP boundaries is recommended utilizing the reclaimed water.

Construction activities should be restricted to one area at a time wherever possible, to allow the movement of fauna species to the nearby undisturbed areas. It is also recommended to avoid construction works when migratory water birds frequent the Qa Khanna area (mainly in the winter time) and to conduct multiple noise-generating activities simultaneously so as to reduce the periods of exposure.

Construction workers should not trap or hunt any existing animal and bird species in the project area. Any caught animals should be moved to nearby undisturbed areas.

Generation of noise, dust, and the spill of chemicals and hazardous materials should be controlled and reduced as much as possible, to prevent the negative impacts on the biodiversity of the area.

6.1.6 Antiquities

Anticipated Impacts

No visible archaeological findings were found in the project site. However, the contractor should take into consideration the possibility of finding and damaging unknown archaeological structures during earthworks.

Proposed Mitigation Measures

The Contractor should stop work within the area in the case of any archaeological findings and immediately contact the DOA. Work should not be resumed until further notice from the DOA is given to proceed. Areas close to archaeological findings should be protected during all project phases.

6.1.7 Land Use

Anticipated Impacts

The adjacent land will subject to elevated levels of dust and noise from construction activity including road construction and increased truck traffic. However, given the absence of development in the immediate vicinity, these issues are unlikely to be a significant concern.

Proposed Mitigation Measures

While measures will be adopted to limit the off-site effects of construction activity to the extent practicable, the surrounding land is vacant and held by ZCI with anticipated future use of a portion of it for an industrial estate. Construction of the IWTP is not expected to negatively impact the current use.

6.1.8 Population and Major Economic Activities

Anticipated Impacts

New job opportunities are expected to be generated for the local community of Zarqa Governorate during the construction phase. This will increase income and ultimately enhance the life conditions of the nearby communities. Jobs as construction workers, drivers or even service providers to the workers onsite may become available; this contributes to the livelihood of the neighboring communities and offers a source of income.

6.1.9 Transportation

Anticipated Impacts

Access roads to the IWTP will be constructed as part of the project in addition to two-way vehicle traffic roads around the IWTP perimeter, to connect the different parts of the IWTP.

In general, the risk of accidents might increase in the project area as a result of traffic increase due to the presence of construction vehicles and the movement of workers from and to the site. Trucks delivering necessary construction material and conveying construction waste out of the site might generate dust if uncovered, which will result in lower visibility along the road.

Proposed Mitigation Measures

The contractor should develop and follow a Traffic Management Plan that is suitable for the construction site conditions. Proper and clear signage, in different languages, should be provided along the access road and inside the plant to indicate that there is a construction site nearby.

The contractor should provide vehicles equipped with seats and barriers for the transportation of workers. Construction material and soil should be securely packed and covered on trucks to prevent loads from falling off or generating dust.

6.1.10 Solid Waste

Anticipated Impacts

The main sources of solid waste during the construction phase are excavation and earthwork activities. Another source of solid waste is the domestic solid waste generated by construction workers. Health and safety risks to workers and nearby communities, in addition to odor and visual impacts, might result from the accumulation of wastes.

Hazardous wastes such as used oil, filters, and tires can also have negative impacts on the environment if proper handling measures are not implemented.

Proposed Mitigation Measures

A Waste Management Plan should be developed and followed. The plan should identify a waste collection schedule, storage locations, qualified carriers, and the final disposal site. Solid waste should be collected in special containers that can be closed tightly to prevent the growth of pathogens, mosquitoes and flies. Solid waste should be collected and disposed of regularly.

Awareness sessions on solid waste management should be provided to workers. Minimizing waste generation, and reusing and recycling should be encouraged whenever possible. There should be no random dumping activities on or off site.

Furthermore, a HMMP should specify the procedures of handling, storing, transporting and disposing of hazardous wastes.

6.1.11 Water and Electric Supply

Anticipated Impacts

There will be an increase in water demand for the various construction activities, such as dust control, and domestic water uses at site offices. In addition, potable water might be used to wash construction equipment and tools. If the contractor will be trucking water in, it is expected that there will be no potential impact on the local water supply.

The demand on electricity will also increase during the construction phase, which will affect the current power supplied to the project area.

Proposed Mitigation Measures

In the pre-construction stage a water source for construction activities should be allocated to confirm that use of water by the contractor will not affect water supply of local community. The Contractor should provide water using tankers. Construction crews should conserve water during all construction activities and handle water resources efficiently.

Increasing the size and capacity of the existing power supplied to the site should be discussed with JEPCO prior to the construction phase.

6.1.12 Occupational Safety and Health

Anticipated Impacts

The construction of each phase of the IWTP will require excavation and/or fill activities. Main injury risks during the construction phase will include falls, electrocution, transportation accidents, and injuries resulting from mishandling of the machinery. Construction workers will work closely with and near heavy machinery, which might lead to accidents. Workers' safety might be jeopardized as some of them may slip or fall down, especially with the presence of small wadis near the IWTP project area, and the new drainage channels. The exposure to high levels of noise might cause hearing impairment.

In addition, workers might be susceptible to health problems such as respiratory diseases, due to the exposure to dust. Heat stress, which can cause dizziness, weakness, breathlessness, as well as accelerated heartbeats, might be a risk due to high temperatures in the project area during summer months.

Adequate safety measures need to be taken to address all of the anticipated safety and health risks.

Proposed Mitigation Measures

Contractor's Tender Documents should include all necessary safety measures in a separate section. These measures should utilize appropriate safety gear and equipment, such as harnesses, hearing protection, guardrails, secured ladders and scaffoldings, and trench shields, to be provided during the construction phase. Proper mitigation measures for noise, dust and traffic should be specified to alleviate construction-induced impacts on workers and the nearby communities.

Work shifts and breaks should be scheduled properly to reduce the incidents of heat stress and keep exposure durations for workers within the acceptable noise limits. Heat stress can be prevented by drinking enough water; potable water should therefore be easily accessed by all workers. In addition, clean cups and water bottles should be provided. Hats and shaded areas should also be provided for workers.

Transportation of workers should be done in vehicles equipped with seats and barriers for their safety. It is not permitted to transport individuals in dump trucks.

A comprehensive Health and Safety Plan (HASP) should be developed prior to construction activities to stipulate the contractor's responsibilities regarding health and sanitary needs of workers. These include proper arrangements for dining, bathing, drinking, sanitation, ventilation and light, firefighting, and safe transportation. The HASP should also assign a Health and Safety Officer to supervise its implementation. Furthermore, the plan should lay out a procedure for reporting and investigating all accidents to identify responsible individuals and to prevent recurrence.

Regular safety awareness sessions and meetings should be held to ensure the proper implementation of the HASP. The location of the closest hospital or medical clinic and the shortest route should be identified.

It is also important to assign a doctor to serve the workers during the construction phase, since the project area is relatively far from hospitals and medical centers. Workers should be provided with health insurance, and should be subject to regular medical checkups.

A Hazardous Materials Management Plan (HMMP) should be developed and abided by. Hazardous materials should be stored within double-skinned tanks to prevent any spills/leaks that might cause injuries. Hazardous material should also be labeled, used and disposed of properly and according to the HMMP.

In addition, it is important to avoid dust-generating activities during windy days. The contractor should also apply dust-suppressing measures such as moistening and water spraying of the excavation areas and any other exposed surfaces.

6.2 During Operation

6.2.1 Geology and Soil

Anticipated Impacts

Unloading activities and the movement of heavy machinery might have a negative impact on soil stability, and might cause soil erosion and compaction. This in turn may affect drainage and increase flooding risk.

Additionally, soil pollution might happen as a result of oil and fuel leakage from vehicles or machines, improper disposal of excess asphalt or concrete generated, as well as waste from workers. Nonetheless, irrigation of land with the treated effluent is expected to improve the soil structure and condition by providing natural nutrients.

Proposed Mitigation Measures

Fuelling and maintenance areas should be dispersed on a sealed floor to prevent soil contamination in different parts of the project area. Any leakage incidents should be dealt with immediately by using spill kits and cleaning up and removing the top contaminated soil.

Such accidents should be reported. Vehicles should be parked on a site that is paved with an impermeable surface. Solid and liquid wastes should be collected regularly, and disposed of to the closest available disposal site.

6.2.1 Surface Water and Groundwater

The IWTP design includes engineered drainage structures that will allow surface water runoff from upstream of the site to continue to flow through the site and discharge to the Wadi. Runoff from the IWTP site itself will be settled prior to discharge to the Wadi.

Treated effluent will normally be reused for irrigation. If there is no demand for irrigation water, the treated water may be discharged to surface water. The treatment process is designed to meet the requirements for discharge to surface water so there should be no adverse impact to surface water from discharge of treated effluent.

Despite the fact that the effluent will have good quality and relatively low TDS that allows it to be used for irrigation, after it is used for irrigation, its runoff from farms may contaminate water bodies.

As no shallow groundwater table was detected on site, there is no risk of groundwater contamination.

Ultimately the project would lead to an overall enhancement of the environmental performance in Zarqa governorate, since it will help in limiting the discharge of untreated industrial wastewater into surface water bodies.

Proposed Mitigation Measures
Engineered drainage channels will be provided to direct flow through the IWTP site in a manner to minimize flooding issues, and to conserve the surface water that would eventually drain to the nearby earth dam to be constructed.

The reuse scheme should be enforced and monitored to minimize runoff of reused effluent. Moreover, farmers should be informed on how to minimize runoff from their farms.

Although groundwater contamination is unlikely, mitigation measures should be implemented to protect this valuable resource. A suitable lining should also be installed in the constructed evaporation and storage ponds.

Fuelling and maintenance areas should be dispersed on a sealed floor to prevent surface water contamination in different parts of the project area. Any leakage incidents should be dealt with immediately by using spill kits and cleaning up and removing the top contaminated soil and surface water.

Such accidents should be reported. Vehicles should be parked on a site that is paved with an impermeable surface. Solid and liquid wastes should be collected regularly, and disposed of to the closest available disposal site.

6.2.2 Air Quality and Noise

Anticipated Impacts
Emissions and dust generated by vehicles during the unloading process might be a source of air pollution; emissions will increase as more vehicles are used within the site area. However, smoothing and paving roads will reduce the amount of dust generated.

Odor might also be another negative impact; however, the receiving and equalization tanks will include a tank cover, and piping for collection and treatment of its odorous vapor stream in the Tank Biofilters. In addition, the use of aerobic digestion for sludge stabilization helps mitigate plant-wide odors by stabilizing the biosolids and making the end product less odorous.

Lime dust is another identified issue of concern; however, since the proposed lime handling system would be a closed one, it is anticipated that there would be no impact as a result.

During operation, some processes at the IWTP would generate noise, but operational noise levels are not expected to exceed standards or present a nuisance since there are no nearby communities.

Proposed Mitigation Measures
In general, the proposed design involves all necessary measures to control odors. However, vehicles used within the project area should be regulated and monitored to verify that they are in good working conditions. An effective ventilation system must be installed and maintained in the different IWTP buildings.

6.2.3 Flora and Fauna

Anticipated Impacts
The quality of generated treated water meets the Jordanian Standards JS 202/2007 and thus the reuse of the treated effluent for irrigation purposes may help in increasing the green cover around the treatment plant and attract birds and wildlife.

However, the expected increase in human activities in the project area might pose a risk to the natural habitat in the area, especially through uncontrolled destructive behavior and littering.

Proposed Mitigation Measures
The IWTP workers should not trap or hunt any existing fauna species in the project area. Any caught animals should be moved to nearby undisturbed areas. Movement of workers, and operation activities should be banned in undeveloped areas immediately outside the IWTP boundaries.

Furthermore, natural vegetation should be planted whenever possible.

6.2.4 Land Use

Anticipated Impacts
The completed facility would represent a change in current land use (i.e. industrial development on a parcel of currently undeveloped land). However, the project would not be incompatible with adjacent land uses.

Proposed Mitigation Measures
The neighboring property is vacant and currently held by Zarqa Industrial Estate with anticipated future use of a portion of it for an industrial park. The IWTP is anticipated to complement the industrial development and no anticipated negative impacts to that use are anticipated during operation. Therefore, the need for mitigation measures is unlikely.

6.2.5 Population and Major Economic Activities

Anticipated Impacts
During the operation phase, new job opportunities will be generated for the local community of Zarqa Governorate. This will increase income and ultimately enhance the life conditions of the nearby communities. This can also encourage and open the opportunity for women in the surrounding areas to make and sell homemade goods in the form of food, crops or even handmade items for the onsite dwelling places.

Economic benefits resulting from reuse of the treated effluent during operation depend on the ultimate use of the treated effluent. Use of reclaimed water for industrial purposes may

enhance the competitiveness of these industrial facilities if they were able to purchase the recycled water at a lower cost than from fresh water tankers.

If the reclaimed water were reused for agriculture, nearby farmers would be encouraged to extend their farming season and thus increase their profit and potentially employ more workers. The farmers would also have higher flexibility in selecting their crops to achieve higher returns. The benefit would ultimately depend on the price they end up paying for the better quality effluent.

6.2.6 Transportation

Anticipated Impacts

During operation of the proposed IWTP, the number of vehicles transporting workers is expected to increase. In addition, septage tankers that are unloading their septage in the treatment plant, as well as trucks that transport reclaimed water and sludge from the plant, will increase traffic at the area.

Proposed Mitigation Measures

A traffic management plan should be developed and followed by the operator. Drivers of septage tanks should adopt a schedule that avoids peak traffic hours. This will reduce traffic congestion and also minimize the risk of accidents on the road.

The operator should provide vehicles equipped with seats and barriers for the transportation of workers.

6.2.7 Solid Waste

Anticipated Impacts

The main source of solid waste during the operation phase is sludge. The digested sludge can be managed onsite, offsite, or in potential future biosolids processing operations. Another source of solid waste is the domestic solid waste generated by operation workers. Health and safety risks to workers and nearby communities, in addition to odor and visual impacts, might result from the accumulation of wastes.

Hazardous wastes such as used oil, filters, and tires can also have negative impacts on the environment if proper handling measures are not implemented.

Proposed Mitigation Measures

Several options for managing sludge should be evaluated including allowing reuse of the biosolids to reduce the negative impacts of disposal.

A Waste Management Plan should be developed and followed. The plan should identify a waste collection schedule, storage locations, qualified carriers, and the final disposal site. Solid waste should be collected in special containers that can be closed tightly to prevent the growth of pathogens, mosquitoes and flies. Solid waste should be collected and disposed of regularly.

Awareness sessions on solid waste management should be provided to workers. Minimizing waste generation, and reusing and recycling should be encouraged whenever possible. There should be no random dumping activities on or off site.

Furthermore, a HMMP should specify the procedures of handling, storing, transporting and disposing of hazardous wastes.

6.2.8 Water and Electric Supply

Anticipated Impacts

There will be an increase in water demand for the various operation activities, such as dust control, and domestic water uses at site offices. In addition, potable water might be used to wash operation equipment and tools. If the operator will be trucking water in it is expected that there will be no potential impact on the local water supply.

The demand on electricity will also increase during operation phase, which will affect the current power supplied to the project area.

Proposed Mitigation Measures

The water source for operation activities should be allocated to ensure that use of water by the operator will not affect water supply of local community. Operation employees should conserve water during all operation activities and handle water resources efficiently.

The size and capacity of the existing power supplied to the site should be increased to cover the demands of the operation phase.

Treated effluent is anticipated to be reused for the IWTP process operations. A pumping station and booster pump/tank system will be provided for that purpose. It is anticipated that potable water will be trucked into the site and a storage tank/booster pump system will also be provided for that purpose. The design team has had discussions with the local electric provider and it is anticipated that they will provide the required power to the site from the road.

6.2.9 Occupational Safety and Health

Anticipated Impacts

During the operation phase, both skilled and unskilled workers that carry out the daily activities at the plant could be exposed to safety risks, such as slipping, falling or mishandling of the machinery if safety measures are not instituted.

Moreover, workers might be susceptible to health problems such as severe skin irritation, chemical burns, blindness, or lung damage, due to the exposure to hydrated lime or calcium hydroxide, Ca(OH)2. The exposure to high concentrations of sodium hypochlorite solutions can also cause burned skin and eye damage.

Another issue related to occupational safety and health pertains to possible health risks to plant operators and farm workers from exposure to reused effluent. However, this risk will be minimal because the treated effluent will be in compliance with the Jordanian standards.

The generated stabilized dewatered sludge would be essentially free of odors and would not serve as a source for fly breeding. Thus, the impact of fly nuisance is insignificant.

Proposed Mitigation Measures

A comprehensive HASP should be developed and abided by during the operation phase. It should specify all responsibilities regarding health and sanitary needs including proper arrangements for dining, bathing, drinking, sanitation, ventilation and light, firefighting, and safe transportation. Safety gear and equipment such as harnesses and guardrails should be provided during the operation phase.

The responsibilities of the “Health and Safety Officer” should also be specified within the HASP to support its implementation. Moreover, the plan should lay out a procedure for reporting and investigating all accidents so as to identify responsible individuals and to prevent recurrence.

Regular safety awareness sessions and meetings should be held to confirm the proper implementation of the HASP. The location of the closest hospital or medical clinic and the shortest route should be identified. Transport of workers on site should be done in vehicles equipped with seats and barriers for their safety.

It is also important to assign a doctor to serve the workers during the operation phase. Workers should be provided with health insurance and should be subject to regular medical checkups.

7 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

The EMMP was developed based on an understanding of the project conditions and on the findings detailed in Section 6.

7.1 EMMP Objectives

The main objectives of the EMMP can be summarized as follows:

- Provide detailed guidance for implementing the mitigation measures.
- Assign responsibilities for implementation.
- Facilitate efficient auditing and monitoring throughout the different project phases.

7.2 Management and Monitoring Plan

Table 7-1 and Table 7-2 present recommended environmental management and monitoring measures to implement the project in a safe and environmentally sound manner during the construction and operation phases. The tables also show the roles and responsibilities of various entities that are required to implement these measures.

The EMMP should be included in the Tender Documents and be binding on the Contractor. The Contractor should be obligated to assign a Health, Safety and Environmental Officer with relevant experience to prepare a detailed Construction Environmental Management Plan (CEMP) and verify that it is applied. The CEMP should contain, but not be limited to the following sections:

- Traffic Management Plan
- Soil Erosion Prevention Plan
- Spill Management Plan
- Health and Safety Plan
- Water Resources Management Plan
- Waste Management Plan
- Site-Specific Dust Management Plan

Table 7-1: EMMP during Construction

Impact/ Issue	Environmental Management Measure	Method/Equipment	Implementation Responsibility	Supervision Responsibility
Occupational safety accidents	Assign a Health, Safety and Environment Officer	Daily inspection by Safety Officer	Contractor	MWI
	Prepare and abide by HASP and HMMP			
	Enforce use of safety gears and equipment			
	Noise, dust and sun exposure durations for workers should be within acceptable limits			
	Meet all health and sanitary needs of workers			
	Hold safety awareness sessions			
	Report and investigate any accident			
	Avoid working in dusty weather			
Soil erosion and contamination	Prepare and abide by a soil erosion prevention plan	Visually	Contractor	MWI MOENV
	Collect waste (both solid and liquid) regularly			
	Prepare and abide by a spill management plan			
	Designate a fueling and maintenance area			
	Provide parking site and collection area paved with an impermeable surface			
Traffic disruptions	Provide proper signage	Weekly report of traffic accidents	Contractor	Local Traffic Department/ MWI
	Prepare and abide by a traffic management plan			
	Securely pack and cover trucks with loose material			
	Provide vehicles equipped with seats and barriers for the transportation of workers			

Impact/ Issue	Mitigation Measure	Method/Equipment	Implementation Responsibility	Supervision Responsibility
Disturbance of biodiversity	Ban workers from trapping or hunting any existing fauna species in the project area and restrict removal during construction	Visually	Contractor	MWI RSCN
	Plant natural vegetation whenever possible			
	Wherever possible, restrict construction activities to one area at a time			
Increase in water demand	Provide an adequate source of water from available and approved off-site sources	Visually	Contractor	MWI
	Conserve water use and restrict the use of groundwater in construction activities			
	Hazardous Materials should be managed properly to prevent groundwater and surface water contamination			
Accumulated waste	Allocate a designated disposal site for construction waste	Visually	Contractor	MWI Hallabat Municipality
	No dumping whatsoever onsite			
	Minimize waste by reusing debris when possible.			
	Hold waste management awareness session for workers			
	Prepare a comprehensive list of all hazardous materials to be used			

Impact/ Issue	Mitigation Measure	Method/Equipment	Implementation Responsibility	Supervision Responsibility
Increased levels of emissions and dust	Prepare a site specific dust management plan	Daily monitoring: • Visually • Particulate Matter measurement (PM10)	Contractor	MWI MOENV
	Keep records of dust and air quality complaints			
	Use dust suppressant on excavated areas and all exposed surfaces			
	Minimize dust generation during dry and dusty weather			
	Cover stockpiles and vehicles delivering materials			
	Keep site perimeter and fences clean			
	Control movement on unpaved paths			
	Remove dusty materials from site as soon as possible			
	Install hard surfacing as soon as practicable on site and maintain in good condition			
	Provide site machinery that is well maintained and in full working order			
	Ensure equipment available for cleaning spills available at all times			
	Provide workers with dust protection equipment			
Increased levels of noise	Adequately muffle and maintain motorized equipment	weekly monitoring: • Noise Meter	Contractor	MWI MOENV
	Provide workers with noise protection equipment			
	Schedule several noisy activities to occur at the same time whenever possible			

Impact/ Issue	Mitigation Measure	Method/Equipment	Implementation Responsibility	Supervision Responsibility
Changes of visual character	The design should facilitate a pleasant appearance for the IWTP	Visually	Contractor	MWI
Damage of unknown archeological findings	Stop work within area surrounding any archaeological findings and immediately contact the responsible authority	Visually	DOA/ Contractor	MWI

Table 7-2 presents the EMMP that should be implemented during operation. Since the day-to-day operations activities will be managed by the SPC, most of the responsibilities in this EMMP are designated to the SPC, in addition to the third part assessor (SGS, RSS) and MWI.

Table 7-2: EMMP during Operation

Impact/ Issue	Mitigation Measure	Method/Equipment	Implementation Responsibility	Supervision Responsibility
Occupational safety accidents	Assign a Health, Safety and Environment Officer	Daily inspection by Safety Officer	Operator	MWI
	Prepare and abide by HASP and HMMP			
	Enforce use of safety gears and equipment			
	Meet all health and sanitary needs of workers			
	Hold safety awareness sessions			
	Report and investigate any accident			
Disturbance of biodiversity	Ban workers from trapping or hunting any existing fauna species in the project area	Visually	Operator	MWI RSCN
	Plant natural vegetation whenever			
	Restrict operation activities outside the IWTP			
	Maintain perimeter security fencing regularly			

Impact/ Issue	Mitigation Measure	Method/Equipment	Implementation Responsibility	Supervision Responsibility
Increased levels of emissions and dust	Monitor gaseous emissions.	Weekly monitoring: • Gas analyzer/ manual observation	Third Party Assessor Department of Traffic	MWI MOENV
	Keep records of dust and air quality complaints			
	Use dust suppressant on all exposed surfaces			
	Regulate and maintain used vehicles			
Contamination of soil and water resources	Monitoring of surface and groundwater	Weekly monitoring of water and soil quality Annual monitoring of heavy metals Log of water quality	Third Party Assessor	MWI MOENV
	Prepare and abide by a soil erosion prevention plan			
	Collect waste (both solid and liquid) regularly			
	Prepare and abide by a spill management plan			
	Designate a fuelling and maintenance area			
	Provide parking site paved with an impermeable surface			
	Install and maintain run-off draining channels			
	Train farmers on how to minimize runoff			
Traffic disruptions	Prepare and abide by a traffic management plan	Weekly report of traffic accidents	Operator	Local Traffic Department/ MWI
	Schedule unloading and uploading activities			
	Avoids peak traffic hours			
	Provide vehicles equipped with seats and barriers for the transportation of workers			

8 PROPOSED ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGY AND SCHEDULE

If the decision is made to implement the proposed project, the project proponent should prepare an EIA in accordance with Jordan Regulations No. (37) of 2005, Environmental Impact Assessment Regulations, and Title 22, Code of Federal Regulations, Part 216, USAID's Environmental Compliance Procedures; and consistent with the requirements of any lending organization that provides financing for the project. The contractor should hire a qualified consulting entity to conduct the EIA study. The consulting entity should conduct field investigations, desktop research and consult with experts, when required, in order to efficiently assess the existing environment, address all the significant environmental impacts related to this project, and formulate an EMMP to mitigate the significant negative impacts and define the institutional responsibilities for implementing these measures.

8.1 Literature and Data Review

8.1.1 Data Collection for Existing Environment

The EIA team should review all available data about the project area, as well as The Zarqa IWTP Final Design Report. This will include review of studies and investigations related to the existing industrial wastewater collection and treatment practices, in addition to the review of all available reports on The Zarqa IWTP.

The data may include: meteorological, population, water resources, soil and archeological resources data.

8.1.2 Review of Available Literature

Data will be collected by reviewing several pertinent documents, including but not limited to the following:

- Zarqa IWTP - Assessment of Treatment Alternatives/Feasibility Study
- Geotechnical Investigation Report – Proposed Zarqa Industrial Wastewater Treatment Plant, 2015
- International Center for Geotechnical Studies, Geotechnical Investigation Report for the Proposed Project at Zarqa Industrial Estate, June 2007
- Data from the Department of Statistics publications
- Jordan Climatological Handbook and Bulletins
- Handbook of the Geology of Jordan, Burden, 1959
- Geology of Jordan, Abed, 2000
- Geology of Jordan, Bender, 1974
- Jordan Country Study on Biological Diversity, Mammals of Jordan and Plant Biodiversity and Taxonomy: the report will aid in the identification of flora and fauna in the project area.

The legal requirements and regulatory constraints in Jordan should also be reviewed and described. Relevant environmental laws, by-laws, guidelines and standards should be addressed.

8.2 Field Investigations

Data should be collected first hand through several field visits to the project site. Field investigations, including "walk" surveys should be conducted during the preparation of the

EIA document to acquire a comprehensive understanding of the environmental conditions at the site. During the investigations, the potential impacts on the project site area should be considered and mitigation measures should be proposed in order to be implemented during the construction and operation phases of the project.

8.2.1 Surface Water and Groundwater Assessment

A field survey should be undertaken to verify details of the existing surface water discharge in the area, and identify the main recharge zones in the project area. Where feasible, water samples from nearby surface water and ground water sources should be collected, to establish the baseline conditions, for comparison with the concentration of elements that may be associated with project activities.

In addition, routing and direction of groundwater flows should also be assessed in order to evaluate the impacts of the proposed project on the groundwater and to identify any potential wastewater run-off issues.

Moreover, the study should include impacts on surface water and ground water quality from project activities, such as waste dumps and leachates. It should also recommend mitigation measures to be implemented to protect water resources in the project area.

The study should also assess water needs for the different project activities and develop a “Water Management Plan”.

8.2.2 Air Quality and Noise Baseline Study

Dust emissions and noise level during construction period should be assessed qualitatively.

Air quality and noise levels associated with the long-term operation of the IWTP also need to be monitored. In order to establish a baseline for the concentrations of air pollutants and noise levels, air quality and noise testing should be carried out. Sampling should be conducted at several testing points inside and outside the disposal facility boundaries. In addition to noise, key parameters that should be tested include:

- Sulphur Dioxide (SO_2);
- Hydrogen Sulfide (H_2S) ;
- Nitrogen Dioxide (NO_2);
- Ozone (O_3);
- Carbon Monoxide (CO);
- Carbon Dioxide (CO_2);
- Ammonia (NH_3);
- Total Suspended Particles (TSP); and
- Particulate matter (PM10, PM 2.5).

Samples should be collected and analyzed according to the JS 1140/2006 Ambient Air Quality Standards (daily and hourly measurements). Odors inside the facility should also be assessed and monitored regularly.

8.2.3 Ecological Assessment

An ecologist should conduct several site visits in order to evaluate the existing ecological conditions. The assessment should focus on obtaining baseline data of the biological environment in the project area. This is to highlight any environmental concerns that may arise upon the implementation of the proposed project on the existing biological conditions, during construction and operation phases. Moreover, the study should recommend

approaches to reduce any potential threats on endangered species, to comply with national and international protection requirements.

8.2.4 Socio-economic Study

A socio-economic study should be conducted to investigate the socio–economic and demographical characteristics of the project area. Both qualitative and quantitative data collection and analysis should be carried out. The quantitative approach would enable the socio-economist to thoroughly analyze the socio-economic conditions of the people in the project area; the qualitative approach would enhance interpretation of the quantitative data.

The study should discuss the socio-economic changes influenced by the project. The socio-economist should hold focus discussion groups meetings to survey and assess the public perceptions and views of the local community in the project area. In addition, the socio-economic study should highlight the influence of the local social norms and socioeconomic conditions on the project.

The study should recommend mitigation measures for adverse impacts.

8.2.5 Human Health Assessment

Statistical data and information related to health conditions in the area should be collected, along with identifying health-related issues resulting from construction and operation of the project. Information can be obtained via different official entities and through face-to-face interviews with people working on site.

8.3 Scoping

If scoping is required, project stakeholders and affected communities should be invited to participate in a scoping session. Public consultation in early stages of the project can prevent potential problems that
may otherwise arise in more serious forms at later stages in the review process.

The scoping session should identify and discuss environmental issues associated with the project. Names of participants and details of the scoping session's activities should be documented in the EIA report.

8.4 Environmental Impact Identification and Assessment

The EIA team should identify and assess the anticipated impacts. The assessment of the impacts should cover the following elements:

- Nature: this indicates whether the impact on the environment is positive or negative
- Significance: the impact should be classified as highly, moderately or mildly significant
- Reversibility: the impact should be classified as reversible, partially reversible, or non-reversible
- Likelihood: the impact should be classified as very likely, likely, or unlikely to occur
- Duration: the impact duration should be provided as long-term or short-term or an actual time should be specified
- Geographic extent / location: the geographic extent of the impact should be provided (e.g., area, village).

The outcomes of any investigations and surveys conducted should be incorporated and evaluated in the EIA report. Consequently, the identified impacts should be thoroughly described and quantified where possible.

8.5 Development of Mitigation Measures

Mitigation measures should be developed for each impact, aiming at either avoiding or reducing the impact. The measures should be developed for various project stages, including design, construction, operation and decommissioning. The measures selected should be realistic and fairly easy to implement.

8.6 Environmental Management and Monitoring Plan Development

A comprehensive EMMP should be developed to verify that the required mitigation measures and monitoring activities are implemented and sustained throughout the progress of the project. In order to facilitate the identification of the mitigation measures and monitoring activities, the EMMP should be presented in a tabular format and should include the following:

- List of environmental and social objectives.
- List of mitigation measures for various phases of the project.
- Designation of the parties responsible for implementation.
- Description of any training needs.
- Time schedule for implementing proposed mitigation measures.
- Monitoring plan for certain parameters.
- Inspection and plan review schedule and methods.
- Public reporting.
- Proposed corrective actions.

8.7 Approvals

If scoping is required, prior to the scoping meeting a draft terms of reference should be prepared and discussed with the MoEnv. Outcomes of the scoping session should be incorporated within the final terms of reference and submitted to the MoEnv to obtain its approval to start the EIA study. Site approval from the DOA should be obtained when necessary.

18 copies of the EIA Reports should be submitted to the MoEnv, in addition to an Executive Summary that should be provided in Arabic and English. The MoEnv will review the EIA report and require further information if needed, the reviewing period is 45 days from receipt of the EIA Report.

8.8 Disciplines Required

The following experts are expected to participate in the preparation of the EIA:

- Environmental Task Leader
- Environmental Specialist
- Socio-economist
- Ecologist
- Archaeologist
- Air Quality Expert
- Health and Safety Specialist
- Geologist

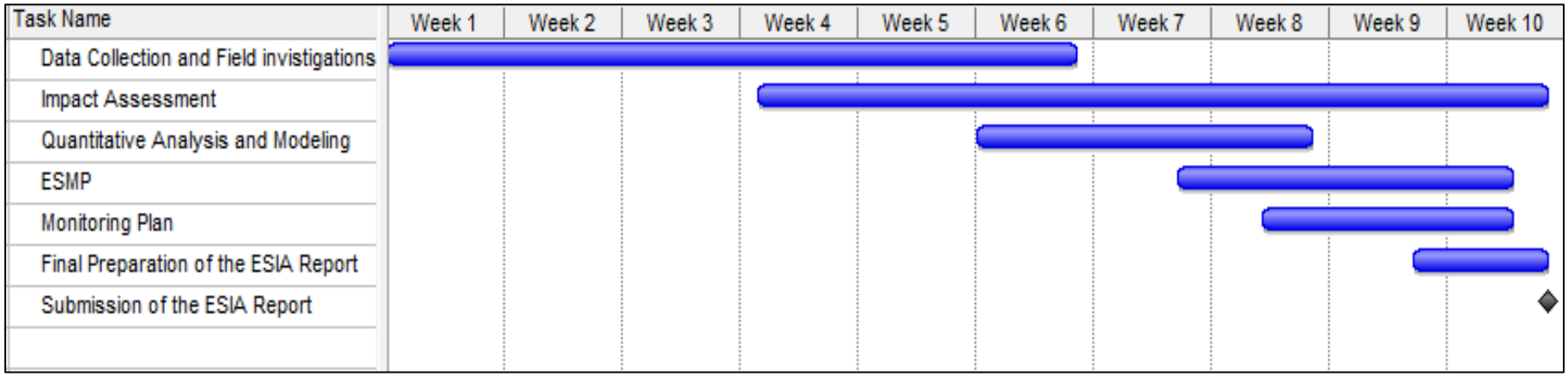
Curricula vitae of the involved experts should be provided within the EIA report.

8.9 Proposed EIA Report Outline

In accordance with EIA Bylaw, the EIA report should include the following contents:

- Executive Summary
- Background and the Purpose of the Project
- Regulatory Framework
- Alternatives including the Proposed Action
- Affected Environment
- Expected Environmental Impacts
- Environmental Management Plan
- List of Preparers
- Appendices

8.10 Schedule



9 CONCLUSIONS

This document is an Environmental Considerations Report for the proposed IWTP located in Hallabat area in Zarqa Governorate. According to the preceding discussions and the outcomes of this document, it can be concluded that the Project is not expected to cause significant adverse environmental or social impacts on the project area during construction or operation. In fact, the overall positive impacts through providing an environmentally friendly solution for the industrial wastewater problem in Zarqa Governorate will be significant, making the construction of the IWTP a necessary remedy to a growing problem.

However; the proper implementation of the EMMP is essential to validate that any negative impacts are minimized and that the environmental performance is being monitored throughout the construction and operation phases of the project.

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