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WATER REUSE AND ENVIRONMENTAL CONSERVATION PROJECT

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

Preliminary Environmental and Social Impact Assessment for As Samra Biosolids Monofill

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IMPLEMENTED BY AECOM

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PRELIMINARY ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT FOR AS SAMRA BIOSOLIDS MONOFILL OCTOBER 2014

Submitted to:

USAID Jordan

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LIST OF ACRONYMS

ACGIH	American Council of Government Industrial Hygiene
ADU	After Digestion Unit
AGTP	Ain Ghazal Treatment Plant
AZB	Amman-Zarqa Basin
B	Boron
BFP	Belt Filter Press
BOD5	Biochemical Oxygen Demand Over A 5-Day Period
BOT	Build-Operate-Transfer
Cd	Cadmium
CEMP	Construction Environmental Management Plan
CFR	Code of Federal Regulations
Cl	Chloride
Cl_2	Chlorine
DAF	Dissolved Air Flotation Units
DB	Drying Beds
dB A	Decibel
DBRW	Drying Beds During Rainy Weather
DOA	Department of Antiquities/ Ministry Of Tourism
DOS	Department of Statistics
DS	Dry Solid
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
ERC	Electricity Regulatory Commission
ET	Evapotranspiration
FAO	Food And Agriculture Organization
FS	Feasibility Study
GHG	Green House Gases
GOJ, GoJ	Government of Jordan
H_2S	Hydrogen Sulphide
HASP	Health And Safety Plan
HCO3	Bicarbonate
HDPE	High Density Polyethylene
HF	Hydrogen Fluoride
HMMP	Hazardous Materials Management Plan
HPS	Hashimyyah Pumping Station
IBA	Important Bird Area
IDI	Infilco Degremont Inc
JPRC	Jordan Petroleum Refinery Company
JS	Jordanian Standard
JSCs	Joint Services Councils
JSMO	Jordanian Standard And Metrology Organization
JVA	Jordan Valley Authority
KTD	King Talal Dam
MCM	Million Cubic Meter
MEMR	Ministry of Energy And Mineral Resources
$\mu g/m^3$	Microgram Per Cubic Meter
MOA	Ministry of Agriculture
MOEnv	Ministry of Environment
MOH	Ministry of Health
MOL	Ministry of Labor
MOMA	Ministry of Municipal Affairs
MOU	Memorandum of Understanding

MSL	Mean Sea Level
MWI	Ministry of Water And Irrigation
Na	Sodium
NEPCO	National Electric Power Company
NH_3	Ammonia
NO_2	Nitrogen Dioxide
NRA	Natural Resources Authority
O_3	Ozone
P2	Pollution Prevention
Pb	Lead
PESIA	Preliminary Environmental and Social Impact Assessment
PM_{10}	Particulate Matter 10
$PM_{2.5}$	Particulate Matter 2.5
PPM	Parts Per Million
PPP	Private-Public Partnership
PVC	Polyvinyl Chloride
RSCN	Royal Society for The Conservation of Nature
RSS	Royal Scientific Society
SAR	Sodium Adsorption Ratio
SAS	Suez Environment
SEPCO	Samra Electric Power Generating Company
SO_2	Sulphur Dioxide
SO3	Sulfur Trioxide
SPC	Samra Project Company
TFCC	Total Fecal Coliform Count [
TH	Total Hardness
TOR	Terms of Reference
TSP	Total Suspended Particulates
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
VATS	Ventilation Air Treatment System
WAJ	Water Authority of Jordan
WHO	World Health Organization
WRECP	Water Reuse and Environmental Conservation Project
WS	West-South
WSP	Wastewater Stabilization Ponds
WW	Wastewater
WWTP	Wastewater Treatment Plant
WZPS	West Zarqa Pumping Station

Executive Summary

Introduction

This chapter offers a summary of the Preliminary Environmental and Social Impact Assessment (PESIA) conducted for the design of a stand-alone biosolids monofill within As Samra wastewater treatment plant property boundary.

This PESIA is prepared in compliance with Regulation No. (37) of the Environmental Impact Assessment Regulation for 2005 and submitted to the Ministry of Environment (MoEnv) for the review and approval. It aims to provide a description of the baseline conditions related to the project so as to provide a reference point for the environmental and social impacts caused by the project. Furthermore, it aims to identify and assess potential environmental and social impacts induced by the project and recommend the relevant mitigation measures as well as an Environmental Management Plan (EMP). The analysis is based on existing available information and best professional judgment. If the MoEnv determines that potentially significant environmental and social effects may result from the proposed action, more detailed evaluations would be required in a Comprehensive EIA.

The methodology pertaining to the development of the study involved multiple visits to the project area and meetings with relevant stakeholders as well as the analysis and incorporation of other studies conducted for the project area. Additionally, sensitive receptors in the vicinity were identified prior to the commencement of the impact assessment. These include: Khirbet As Samra Village, Mazraa Village and Hashimyyah District. The team then identified the impacts of each of the relevant activities, taking into account local laws and regulations as well as the outcomes of the baseline studies and data collection.

Project Description

The biosolids monofill aims primarily at resolving the ongoing sludge storage and disposal issues at the As Samra Waste Water Treatment Plant (WWTP). Given the limited end use markets for sludge/biosolids, the monofill will allow environmentally and sound disposal of the As Samra sludge/biosolids.

As Samra WWTP is located in Al Khirbeh As Samra area within Al Hashimyyah District in Zarqa Governorate. It serves the populations of both Amman and Zarqa. An approximate number of 35,000 people live within the vicinity of a 5 km radius from As Samra WWTP in the communities southwest of the project site.

As Samra WWTP construction was completed in 2008 as part of a two-phase project. The first phase involved the construction of West Zarqa and Hashimyyah Pumping Stations, Ain Ghazal Pre-treatment Plant and conveyor lines to the WWTP from these facilities. The second phase of this project started in 2013 and is currently underway; it involves increasing the capacity of the WWTP by 40% (from 267,000 m^3/day to 367,000 m^3/day) through a Build-Operate-Transfer (BOT) contract for 25 years.

Currently, the biosolids storage areas in As Samra WWTP is around 0.56 km^2 with a capacity of 1,119,000 m^3 and a volume of 620,250 m^3 available for biosolids storage. In the years between 2008 and June 2013 a total of 203,780 tons of Dried Solids (DS) were produced at As Samra WWTP, with the DS content of solar-dried digested biosolids reaching up to 90% in over a year.

The conceptual design of the As Samra biosolids monofill was based upon the projected capacity requirements, the geometric limitations of the chosen siting area, the stability of the biosolids mass and the goal of providing an environmentally sensitive and protective solution for the disposal and management of the biosolids.

The design criteria for the project design are compliant with the United States Environmental Protection Agency (USEPA) Regulations "40 CFR, Subpart C of Part 503," which are specific to biosolids monofills.

The monofill is designed to target airspace of approximately 2,346,000 m^3 and an expected 20 years of disposal with the potential for expansion as geometry and engineering parameters allow.

Construction of monofill infrastructure and other facilities will be required in support of security, access, operations, management, and monitoring functions. It is anticipated that these features would generally be constructed in advance of or in conjunction with the first disposal cell.

The conceptual design of the biosolids monofill constitutes of the following main components:

- The installation of a single flexible membrane liner and a geo-composite drainage layer
- Daily protective cover
- A final capping system
- A stormwater management system with stormwater management basins located along the northern edge of the monofill
- A leachate collection system
- A gas collection system, a gas generation power facility with a backup utility flare station

The design will further include the following facilities and infrastructure:

- Perimeter security fencing and lockable access gates
- Exterior lighting
- Two-way vehicle traffic roads around the monofill perimeter as well as access roads on the monofill development surface
- Parking areas
- Refurbishment of the existing chlorine handling building
- An equipment fuel dispensary
- A lined leachate evaporation lagoon
- Groundwater monitoring wells
- Electrical conduit/cables within the utility trench

The proposed project further recommends and suggests measures to be taken for closure and post-closure care, methane and groundwater monitoring and restrictions for the growing of crops and grazing of animals on the vegetative surface and surrounding area.

Baseline Conditions

This sub-section offers a summary of the existing environmental and social conditions for the project area.

Climate

The climate in the study area is a Mediterranean one where the summers are dry and hot and the winters are rainy and cold. Average annual temperatures can typically range from a minimum of 13.6°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 123.4mm was recorded in the period of 2009-2013. The humidity recorded for the period of 2009-2013 was 55.6% while average annual wind speed for that same period was 3.6 knots. Metrological parameters were obtained from Zarqa Metrological Station, which is the nearest station to the study area. Additionally, the

Samra Project Company (SPC) has its own weather station which monitors and regulates various meteorological parameters.

Geology, Hydrogeology and Soils
The study area is dominated by Tertiary, Quaternary and Recent deposits. The general geology of the project area shows that the site is dominated by rock consisting of basalt belonging to Abed Olivin Basalt Geologic formation of Pliocene of upper Tertiary. This formation is exposed partly at the wadi sides within the study area, and covers the Wadi As Sir limestone formation which is exposed at adjacent areas within the As Samra WWTP.

Thick brown and pale brown soils characterize the study area; these soils consist of silty clay associated with basalt clasts. As regards structural geology, the major fault systems in the area are the Berin Fault (E-W) and the Amman Hallabat Fault System (NE-SW). No groundwater was detected onsite.

Topography
The main characteristic feature of the area's topography is the Amman-Zarqa syncline which has slopes of 20% to 30%. This syncline constitutes mountains on its northern and western sides with clear topographic relief and elevations reaching up to 1,000-1,085 m above mean sea level (MSL). The Amman-Zarqa syncline also dictates the west-east flow direction of the groundwater. Elevations in the area range from about 450 m to 1,000 m above MSL. A topographic survey of the project area was conducted by the project team.

Biodiversity
The project area falls within the Irano-Turanian realm, characterized in the main by grass steppe vegetation with small parts being dominated by perennial bushes. Additionally, the area surrounding the treatment plant is densely populated with intensive agricultural land use.

As per data obtained from the Royal Society for the Conservation of Nature (RSCN) in 2014, the area wildlife is made up predominantly of wild rodents and reptiles. Sheep have also been noted to graze in the area while the presence of the red fox (*Vulpes vulpes*) was recorded.

Critical and particularly relevant to the project area is that it falls within a designated International Bird Area (IBA). As Samra was mainly chosen due to the migrating birds passing through it during spring and autumn migration where large numbers of white storks pass. Worth noting here is that As Samra, as part of the bigger Zarqa River Basin has also been recognized as a wetland of international importance due to it being an important staging and wintering area for a wide assortment of migratory waterbirds. As of the year 2001, As Samra has been one of 22 sites subject to the annual waterbirds' census coordinated by the RSCN.

Agriculture
The treated effluent from As Samra WWTP is used to irrigate the surrounding agricultural lands which cover an overall irrigated area of more than 2,400 ha over a distance of 42 km between the treatment plant and the King Talal Dam (KTD).

These agricultural lands can be divided into two categories based on the source of irrigation; the first category includes farms irrigated directly from the As Samra WWTP while the second includes the agricultural land along the Zarqa river banks.

Water Resources
As Samra WWTP is located within Amman-Zarqa Basin (AZB) which is one of the important fresh groundwater sources in Jordan and covers mainly Amman Zarqa and Mafraq cities. The final effluent of As Samra WWTP flows into the Zarqa River through Wadi Dhuleil and

then collects in the KTD; the treated water contributes to the irrigation water supplies in the Jordan Valley.

Abstraction from the basin was around 158.6 MCM in 2010; while the basin's annual safe yield is 87.5 MCM. Water abstracted from the AZB is used for municipal, agricultural, and industrial uses.

The depth of the groundwater in the project area is at about 80 m. The groundwater flows in the same direction as the Wadi Dhuleil stream. The quality of groundwater in the vicinity of As Samra WWTP is monitored regularly by a third party (the RSS) in order to investigate and analyze the effect of As Samra WWTP effluent on the groundwater quality. Regulated wells are located up and downstream of As Samra WWTP; other wells are located to the west, southwest, east, and southeast of the plant.Recent results of groundwater quality tests for the monitoring wells showed that SO_4 concentrations are higher than the maximum allowable limits for drinking water as per the Jordanian Standards (JS 286/2008). In addition, the Boron (B) concentrations in most of the monitored wells exceed the maximum allowable limits for drinking water and require a slight to moderate degree of restriction on the use of groundwater in agriculture from most of the monitored wells.

The Sodium (Na) concentrations are higher than the maximum allowable limits for drinking water as per the Jordanian Standards (JS 286/2008), and the Sodium Adsorption Ration (SAR) imposes a slight to moderate degree of restriction on surface irrigation in all of the monitoring wells except for one. Additionally, Chloride levels (Cl) are higher than the maximum allowable limits for drinking water as per the Jordanian Standards (JS 286/2008) in most of the monitoring wells, which imposes a severe degree of restriction on surface irrigation.

Water Total Hardness (TH) levels exceeded the maximum allowable limits for drinking water specified by the Jordanian Standards (JS 286/2008) for all of the monitoring wells but one. In addition, NO3-H levels are higher than the maximum allowable limits for drinking water in the majority of wells and impose a slight to moderate degree of restriction on the use of groundwater in agriculture, while the NO3-H levels in the other wells require a severe degree of restriction on the use of groundwater in agriculture.

According to the "FAO Irrigation and Drainage Paper, Water Quality for Agriculture, 1989", HCO3 concentrations in most of the monitoring wells impose a slight to moderate degree of restriction on overhead sprinkling irrigation, with the exception of one well.

The E. coli levels in all of the monitoring wells allow the use of groundwater in agriculture as per the "WHO Guidelines for The Use of Wastewater in Agriculture, 1989".

The main sources of surface water in the project area are Wadi Dhuleil in which the effluent of As Samra WWTP flows downstream towards the Zarqa River and then collected in KTD.

Land Use

The biosolids monofill will be located within the boundaries of the existing facilities where the lands within As Samra boundaries are owned by the Ministry of Water and Irrigation (MWI).

The project area is classified as a rural area (class two) and is mostly uninhabited. Adjacent to the WWTP there is intensive agricultural land. The Project site is treeless, with few scattered small shrubs and few palm and forest trees that were cultivated by the SPC.

Additionally, a number of industries are currently located near the project site. Such projects include the Jordan Petroleum Refinery, Samra Electric Power Generation Company and Al Rajhi Cement Factory.

Air Quality
As Samra WWTP was designed and constructed in a way that reduces Greenhouse Gas (GHG) emissions by producing renewable energy from biogas collection and the utilization of hydraulic turbines. Air quality monitoring is done on a regular basis through the SPC and a third part assessor to ensure that air quality specifications stated by JS 1140/2006 are met. Recorded results for May 2013 - June 2014 showed that the concentrations of Hydrogen Sulphide (H_2S) exceeded the legal limits in all monitoring locations. Additionally, most NH_3 concentrations measured in May 2013 exceeded the legal limits in the majority of the locations.

Odors inside the treatment plant are monitored regularly by a "Five-Member-Odor Group", which consists of: two representatives from MWI, two representatives from As Samra WWTP Operation and Maintenance department, and another independent person representing the Hashimyyah Municipality. Records are kept. Odor observation records in 2014 showed that the odor was acceptable in most of the representative locations. However, in February 2014 and June 2014 the records indicated that there was strong odor in a number of areas in the plant which was shown to have resulted mainly from the limed sludge lagoons.

Noise
Noise levels are monitored in various locations both indoors and outdoors of As Samra WWTP and monitored every six months by SGS. Records show that noise levels in As Samra WWTP are below the maximum permissible limit of the Jordanian Noise Protection guidelines for industrial areas.

Solid Waste
SPC keeps records of the waste generated onsite and also from the Ain Ghazal Treatment Plant (AGTP), West Zarqa Pumping Station (WZPS) and Hashimyyah Pumping Station (HPS). Generated wastes are transferred either to Ghabawi landfill or are disposed of in As Samra itself. SPC divides its wastes into the following categories: Refusals and grits, Used Oil, Office Wastes and Sludge. It recycles a percentage of its wastes.

Fly Nuisance
SPC seeks to combat and eradicate flies via the following methods: Mixing of drying beds, fogging of the biosolids area, and spraying of storage ponds. SPC also keeps records of these measures, which intensify in the summer months, and also keeps records of the complaints received regarding fly nuisance.

Socio-Economic

Demographic Profile
As-Samra falls within Zarqa governorate and particularly within Hashimyyah locality. The total population for Hashimyyah is 32,413 (DOS, 2013), with an almost even distribution of males and females.

As per SPC records in 2014, As Samra employs 186 people. The vast majority of the employees are males and of Jordanian nationality with most (73%) being local residents of Sukhna, Hashimyyah and Zarqa.

Gender
SPC consistently keeps track of its employees and pursues a policy of hiring qualified persons regardless of gender. SPC records for 2014 show that the number of female employees stands at 3%.

Economic Activity and Income
The main industries and economic activities in the area of As Samra WWTP and its surroundings include the following:

- The Jordan Petroleum Refinery company, Samra Electric Power Generation Company, a forage crops mill, and a factory for metal pipes and iron bars in Hashimyyah
- Al Rajhi Cement Factory which is about 9 km away from SPC
- A nails and barbwire factory in Um Suleih

The average unemployment rate in Zarqa is 12.3%, with the male unemployment standing at 11.5% and the female unemployment rate at 17.3% (DOS, 2012). Average wages in the Kingdom in the reference month of 2011 were 429JDs for males and 379JDs for females (DOS, 2012).

Health
SPC has an appointed health officer and two safety officers as well as a committee for Occupational Health and Safety. This committee meets monthly and constitutes the General Manager, the head of the Health and Safety Department, a manager from each available department, an employee from each available department, and a doctor or a nurse. The health officer is responsible for following up on the medical checkups and vaccinations for the employees which are conducted every two years. Additionally, specific checkups are required for some employees depending on the nature of their jobs.

Furthermore, the safety officers are responsible for regular inspections of machinery and equipment as well as the operations. They are also responsible for handing out risk identification reports for the employees to fill out as well as taking care of work permits. Safety officers also coordinate meetings, conduct drills and follow up daily on maintenance, production and safety.

Cultural Environment
The project area falls entirely within the vicinity of the existing and operational Samra Treatment Plant. No cultural heritage sites are identified therein.

On a wider scale, Zarqa has historical relevance dating back to Saladin's days and is also home to important archaeological sites which include a number of castles and palaces.

Impacts and Mitigation Measures

This project was proposed as a solution to the existing problem of accumulated biosolids at As Samra WWTP until better beneficial reuse options can be developed. The relevant impacts and mitigation measures were identified as per project phase.

Construction Phase
Major impacts during the construction phase pertain to occupational health and safety; these relate mainly to onsite accidents and potential health problems due to gaseous and dust emissions. As a mitigation measure, all security measures (such as safety gear and equipment) as well as noise, dust and traffic controlling measures should be outlined and detailed by the Contractor in the Tender Documents and a Health and Safety Plan (HASP) as well as Hazardous Materials Management Plan (HMMP). Furthermore, traffic will increase during construction and a traffic management plan will need to be developed.

Effects on flora and fauna are expected to be minimal given that there is no significant vegetation in the vicinity of the project area and that no fauna species are likely to be affected with the exception of a herd of grazing sheep and some stray dogs. However, As Samra, as part of the bigger Zarqa River Basin, is recognized as a wetland of international importance since it is an important staging and wintering area for a wide assortment of migratory water birds. Therefore, these water birds might be at risk of disturbance due to construction noise, traffic, and presence of people. As a mitigation measure, it is recommended that construction activities be limited to one area at a time and that any removed trees be relocated or replaced. Additionally, hunting should be prohibited.

It is expected that the water demand will increase during the construction phase. This will be mediated by requiring the contractor to provide an adequate source of water that does not result in further further drawdown of local sources (such as trucking in the water supply by the Contractor) so as not to affect the local community's water supply. No impacts are expected on groundwater as the groundwater table was found to be at about 80 m below the surface thus making contamination unlikely. Additionally, fuelling and maintenance areas should be dispersed and on a sealed floor to prevent water contamination in different parts of the project area. Any leakage incidents should be dealt with immediately by using spill kits and cleaning up. Such accidents should be reported.

Soil stability might be negatively impacted by the construction activities and soil contamination might occur due to spills. Soil Erosion Prevention and Spill Management Plans that include all necessary measures and concerns should therefore be developed and abided by. Leakage incidents should be dealt with immediately and reported.

Excavation and earthwork are considered the main sources of solid waste during the construction phase in addition to the domestic solid waste generated by construction workers. Displaced soils will be stockpiled to be used later on as daily cover and for the ET cover, whereas the generated waste would need to be collected on a regular basis and a Waste Management Plan should be developed.

Impacts on air quality during construction are temporary and caused by dust generated from excavation, vehicles movement, and uncovered construction materials as well as the emissions from heavy construction machinery. Mitigation measures include the development of a Dust Management Plan, conducting dust suppression measures and minimizing dust generating activities in dry and dusty weather, whereas the regular maintenance of the machinery can help reduce emissions.

Construction activities are expected to increase the ambient noise levels. The Contractor should therefore abide by the Jordanian Instructions for Controlling and Preventing Noise and workers should be provided with noise protection equipment.

No major changes are expected concerning the visual character of the area: it will have a typical construction site appearance. No visible archaeological findings were found in the project site; however, in the case of any findings, construction works should stop and the Department of Antiquities (DoA) contacted. Additionally, the project is expected to improve the livelihood of neighbouring communities during the construction phase by creating new job opportunities.

Operation Phase

Occupational health and safety issues during the operation phase are mainly linked to the stability of the biosolids: biosolids with less than 20% DS cannot support machinery which may lead to landfill settlement and accidents. Mitigation measures involve the development of a comprehensive HASP and the appointment of a Health and Safety Officer to support its implementation. Additionally, a doctor should be assigned onsite and workers be provided with health insurance and regular checkups.

Generally, the biosolids monofill will enhance the environmental conditions within the project area given the high quality of the generated biosolids. As concerns air quality, (a) the installation of a gas collection system and (b) the development of alternatives for the utilization of gas, in addition to (c) a backup flaring system and gas monitoring wells all help to mitigate the negative impacts associated with the gas emissions (methane, hydrogen sulfide and ammonia) produced from biosolids decomposition. Additionally, the application of a daily soil cover and a final cap mitigate the bad odor that is perpetuated in the site.

Anticipated impacts to soil and water resources are minimal. The monofill is designed to include a single flexible membrane liner with a geo-composite drainage layer, in addition to the application of daily soil covers and a final capping system. Furthermore, a leachate collection system will be installed to ensure that there are no unacceptable levels of contaminants from biosolids disposal at the facility boundary and to prevent the seepage of leachate into the subsurface. Moreover, groundwater monitoring wells will be installed and regular monitoring conducted should any leakage occur. For the mitigation of runoff and run-on, a surface water runoff channel that drains the water to surface lagoons and wraps around the perimeter of the monofill is proposed.

For aesthetic purposes, a vegetative cover can be planted on the surface of the monofill. Furthermore, the design will help reduce fly nuisance by covering the currently exposed and accumulating biosolids.

The proper operation of the monofill via the burial of the accumulated sludge and application of a daily cover will also decrease fly nuisance, odour and other impacts of the sludge on air quality, which will help improve the living conditions of the surrounding communities. The monofill will additionally create new job opportunities and create a new source of revenues for SPC, either via energy generated from the gas emissions or commercial sale of the generated gas.

Closure Phase
Ongoing gas emissions and leachate production might still be a source of air, and groundwater pollution and monofill settlement is another risk after the closure. However, proper operation of the monofill and adherence to the assigned design criteria form the best precursor to ensuring proper and trouble-free monofill closure.

Furthermore, the procedures and activities pertaining to monofill closure must be planned prior to the commencement of the project. They include the following: final monofill cover, regular monitoring of settlement and air and water quality after closure, public access restriction and the vegetation of the cover.

Environmental Management Plan

The Environmental Management Plan (EMP) was developed based on the Environmental Team's understanding of the project conditions and on the findings detailed in Section 6.

Table 1, Table 2 and Table 3 present mitigation and monitoring measures recommended by the Environmental Team to ensure that the project is implemented in a safe and environmentally sound manner during the construction, operation and closure phases. The tables also show the roles and responsibilities of various entities that are required to implement these measures.

The EMP during construction 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 ensure that it is applied. The CEMP should contain, but is not limited to, the following sections:

- Traffic Management Plan
- Soil Erosion Prevention Plan
- Spill Management Plan
- Health and Safety Plan

- Waste Management Plan
- Site Specific Dust Management Plan
- Water Resources Management Plan

Table 1: EMP during Construction

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Occupational safety accidents	Assign a Health, Safety and Environment Officer	Daily inspection by Safety Officer / Supervision Consultant Team	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			
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			
Disturbance of biodiversity	Ban workers from trapping or hunting any existing fauna species in the project area and restrict removal during construction		Contractor	MWI RSCN
	Plant natural vegetation whenever possible and replace any trees moved from the project area			
	Wherever possible, restrict construction activities to one area at a time			

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Increase in water demand			Contractor	MWI
	Provide an adequate source of water from available and approved off-site sources and encourage the reuse of treated water when possible		Contractor	MWI
	Conserve water use and restrict the use of groundwater in construction activities		Contractor	MWI
	Hazardous Materials should be managed properly to prevent groundwater and surface water contamination		Contractor	MWI
Soil erosion and contamination	Prepare and abide by a soil erosion prevention plan		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			
Accumulated waste	Allocate a designated disposal site for construction waste		Contractor	MWI Zarqa 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	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Increased levels of emissions and dust	Prepare a site specific dust management plan	Monitor levels of TSP and PM10 for 3 days / monthly within WWTP	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 near sensitive receptors.			
	Remove dusty materials from site as soon as possible			
	Install hard surfacing as soon as practicable on site and ensure that it is maintained in good condition			
	Ensure any site machinery 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		Contractor	MWI
	Provide workers with noise protection equipment			
	Schedule several noisy activities to occur at the same time whenever possible			

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Changes of visual character	The design should ensure pleasant appearance of the monofill		Contractor	MWI
Damage of unknown archeological findings	Stop work within area surrounding any archaeological findings and immediately contact the responsible authority		DOA/ Contractor	MWI

Table 2 presents the EMP 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 EMP are designated to the SPC, in addition to the third part assessor (SGS, RSS) and MWI.

Table 2: EMP during Operation

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Occupational safety accidents	Assign a Health, Safety and Environment Officer	Daily inspection by Safety Officer / Supervision Consultant Team	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			
Disturbance of biodiversity	Ban workers from trapping or hunting any existing fauna species in the project area		Contractor/SPC	MWI RSCN
	Plant natural vegetation whenever possible and replace any trees moved from the project area			
	Restrict operation activities outside the monofill			
	Maintain perimeter security fencing regularly			

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Increased levels of emissions	Maintain and monitor the installed gas collection system and leachate collection system.	-	SPC/ Third Part Assessor (SGS)	MWI MOENV
	Collect, vent, or incinerate excess amount of gases		SPC	
	Regulate and maintain used vehicles		SPC/ Department of Traffic / General Directorate of Civil Defense	
	Immediate reporting of fires to local fire-fighting offices			
Contamination of soil and water resources	Monitoring of surface and groundwater	Log of water quality	SPC/Third Part Assessor (RSS)	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 channel and run-on diversion channel should be encouraged			
Changes of visual character	Ensure pleasant appearance of the monofill by applying daily cover and possibly vegetating the surrounding area	_	SPC	MWI

Table 3: EMP during Closure

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Public and occupational safety accidents	• Placement and maintenance of final monofill cover	Monthly or quarterly for three years	SPC/Third Part Assessor/ MWI	MWI
	• Regularly monitoring of monofill settlement and soil cover grading after closure and for several years			
	• Regular monitoring of air quality after closure and for several years			
	• Regular monitoring of surface and groundwater quality after closure and for several years			
	• Restricting public access to the monofill and maintain security fence regularly			
	• Maintaining vegetative surface of the monofill.			

Conclusion

According to the previous discussions and the outcomes of the PESIA, 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 sludge storage problem at As Samra WWTP will be significant, making the construction of the monofill a necessary mitigation measure to an accumulating problem until other beneficial reuse options for the generated biosolids are implemented. However, the proper implementation of the EMP is essential to ensure that any negative impacts are minimized and that the environmental performance is being monitored throughout the construction, operation and closure phases of the project.

INTRODUCTION

1.1 Background

The USAID Water Reuse and Environmental Conservation Project 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 this project 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

As part of Task 4, the project team will prepare a detailed design for a stand-alone biosolids monofill within the As Samra Wastewater Treatment Plant (WWTP) property boundary. The conceptual design report has been prepared in general conformance with the "Terms of Reference (TOR) – As Samra Sludge Management (treatment, reuse and disposal) Feasibility Study" that the project developed in November 2012. The FS report aimed at analyzing the current situation of sludge storage, disposal and reuse, and developing options for recovery/reuse and disposal over the project period in ways that are compliant with the applicable laws in Jordan and in conformance with international best practices.

In response to the Ministry of Water and Irrigation (MWI) request, the project team conducted the activities required for biosolids monofill site selection and design and gave their recommendations for the potential Biosolids Monofill site within the As Samra WWTP area; as seen in Figure 1-1.

In August 2014, the MWI approved the conceptual design report for the As Samra biosolids monofill, and based on that the project team started to develop the final feasibility report, financial and economic analysis of the biosolids facility, and the Preliminary Environmental and Social Impact Assessment (PESIA) presented herein.

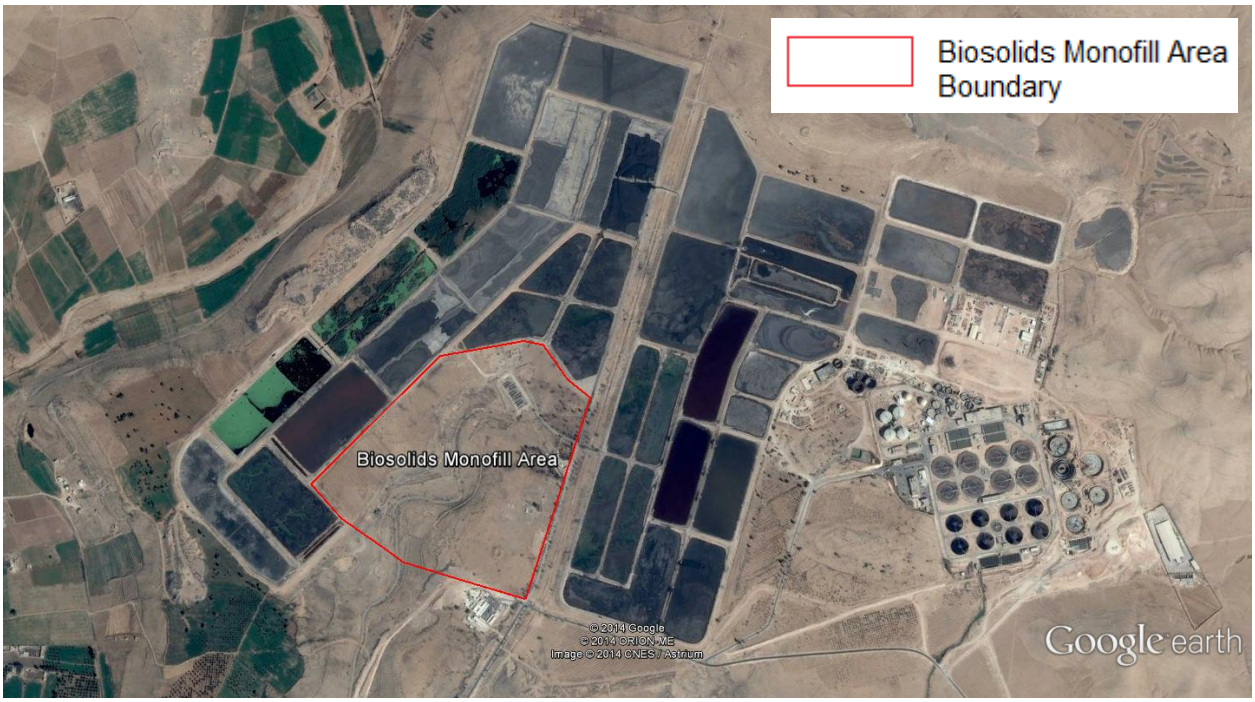

Figure 1-1: Proposed Biosolids Monofill Site within As Samra WWTP

1.2 Preliminary Environmental and Social Impact Assessment Report

This document has been prepared in accordance with Regulation No. (37) of the Environmental Impact Assessment Regulations 2005, and will be submitted to the Ministry of Environment (MOEnv) for review and approval. It was prepared by Engicon on behalf of AECOM, the implementing company for the USAID-funded Water Reuse and Environmental Conservation Project (WRECP).

Consistent with the regulations of MOEnv for Preliminary EIAs, there was no formal scoping or Terms of Reference (TOR) done. This PESIA study is based on review of the conceptual design report and previous studies and reports, data collection through field visits, and meetings with relevant authorities. The primary objectives of the study are as follows and are elaborated on in Section 4.3:

- Provide a full description of relevant baseline conditions to establish a reference point for environmental impacts induced by the project.
- Identify and assess the potential environmental and social impacts of the project.
- Propose mitigation measures to minimize the potential adverse impacts of the project on the environment and assign appropriate entities for implementation.

The study covers the regulatory and institutional framework for the project, current operations at the As Samra Wastewater Treatment Plant (WWTP) including biosolids management practices, the proposed design of the biosolids monofill landfill at the plant, the expected environmental and social impacts of the project, proposed mitigation measures for each of the impacts, and an environmental management plan (EMP) that defines the rules and responsibilities of each of the involved entities. The appendices provide supplementary information and data.

1.3 PESIA Methodology

1.3.1 Baseline Studies and Data Collection for Existing Environment

The PESIA team and the design team have conducted several site visits to the project area to obtain a better understanding of the area and its diverse components. The teams met with different concerned entities. The outcomes of these interviews were analyzed and incorporated in the PESIA report. Additionally, the results of several other studies were incorporated, some of which include:

- As Samra Biosolids Monofill Conceptual Design Report, July 2014
- As Samra Biosolids Use And Disposal Options Selection Report, April 2014
- As Samra Biosolids Management Feasibility Study, Inception Findings Report, September 2013
- As Samra Biosolids Monofill, Geotechnical Study, November 2014

1.3.2 Sensitive Receptors

Sensitive receptors were identified prior to commencing with the impact assessment process. Sensitive receptors were defined as the populated areas where the occupants would be the most affected by any adverse health and/or environmental impacts that may be caused by the project. As such, the following were identified as the main sensitive receptors given their close proximity to the project area:

- As Samra WWTP Employees
- Al Khirbeh As Samra Village
- Mazraa Village
- Hashimyyah District

The locations of the sensitive receptors and the respective distances from their boundaries to the boundaries of the WWTP can be seen in Figure 1-2 below.

In coordination with the design team, the PESIA Team identified the short- and long-term implications of each project activity on the existing environment. The impact assessment took into consideration the outcomes of the onsite investigation and interviews, relevant Jordanian regulations and standards and results of the baseline studies.

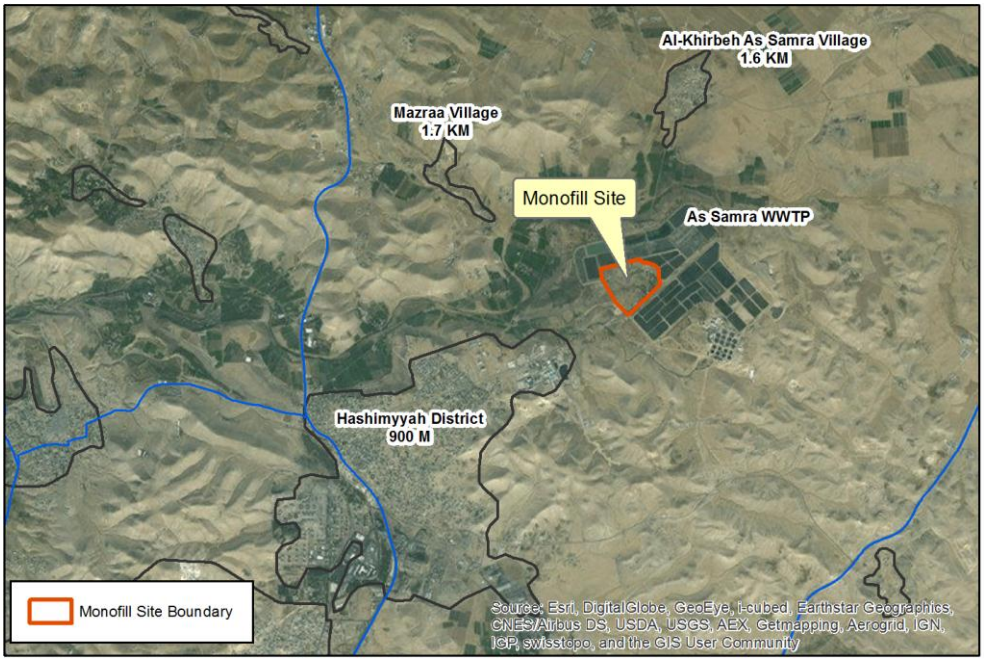

Figure 1-2: Sensitive Receptors and the Respective Distances from the WWTP

2 REGULATORY FRAMEWORK

This PESIA is done in accordance with the Jordanian Environmental Impact Assessment Regulation No. 37 for the year 2005. This section aims to identify the applicable regulatory framework in Jordan as relevant to the project. It includes the laws, regulations and standards related to environmental, health and safety, labor and planning issues.

2.1 Laws

2.1.1 Environment Protection Law (No. 52 for 2006)

In 2006, the Jordanian Law for Protection of the Environment was decreed. Article 5 of this law states that the Ministry of Environment (MOEnv) shall in cooperation and coordination with the authorities concerned with environmental affairs at the local, Arab and international level, assume the preservation of the environment elements and components from contamination.

To ensure that MOEnv is able to do that, 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 environmental impact assessment report for its projects and submit such report to the MOEnv to take the appropriate decision in its regard.

2.1.2 Public Health Law (No. 47 for 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 for 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 5-25 m 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 for 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 WWTPs, and thus it is concluded that WAJ's mandate also encompasses any product of WWTPs. However, the law does not include any explicit provisions regulating the means of sludge disposal and/or the production of biosolids for disposal or reuse.

2.1.5 Agriculture Law (No. 44 for 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 for 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 General Electricity Law (No. 64 for 2003)

By virtue of this law the Ministry of Energy and Mineral Resources (MEMR) is the responsible and governing entity for electrical energy generation and for the licensing of power-producing facilities. Article 4F of the law gives MEMR the mandate to promote the use of renewable energy for electricity generation.

This law clarifies the role and function of the Energy and Mineral Resources Regulatory Commission (previously known as the Electricity Regulatory Commission but changed by virtue of the Law for Restructuring of Governmental Organizations and Directorates No. 17 for 2014) as an independent agency responsible for regulating the power sector in three areas: generation, transmission, and, distribution.

Article 7 of the law gives the mandate to license persons engaged in electricity generation, transmission, supply, distribution and system operation. It also gives the Commission the power to determine the electric tariff, subscription fees, service fees, disbursements, and the connection charges to the transmission and distributions systems. Additionally, the Commission has the mandate to participate in determining the necessary requirements for the implementation of the environmental standards to which electrical installations ought to conform in coordination with other concerned parties.

2.1.8 Renewable Energy and Energy Conservation Law (No. 13 for 2012)

This law defines renewable energy as “energy produced from inexhaustible natural resources”, and defines renewable energy sources as “natural resources of energy including solar energy, wind energy, bio-energy, geothermal energy and hydropower”. However, there are no clear statements within the legislation in force that classify the generation of electricity from biosolids and sludge as renewable energy. Nevertheless, the legislation addresses bio-energy.

2.1.9 Labour Law (No. 8 for 2002)

The key component of this Law is stated by Article 56 paragraphs (A) and (B) regarding the right of the laborer not to 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 the Project shall comply with article 78 related to occupational health and safety, and provides essential precautions and arrangements to protect the workers from the risk of hazards and supply Personal Protective Equipment (PPE).

2.2 Bylaws and Regulations

2.2.1 Environmental Impact Assessment (EIA) Regulations (No 37 for 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 the EIA study is determined by the MOEnv and is included in the Law's annexes for the majority of projects. This regulation also states that the EIA review period for the MOEnv is 45 calendar days.

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

The provisions of this regulation prohibit anyone from causing any health nuisances within the municipal area. 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 for 1998)

The provisions of this regulation obligate any institution to take precautions and procedures to ensure prevention of occupational accidents. It identifies all 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 for 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 for 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 the 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 to detect any excesses and monitor the compliance with this regulation.

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

The Ministry of Environment 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 Ministry is responsible for assigning the 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 for 2005)

The relevance of this bylaw is in Article 3-E, which states that the MoEnv, in coordination with the relevant authorities, is responsible for protecting the 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 MOA is responsible for studying the sites of development projects and their impact on land and natural resources as well as preparing the necessary programs for the rehabilitation and cultivation of waste dumping sites after their reclamation with the appropriate crops.

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

This regulation was issued pursuant to the Environmental Protection Law No. 52 for 2006. It categorizes three levels of operational facilities based on their risk to cause environmental pollution. This categorization is further reflected in the needed frequency of environmental inspections. 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 becomes obliged to submit its original audit reports to MOEnv Article 9.

2.2.9 Regulation for Protecting the Environment from Pollution in Emergency Situation (No. 26 for 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 The Groundwater Control Regulation (No. 85 for 2002)

This regulation was issued pursuant to articles 6 and 32 of the Water Authority Law No. 18 for 1988. It governs groundwater extraction and marks 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, the Criminal Law No. 16 for 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 the water sources from pollution. It stipulates that the MWI sets 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 Ministry'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 for the Exemption of Renewable Energy Systems, Devices, Equipment and Energy Conservation (No. 10 for 2013)

This regulation defines renewable energy as "energy produced from inexhaustible natural resources", and defines renewable energy sources as "natural resources of energy including solar energy, wind energy, bio-energy, geothermal energy and hydropower." As per Annex 1 of this regulation, bio-energy systems are to be considered exempt renewable energy sources, specifically "the biogas system for electric power generation and the system for direct waste incineration for electric power generation."

2.2.13 Regulation of Land Use for 2007

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

2.2.14 Sewerage System Regulation (No. 66 for1994)

This regulation was issued pursuant to Article 32 of the Water Act No. 18 for 1988. It regulates the subscription in sewerage systems in Jordan, specifies the fees of the service

and the terms of participation. It prohibits any disposal of wastewater in the public sewerage without permission. The regulation specifies the penalties that would be applied if the authority finds that the wastewater disposed to public sewerage contains any prohibited materials. The authority has the right to subject wastewater of any institute at any time to inspection.

2.2.15 Hazardous Materials and Wastes Management, Transfer and Circulation Regulation (No. 24 for2005)

This regulation prohibits dealing with hazardous waste or dangerous substances unless a permit is obtained from MOEnv. As 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 and waste treatment and disposal of hazardous waste and dangerous substances.

2.2.16 Regulation for the Formation of Committees and Moderators of Occupational Safety and Health (No 7 for 1998)/Arabic

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, which should be commensurate with the size of the institution. The regulation also specifies the responsibilities of this committee.

2.3 Instructions

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

These instructions specify all 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 the facilities.

2.3.2 Instructions for Preliminary Medical Testing of Workers for 1998

These instructions classify all types of industries where 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 for 1998

These instructions classify all types of industries where 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 for 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 for 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 Instruction for Regulating the Transport, Storage, Manufacture, Trade and Use of Compost for 2003

These instructions are the basis for the establishment of a committee for the licensing of organic fertilizer factories. The duties of this committee are specified in this set of instructions, which specify all the requirements for the transport, storage, production, trade and use of compost.

2.3.8 Instructions for Noise Prevention for 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 Limits of the Equivalent Volume Level (dB A) according to Area Classification - Article 6 of Jordanian Instructions for Noise Prevention

Classification of the Area	The allowable maximum limit of the equivalent volume level (dB A)	
	Day	Night
Residential areas in cities	60	50
Residential areas in the suburbs	55	45
Residential areas in villages	50	40
Residential areas that have some workshops, simple crafts or business and commercial and administrative areas and center of the city	65	55
Industrial areas (heavy industries)	75	65
Education, worship and treatment places and hospitals	35	45

2.4 Standards

2.4.1 Ambient Air Quality Standards (JS 1140 for 2006)

These standards provide definitions of ambient air pollutants in addition to the maximum allowable concentration for each of those pollutants in the atmosphere, in addition to approved methods of measurement.

Table 2-2 shows the allowable maximum limits for some of the pollutants listed in JS 1140/2006. The project should comply with these limits during construction. During the operation of the highway, the pollutants generated should also comply with limits detailed hereunder.

Table 2-2: Maximum Allowable Limits Set by JS 1140/2006

Pollutant	Averaging Period	Maximum Limit	Number of Times Limit is Allowed to be Exceeded
Sulphur Dioxide (SO2)	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 (NO2)	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 (O3)	1 hour	0.12 ppm	-
	8 hours	0.080 ppm	-
Particulate Matter 10 (PM10)	24 hours	120 µg/m^3 **	3 times in any 12-month period
	Annual	70 µg/m^3	-

Pollutant	Averaging Period	Maximum Limit	Number of Times Limit is Allowed to be Exceeded
Particulate Matter 2.5 (PM2.5)	24 hours	65 µg/m^3	3 times in any 12-month period
	Annual	15 µg/m^3	-
Total Suspended Particulates (TSP)	24 hours	260 µg/m^3	3 times in any 12-month period
	Annual	75 µg/m^3 (geometric average)	-

*ppm: parts per million ** µg/m^3: microgram per cubic meter

2.4.2 Air Emissions from Stationary Sources (JS 1189 for 2006)

These standards provide definitions of stationary sources of air pollutants in addition to the maximum allowable concentration for each of those pollutants in the atmosphere. They also define approved methods of measurement. Furthermore, MOEnv has the legal mandate to oblige entities with an expected risk of exceeding permissible air emission levels to install the required equipment to make air emissions fall within standards. Table 2-3 shows the allowable maximum limits for some of the pollutants listed in JS 1189/2006.

Table 2-3: Maximum Allowable Limits Set by JS 1189/2006

Pollutant	Maximum Limit mg/ m^3
Sulphur Dioxide (SO_2):	
Combustion of petroleum products	6500
Non-ferrous metal industries	3000
Sulfuric acid industries	1500
Sulfur trioxide (SO_3), Sulphur Dioxide particulates	150
Nitrogen Dioxide (NO2):	
Combustion processes under 1200^o C	200
Combustion processes above 1200^o C	1500
Non–combustion Industrial processes	300
Volatile organic compounds	20
Lead (Pb)	0.5
Lead compounds	20

Cadmium (Cd)	0.05
Cadmium compounds	10
Chlorine (Cl_2)	30
Hydrogen Chloride (HCl)	10
Hydrogen Fluoride (HF)	15
Copper (Cu)	1
Nickel (Ni)	2
Fluorine (F_2)	5
Ammonia	50
Dioxin	$1x\ 10^{-6}$

2.4.3 Water-Sludge-Uses of Treated Sludge and Sludge Disposal (JS 1145 for 2006)

These standards regulate the entire cycle of biosolids production, transport, and eventually their reuse and/or disposal. As shown in Table 2-4, this technical regulation defines three categories of biosolids and sludge, specifies allowable reuse options for the classes 1 and 2 biosolids and permits the landfilling of all three categories (Class 3 sludge cannot be reused for any purposes and should only be landfilled). As per the Technical Regulation, the requirement for Class 3 sludge is thickening with a minimum of 3% DS (dry solids) prior to landfilling. However, relevant EPA standards require the stabilization of all biosolids/sludge prior to landfilling. JS 1145/2006 also stipulates that the piling up of biosolids prior to reuse should be done in enclosed and lined areas away from locations prone to flooding or near water bodies; the period for biosolids piling should not exceed 3 years.

This regulation further stipulates that biosolids and sludge producers should prepare and present their biosolids management plan to the regulatory and monitoring bodies. In addition, Article 5-16 prohibits the disposal of any category of biosolids/sludge in water bodies, wadis, groundwater recharge locations and sewer networks. Regulatory and monitoring bodies are authorized to enforce more stringent restrictions to what is mentioned in this Technical Regulation. The respective bodies/authorities are responsible for overseeing the adoption, review and monitoring of the implementation of these regulations. As per the JS 1145/2006, the normative reference for the application of this standard is the “Standard Methods for Testing Water and Wastewater” issued by the American Public Health Society and the Federal American Society for Water Research and Monitoring, 2001.

Table 2-4: The Maximum Allowable Concentrations in Treated Sludge, JS 1145/2006

Parameter	JS 1145/2006 Concentration limit (Metals in mg/kg on dry basis)		
	Category 1	Category 2	Category 3
As	41	75	75
Cd	40	40	85
Cr	900	900	3000
Cu	1500	3000	4300
Hg	17	57	57
Mo	75	75	75
Ni	300	400	420
Se	100	100	100
Pb	300	840	840

Zn	2800	4000	7500
Moisture Content (%)	10	50	
TFCC (MPN/g)	1,000	2,000,000	
Enteric Viruses (PFU/4g dry wt.)	1		
Intestinal pathogenic nematodes (eggs/gDS)	1		
Salmonella (MPN/4g dry wt.)	3		

3 INSTITUTIONAL FRAMEWORK

As Samra Wastewater Treatment Plant Company, Ltd. is owned jointly by the Samra Plant Consortium and the Government of Jordan (the latter being represented by the Ministry of Water and Irrigation). The Samra Plant Consortium consists of Suez Environnement (SAS) of France, Infilco Degremont Inc. (IDI) of the United States and the Morganti Group.

This section gives a brief description of each of the institutions and entities relevant to the Project.

3.1 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 would be the entity responsible for reviewing this PESIA 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 are shown in Section Two under the Regulatory Framework.

3.2 Ministry of Water and Irrigation (MWI)

MWI and its respective authorities (WAJ and JVA) 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.

3.2.1 The Water Authority of Jordan (WAJ)

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

As relevant 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 (PPPs), 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.

3.3 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.

3.4 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 agricultural farms which use the As Samra WWTP effluent.

3.5 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.

3.6 Ministry of Energy and Mineral Resources (MEMR)

MEMR is the regulator and the entity that grants permits for power generation facilities. These mandates are further extended to the Energy and Mineral Resources Regulatory Commission (previously the ERC in issues relating to electrical energy).

In the case of the project choosing to produce electricity from the collected gas, MEMR and the Commission should be informed of the expected power generation capacity. Accordingly, MEMR and the Commission have the mandate to require additional studies as they see needed. Furthermore, MEMR and the Commission are the governing entities and the ones responsible for setting the tariffs and regulating the selling of the produced power.

3.7 The National Electric Power Company (NEPCO)

The National Electric Power Company (NEPCO) is the national company responsible for the transportation of electric power via the electricity grid. NEPCO would be the entity buying the generated electricity from incineration and power generating facilities on-grid.

3.8 Samra Electric Power Generating Company (SEPCO)

SEPCO is the second largest electrical energy generator across the Kingdom. It is of relevance to the project in the event that it is decided to sell the produced gas to SEPCO rather than to independently generate electrical power from it.

3.9 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.

3.10 The General Directorate of Jordan Civil Defence

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

3.11 Jordanian Standard and Metrology Organization (JSMO)

JSMO is the entity responsible for the issuance of specifications and technical regulations, their adoption, revision and the monitoring of their implementation for all services and products. However, despite being legally authorized to do so, JSMO delegates the responsibility of overseeing the implementation to the respective bodies, which are the

relevant ministries. This includes the technical regulations and standard concerning biosolids and sludge disposal as is elaborated in Section Two “Regulatory Framework”.

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

RSCN is a non-profit, non-governmental organization which 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 Area (IBA) and is subject to the RSCN’s annual waterbirds’ census.

4 PROJECT DESCRIPTION

4.1 Project Background

The biosolids monofill intends to resolve the ongoing sludge storage and disposal issues at the As Samra Waste Water Treatment Plant (WWTP). Given the limited end use markets for sludge/biosolids, the monofill will allow environmentally sound disposal of the As Samra sludge/biosolids.

The conceptual design of the As Samra biosolids monofill was based upon the projected capacity requirements, the geometric limitations of the chosen siting area, the stability of the biosolids mass and the goal of providing an environmentally sensitive and protective solution for the disposal and management of the biosolids. The design criteria are compliant with the United States Environmental Protection Agency (USEPA) Regulations “40 CFR, Subpart C of Part 503” which are specific to biosolids monofills.

The monofill is designed to target airspace of approximately 2,346,000 m^3 and an expected 20 years of disposal with the potential for expansion as geometry and engineering parameters allow. The conceptual design and its components are discussed later on in specific detail in Section 4.2 “Proposed Design”.

As Samra Wastewater Treatment Plant is located in Al Khirbeh As Samra area within Al Hashimyyah District in Zarqa Governorate. It is 13 km north of Zarqa and 36 km from Downtown Amman 1(32° 9'15.28”N / 36° 9'50.38”E). The site location can be seen in Figure 4-1.

[1] ESIA report, 2012

Figure 4-1: The Hashemite Kingdom of Jordan Map

As Samra WWTP serves the population of Amman and Zarqa which is approximately 2.265 million people. The closest populated areas within a 5-km radius from As Samra WWTP are Al Khirbeh As Samra, Mazraa, and Hashimyyah. The WWTP is also close to the refinery and thermal power plant.

Approximately 35,000 people live within a 5-km radius of the Samra WWTP in the nearby communities of Al Khirbeh, As Samra, Mazraa, and Hashimyyah located southwest of the project between the project, refinery and thermal power plant.

As Samra WWTP was first constructed in 1985 as temporary stabilization ponds (WSP) with a capacity of 68.000m^3 /day. Due to the dramatic increase in the population of the Amman-Zarqa basin, As Samra WSP became quickly overloaded, which led to the effluent failing to meet the Jordanian standards for the discharge of treated domestic wastewater effluents to streams, wadis and reservoirs. This in turn raised a public, economic, and health concern.

A Second Master Plan funded by USAID in 1997 for the Amman-Zarqa basin from 2000 through the year 2025 recommended the construction and expansion of As Samra WWTP in two phases: phase one is the construction of As Samra WWTP through the year 2015; in phase two, As Samra WWTP will be expanded through the year 2025.

The construction of As Samra WWTP was completed in 2008. Phase one included the construction of West Zarqa and Hashimyyah Pumping Station, Ain Ghazal Pre-treatment Plant, and Conveyor lines to the WWTP from the three facilities.

In 2010, it was decided to increase the capacity of As Samra WWTP by 40% (from 267,000 m^3/day to 367,000 m^3/day), consistent with the recommendation made in the Master Plan. The expansion of As Samra WWTP is being done through a Build-Operate-Transfer (BOT) contract for 25 years, starting from 2012. The first BOT project in Jordan, it is a Public Private Partnership (PPP) financed by the USAID, Bank Consortium, Samra Plant Consortium, and the Government of Jordan (GoJ).

The expansion of As Samra WWTP will increase sludge treatment capacity by 80%, and power generation capacity to 14 MW. The expansion includes the installation of:

- one primary settling tank
- three biological tanks
- three secondary clarifiers
- three primary sludge thickeners
- two dissolved sludge activation units
- three digesters
- one francis turbine
- one digested sludge storage tank
- one mechanical sludge dewatering facility

4.1.1 Description of Existing Wastewater Treatment Practices at As Samra WWTP

Wastewater coming from Ain Ghazal Pretreatment Facility flows into two Pelton turbines in the inlet structure and generates electrical power. That wastewater is then mixed with the wastewater coming from Hashimyyah and Zarqa pumping stations and distributed into two grit and sulfide removal tanks, each divided into two chambers. Heavy particles, oil and grease and sulfide are removed in this stage. The effluent is then distributed into four primary settling tanks and up to 65% of the total suspended solids, and 40% of the BOD_5 are removed.

The settled water is then distributed into eight biological reactors that consist of three zones:

- Anoxic Zone for exogenous denitrification
- Oxic Zone for BOD_5 removal and initial nitrification
- Endogenous Zone for complete nitrification

Effluent passes through eight secondary clarifiers, and flows to two plug flow chlorine contact basins. The final effluent meets the Jordanian Standards 893/1995. Treated water is then discharged to Wadi Dhuleil and flows into the Zarqa River and then collects in King Talal Dam (KTD). Initially, three irrigation lagoons were utilized for local farmers' use (M1-1, M1-2, and M1-3). However, two months ago, these lagoons were drained and a new irrigation network was put in place instead. The wastewater treatment processes are shown in Figure 4-2.

Primary sludge from the primary settling tanks is thickened in three covered circular thickeners, while the biological sludge from the aeration tanks is thickened in three covered Dissolved Air Flotation units (DAF). The two are then mixed together in a covered tank before being pumped to four anaerobic digesters. The sludge is kept in the anaerobic digesters for three weeks at 35ºC where it is mixed thoroughly. The digested sludge flows then to the digested sludge storage tank prior to being pumped to 25 solar evaporation basins where it is dried to about 30% dry solids (DS). Lime will be used if necessary for sludge stabilization[2].

Produced biogas is stored in two gas holders and undergoes Hydrogen Sulfide (H_2S) removal before being using for electrical generation.

Odors are extracted at different points in the plant to so that no odor nuisance occurs at the site boundary. Polluted air is treated in a scrubber system that contains Biolite, a special inert medium that with naturally existing bacteria. These bacteria absorb polluting gases, after which the treated air is discharged into the atmosphere.

[2] Samra Wastewater Treatment Plant Jordan, Degrémont Jordan, 2008.

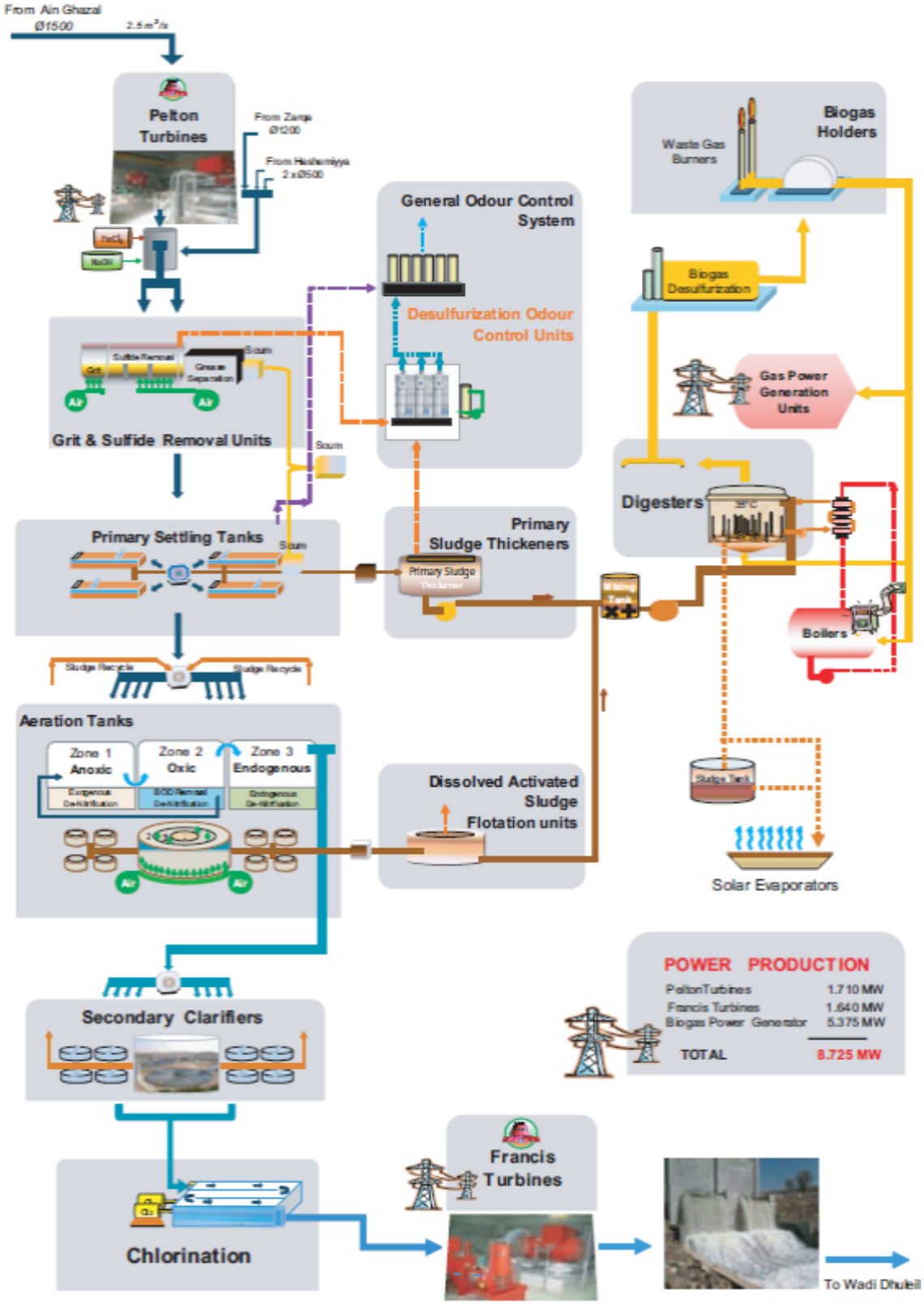

Figure 4-2: As Samra Wastewater Treatment Processes[3]

[3] Samra Wastewater Treatment Plant Jordan, Degrémont Jordan, 2008.

4.1.2 Description of Existing Biosolids Management Practices at As Samra

Most of the digested biosolids are transferred to the 16 solar drying beds to be dried from approximately 3%DS to around 30%DS and then transferred to the biosolids storage ponds; the remaining biosolids are dewatered to around 22%DS through centrifugation and sent directly to the biosolids storage ponds. If the sludge flow exceeds the capacity of the digesters, it is treated with lime and transferred to separate solar drying beds, and then stored separately in the biosolids storage ponds. This process will continue to happen until November 2014 when a new Belt Filter Press (BFP) dewatering facility will be installed and operated. The BFP facility will consist of 14 machines that will dewater the sludge continuously, 24 hours per day and seven days a week. Two machines will be on standby as redundant. The biosolids cake will be produced at a minimum of 18% DS.

The biosolids storage area in As Samra WWTP is around 0.56 km^2, and has a capacity of 1,119,000m^3. The available volume for biosolids storage is 620,250 m^3. Figure 4-3: Schematic Diagram of The Sludge Drying Lagoons and Sludge Storage Area for Biosolids Management in As Samra WWTP. There are 18 solar drying beds; only two of which are with drainage systems (M 2-3 and M 2-4). Digested sludge is placed in the solar drying beds and the supernatant is removed to M1-4. The sludge is kept to settle for two months and is mixed to enhance evaporation. When the solids reach 20% DS, sludge is transferred to the four storage ponds that are currently in use (F 2-3, F 2-4, M 2-1 and M 2-2), none of which have a liner. Generally, biosolids piles at the storage ponds' edges are the oldest, with approximately one-year difference in age between the various piles.

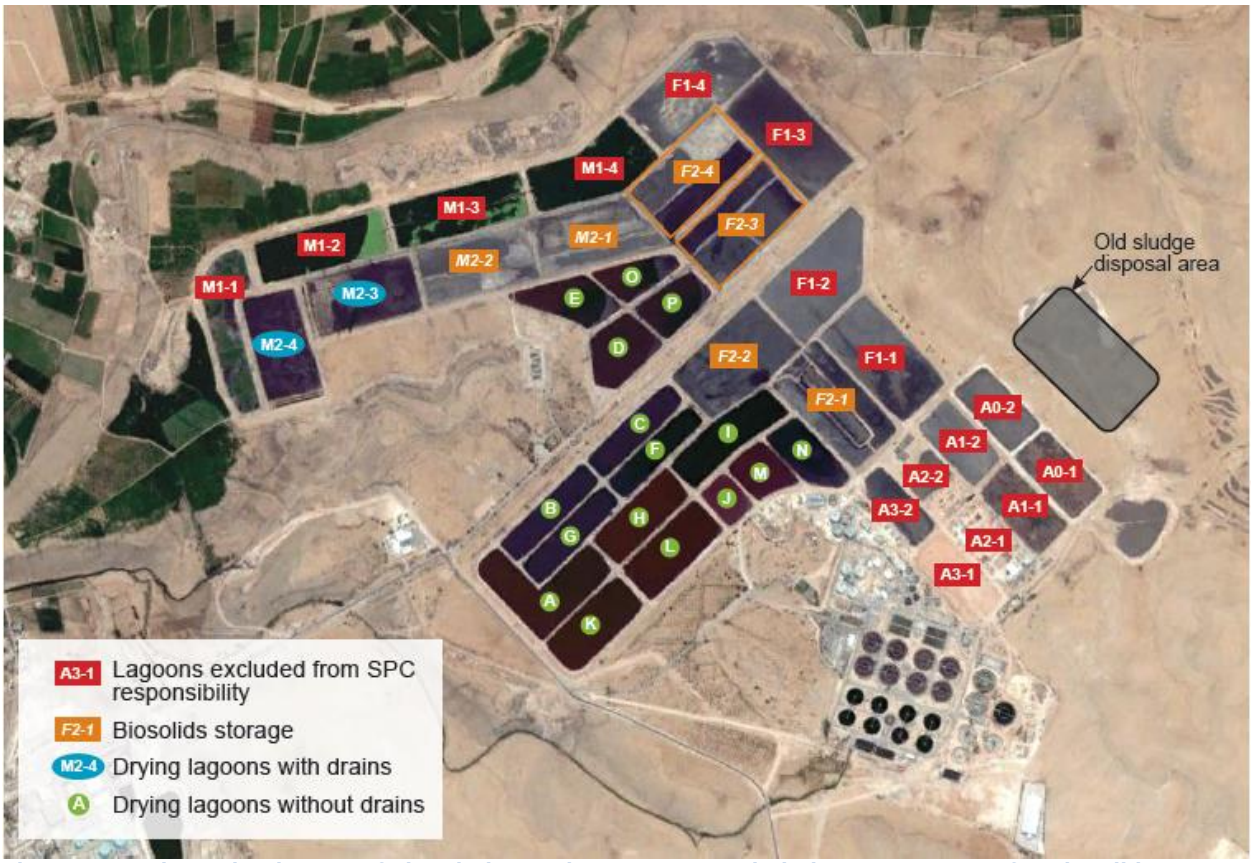

Figure 4-3: Schematic Diagram of The Sludge Drying Lagoons and Sludge Storage Area for Biosolids Management 4

[4] Source: Sogreah Report 2011

Currently, lime-treated biosolids are stored in pond I, and stay there for almost one year before being moved and mixed with other biosolids in F 2-3 and F 2-4 for storage.

Between the years 2008 and June 2013, 203,780 tons of DS were produced in As Samra WWTP. The solids content in fresh digested biosolids is about 3%, while it reaches to about 90% in solar dried biosolids that have been stored for more than one year[5]. Table 4-1shows the average daily and annual production at the plant for the years 2008-2013.

Table 4-1: Average Daily and Annual Production of Dry Solids in As Samra WWTP

Year Tons	Tons DS/day	Tons DS	Cubic Meters
2008	78.6	28,689	31,877
2009	88.0	32,120	35,689
2010	117.8	42,997	47,774
2011	103.6	37,814	42,016
2012	111.3	40,625(1)	45,139(1)
2013	118.0	21,535(2)	23,928(2)

(1) Covers quantities up to 11/11/12
(2) Covers quantities up to June 2013
Source: 2012/2013 Sludge Management Plan (SMP) report, Sludge Management Plan for the As Samra WWTP Expansion BOT Project, jointly prepared by the Samra Plant Company and the MWI

Biosolids samples are collected from several locations and tested regularly by As Samra Project Company (SPC) and a third party assessor. The Royal Scientific Society (RSS) as a third part assessor has developed the "Annual Report for Monitoring of Wastewater influent and Effluent of As Samra and Zarqa River, 2013" for the period between March 2012 to April 2013, in which it analyzed the quality of the produced biosolids in As Samra WWTP. Table 4-2 shows the average yearly concentration of physical, chemical and biological characteristics of biosolids at As Samra from April 2012 to March 2013.

Table 4-2: Average Yearly Concentration of Physical, Chemical and Biological Characteristics of Biosolids at As Samra from April 2012 to March 2013

Parameter	JS 1145/2006 Concentration limit (Metals in mg/kg on dry basis)			Sample Source		
	Category 1	Category 2	Category 3	DB(1)	ADU(2)	DBRW(3)
As	41	75	75	<7.5	<7.5	<7.5
Cd	40	40	85	1.7	1.1	2.7
Cr	900	900	3000	22	21	61
Cu	1500	3000	4300	128	163	248
Hg	17	57	57	<1.0	<1.0	<1.0
Mo	75	75	75	13.2	15	14
Ni	300	400	420	25	26	38
Se	100	100	100	<10.0	<10.0	<10.0
Pb	300	840	840	54	56	92

[5] As Samra Biosolids Management Feasibility Study, Inception Findings Report, 2013

Parameter	JS 1145/2006 Concentration limit (Metals in mg/kg on dry basis)			Sample Source		
	Category 1	Category 2	Category 3	DB(1)	ADU(2)	DBRW(3)
Zn	2800	4000	7500	1143	1120	1723
Moisture Content (%)	10	50		5.9	97.7	16.2
TFCC (MPN/g)	1,000	2,000,000		<3	6.4E+05	5.5E+01
Enteric Viruses (PFU/4g dry wt.)	1			<1	<1	<1
Intestinal pathogenic nematodes (eggs/gDS)	1			Not seen	Not seen	Not seen
Salmonella (MPN/4g dry wt.)	3			<3	<3	<3

(1) DB: Drying beds (solid) of about two years old, average of five readings
(2) AD: After digestion unit (slurry), average of two readings
(3) DBRW: Drying beds at rainy weather (solid), average of three readings
Source: Draft copy in Arabic of "Annual Report for Monitoring of Wastewater influent and Effluent of As Samra and Zarqa River," produced by RSS in April 2013 (RSS 2013).

The report indicates that Drying Beds (DB) biosolids meet Category 1 of Jordanian Standards JS 1145/2006 after a storage period of two years; therefore, they could be used as fertilizer for agricultural use. Biosolids from the After Digestion Unit (ADU), however, meet Category 3 of these standards (mainly due to Total Fecal Coliform Count [TFCC] concentration and to the moisture content), which exceeds the upper limit of Category 2. Drying Beds during Rainy Weather (DBRW) biosolids meet Category 2 of JS 1145/2006, solely due to the moisture content of the biosolids; otherwise they would meet Category 1 with regards to biological concentration[6].

4.2 Proposed Design

The conceptual design of the As Samra biosolids monofill has been based upon the projected capacity requirements, the geometric limitations of the recommended siting area (as detailed later in Section 4.4), the stability of the biosolids mass, and the intention of providing an environmentally sensitive and protective means for disposal/management of biosolids (i.e. base liner and closure cover systems).

The basis for the design of this project is the United States Environmental Protection Agency (USEPA) Regulations "40 CFR, Subpart C of, Part 503" for lined biosolids monofills.
The design recommends the installation of a single flexible membrane liner with a geo-composite drainage layer, daily protective cover, a final cap and leachate and gas collection systems to ensure that potential unacceptable levels of contaminants from biosolids disposal are not encountered at the facility boundary.

[6] As Samra Biosolids Management Feasibility Study, Inception Findings Report, 2013

The proposed design for the leachate collection system will consist of perforated polyvinyl chloride (PVC) pipes placed at regular intervals and connected to a common solid central trunk line which drains to a sump near the perimeter of the cell. Leachate collected within each sump will be pumped up to the crest of the perimeter of the cell to a leachate valve box (sump house). From there it will be directed via a subsurface High Density Polyethylene (HDPE) force main to the leachate evaporation lagoon.

A rock-lined or grouted riprap surface water runoff channel is proposed around the perimeter of the monofill adjacent to the perimeter access road and draining into the surface water lagoons. A separate run-on diversion channel will be constructed outside the monofill footprint to drain topographic low areas and to direct run-on around the monofill into the surface water lagoons.

The monofill conceptual design includes a gas collection system that consists of vertical gas extraction wells (perforated PVC piping connected to surface accessible wellheads) with connections to a flare station or monofill gas electric generator via a network of HDPE collection laterals and header piping. Generated gas might also be collected, and sold to other electric power generating companies, or even liquefied and retailed to other industries. Perforated collection pipes within sloped horizontal trenches may also be installed at lower elevations in the waste mass in order to collect produced gas before final waste heights are reached and vertical wells are installed. The gas collection efficiency was assumed to be 50%.

Although the permeability of biosolids is very low, a closure cap system will be included as part of the As Samra biosolids monofill design. The closure cap will minimize infiltration, prevent erosion, minimize odors, aid in the collection of monofill gas, and improve the visual appearance of the closed facility. Closure caps typically involve either a geosynthetic membrane system similar to the base liner system, or they consist of an evapotranspiration (ET) layer of soil, which is appropriate for the As Samra biosolids monofill due to the arid conditions in the project area.

The conceptual design further recommended that measures be taken for closure and post-closure care, methane monitoring, and public access restrictions. In addition to the managerial requirements for runoff collection, leachate collection and disposal vector control, groundwater monitoring or certification, and restrictions for the growing of crops and grazing of animals will be implemented.

The targeted airspace of the monofill is to provide for a minimum 20 years of disposal (approximately 2,346,000 m^3) with the potential for expansion of additional years as the geometry and engineering parameters allow. The geometry and operational space requirements in the chosen site Area B will have a direct influence on the total life expectancy for the facility.

The maximum monofill development slopes will be no steeper than 6H: 1V due to the shear strength of the biosolids. The phased conceptual capacity of the monofill is summarized in Table 4-3. Figure 4-4 displays the cells layout as per the conceptual design.

Table 4-3: Monofill Design Capacity

Cell Designation	Lined Area (m2)	Gross Cell Capacity (m3)	Final Cover (Assumed 1.5m thick) (m3)	Net Capacity (m3)	Life Expectancy (years)	Cumulative Life Expectancy (years)
Cell 1	59,606	575,832	14,556	561,276	5.5	5.5
Cell 2	31,324	655,845	39,880	615,965	6.3	11.8
Cell 3	46,481	726,731	18,934	707,797	5.6	17.4
Cell 4	27,916	698,340	52,844	645,496	5.1	22.5
Cell 5	36,081	917,408	175,746	741,662	5.9	28.4
Totals	201,408	3,574,156	301,960	3,272,196	28.4	

Source: As Samra Biosolids Monofill Conceptual Design

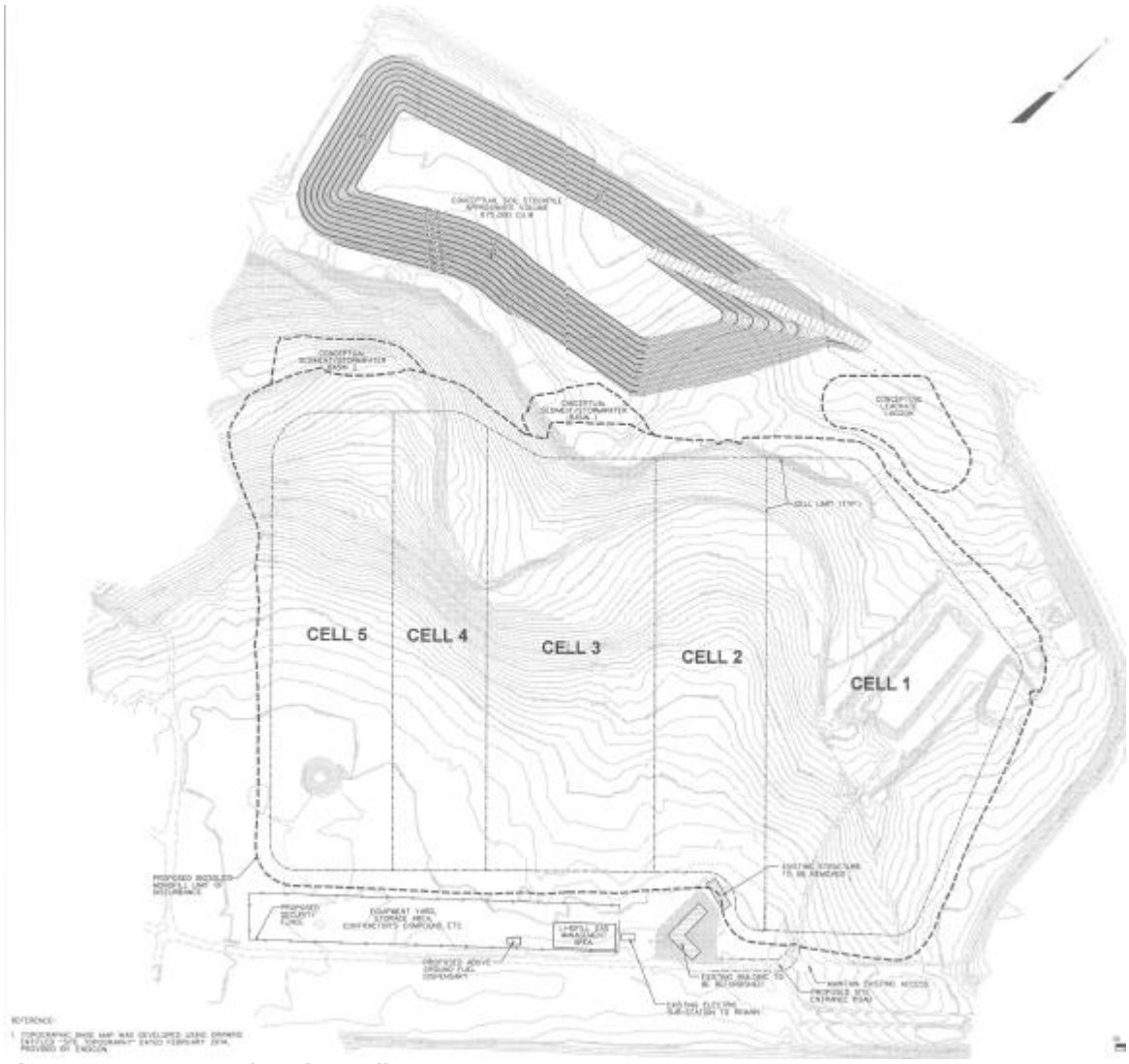

Figure 4-4: Conceptual Design Cell Layout

Each phase (or cell) of monofill development will require excavation and/or fill from the design top of subgrade elevations (cell floor and perimeter berm) to the existing topographic elevations. Cut and fill slopes will generally be no greater than 3H: 1V, except in limited areas where steeper slopes may be required for clearance issues or to minimize disturbance of adjacent features while maximizing available space for monofill disposal. Surplus excavated soils will be loaded and hauled to stockpile area(s) north of the proposed monofill area for potential future use as structural fill, daily cover, intermediate cover, and ET cap soil. The ET cap constitutes of a layer of cover soil topped with a layer of aggregate; the choice of ET cap has been found ideal given the arid nature of the region. ET covers rely on the water balance components at the site which include the water storage capacity in the soil, precipitation, surface runoff, evapotranspiration and infiltration.

Construction of monofill infrastructure and other facilities will be required in support of security, access, operations, management, and monitoring functions. It is anticipated that these features would generally be constructed in advance of or in conjunction with the first disposal cell.

The proposed monofill infrastructure and facilities include but are not limited to:

- A perimeter security fence (minimum of two meters height with barbed top extension sections and lockable access gates)
- Exterior lighting
- Two-way vehicle traffic roads around the monofill perimeter, as well as access roads on the monofill development surface (roads surfaced with crushed stone or gravel, typically 150mm to 230mm thick)
- Parking areas
- Upgraded and/or retrofitted existing chlorine handling building
- An above-ground equipment fuel dispensary within the securely fenced area
- A lined leachate evaporation lagoon, minimum size to be evaluated during the detailed design phase
- A small monofill gas generation power facility with a backup utility flare station in the monofill infrastructure area adjacent to the operations building
- Storm water management basins located along the northern edge of the monofill
- A minimum of one up-gradient and two down-gradient groundwater monitoring wells
- A common HDPE leachate force main within a perimeter utility trench along the north side of the monofill.
- Electrical conduit/cables within the utility trench

4.3 Project Objectives

The biosolids monofill aims primarily at resolving the ongoing sludge storage and disposal issues at the As Samra WWTP. Given the limited end use markets for sludge/biosolids, the monofill will allow environmentally and sound disposal of the As Samra sludge/biosolids.

This project helps in assisting the MWI in achieving the biosolids management policy objectives which include but are not limited to:

- Consider municipal wastewater biosolids as a resource and not waste
- Develop sustainable economically feasible biosolids management options through beneficial use rather than disposal, such options to be practiced in an environmentally friendly manner while protecting public health
- Encourage the reuse of biosolids as soil conditioner and fertilizer in agriculture and rangelands as may be feasible and to help address impacts of climate change

- Recover energy from the biosolids as feasible and help address impacts on climate change
- Put contingencies in place to alter the management plan should components of a selected option suddenly be no longer feasible in the future

4.4 Evaluation Of Site Alternatives

The project team evaluated two alternative locations for the proposed biosolids monofill within the As Samara property boundary. Further land procurement is not required. Figure 4-5 below shows the two alternative locations (indicated A and B) within red boundaries.

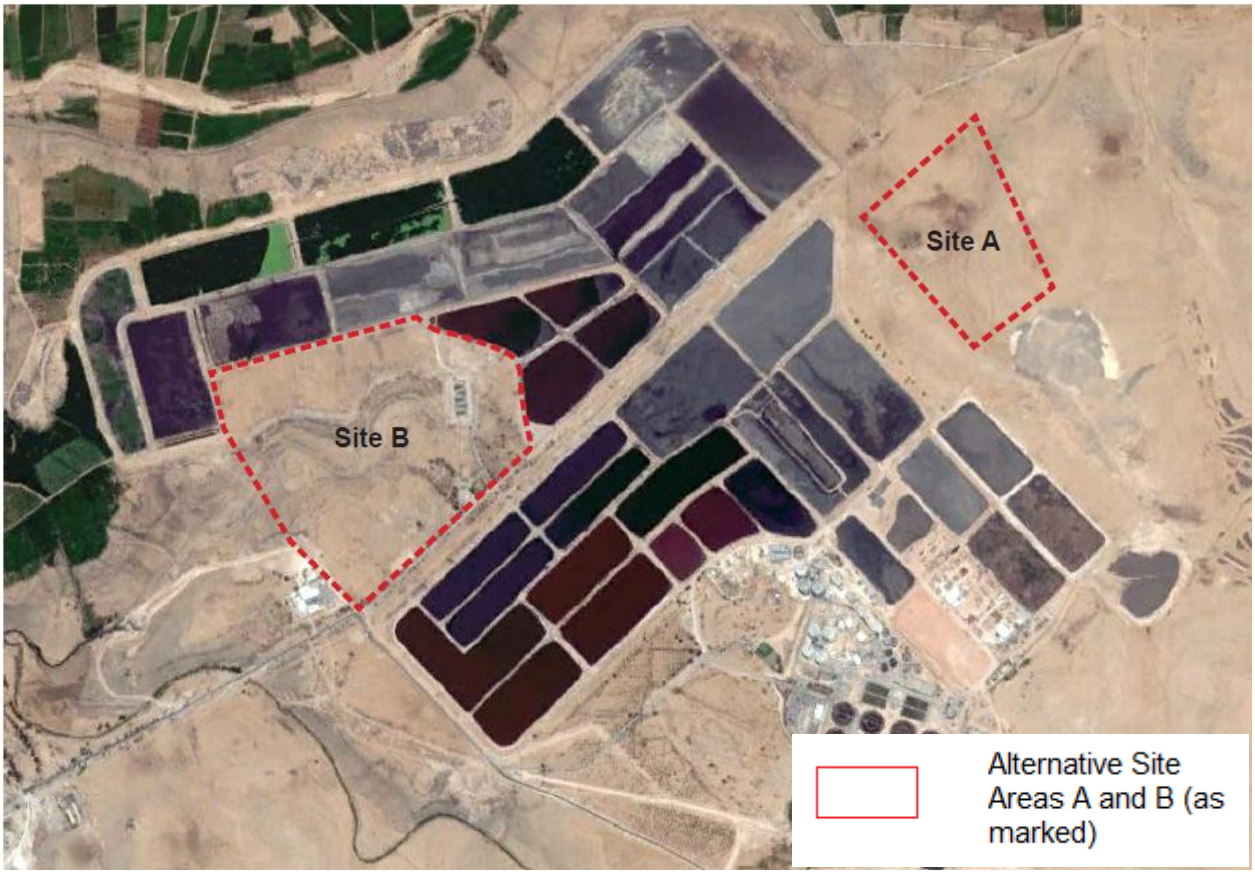

Figure 4-5: Alternative Biosolids Monofill Locations (A and B) within the As Samara WWTP

Initially, Area A was identified within the approximate 380 hectare investigation area at the head of a wadi northeast of the existing As Samra WWTP. Area B was later identified as a second potential site to the northwest of the WWTP and the existing lined drying lagoons in an area occupied by a wadi and an abandoned chlorine facility.

A topographic survey and site visits conducted for area A revealed that much of the area is not suitable for a landfill, because it is close to housing and because a wadi runs through the middle of the site. The surveyed area also has steep slopes. Exposed limestone bedrock is evident in much of the site and is partially covered in some locations by soil generally less than one meter thick. The bedrock is moderately weathered, and moderately strong. Estimated side cut excavations would be 1 Horizontal to 3 Vertical (1H: 3V).

Regarding its rippability (its ability to be excavated with conventional excavation equipment), the material is “hard” and would need to be excavated using a rock breaker. Groundwater is not expected to be encountered within the target depth.

A 3-dimensional model and resulting preliminary concept drawings were prepared, and the following conclusions were reached regarding area A:

- Does not contain sufficient space for expansion of the monofill to 20 years
- Requires a leachate manhole to be relocated at each cell construction
- Falls under the gross airspace target of 2.5 million cubic meters for the 20-year design
- Requires significant rock excavation and excavation into the current soil stockpile

The second site B was identified for consideration. It is located in the area of the abandoned chlorine facility. The site in Area B is covered by soil estimated to be greater than 4 meters deep. The soil consists of silty clay with gravel and is mostly fine (may be classified as A6-7 according to the American Association of State Highway and Transportation Officials). Estimated side cut excavations would be 1H: 1V. Regarding its rippability, the material can be considered "soft" and would have to be excavated using a backhoe. Groundwater is not expected to be encountered within the target depth.

The 3-dimensional model and preliminary concept drawings for area B revealed that:

- The site is large enough to be expandable for 25 years
- Site cut/fill balance should be achievable, assuming a restriction of 4 meters in excavation.
- The site is not anticipated to require significant rock excavation

Other criteria such as airport safety, floodplains, wetlands, fault areas, seismic impact zones, and unstable areas were reviewed and the review indicated that both Areas A and B under consideration fall outside of the associated location restrictions. These will be discussed in detail as part of the feasibility study.

Based on the field observations and preliminary modeling and concept layouts as discussed above, it is apparent that Area A has limiting factors, such as a lack of expansion capability and high costs associated with rock excavation. For these reasons, the project team recommends proceeding with Area B as the most viable option.

5 BASELINE CONDITIONS OF THE STUDY AREA

The section below details the existing environmental conditions for the project area. The project is located in Al Khirbeh As Samra area within Al Hashimyyah District in Zarqa Governorate. (See Figure 5-1).

Desktop research and literature review were conducted in order to have a general description of the biophysical and socio-economic existing conditions. Where firsthand data was needed, site visits and baseline surveys were conducted in collaboration with the design team, all outcomes obtained from the design team through their investigations and site visits are embedded in this report. Where no specific data is available for As Samara WWTP, then data from Zarqa Governorate or of the Hashemite Kingdom of Jordan is presented instead.

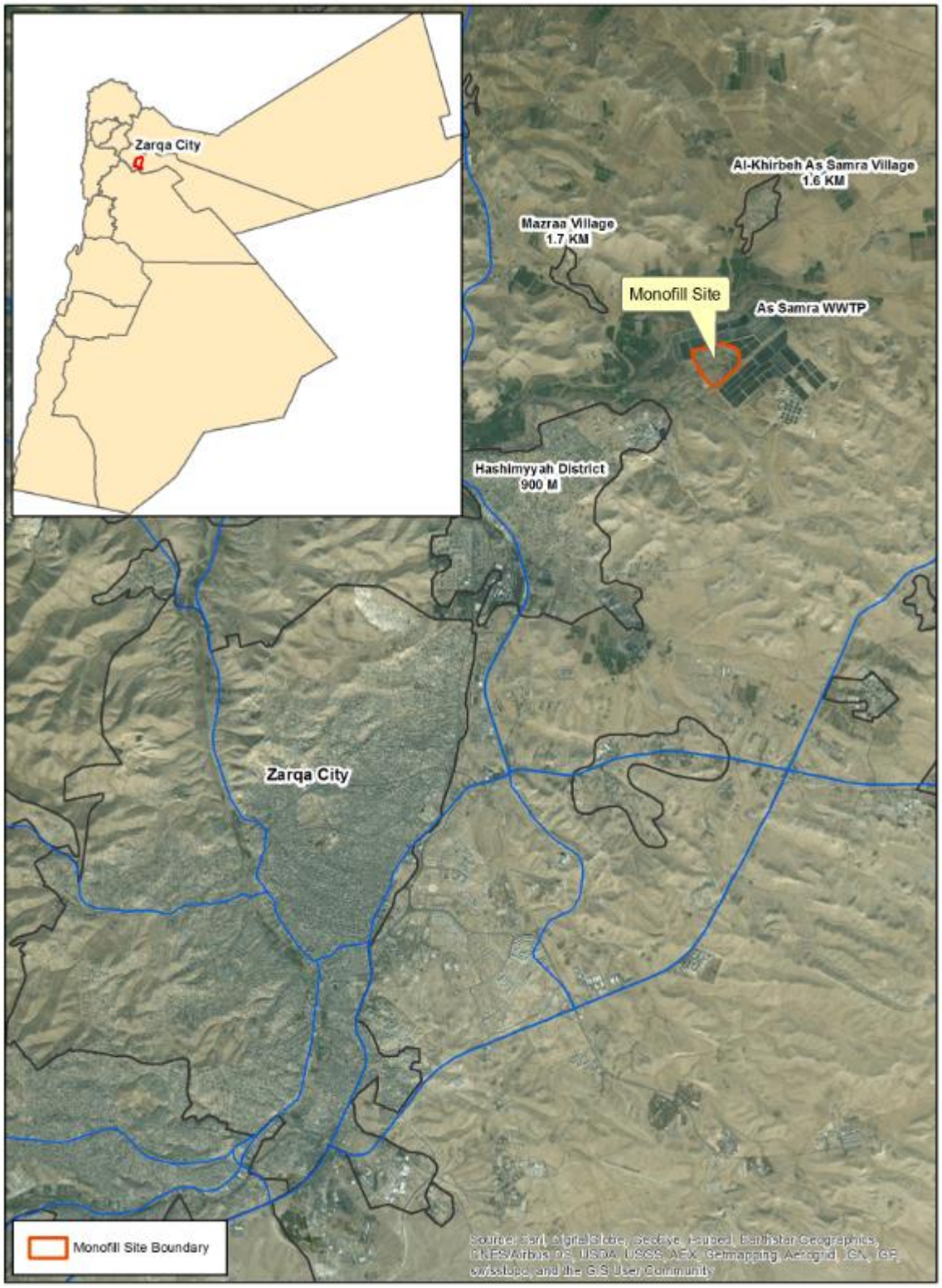

Figure 5-1: As Samra WWTP Site Location

5.1 Biophysical Environment

5.1.1 Climate

The climate in Zarqa governorate is a Mediterranean one where the summers are dry and hot and the winters are rainy and cold. Average annual temperatures can typically range from a minimum of 13.6°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 mm was recorded in the period of 2009-2013 with the maximum rainfall (136.0 mm) being in 2013. 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.

Table 5-1, Table 5-2, Table 4-3 and Table 4-5 present the metrological parameters obtained from the Zarqa Metrological Station, which is the nearest station to the study area. Additionally, SPC has its own weather station which monitors and regulates various meteorological parameters onsite. A copy of the weather logs obtained from SPC for the year 2014 is attached in Appendix A.

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 Metrological 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 Metrological Station

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

Station: Zarqa													
Total Rainfall Amount (mm)													
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 Metrological 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 Metrological 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 Metrological Station

5.1.2 Geology, Hydrogeology and Soils

The study area (monofill site) is dominated by Tertiary, Quaternary and Recent deposits. The regional geological map available for the area is of scale 1: 50,000 prepared by Mohammad Abu Qudaira, NRA (2000). A general geological map of the area is shown in Figure 5-2 below.

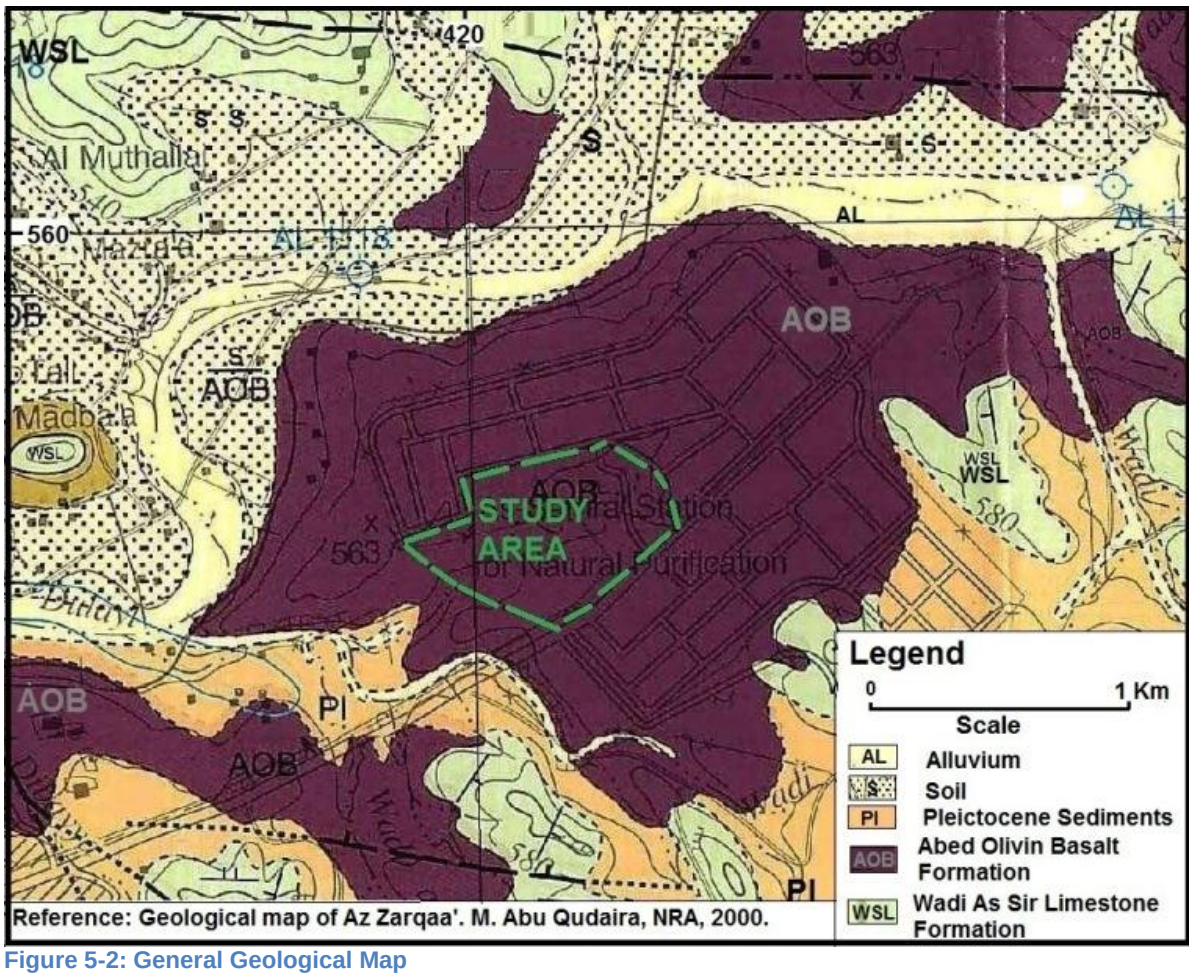

Figure 5-2: General Geological Map

The general geology of the project area shows that the site is dominated by rock consisting of Basalt belonging to Abed Olivin Basalt Geologic formation of Pliocene of upper Tertiary. This formation is exposed partly at the wadi sides within the study area, and covers the Wadi As Sir limestone formation which is exposed at adjacent areas within the As Samra WWTP.
The Basaltic formation at the study area is covered mostly by superficial deposits of soil, alluvium and Pleistocene sediments. The thickness of the superficial deposits ranges from 1.5m to more than 10m as indicated in the drilled borings at the study area. Table 5-6 shows the thickness of the superficial deposits encountered in the drilled boreholes.

5.1.2.1 Superficial Deposits

Superficial deposits in the study area can be differentiated into Pleistocene gravels, soil and alluvial deposits.

Table 5-6: Thickness of Superficial Deposits per Borehole

Borehole No	Thickness of superficial deposits (m)	Borehole No	Thickness of superficial deposits (m)
BH 1	5	BH 13	>10
BH 2	4	BH 14	>10
BH 3	4.5	BH 15	>10
BH 4	4.5	BH 16	>10
BH 5	4.5	BH 17	0.8
BH 6	3.5	BH 18	4.5
BH 7	3.5	BH 19	7.5
BH 8	5.8	BH 20	4.5
BH 9	8	BH 21	5
BH 10	5	BH 22	5
BH 11	10	BH 23	4.5
BH 12	>10	BH 24	1.5

5.1.2.2 Pleistocene Gravels

Pleistocene gravels are deposited in neighboring areas south and southwest of the study area. They consist of alternating beds of gravels, conglomerates, soil and carbonaceous arenaceous marl; these sediments are early Pleistocene in age.

5.1.2.3 Soil

Thick brown and pale brown soils characterize the study area. They consist of silty clay associated with basalt clasts. The soil in the study area is characterized as well-drained with low run-off potential.

5.1.2.4 Alluvium

Alluvium sediments of Holocene include alluvial deposits of ephemeral wadis and associated flood plains. They consist of different faces of moderate to unsorted matrix and clast-supported conglomerates. Clasts are in the range of sand to cobbles size.

5.1.2.5 Abed Olivine Basalt Formation

The volcanic exposures are represented by the Abed Olivine Phyric Basalt Formation that is exposed adjacent to and within the study area. It covers the Wadi As Sir Limestone formation.

Abed Olivine Phyric Basalt Formation is dark to medium grey and brown to dark brown in color where it is weathered, and dark grey-black to bluish black on fresh surfaces. It is holocrystalline, medium to fine grained, constituted of porphyritic basalt flows and boulders with microvesicular texture.

Petro-graphically, the formation that is relatively uniform in mineralogical composition is characterized by phenocrysts of olivine, less commonly of plagioclase and very rarely of pyroxene.

The formation is comprised of a thick and massive flow unit with a total thickness of 20 m in the study area which is of the Pliocene age (4 Ma).

5.1.2.6 Structural Geology

Regionally, the major fault systems in the area are the Berin Fault (E-W) and the Amman Hallabat Fault System (NE-SW). The Berin Fault is located approximately 6 km south of the study area whereas the Amman Hallabat Fault is located approximately 15 km southeast of the study area.

The nearest minor faults to the study area are located as follows:

- WNW-ESW Faults: Two faults were recorded: the first is located 2 km to the north of study area, while the second one is located 1.5 km south of the study area. The downthrown (which is the downward displacement of rock formations) of these two faults are towards northeast.
- NE-SW Fault: A fault trending with this direction was recorded and downthrows towards the northwest.

5.1.2.7 Seismic Impact

According to Jordan's seismic map (Jordanian National Code, 2005), the project area is located within area 2A and has a seismic zone factor (Z) of 0.15 which indicates moderate seismic activity.

5.1.3 Topography

The main characteristic feature of the area's topography is the Amman-Zarqa syncline which is the cause for the clear 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 m above mean sea level (MSL). The Amman-Zarqa syncline also dictates the west-east flow direction of the groundwater.

Furthermore, elevations in the area range from about 450 m to 1,000 m above MSL, decreasing progressively towards the east and more sharply to the west in the direction of the Jordan Rift Valley. The Zarqa River is the only water body passing through the area. The topographic survey for the Project Area was conducted in October 2013 by the Arab Surveyors and is attached in Appendix B.

5.1.4 Biodiversity

The project area (As Samra WWTP) falls within the Irano-Turanian realm where grass steppe vegetation is generally dominant with small parts being dominated by perennial bushes. Critical and particularly relevant is that the project area falls within a designated International Bird Area (IBA). The following subsections are based on data obtained from the Royal Society for the Conservation of Nature (RSCN) in the current year 2014.

5.1.4.1 Flora

As per data obtained from the RSCN in 2014, no flora surveys have been conducted in the area. It was mentioned, however, that a few batches of Aleppo Pine and River Red Gum (*Eucalyptus camaldulensusis*) are distributed randomly in the area in addition to Reed (*Phragmites australis*), which is dominant within the treatment plant. Other species present in

the hilly areas of the site include *Anabasis syriaca, Urginea maritime, Asphodelus microcarpus, Sianpis arvensis, Papver syriaca, Calendula tripterocarpa, Trifolium sp. Plantago ap. Iflago spicata, Gynandiris Sisyrhinchium, Carlina hispanis, Poa bulbosa, Romulea hybrid, Picnomon acarna, Hordeum bulbosum, Plantago app. Erodium spp.*

Furthermore, the area surrounding the treatment plant is densely populated with intensive agricultural land use. The land is generally cultivated with field crops such as tomatoes, corn and eggplant. Visits to the site indicated the presence of some forest and palm trees, as can be seen in Figure 5-3.

Figure 5-3: Forest Trees at As Samra WWTP, 11.08.2014

5.1.4.2 Fauna

As per data obtained from RSCN in 2014, the area's fauna can be said to be predominantly wild rodents and reptiles. Additionally, sheep have been noted to graze in the area while the presence of the red fox (*Vulpes vulpes*) was recorded.

Wild rodents are mainly found in the wadi systems, with *Meriones crassus* and *Gerbillus dasyurus* being characteristic and the Levant Vole (*Spalax leucodon*) being present at the boundaries of the agricultural fields.

Reptiles known in the area include *Laudakia stellio, Trapelus ruderatus* and *Acanthodactylus boskianus, Acanthodactylus grandis, Mesalina brevirostris, Mesalina guttulata, Ophisops elegans, and Varanus griseus.* At least seven species of snakes have been identified as follows: *Coluber rogersi, Eirenis coronella, Eirenis rothi, Malpolon moilensis, Psammophis schokari, Spalerosophis diadema* and *Pseudocerastes fieldi.* Figure 5-4 shows a lizard captured onsite; Figure 5-5 shows sheep grazing onsite.

Figure 5-4: Onsite Photography, As-Samra WWTP, 2011

Figure 5-5: Onsite Photography, As-Samra WWTP, 2011

5.1.4.3 Birds

As per the Royal Society for the Conservation of Nature (RSCN), As-Samra is an 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-Samra was mainly chosen due to the migrating birds passing through it during spring and autumn migration when large numbers of white storks pass. As part of the bigger Zarqa River Basin, As-Samra has also been recognized as a wetland of international importance due to it being a significant staging and wintering area for a wide assortment of migratory waterbirds.

As of the year 2001, As-Samra has been one of 22 sites subject to the annual waterbirds' census coordinated by the RSCN, a census that is part of a worldwide initiative coordinated by Wetlands International. As of 2004, the census has been continued by the RSCN to help assess the status of waterbirds and wetlands in the country for conservation purposes (The State of Jordan's Birds, 2013). The method involves the selection of vantage points from which direct counts are conducted by recording all the waterbird species observed and their individual counts (The State of Jordan's Birds, 2013). Table 5-7 below displays the latest census data provided by the RSCN for the month of January in each of the years 2009, 2010 and 2011. Figure 5-6 and Figure 5-7 provide images of the birds taken onsite.

Table 5-7: The Latest Birds Census Data for the Years 2009, 2010 And 2011 Reported In Jan.

Water Bird Type	Number recorded in Year:		
	2009	2010	2011
Wood Sandpiper	1	N/A	2
Wagtail	3	N/A	N/A
Spur-Winged Lapwing	9	N/A	N/A
Grey Heron	1	1	6
Little Stint	3	N/A	N/A
Snipe	1	19	N/A
Greenshank	1	N/A	N/A
Green Sandpiper	1	2	1
Black-headed Gull	N/A	2	N/A
White-fronted Goose	N/A	1	N/A
Lapwing	N/A	37	2
Spur-winged Plover	N/A	52	18
Coot	N/A	N/A	3
Teal	N/A	N/A	12
Pintail	N/A	N/A	7
Ruff	N/A	N/A	144
Red Shank	N/A	N/A	44
Black-winged Stilt	N/A	N/A	16
Dunlin	N/A	N/A	4
Moorhen	N/A	N/A	1
Common Snipe	N/A	N/A	6
Black Kite	N/A	N/A	1
Marsh Harrier	N/A	N/A	2

Source: RSCN, 2014

Figure 5-6: Onsite Photography, As-Samra WWTP, 2011

Figure 5-7: Onsite Photography, As-Samra WWTP, 2011

5.1.5 Agriculture

The treated effluent from As-Samra WWTP is used to irrigate the surrounding agricultural lands which cover an overall irrigated area of more than 2,400 ha over a distance of 42 km between the treatment plant and the King Talal Dam (KTD). Initially, irrigation lagoons were utilized for local farmers' use. However, these have been drained and in 2014 a new irrigation conveyance network was put in place.
These agricultural lands can be divided into two categories based on the source of irrigation: the first category includes farms irrigated directly from the collection ponds inside As-Samra WWTP; the second includes the agricultural land along the Zarqa river banks. The total agricultural land around As-Samra WWTP and Zarqa River can be seen in Table 5-8 below.

The first category of agricultural land includes 30-40 farms located in Al Mazraa and cover an area of 400 ha. These farms grow forage crops such as alfalfa and sorghum as well as olives and other fruit trees. The main irrigation methods employed by these farms are surface and sprinkler irrigation.

The second category includes over 348 farms that have an area of 2,000 ha and which mostly pump water randomly from the Zarqa River, with some using supplemental water sources such as groundwater and portable municipal water. The second category farms cover the area from the treatment outlet going through Wadi Dhuleil, Um Seleih, Gharisa, Hesaia, Douqrah and ending at KTD and are planted with forage crops such as alfalfa and sorghum most of which are sold to the local livestock breeders and dairy farms in Dhuleil area. Moreover, fruit trees (olive and almond trees mainly) are planted alongside the river.

Table 5-8 depicts the cropping patterns in the vicinity of As-Samra WWTP as shown in MWI's wastewater report for Jordan in 2013.

Table 5-8: Cropping Patterns in the Vicinity of As-Samra WWTP

Location	Area (ha)	Cropping Pattern	Water Source
Al Mazraa Area	400	- Forage (Alfalfa, Sorghum) - Fruit trees (Olive)	As-Samra WWTP (Collection Ponds)
As-Samra WWTP Outlet	300	- Forage (Alfalfa, Sorghum) - Fruit trees (Olive)	Zarqa River (As-Samra WWTP effluent)
Dhuleil		- Forage (Alfalfa, Sorghum) - Fruit trees (Olive)	- Zarqa River (As-Samra WWTP effluent) - Groundwater (Artesian) - Runoff Water - Municipal Water
Um Suleih/Gharisa		- Forage (Alfalfa, Sorghum) - Fruit trees (Olive) - Vegetables (Winter and summer crops)	
Um Sulieih Triangle		- Fruit trees (Olive) - Vegetables (Winter and summer crops) - Landscape (Turf grass, nurseries)	
Hesaia/Douqrah		- Forage (Alfalfa, Sorghum) - Fruit trees (Olive, Almonds) - Vegetables (Winter and summer crops)	
Zarqa River to King Talal Dam	1,700	- Forage (Alfalfa, Sorghum) - Fruit Trees (Olive, Almonds) - Vegetables (Winter and Summer crops)	- Zarqa River (As-Samra WWTP effluent) - Groundwater (Artesian) - Runoff Water - Municipal Water

Source: MWI Wastewater Report for Jordan, 2013

5.1.6 Water Resources

As Samra WWTP is located within the Amman-Zarqa Basin (see Figure 5-8), one of the important fresh groundwater sources in Jordan. The basin area is approximately 3950 km^2 and covers mainly Amman Zarqa and Mafraq cities. Annual average rainfall in Zarqa Governorate is 123.4 mm (2009-2013).

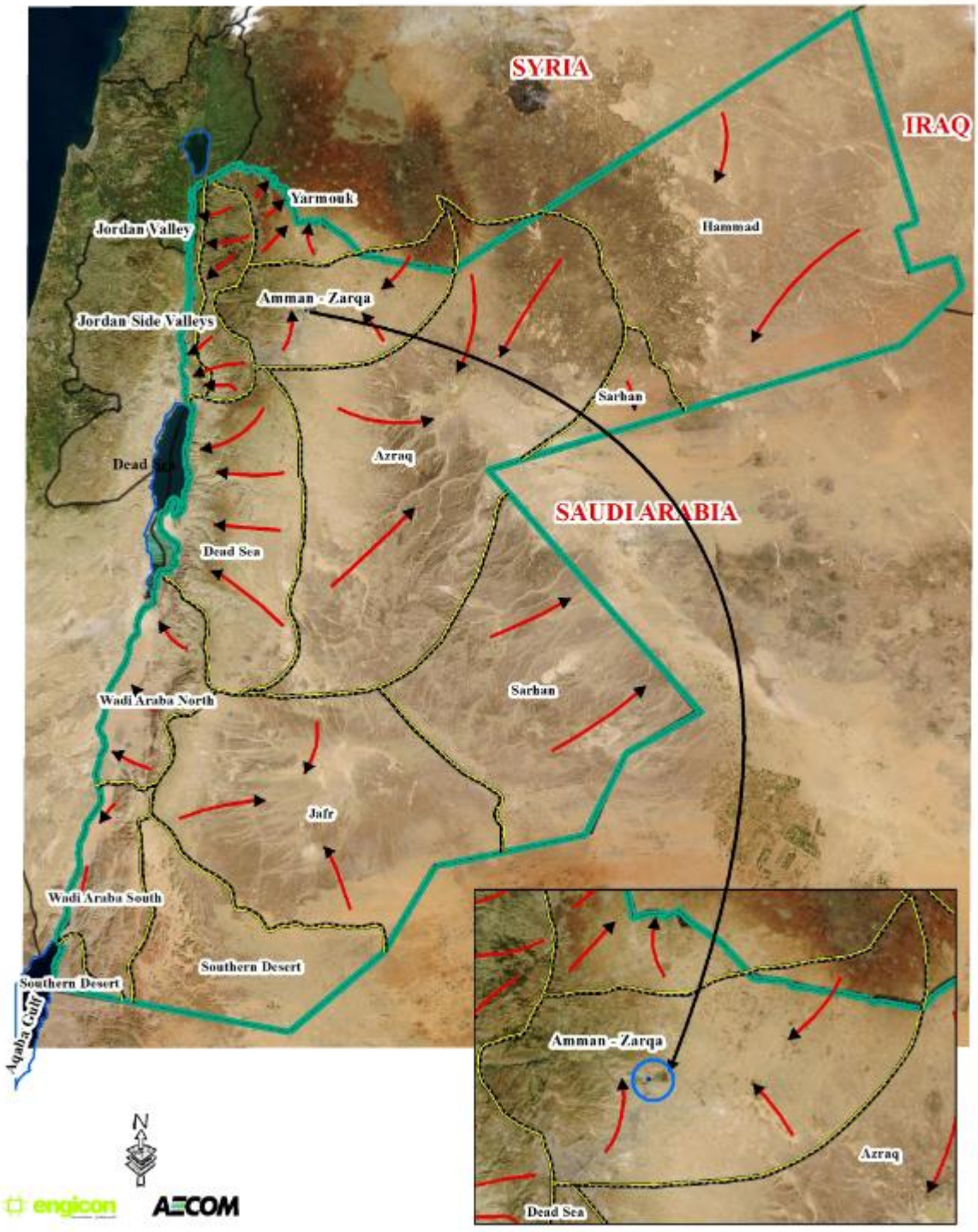

Figure 5-8: As-Samra WWTP location within Amman Zarqa Basin

The drainage pattern in Amman-Zarqa basin is primarily towards the west into the Jordan Valley area. Zarqa River main drainage course originates from the Amman area[7]. The final effluent of As Samra WWTP flows into the Zarqa River through Wadi Dhuleil and then collects in KTD. The treated water supports the irrigation water which is supplied to the Jordan Valley.

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 South-West, and by the Reft Sidis Basin to the West. Within the Amman-Zarqa Basin, the most important aquifer is the Amman-Wadi Sir (B2/A7) system.

Groundwater, surface, and non-conventional water resources in the basin area are described below:

Groundwater

The Amman-Zarqa basin is divided into two parts: an eastern part north-east 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.

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 north-east to south-west. Sub-surface recharge comes primarily from northwest (basalts). It also comes from the eastern and south-eastern 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 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 the 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 m 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, 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.

[7] ESIA for The Expansion of As-Samra Wastewater Treatment Plant

Abstraction from the basin was around 158.6 MCM in 2010; while the basin's annual safe yield is 87.5 MCM. Water abstracted from the AZB is used for municipal, agricultural, and industrial uses.

Figure 5-9 and Figure 5-10 below are based on data obtained from the Department of Statistics (DOS) and show the number of groundwater wells utilized for each sector, as well as the quantities of water extracted for each sector.

The number of registered wells was 867 in 2010. There are some illegal wells in the basin, but the number is unknown.

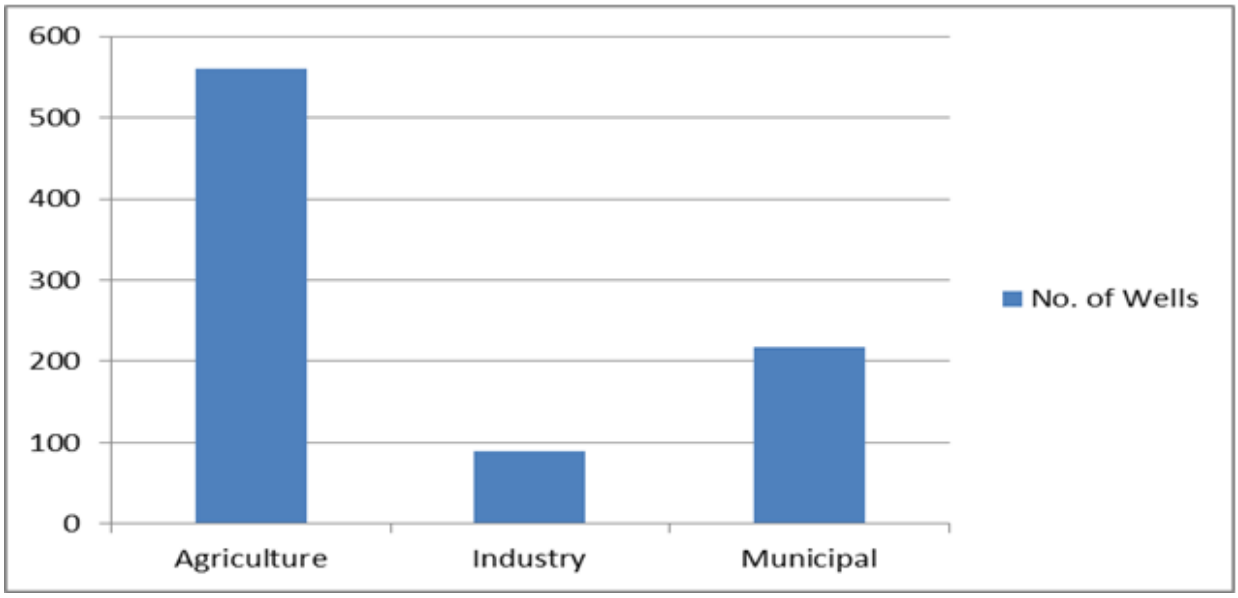

Figure 5-9: Number of Groundwater Wells in AZB Used for the Various Sectors, 2010

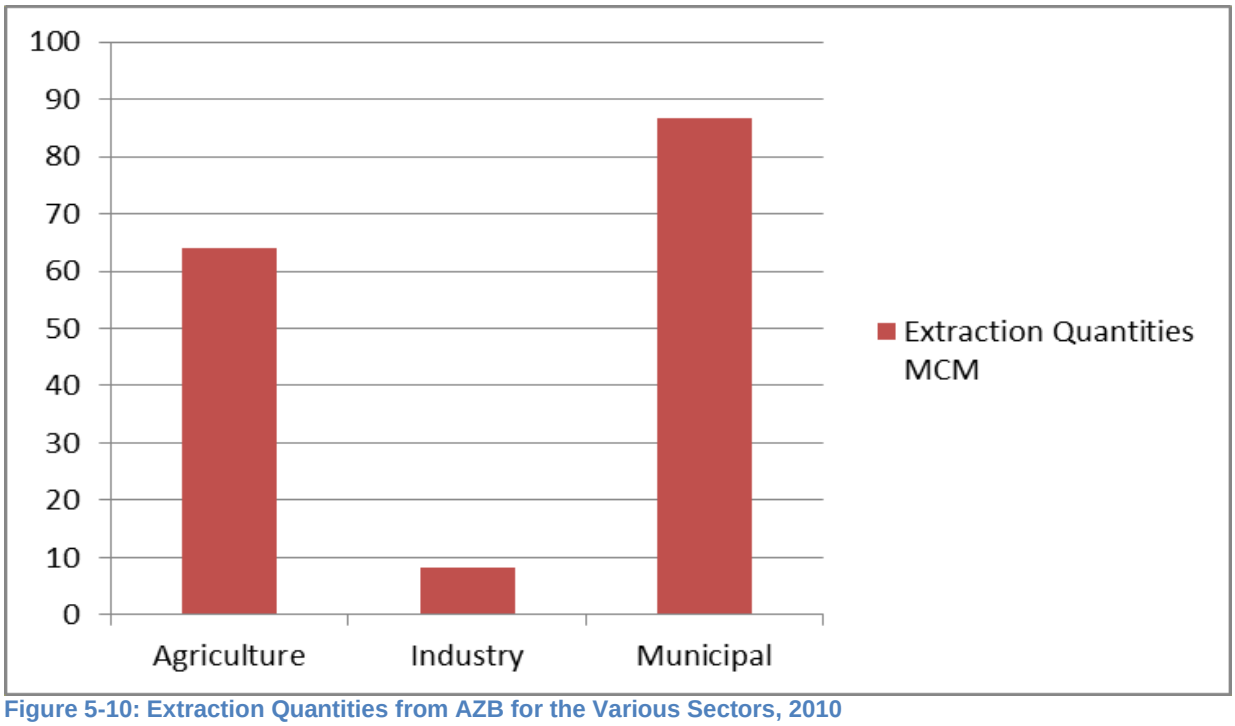

Figure 5-10: Extraction Quantities from AZB for the Various Sectors, 2010

As per the ESIA for the expansion of As Samra WWTP, all the wells designated for domestic use in the Amman - Zarqa basin are located in the Hallabat and Hashimyyah well fields.

The depth of the groundwater in the project area ranges between 45-70 m. The groundwater flows in the same direction of Wadi Dulail stream.

The quality of groundwater in the vicinity of As Samra WWTP is monitored regularly by a third party (RSS) in order to investigate and analyze the effect of As Samra WWTP effluent. Regulated wells are located up and downstream of As Samra WWTP; other wells are located to the west, southwest, east, and southeast of the plant (see Figure 5-11). Detailed information regarding the monitored wells is presented in Table 5-9.

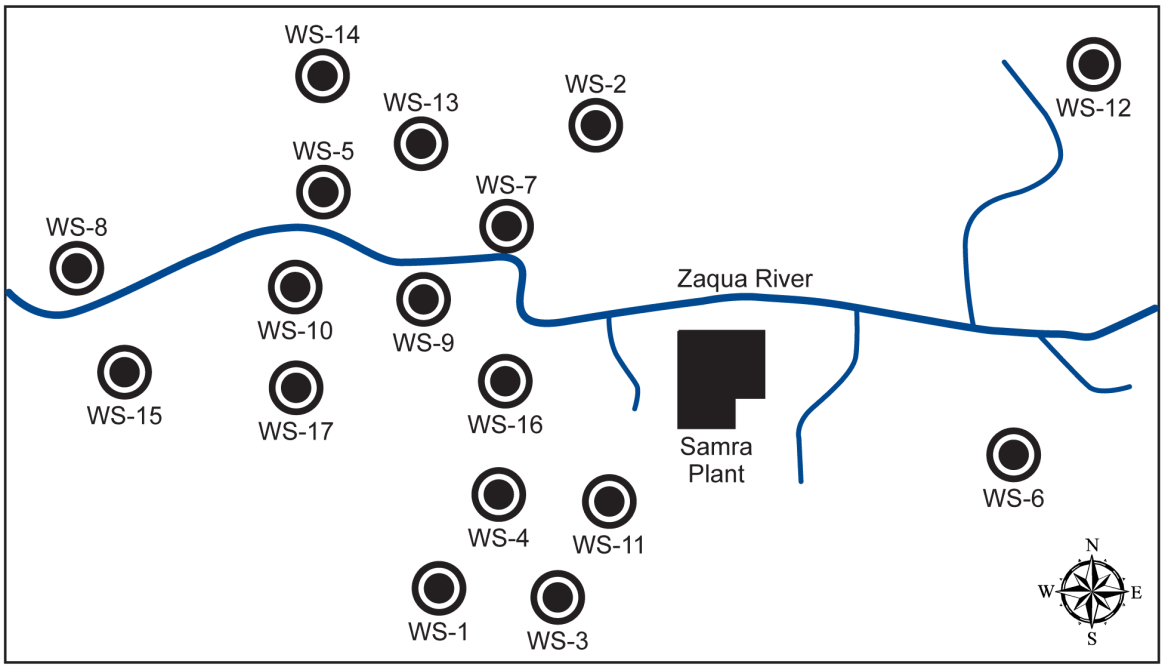

Figure 5-11: Locations of Groundwater Wells Monitored by the RSS

Table 5-9: Detailed Information on Wells Monitored by the RSS, 2012/2013

	Well Name	Well Code	Location from As Samra WWTP	Distance from As Samra WWTP (Km)	Well Depth (m)	Type of Usage
Group 1 (Upstream Wells)	Fares Al Moasher	WS-12	Northeast	40	147	Drinking
	Faisal Adogmy	WS-6	East	20	103	Agricultural
Group 2 (Downstream close to Wadi Dhuleil)	Al- Oleimat	WS-2	Northwest	4	---	---
	Fayad Azyod	WS-5	Southwest	7	---	---
	Pipes Industry	WS-7	Close to Wadi Dhuleil	4	250	Industrial
	Nezar Sha'sha'a	WS-8	Close to Wadi Dhuleil	15	39	Agricultural
	Paper Industry	WS-9	Close to Wadi Dhuleil	6	298	Industrial
	Mohammed Jardanh	WS-10	Close to Wadi Dhuleil	6.5	200	Agricultural
	Khalaf Al Mfaddi	WS-13	Close to Wadi Dhuleil	5.5	58	Agricultural
	Khalaf Salman	WS-14	West	6	---	Agricultural
	Taha	WS-15	West	13	72	Agricultural
	Abu- Riyad	WS-16	West	4	---	Agricultural
	Al Baghal	WS-17	West	4	35	Agricultural
Group 3 (Downstream Southwest of Wadi Dhuleil)	Petroleum Refinery	WS-1	Southwest	9	120	Industrial
	Al Hussein Thermal Plant	WS-3	Southwest	8	116	Industrial
	Al Hashimyyah	WS-4	Southwest	7	128	Drinking
	Al Hashimyyah	WS-11	Southwest	7	102	Drinking

Source: RSS Records, 22012/2013

As presented in Table 5-10, recent results of groundwater quality tests for the monitoring wells WS-1 and WS-17, showed that SO_4 concentrations are higher than the maximum allowable limits for drinking water as per the Jordanian Standards (JS 286/2008). According to the "FAO Irrigation and Drainage Paper, Water Quality for Agriculture, 1989", HCO_3 concentrations in most of the monitoring wells impose a slight to moderate degree of restriction on overhead sprinkling irrigation, except for the groundwater of WS-6 in which HCO_3 concentrations impose no restriction.

The Sodium (Na) concentrations are higher than the maximum allowable limits for drinking water as per the Jordanian Standards (JS 286/2008) in all of the monitoring wells except for WS-6. The Sodium Adsorption Ratio (SAR) impose a slight to moderate degree of restriction on surface irrigation for all the monitoring wells but WS-6.

Table 5-10 shows also that Chloride levels (Cl) are higher than the maximum allowable limits for drinking water as per the Jordanian Standards (JS 286/2008) in most of the monitoring wells except for WS-3, WS-4, and WS-14. Chloride levels impose a severe degree of restriction on surface irrigation for all the monitoring wells.

According to the Jordanian Standards (JS 286/2008), the Boron (B) concentrations in most of the monitored wells exceed the maximum allowable limits for drinking water. As per the FAO guidelines, the Boron levels require a slight to moderate degree of restriction on the use of groundwater in agriculture from most of the monitored wells, except for the wells located in the southwest of As Samra WWTP, WS-6, WS-12, WS-9.a, and WS-14 where no restriction is needed.

Water Total Hardness (TH) levels exceeded the maximum allowable limits for drinking water specified by the Jordanian Standards (JS 286/2008) for all of the monitoring wells but WS-4. In addition, NO_3-H levels are higher than the maximum allowable limits for drinking water in all wells except WS-3, WS-4, and WS-9.a.

NO_3-H levels in WS-1, WS-3, WS-4, WS-9.a, WS-11, and WS-12 impose a slight to moderate degree of restriction on the use of groundwater in agriculture, while the NO_3-H levels in the other wells require a severe degree of restriction on the use of groundwater in agriculture.

The E. coli levels in all of the monitoring wells allow the use of groundwater in agriculture as per the "WHO Guidelines for The Use of Wastewater in Agriculture, 1989".

Table 5-10: Average Annual Results of Groundwater Quality Tests for the Period Between (4/2012-3/2013)*

Parameter	WS-1	WS-3	WS-4	WS-5.a	WS-6	WS-7	WS-8.a	WS-9.a	WS-11	WS-12	WS-13	WS-14	WS-15	WS-16	WS-17
pH (SU)	7.32	7.19	7.20	7.09	7.26	7.04	7.19	6.61	6.99	7.29	6.93	7.17	7.73	6.88	7.05
EC (us/cm)	4423	2197	2049	3686	2827	4094	4313	3273	3301	3077	4305	2505	3785	3394	7198
Alkalinity (mg/L)	226	236	209	297	72	341	238	267	245	92	294	215	231	397	229
SO4 (mg/L)	760	208	223	X	X	X	X	X	452	X	X	X	X	X	1475
TKN (mg/L)	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5	<4.5
NH4-N (mg/L)	0.12	<0.06	<0.06	0.10	<0.06	<0.06	<0.06	0.09	<0.06	<0.06	0.08	0.07	<0.06	0.64	<0.06
NO3-N (mg/L)	23.65	7.76	8.42	54.21	38.01	44.31	47.21	6.78	13.66	14.01	30.76	32.90	35.55	<0.23	52.04
Cl (mg/L)	992	455	406	924	642	705	879	572	700	759	652	479	723	574	1610
Na (mg/L)	464	229	220	499	135	484	442	278	383	324	471	259	417	371	790
Ca (mg/L)	231	119	104	250	234	200	260	260	160	142	237	135	205	364	435
Mg (mg/L)	148	62	58	163	121	133	139	111	90	91	151	74	107	84	264
B (mg/L)	0.60	0.40	0.20	1.10	<0.10	1.20	0.80	0.40	0.60	0.30	1.20	0.50	1.30	0.70	1.50
HCO3 (mg/L)	276	288	255	343	88	416	290	325	298	113	359	262	282	485	279
SAR	5.8	4.2	4.2	6.0	1.8	6.4	5.5	3.6	6.0	5.2	5.8	4.4	5.8	4.5	7.3
Turbidity (NTU)	0.95	10.03	<0.05	2.65	0.08	1.58	3.53	0.33	0.18	0.60	0.08	0.08	0.13	32.50	0.08
Color (PCU)	7.5	<5.0	7.5	7.5	7.5	7.5	<5.0	7.5	7.5	7.5	7.5	7.5	<5.0	7.5	7.5
E. coli (MPN/100ml)	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	4.8E+01	<1.8	3.7E+01	<1.8	<1.8	<1.8	4.6E+02
AL (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cu (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fe (mg/L)	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039

Parameter	WS-1	WS-3	WS-4	WS-5.a	WS-6	WS-7	WS-8.a	WS-9.a	WS-11	WS-12	WS-13	WS-14	WS-15	WS-16	WS-17
Mn (mg/L)	0.057	<0.017	0.031	<0.017	<0.017	<0.017	<0.017	0.024	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017
Zn (mg/L)	0.083	0.083	<0.016	0.028	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016
Cr (mg/L)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Source: Annual Report for Monitoring of Wastewater influent and Effluent of As Samra and Zarqa River, produced by RSS in Arabic (RSS 2013).
* WS-2 is closed

Surface Water

The main surface water resources in the project area are:

- Wadi Dhuleil. Effluent from As Samra WWTP discharges to the Wadi Dhuleil stream. The stream rises in the desert that is northeast of the project area.
- 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 constitutes of two tributary streams that join the river at Sukhna. The River flows about 50 km downstream of As-Samra towards King Talal Dam (KTD).
- King Talal Dam (KTD). This dam was built as a reservoir with a total capacity of 86 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.

Treated Wastewater (Non-Conventional Resources)

Treated wastewater at As Samra WWTP is discharged to Wadi Dhuleil and flows downstream towards the Zarqa River. Treated wastewater formed about 55% of the total inflow to King Talal Dam (KTD). Mixed effluent from As-Samra and natural base flows and runoff are stored at KTD for irrigation. Water is released from KTD through a hydroelectric facility and passes down the river channel to a series of diversion weirs that serve irrigation projects in the Jordan Valley[8].

The quality of the streams' water is monitored regularly by the RSS in order to investigate any changes on the quality of As Samra WWTP effluent. Water samples are taken from different locations up and downstream of As Samra WWTP, to measure the effect of draining As Samra effluent to streams. Table 5-11 below presents some chemical and microbiological characteristics of water in the streams of Wadi Dhuliel, Siel Al-Zarqa, and Siel Jerash. It also compares these characteristics with those specified in the Jordanian Standards JS (893/2006) for discharging into streams, valleys or lakes and reuse in irrigation.

The table shows that most of the stated chemical characteristics meet the criteria limits of JS (893:2006). It also indicates that only the NO_3-N levels are higher than those specified in the standards for irrigation of fruit trees, highway trees and green areas.

On the other hand, E.coli levels are higher than the maximum acceptable limits as per the JS (893:200-6) for the irrigation of fruit trees, highway trees and green areas, although they meet the criteria for the irrigation of field crops, industrial crops and forest trees.

[8] ESIA for The Expansion of As-Samra Wastewater Treatment Plant

Table 5-11: Chemical and Microbiological Characteristics of Water in the Streams in Comparison to the JS (893/2006)

Parameter	Wadi Dhuleil with effluent from As Samra WWTP5	Siel Al-Zarqa with effluent from As Samra WWTP 5.1	Siel Al-Zarqa with effluent from As Samra and Jerash WWTPs 7	JS (893/2006)		
				Discharged Into streams, valleys or lakes	Reused for Irrigation of fruit trees, highway trees and green areas	Reused for Irrigation of field crops, industrial crops and forest trees
BOD_5 mg/l	8	5	5	60	200	300
COD mg/l	56	53	49	150	500	500
pH	8.0	7.7	8.4	6.0-9.0	6.0-9.0	6.0-9.0
TSS mg/l	40	33	90	60	200	300
NO_3-N mg/l	14	16	12	18	10	16
TDS mg/l	1103	1226	1285	1,500	1,500	1,500
Escherichia Coli CFU/100Ml	1.60E+03	3.40E+03	5.20E+03	1.0E+03	1.0E+03	-

Source: Annual Report for Monitoring of Wastewater influent and Effluent of As Samra and Zarqa River, produced by RSS in Arabic (RSS 2013).

5.1.7 Land Use

As shown in Figure 5-12, the area within which the monofill site falls is classified as a class 2 rural area as per the Land Use Regulation for 2007. This identifies the allowable land use applications within the area, which include the construction of wastewater treatment plants, power generation facilities and light to medium industries amongst others. It is mostly uninhabited with the exception of a small cluster of residences for As Samra WWTP workers, which are located on the main road to the WWTP. Populated areas to the north and southwest of the As Samra WWTP include Al Khirbeh As Samra, Al Mazraa, and Al Hashimyyah. Adjacent to the WWTP there is intensive agricultural land. The land is generally cultivated with field crops such as tomatoes, corn and eggplant. The Project site is treeless, with few scattered small shrubs and few palm trees that were cultivated by the SPC.

The Biosolids Monofill will be located within the boundaries of the existing facility; lands within these boundaries are owned by MWI.

A number of industries are currently located near the project site. Such projects include the Jordan Petroleum Refinery, Samra Electric Power Generation Company and Al Rajhi Cement Factory.

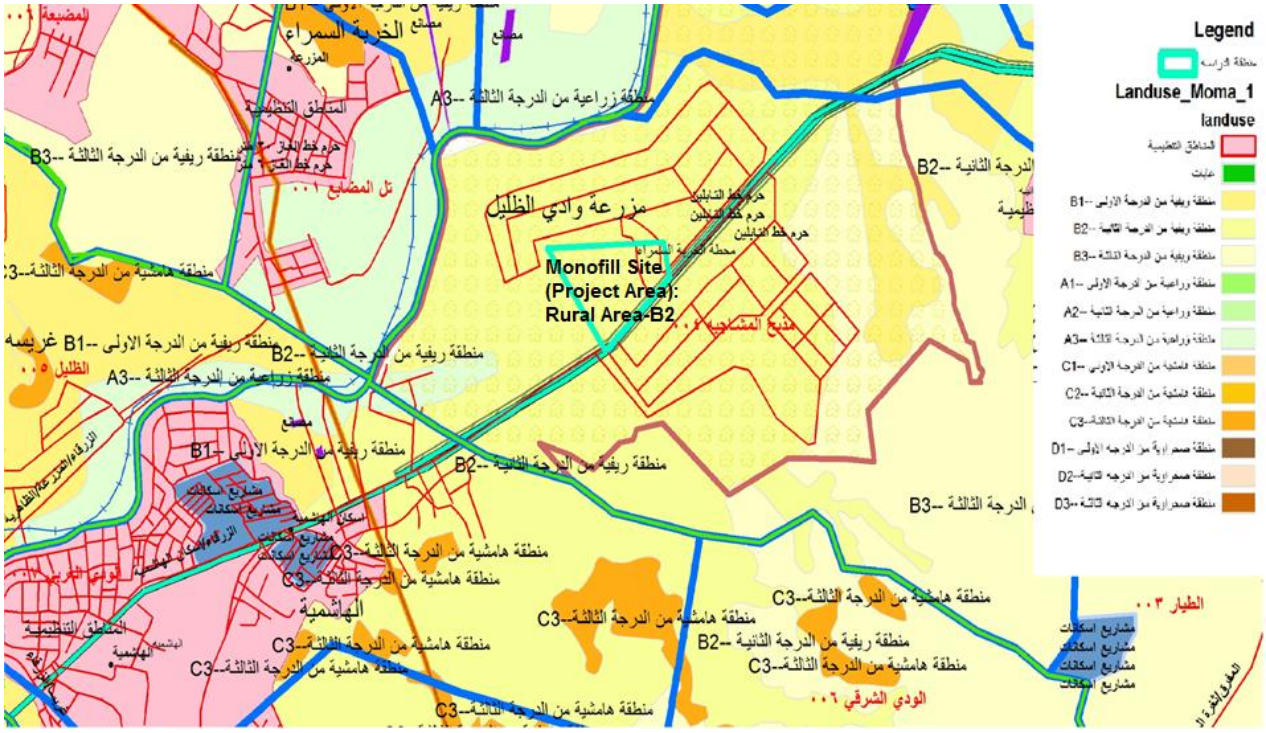

Figure 5-12: Land Use Map for the Project Site and the Surrounding Study Areas

5.1.8 Air Quality

In general, wastewater treatment plants are a source of air pollutants, odor, and noise. However, As Samra WWTP was designed and constructed in a way that reduces Greenhouse Gas (GHG) emissions by producing renewable energy from biogas collection and the utilization of hydraulic turbines. Air quality monitoring is done on a regular basis through the SPC and a third party assessor to ensure that air quality specifications stated by JS 1140/2006 are met.

Until the end of 2012, the RSS was responsible for the monitoring of noise and Ventilation Air Treatment Systems (VATS) by measuring three air quality parameters (Mercaptan, Ammonia [NH_3] and Hydrogen Sulphide [H_2S]) in seven sites at As Samra WWTP. Monitoring responsibilities were handed over to SGS in January 2013.

Tables 5-12 and Table 5-13 below show air quality monitoring test results obtained by SGS for the period between May 2013 and June 2014. Comparing these results with the Jordanian Standards for Ambient Air Quality (JS: 1140/2006) it is clear that the concentrations of Hydrogen Sulphide (H_2S) exceeded the legal limits in all monitoring locations which further contributes to the odor problem. The higher recorded results were obtained in location “35 In”. NH_3 concentrations were within the legal limits during 2014 except for the last recorded measures in June 2014, where NH_3 concentrations in locations “35 In” and “121 In” exceeded the limits. On the other hand, most of NH3 concentrations measured in May 2013 exceeded the legal limits in the majority of the locations.

Since there are no limit values for Mercaptan in Jordanian legislation, the results were compared to the Methyl /Ethyl Mercaptan threshold limit values of 0.5ppm recommended by American Council of Government Industrial Hygiene (ACGIH). Mercaptan concentrations in location “35 In” during the above mentioned monitoring period exceeded the limit values in location “121 In” except for recorded measures in January 2014. The last recorded monitoring results in June 2014 showed that most Mercaptan concentrations were above limit values in most of the monitoring sites. However, the Mercaptan levels are expected to fall in January when the new Belt Filter Press Dewatering System is implemented in lieu of the current solar drying process. (Solar drying will however continue for sludge cake that comes out of the BFPs.)

Other air pollutants were measured such as Total Suspended Particulates, Particulate Matter (PM), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Ozone (O_3), and Sulphur Dioxide (SO_2). Concentrations of these tested pollutants were within the maximum allowable limits stated in JS 1140/2006.

Furthermore, odors inside the treatment plant are monitored regularly by a “Five-Member-Odor Group”, which consists of two representatives from MWI, two representatives from As Samra WWTP Operation and Maintenance department, and another independent person representing the Hashimyyah Municipality. Odor observation records in 2014 showed that the odor was acceptable in most of the representative locations. However, in February 2014 the records indicated that there was strong odor in aeration area (area 51), in border-cross of lagoons L and K, as well as in the south west area of the plant. In June 2014 strong odor was recorded in border-cross of lagoons L and K, the south east area, and the old entrance area of the WWTP. This odor resulted mainly from the limed sludge lagoons.

Table 5-12: Monitoring Test Results for Mecaptan, Ammonia, and Hydrogen Sulfide, for the Period between May 2013- June 2014
Source: SGS Records, 2014

Parameter		JS (1140/2006)		121 In	121 Out	35 In	35 Out	Inlet Structure (21)	Grit Storage Area (31)	Sludge Thickener Area (82)
	Month/ Year	ppm	Number of permissible exceedances/year							
Hydrogen Sulphide (H_2S)	May.2013	0.03	3	20	3.2	110	0	0.3	0.7	0.2
	Jan. 2014			15	3.5	153	0.73	0.50	0.40	0.60
	Mar.2014			22	6	140	0	0.70	0.95	0.56
	Jun.2014			15.50	5.00	180.00	0.20	0.42	0.28	0.65
Ammonia (NH_3)	May.2013	0.39	3	0.5	0	0.25	0	2.3	2.6	2.0
	Jan. 2014			0.10	0	0.10	0	0.01	0	0
	Mar.2014			0.10	0	0	0	0	0	0
	Jun.2014			0.40	0	0.50	0	0	0	0
Mercaptan	May.2013	----	----	2.5	0	6	0.3	0.25	0.24	0.21
	Jan. 2014			0.20	0.10	3.00	1.40	0.50	0.10	0.10
	Mar.2014			0.70	0.40	4.50	0.50	0.10	1.30	0
	Jun.2014			0.70	0.30	10.0	4.30	1.30	1.20	1.30

Table 5-13: Air Quality Monitoring Tests Results for the Period between May 2013-June 2014

Parameter	Between expansion & secondary of clarifiers	Beside building No.62	Beside building No.82	Front management offices (parking)	JS (1140/2006)			
					Averaging time	ppm	µg/m^3	Number of permissible exceedences/year
Nitrogen Dioxide (NO_2)	ND*	0.01	0.01	0.01	1 hour	0.21		3
Sulphur Dioxide (SO_2)	ND*	0.01	0.01	ND*	1-hour	0.31		3
Carbon Monoxide (CO)	4.8	4.9	4.0	3.7	1-hour	26.00		3
Hydrogen Sulphide (H_2S)	0.02	0.01	0.31	0.03	1 hour	0.03		3
Ozone (O_3)	0.03	0.05	0.03	0.02	8-hour	0.08		---------
Ammonia (NH_3)	2.60	2.20	2.40	2.10	24 hour	0.39	270	3
Total Suspended Particulates (TSP)	63	41	50	93	24 hour		260	3
PM10	59	36	41	68	24 hour		120	3
PM2.5	55	34	34	49	24 hour		65	3

Source: SGS Records, 2014
**ND: Not Detected*

5.1.9 Noise

Noise levels in both 24 indoor sites in 9 buildings inside As Samra WWTP and 11 outdoor (boundary) sites are monitored every six months by SGS. Noise level measurements are presented in Table 5-14. This table shows that noise levels in As Samra WWTP are below the maximum permissible limit of the Jordanian Noise Protection guidelines which is 75 dBA for industrial areas.

Table 5-14: Noise Level Measurement at As Samra WWTP, Mar.2014

Site No.	Building No.	Building Name	Noise Level (dBA)
1	034	Air blower building	62
2			66.5
3			64.5
4			57
1	035	Desulphurization odor control building	66.5
2			68
1	43A	Primary sludge pumping station	63
2			60
1	053	Secondary sludge tank	58
2			60.7
3			55
4			54
1	057		59
2			57
3			61
1	093	Activated sludge flotation building	62
2			63
1	103	Biogas compressor building	72
2			68
1	107	Boiler building	69
2			67
3			64.6
1	121	Odor control building	67
2			64
Boundary Code		**Noise Level (dBA)**	
NB1		53	
NB2		60	
NB3		60.5	
NB4		58	
NB5		57	
NB6		50	
NB7		52	
NB8		53	
NB9		65.5	
NB10		63	
NB11		62	

Source: SGS Records, 2014

5.1.10 Waste

SPC keeps records of the waste generated onsite and also from the Ain Ghazal Pre-Treatment Plant (AGTP), West Zarqa Pumping Station (WZPS) and Hashimyyah Pumping Station (HPS). Generated wastes are transferred either to Ghabawi landfill or are disposed of in As Samra itself.

SPC divides its wastes into the following categories: Refusals and grits, Used Oil, Office Wastes and Sludge. In the year 2013, SPC recycled 185kg of office waste (paper). In that same year SPC disposed of 1.425 tons of used oil monthly. Table 5-15 below shows the total refusals and grits generated per location; these are disposed of at SPC.

Table 5-16 displays the quantities of sludge generated and turned into biosolids and which are stored onsite.

Table 5-15: Refusals and Grits at SPC in the year 2013

Month	Total from Samra (ton)	Total from AGTP (ton)	Total from WZPS (ton)	Total from HPS (ton)	Total Refusals and Grits (ton)
January	34	537	61	0	632
February	32	591	31	0	654
March	50	224	67	0	341
April	38	357	68	0	463
May	40	370	40	0	450
June	56	382	50	0	488
July	54	391	83	0	529
August	53	451	90	0	594
September	31	268	40	0	339
October	43	423	70	0	537
November	52	170	58	0	280
December	19	550	48	0	618

Source: SPC Records, 2014

Table 5-16: Quantities of Sludge turned into Biosolids and stored Onsite

Month	Transferred to Biosolids (Ton)
January	2,512
February	2,672
March	3,092
April	3,589
May	4,145
June	3,692
July	3,774
August	4,240
September	3,684
October	3,655
November	3,527
December	3,055
Total Biosolids in the Year 2013	**41,637**

Source: SPC Records, 2014

5.1.11 Fly Nuisance

Generally speaking, flies and mosquitoes pose a problem in the area of As Samra WWTP and its surroundings. However, SPC seeks to combat flies and eradicate them via the following:

1. Mixing of drying beds, where one cycle of mixing covers two working days. It is worth noting that the cycles recur more in the warmer months; for example, mixing is done on a daily basis in the months of July and August.
2. Fogging of the Biosolids area and the Sukhna and Zarqa Emergency Pond.

3. Spraying of the Hashimyyah pump station, Sukhna and Zarqa Emergency ponds as well as the irrigation ponds.

SPC keeps records and makes schedules for the above mentioned measures, which intensify in the summer months. Furthermore, SPC keeps records of the complaints received regarding pests and nuisance and deals with them as received. As per SPC records in 2014, three complaints were received in the year 2012 and four in the year 2014.

5.2 Socio-Economic Conditions

5.2.1 Demographic Profile

As-Samra falls within the Al-Hashimyyah locality of the Zarqa governorate. The total population for Al Hashimyyah is 32,413 (DOS, 2013) with an almost even distribution of males and females: 16,949 males and 15,464 females (DOS, 2013). Table 5-17 below shows the population distribution within Al Hashimyyah Locality as per the Jordanian Department of Statistics (DOS).

Table 5-17: Population Distribution within Al-Hashimyyah Locality

Sub-Locality	Males	Females	Total
Al Hashimyyah	12,216	11,190	23,406
Iskan Al Hashimyyah	3,976	3,631	7,607
Al-Fayha'a	757	643	1,400
Total	**16,949**	**15,464**	**32,413**

Source: DOS, 2013

As per SPC records in 2014, As Samra employs 186 people. The vast majority of the employees are males and of Jordanian nationality with most (73%) being local residents of Sukhnha, Hashimyyah and Zarqa. Table 5-18 below displays the number of employees at SPC by nationality, whereas Table 5-19 displays their numbers according to residence.

Table 5-18: Samra Employees by Nationality

Nationality	Number of Employees	Percentage (%)
Jordanian	181	97%
Non-Jordanian	5	3%
Total	**186**	

Source: As Samra Records, 2014

Table 5-19: Samra Employees according to Residence

Residence	Number of Employees	Percentage (%)
Local (Sukhneh,Hashimyyah,Zarqa)	135	73%
Amman, Irbid	51	27%
Total	**186**	

Source: As Samra Records, 2014

5.2.2 Gender

SPC consistently keeps track of its employees and pursues a policy of hiring qualified persons regardless of gender. Table 5-20 displays the gender distribution at SPC.

Table 5-20: Samra Employees by Gender

Gender	Number of Employees	Percentage (%)
Female	6	3%
Male	180	97%
Total	**186**	

Source: As Samra Records, 2014

It can be noted from the table above that the percentage of women, which stands at 3%, is minimal.

Table 5-21 displays the distribution of women in Zarqa, on a governorate scale, according to economic activity.

Table 5-22 and Table 5-23 show the education levels of both males and females in Zarqa and indicate the gender gap.

Table 5-24 indicates the distribution of females in Zarqa per occupation.

Table 5-21: Percentage Distribution of Jordanian Females Aged 15 Years and above by Economic Activity Status in 2013 in Zarqa

Employed	Unemployed	Student	Housewife	With Means/Income	Disabled
6.3%	1.8%	15.5%	74.6%	0.4%	1.5%

Table 5-22: Education in Zarqa by Gender in 2013

Indicator	Gender (%)		Gender Gap
	Male	Female	
Illiteracy Rate (Population Age 15++)	3.0	9.3	-6.3
Children in Kindergarten	52.4	47.6	4.8
Students in Basic Education	51.3	48.7	2.6
Students in Secondary Education	46.4	53.6	-7.2
Students in Vocational (Industrial) Education	100.0	0.0	100.0
Students in Vocational (Agricultural) Education	100.0	0.0	100.0

Source: DOS, 2013

Table 5-23: Higher Education in Zarqa by Gender in 2013

Indicator	Gender (%)		Gender Gap
	Male	Female	
Students in Universities Education	43.9	56.1	-12.2
Students in Science Colleges	47.8	52.2	-4.4
Students in Art Colleges	40.8	59.2	-18.4

Source: DOS, 2013

Table 5-24: Percentage Distribution of Jordanian Females Aged 15 Years and above by Occupation for Zarqa Governorate in 2013

Main Occupation	Percentage (%)
Legislators, Senior Officials and Managers	1.2
Professionals	52.0
Technicians and Associate Professionals	19.5
Clerical Support Workers	8.5
Service and Sales Workers	7.7
Skilled agricultural, forestry and fishery Workers	0.1
Craft and related Trades Workers	5.3
Plant and Machine Operators and Assemblers	0.3
Elementary Occupations	5.3
Total	**100.0**

Source: DOS, 2013

5.2.3 Economic Activity and Income

The main industries and economic activities in the area of As Samra WWTP and its surroundings are as follows:

- A factory for metal pipes and iron bars in Al Hashimyyah
- A mill for forage crops in Al Hashimyyah
- Nails and barbwire factory in Um Suleih
- The Jordan Petroleum Refinery Company (JPRC) in Al Hashimyyah
- Samra Electric Power Generation Company (SEPCO) in Al Hashimyyah
- Al Rajhi Cement Factory about 9 km away from SPC

The average unemployment rate in Zarqa is 12.3% with the male unemployment standing at 11.5% and the female unemployment rate at 17.3% (DOS, 2012). As compared to the Kingdom, the unemployment rates in Zarqa fall into mid-level as seen in Table 5-25 below.

Table 5-25: Unemployment Rates by Sex and Governorate, 2012

Governorate	Male (%)	Female (%)	Total
Amman	8.8	16.8	10.3
Balqa	12.9	19.1	14.2
Zarqa	11.5	17.3	12.3
Madaba	12.9	29.7	17.0
Irbid	10.2	20.9	11.9
Mafraq	9.8	15.2	10.7
Jerash	9.3	19.8	11.2
Ajloun	7.8	25.8	11.4
Karak	12.7	29.9	17.7
Tafila	15.8	31.5	19.6
Ma'an	18.2	22.6	19.0
Aqaba	14.7	21.0	15.7
Kingdom-wide Average	**10.4**	**19.9**	**12.2**

Source: DOS, 2012

Average wages in the Kingdom in the reference month of 2011 were 429 JDs for males and 379 JDs for females (DOS, 2012).

Table 5-26 below displays the average annual current income of households in Zarqa by source for the year 2010, drawn from 169,818 households and 909,653 household members.

Table 5-26: Average Annual Current Income of Household by Source

Source of Income	Income (JDs)
Income from Employment	3,385.8
Own Account Income	1,116.3
Income from Rent	1,048.2
Property Income	66.1
Current Transfers Income	1,681.1
Total	7,297.5

Source: DOS, 2010

5.2.4 Health and Education

SPC has an appointed health officer and two safety officers as well as a committee for Occupational Health and Safety. This committee meets monthly and consists of the General Manager, the head of the Health and Safety Department, a manager from each available department, an employee from each available department and a doctor or a nurse. The health officer is responsible for following up on the medical checkups and vaccinations for the employees, which are conducted every two years. Additionally, specific checkups are required for some employees depending on the nature of their jobs.

Safety officers are responsible for regular inspections of machinery and equipment as well as the operations. They are also responsible for handing out risk identification reports for the employees to fill out as well as taking care of work permits. Safety officers also coordinate meetings, conduct drills and follow up daily on maintenance, production and safety.

The Zarqa health directorate aims to monitor and control epidemic and water-borne diseases via periodical recording and reporting of incidences. These diseases are mainly Typhoid and Para Typhoid, Hepatitis A, Diarrhea, Amoebic Dysentery and Giardia Dysentery. The periodical recording of these diseases by the Health Directorate shows them to be below the national average. Additionally, a couple of insects that tend to live either on animal manure or sewage water have been recorded as causing skin swellings in the area; however, strict control is kept by the local health authorities on all insects in the villages surrounding the WWTP.

As per DOS statistics for the year 2012, Zarqa governorate has 38 health centers of which eleven are in the vicinity of SPC, Seil Zarqa and Khirbet As Samra to King Talal Dam; 6 village centers; 36 maternity and children centers; 1 communicable diseases center; and 30 dental clinics. Additionally, Table 5-27 below displays the number of hospitals and patient beds in Zarqa for the year 2013.

Table 5-27: Hospitals and corresponding Beds in Zarqa Governorate in 2013

Ministry of Health		Private Hospitals		Other Governmental		Total	
No. of Hospitals	No. of Beds	No. of Hospitals	No. of Beds	No. of Hospitals	No. of Beds	No. of Hospitals	No. of Beds
2	412	5	315	1	226	**8**	**953**

Source: DOS, 2013

With regards to education, Zarqa governorate has a total of 247,548 students of which approximately 51% are males and 49% are females. The distribution of schools per gender and directorate in Zarqa can be seen in

Table 5-28 below. There are two universities in Zarqa governorate and in close proximity to the Project site; Hashimyyah University and Zarqa University.

Table 5-28: Number of Schools in Zarqa by Governorate and Sex in 2011/2012

Directorate	Male	Female	Co-ed.	Total
Zarqa 1	77	65	196	338
Zarqa 2	36	5	90	131
Russeifah	43	25	127	195
Total	**156**	**95**	**413**	**664**

Source: DOS, 2012

5.2.5 Water Demand, Wastewater and Drainage

In 2011, Zarqa had the largest water supply for household and municipal purposes after the capital Amman. The water supply for household and municipal purposes in Zarqa for the year 2011 was 50.1MCM (DOS, 2011) which adds up to a per capita water supply of 147L/d for a population of 910,800 (DOS, 2011).

As concerns sewerage and wastewater management, the total wastewater management expenditure in 2010 was as follows (DOS, 2010):

- 20,317.6 JDs of current expenditure
- 113,415.1 JDs of capital expenditure
- 133732.7 JDs of total expenditure

Table 5-29 below shows the type of sewage system (public or cesspool) used in a total of 169,818 housing units in Zarqa in 2010.

Table 5-29: Distribution of Housing Units by Type of Sewage System in Zarqa

Type of Sewage System	Distribution (%)
Public Network	80.5
Cesspool	19.5

Source: DOS, 2010

5.3 Cultural Environment

Given that the project area (monofill site) falls entirely within the vicinity of the existing and operational Samra Treatment Plant, no adverse impacts on indigenous people or cultural heritage are expected nor is any sort of displacement expected. However, a Chance Finds Procedure will be conducted to account for any possible finds during excavation and construction.

Historically, Zarqa thrived during the Islamic period particularly due to the Shami Pilgrimage Route passing through it and its relevance to Saladin. Archaeologically, Zarqa is home to the following important sites amongst others: Jabal al Mutawaq, Al Khirbeh As Samra, Russeifah (which belongs to the Bronze Age) as well as a number of palaces and castles such as: al Azraq Desert Castle, Qasr Shabib, Qasr el Hallabat ,Qasr Uwained, and Hammam el Sarkh.

6 ENVIRONMENTAL IMPACTS AND MITIGATIONS

This section addresses the anticipated environmental impacts of the implementation of As Samra Biosolids Monofill Project. The analysis was qualitative in nature and was based on professional judgment and experience as well as the fact that the project in itself is largely a remediation action for an existing problem. Each environmental impact was considered and detailed according to the three project phases:

- Design phase
- Construction phase
- Operation phase

Mitigation measures for each environmental impact were also proposed and recorded.

6.1 During Design

The design team worked closely with the environmental specialists to minimize the environmental impacts on the project area.

The design team took into consideration the projected capacity requirements, the geometric limitations of the recommended siting area, the stability of the biosolids mass, and the intention of providing an environmentally sensitive and protective means for disposal and management of biosolids (i.e. base liner and closure cover systems).

The design recommends the installation of a single flexible membrane liner with a geocomposite drainage layer, daily protective cover, a final cap and leachate and gas collection systems so that potential unacceptable levels of contaminants from biosolids disposal are not encountered at the facility boundary.

The monofill conceptual design includes a gas collection system that consists of vertical gas extraction wells connected to a flare station or a monofill gas electric generator. The gas collection efficiency was assumed to be 50%.

A closure cap system is included as part of As Samra biosolids monofill design. A closure cap will minimize infiltration, prevent erosion, minimize odors, aid in the collection of monofill gas, and improve the visual appearance of the closed facility.

The conceptual design recommended that measures be taken for closure and post-closure care, leachate collection and disposal, methane monitoring, and public access restrictions. In addition, managerial requirements for runoff collection, vector control, groundwater monitoring or certification, public access restrictions, and restrictions for the growing of crops and grazing of animals were also recommended.

The biosolids monofill design also took into consideration the construction of infrastructure and other facilities to enhance security, access, operations, management, and monitoring functions. These proposed monofill infrastructure and facilities include but are not limited to:

- A perimeter security fencing
- Exterior lighting
- Two-way vehicle traffic roads around the monofill perimeter, as well as access roads on the monofill development surface
- Parking areas

- A lined leachate evaporation lagoon
- A small monofill gas generation power facility with a backup utility flare station
- Stormwater management basins
- A minimum of one upgradient and two downgradient groundwater monitoring wells

6.2 During Construction

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

6.2.1 Occupational Safety and Health

6.2.1.1 Anticipated Impacts

The construction of each phase (or cell) of monofill development will require excavation and/or fill activities. Main injury sources during the construction phase include falls, electrocution, transportation accidents, and excavations and mishandling of the machinery. Construction workers will work closely with and nearby heavy machinery which might lead to accidents. In addition, workers might be susceptible to health problems such as respiratory diseases, due to the exposure to hazardous materials, high levels of dust, and high concentrations of H_2S and NH_3 in the vicinity of the project area.

Exposure to high concentrations of H_2S might cause fatigue, headaches, eye irritation, cough and sore throat, nausea, and breath shortness. However, these effects disappear usually in a few weeks. H2S is also a highly flammable gas, which if not controlled properly might lead to an increase in risk of fires in the project area.

High concentrations of NH3 might lead to irritation and lungs damage. However, the strong odor of NH3 can be a warning alarm of potentially dangerous concentrations.

The exposure to high levels of noise might cause hearing impairment. Moreover, the presence of small wadis near the monofill project area, as well as the change in natural drainage systems, might jeopardize workers' safety: some workers may slip or fall down without adequate safety measures.

The project area is characterized by high temperatures, such that if construction works were commenced during summer months direct exposure to the sun might pose heat stress risk on the workers. Heat stress can cause dizziness, weakness, breathlessness, as well as accelerated heartbeats.

6.2.1.2 Proposed Mitigation Measures

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

Personal safety gas detectors should be provided to workers to warn them of high levels of H_2S. The contractor should schedule the work shifts in a way that keeps 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.

Proper scheduling of work durations and breaks can reduce the incidents of heat stress by reducing individual workload. Hats and shaded areas should also be provided for workers.

Prior to construction activities, a comprehensive Health and Safety Plan (HASP) should be developed 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 ensure its implementation. Moreover, 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. 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.

It is also important to assign a doctor to serve the workers during the construction phase. 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.

6.2.2 Traffic

6.2.2.1 Anticipated Impacts

One of the project components is to construct two-way vehicle traffic roads around the monofill perimeter, as well as access roads on the monofill development surface. These roads will connect the monofill with the different parts of the WWTP.

Traffic at the area in general will increase due to the presence of construction vehicles and the movement of workers from and to the site. Therefore the risk of accidents might increase in the project area. 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.

6.2.2.2 Proposed Mitigation Measures

A traffic management plan should be developed and followed by the contractor. The plan should be suitable for the construction site conditions. Proper and clear signage, in different languages, should be provided along the access road inside the plant to indicate that there is a construction site nearby.

Construction material and soil should be securely packed and covered on trucks to prevent loads from falling off or generating dust.

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

6.2.3 Biodiversity

6.2.3.1 Anticipated Impacts

There is no significant vegetation in the vicinity of the project, except for the few cultivated palm and forest trees. Some shrubs and bushes can also be found within the project area.

Parts of the vegetation cover might 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 minimum negative impacts on the fauna species that exist in the project area. No fauna species is anticipated to be affected, except for one small herd of sheep that graze in the area and dogs that should be kept away from the monofill site.

As-Samra as part of the bigger Zarqa River Basin is recognized as a wetland of international importance since it is an important staging and wintering area for a wide assortment of migratory water birds. Therefore, these water birds might be at risk of disturbance due to construction noise, traffic, and presence of people. It is thus suggested to avoid construction works during the migratory season (mainly in the winter time) and to conduct multiple noise-generating activities simultaneously so as to reduce the periods of exposure. Additionally, workers should be warned and prohibited from any hunting or trapping of animals and birds.

6.2.3.2 Proposed Mitigation Measures

Reclaimed water should be utilized to increase the vegetation cover inside As Samra WWTP boundaries. All removed trees should be relocated within the WWTP and replaced if trees were damaged during the relocation process.

It is recommended that construction activities are restricted to one area at a time wherever possible, to allow the movement of fauna species to the close undisturbed areas.

Construction workers should not trap or hunt any existing fauna 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.

6.2.4 Water Resources

6.2.4.1 Anticipated Impacts

It is anticipated that there will be an increase on water demand for the various construction activities, dust control, and domestic water uses at site offices. In addition, construction workers might use the potable water to wash their equipment and tools. This water will be trucked in by the Contractor and thus poses no potential impact on the local water supply.

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

6.2.4.2 Proposed Mitigation Measures

Allocation of a water source for construction should be discussed in the pre-construction meeting. To ensure that use of water by the Contractor will not affect water supply of local community, the Contractor should consider providing water from tankers or reusing the treated water when possible, rather than using water from the public network. Construction crews should handle water resources efficiently and conserve water during all construction activities.

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. Hazardous material should also be labeled, used and disposed of properly and according to the HMMP.

6.2.5 Soil

6.2.5.1 Anticipated Impacts

Construction activities such as drilling, excavating, and land leveling, might have a negative impact on soil stability, and might cause soil erosion. These activities will mostly affect topsoil while lower soil layers will only be affected by road construction.

Soil compaction might result from the movement of heavy machinery on unpaved surfaces, which 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.

6.2.5.2 Proposed Mitigation Measures

A Soil Erosion Prevention Plan and Spill Management Plan should be developed and abided by the contractor. These plans should include all the necessary measures, main concerns, actions, as well as responsibilities to prevent soil erosion and pollution.

Fuelling and maintenance areas should be dispersed and 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.

6.2.6 Waste

6.2.6.1 Anticipated Impacts

Excavation and earthwork are considered the main sources of solid waste during the construction phase. Another source of solid waste is the domestic solid waste generated by construction workers. The accumulation of wastes might result in growth of pathogens, which poses health and safety risks to workers and nearby communities, in addition to bad odor and visual impacts.

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

6.2.6.2 Proposed Mitigation Measures

Excavated soils will be loaded and hauled to stockpile area(s) north of the proposed monofill area for potential future use as structural fill, daily cover, intermediate cover, and ET cap soil.

Solid waste should be collected and disposed of regularly. A Waste Management Plan should be developed and abided by. The plan should identify 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.

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

In addition, a Hazardous Materials Management Plan should specify the procedures of handling, storing, transporting and disposing of hazardous wastes.

6.2.7 Air Quality

6.2.7.1 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.

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

6.2.7.2 Proposed Mitigation Measures

A Dust Management Plan should be developed and abided by during the construction phase. The plan should identify all necessary dust abatement measures such as the following:

- Schedule dust-generating activities in accordance with weather conditions, minimizing dust generation during dry and dusty weather
- Use water spraying and moistening of excavation areas and exposed surfaces to suppress dust
- Cover all stockpiles and trucks transporting sand and other construction materials
- Control vehicles movement on unpaved roads
- Follow good housekeeping within the site and its perimeters
- Pave unsmoothed roads as soon as practicable
- Provide workers with dust protection equipment
- Undertake and record visual on-site and off-site inspections on a daily basis, especially during periods of high activity or prolonged dry, windy weather.

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

6.2.8 Noise

6.2.8.1 Anticipated Impacts

Ambient noise levels are expected to increase during the construction phase, due to excavation activities and operation of heavy machinery. Nevertheless, since there are no neighbourhoods in close proximity to the site, As Samra WWTP employees and constructions workers are the most affected from noise.

6.2.8.2 Proposed Mitigation Measures

The Contractor should abide by the Jordanian Instructions for Controlling and Preventing Noise, such that noisy activities are prevented from 8 pm to 6 am.

Furthermore, workers should be provided with noise protection equipment. Several noise generating activities should be scheduled at the same time, to prevent prolonged periods of noise. Heavy machinery should be maintained and greased regularly to minimize unnecessary noise.

6.2.9 Visual

6.2.9.1 Anticipated Impacts

The project site is within As Samra WWTP boundaries. It is therefore expected that there will be no major changes to the visual character of the area. The project site will have a typical construction site appearance during the construction phase.

6.2.9.2 Proposed Mitigation Measures

The project design should ensure the pleasant appearance of the monofill. It should minimize the regular maintenance required, while ensuring that the project's appearance will not deteriorate over time.

6.2.10 Archaeological Resources

6.2.10.1 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

6.2.10.2 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.

6.2.11 Socioeconomic Impacts

6.2.11.1 Anticipated Impacts

During the construction phase, new job opportunities will be generated for the local community of Zarqa Governorate. This will help in increasing generated income and ultimately enhance the life conditions of the nearby communities. Jobs can be in the form of construction workers, drivers or even service providers to the workers onsite; this contributes to the livelihood of the neighbouring communities and offers a source of income.

Furthermore, 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.

6.3 During Operation

6.3.1 Occupational Safety and Health

6.3.1.1 Anticipated Impacts

The main concern during the operation phase is the stability of biosolids that are being disposed. Workers' safety might be jeopardized and some workers may slip or fall if safety measures are not instituted. Biosolids with less than 20% dry solids will not support the machinery used to place the cover material or fill sludge in other monofill cells, which in turn increases the risk of monofill settlement and accidents.

Mishandling of the machinery is another source of injuries during the operation phase. Construction workers will work closely with and nearby heavy machinery which might lead to accidents. Moreover, in addition to experiencing odor nuisance, workers might be susceptible to health problems such as respiratory diseases, due to the exposure to methane gas generated from decomposition of biosolids in the monofill.

In addition, workers might be susceptible to health problems due to the exposure to high of H_2S and NH_3 in the vicinity of the project area. Risk of fires might also increase in the project area.

6.3.1.2 Proposed Mitigation Measures

A comprehensive Health and Safety Plan (HASP) should be developed and abided by for 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 gears and equipment such as harnesses, guardrails, safety gas detectors, and trench shields should be provided during the operation phase.

The responsibilities of the “Health and Safety Officer” should also be specified within the HASP to ensure 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 ensure the proper implementation of the HASP. The location of the closest hospital or medical clinic and the shortest route should be identified. 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.

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

6.3.2 Biodiversity

6.3.2.1 Anticipated Impacts

Generally, the new monofill will enhance the environmental conditions within the project area. The quality of generated biosolids meets Category 1 of Jordanian Standards JS 1145/2006 after a storage period of two years; the biosolids could therefore be theoretically used as fertilizer for agricultural use.

However, due to the fact that there is no legal basis for the utilization of biosolids for agricultural use, the generated biosolids can only be landfilled. Meanwhile, the biosolids can be utilized to increase the vegetative cover inside the plant by planting trees at the monofill boundaries and above the filled cells. Nevertheless, livestock should be prohibited from grazing inside the monofill until changes in regulations are made and the use of biosolids for agricultural use and forage production is permitted.

On the other hand, the expected increase in human activities in the project areas might pose a risk to the natural vegetation, especially through uncontrolled destructive behavior and littering.

6.3.2.2 Proposed Mitigation Measures

Movement of workers, sludge transferring and stockpiling and other operation activities should be banned outside the monofill boundaries. Wherever possible, access roads should be minimized to limit the disturbance of biodiversity. Additionally, it is recommended to plant natural vegetation whenever possible and replace any trees moved from the project area.

Perimeter security fencing should be maintained regularly to prevent the access of livestock and other animals to the monofill area.

Monofill workers should not trap or hunt any existing fauna species in the project area. Any caught animals should be moved to nearby undisturbed areas. Proper signs should be provided emphasizing the importance of protecting the natural habitat of the area. Additionally, some bins should be distributed around the area.

6.3.3 Air Quality

6.3.3.1 Anticipated Impacts

The decomposition of organic matter in sludge produces Methane (CH_4) and other gases that include H_2S. Besides the high levels of NH_3 and H_2S in the ambient air of As Samra WWTP, these gases are considered significant sources of pollution. Methane is a toxic and extremely flammable gas that can seep through sludge and other materials into close-by buildings where it can accumulate until it reaches explosive levels.

Odor might also be another negative impact. Generated mainly from the H_2S, and described as a rotten eggs odor, it can affect the surrounding areas in certain weather conditions. Odor can also be caused by leachate, and it can also affect the workers inside the WWTP as well as the surrounding areas.

It should be noted that the monofill design includes a gas collection system that is connected to a flare station or monofill gas electric generator, as well as a leachate collection system to prevent such impacts. However, it is expected that there might be some odor associated with fugitive emissions during the handling and evaporation of the leachate.

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

6.3.3.2 Proposed Mitigation Measures

The installed gas collection system should be maintained regularly to ensure that CH_4 doesn't accumulate to explosive levels. In emergency cases, excess amounts of gases should be collected, vented to the atmosphere or flared. An effective ventilation system must be installed and maintained in the surrounding buildings. Regular air quality monitoring that considers the accumulative impact of gas emissions in the As Samra WWTP should also be performed.

The leachate collection system should also be maintained regularly to reduce generated odor, and periodic gas monitoring should be done to detect any increase in the emissions.

Vehicles used within the project area should be regulated and monitored to ensure they are in good working condition.

Furthermore, the practice of applying daily covers and the final capping of the site also aid in the reduction of emissions released to the atmosphere as well as mitigation of odors.

In addition, the HASP should include a procedure for immediate reporting of all fires to local fire-fighting offices. The general directorate of Civil Defense in Zarqa is the entity to be contacted in the case of fires or accidents.

6.3.4 Soil and Water Resources

6.3.4.1 Anticipated Impacts

Anticipated impacts to soil and water resources are minimal. The monofill is designed to include a single flexible membrane liner with a geocomposite drainage layer. Furthermore, a leachate collection system ensures that there are no unacceptable levels of contaminants from biosolids disposal at the facility boundary and prevents the seepage of leachate into the subsurface. This is unlike the ongoing sludge storage practices that rely on the slope of the storage piles, and the layer of compacted sludge material beneath the storage area that creates a barrier to prevent seepage in heavy rainfall events. The monofill can therefore be considered as a mitigation measure to avoid soil and groundwater contamination.

Nonetheless, liner leakage that leads to uncontrolled leachate filtration might occur and that poses a risk of soil and groundwater pollution. However, the groundwater table in the project area is around is 80 m below the surface, which makes groundwater contamination unlikely.

As was shown in Table 5-10, continuous monitoring of groundwater quality around As Samra WWTP indicates that there is no significant impact from As Samra WWTP on groundwater.

There are no permanent water bodies within the monofill site and it is dry most of the year. Therefore, there are no expected risks to surface water quality in the catchment area. The monofill design includes a stormwater drainage system, but negative impacts on surface water from runoff should be considered in the event of extreme flooding.

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.

6.3.4.2 Proposed Mitigation Measures

As mentioned earlier, the monofill is designed in a way that minimizes the risk of soil and groundwater contamination. Monitoring of surface and groundwater quality around As Samra should be performed regularly during the operation phase to ensure no negative impacts on the quality of water.

A surface water runoff channel that drains the water to surface lagoons and wraps around the perimeter of the monofill adjacent to the perimeter of the access road is to be constructed. Additionally, a separate run-on diversion channel will also be constructed outside the monofill site to drain topographic low areas and to direct run-on around the monofill into the surface lagoons.

A Soil Erosion Prevention Plan and Spill Management Plan should be developed and abided by. These plans should include all the necessary measures, main concerns, actions, as well as responsibilities to prevent soil erosion and pollution.

Fuelling and maintenance areas should be dispersed and 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.

6.3.5 Visual

6.3.5.1 Anticipated Impacts

The project site is within As Samra WWTP boundaries. There will therefore not be any expected negative or positive impacts on visual character of the area. No change on land usage or in landscape will be done.

6.3.5.2 Proposed Mitigation Measures

The project design should ensure the pleasant appearance of the monofill. It should minimize the regular maintenance required, while ensuring that the project's appearance will not deteriorate over time. To aid aesthetic purposes, a vegetative cover can be planted on the surface of the monofill.

6.3.6 Fly Nuisance

6.3.6.1 Anticipated Impacts

At the moment, biosolids are accumulating onsite and stored in biosolids storage ponds with neither cover nor capping; this practice intensifies fly nuisance. The application of a closure cap system as per the proposed design and the proper operation of the monofill which includes the application of a daily soil cover will reduce and mitigate the exposure of the biosolids, thus reducing fly nuisance.

6.3.7 Socioeconomic Issues

6.3.7.1 Anticipated Impacts

The biosolids monofill aims primarily at resolving the ongoing sludge storage and disposal issues at the As Samra WWTP. This project helps in assisting the MWI in developing sustainable economically feasible biosolids management options that are environmentally friendly.

The project will help in reducing the impacts of sludge on water resources and air quality. This will eventually improve the quality of living for the surrounding communities as well as facilitating sustainable growth. It will also improve public safety by reducing disease vectors, fly nuisance, odor and emissions.

It is anticipated that the project will create 2-4 new job opportunities, mainly for technicians and operators.

The project will create a new source of revenue by generating energy from gas emissions, as well as reducing fossil fuel consumption.

6.4 During Closure

6.4.1 Anticipated Impacts

Public and occupational health and safety impacts can still occur at the closure of the biosolid monofill. Ongoing gas emissions and leachate production might still be a source of

air and groundwater pollution. Monofill settlement is another risk after the closure. Other impacts that result from closure activities if not performed properly include: direct contact with sludge, soil erosion and sedimentation, uncontrolled vegetation and grazing.

6.4.1.1 Proposed Mitigation Measures

Ensuring proper and trouble-free monofill closure is best achieved by proper operation of the monofill, adherence to proper application of the sludge at the proposed slopes, the regular application of daily cover, and maintenance of the leachate and gas collection systems during the lifetime of the monofill.

Additionally, proper monofill site closure procedures and activities should be planned ahead and prior to the commencement of the project.

These activities include but are not limited to:

- Placement and maintenance of final monofill cover
- Regular monitoring of monofill settlement and soil cover grading after closure and for several years
- Regular monitoring of air quality after closure and for several years
- Regular monitoring of surface and groundwater quality after closure and for several years
- Restricting public access to the monofill and maintaining security fence regularly
- Maintaining previously established vegetative growth around the monofill.

6.5 Summary of Impacts

Table 6-1 below summarizes the identified impacts that could potentially be caused by implementing the proposed project as described above. Even though most of the impacts are negative, the majority will occur during construction and are therefore temporary. Abiding by the EMP presented in Section 7 will help address most of these impacts. Furthermore, it is not to be forgotten that current biosolids accumulation onsite is negatively impacting the surrounding environment. Thus, the construction of the monofill is seen as a mitigation measure and a solution to an accumulating problem.

Table 6-1: Summary of Potential Impacts during Construction and Operation

Issue	Potential Impact	Type of Impact
Occupational Safety and Health	During construction:	
	• Worker accidents, injuries, heat stress and health problems	Negative
	• High levels of noise, dust, H_2S and Ammonia	Negative
	During Operation:	
	• Instability of disposed sludge	Negative
	• Worker accidents, injuries, heat stress and health problems	Negative
	• High levels of noise, dust, H_2S and Ammonia	Negative
Traffic	During Construction:	
	• Traffic caused by construction activities and machinery	Negative
	• Dust generated from construction activities (trucks) may reduce visibility	Negative

Issue	Potential Impact	Type of Impact
Biodiversity	During construction:	
	• Some vegetation cover may be removed	Negative
	• Construction activities may pose some pollution and damage natural vegetation in the area	Negative
	During Operation:	
	• Increase vegetation cover within monofill boundaries	Positive
	• Increase human activity could disrupt the natural vegetation	Negative
Water Resources	During Construction:	
	• Increase demand on water resources	Negative
	• Groundwater contamination from discharges of construction activities	Negative
	During Operation:	
	• Groundwater contamination from leakage of leachate	Negative
	• Enhanced leachate collection in the WWTP	Positive
	• Run-off to surface water in extreme flooding	Negative
Soil	During Construction and Operation:	
	• Soil erosion	Negative
	• Soil compaction which may cause drainage and increase risk of flooding	Negative
	• Soil pollution	Negative
Solid Waste	During Construction:	
	• Growth of pathogens from accumulated waste	Negative
	• Hazardous waste that is not handled correctly	Negative
Air Quality	During Construction:	
	• Dust generated from excavation, vehicles movement, and uncovered construction materials	Negative
	• Emission from heavy construction • Machinery	Negative
	During Operation:	
	• Emissions from vehicles	Negative
	• Emissions from the decomposition of sludge	Negative
	• Bad odor	Negative
Noise	During Construction:	
	• Increased noise	Negative

Issue	Potential Impact	Type of Impact
Visual	During Construction:	
	• In undeveloped area, construction site will cause noticeable changes to the visual character	Negative
	During Operation:	
	• Minor Changes of visual character of the area	Negative
Socioeconomic Issues	During Construction:	
	• New job and business opportunities during construction phase	Positive
	During Operation:	
	• New infrastructure will benefit the community	Positive
	• Reduce the negative impacts of sludge on soil, air quality and groundwater	Positive
	• New job and business opportunities	Positive
Fly Nuisance	During Operation:	
	• Reduce flies nuisance	Positive

7 ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan (EMP) was developed based on the Environmental Team's understanding of the project conditions and on the findings detailed in Section 6.

7.1 EMP Objectives

The main objectives of the EMP 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 Mitigation and Monitoring Plan

Table 7.1, Table 7.2 and Table 7-3 present mitigation and monitoring measures recommended by the Environmental Team to ensure that the project is implemented in a safe and environmentally sound manner during the construction, operation and closure phases. The tables also show the roles and responsibilities of various entities that are required to implement these measures.

The EMP 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 ensure 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: EMP during Construction

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Occupational safety accidents	Assign a Health, Safety and Environment Officer	Daily inspection by Safety Officer / Supervision Consultant Team	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			
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			
Disturbance of biodiversity	Ban workers from trapping or hunting any existing fauna species in the project area		Contractor	MWI RSCN
	Plant natural vegetation whenever possible and replace any trees moved from the project area			
	Wherever possible, restrict construction activities to one area at a time			

Increase in water demand			Contractor	MWI
	Provide an adequate source of water from available and approved off-site sources and encourage the reuse of treated water when possible		Contractor	MWI
	Conserve water use and restrict the use of groundwater in construction activities		Contractor	MWI
	Hazardous Materials should be managed properly to prevent groundwater and surface water contamination		Contractor	MWI

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Soil erosion and contamination	Prepare and abide by a soil erosion prevention plan		Contractor	MWI MOENV
	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			
Accumulated waste	Allocate a designated disposal site for construction waste		Contractor	MWI Zarqa Municipality
	Allow 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			
Increased levels of emissions and dust	Prepare a site specific dust management plan	Monitor levels of TSP and PM10 for 3 days / monthly within WWTP	Contractor	MWI MOENV
	Record and keep dust and air quality complaints			
	Use water as 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			

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
	Control movement on unpaved paths near sensitive receptors.			
	Remove dusty materials from site as soon as possible			
	Install hard surfacing as soon as practicable on site and ensure that they are maintained in good condition			
	Ensure any site machinery 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		Contractor	MWI
	Provide workers with noise protection equipment			
	Schedule several noisy activities to occur at the same time whenever possible			
Changes of visual character	The design should ensure pleasant appearance of the monofill		Contractor	MWI
Damage of unknown archeological findings	Stop work within area surrounding any archaeological findings and immediately contact the responsible authority		DOA/ Contractor	MWI

Table 7.2 presents the EMP 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 EMP are designated to the SPC, in addition to the third part assessor (SGS and RSS) and MWI.

Table 7-2: EMP during Operation

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Occupational safety accidents	Assign a Health, Safety and Environment Officer	Daily inspection by Safety Officer / Supervision Consultant Team	Contractor	MWI
	Prepare and abide by HASP and HMMP			
	Enforce use of safety gears and equipment			
	Establish noise, dust and sun exposure durations for workers within acceptable limits			
	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		Contractor/SPC	MWI RSCN
	Plant natural vegetation whenever possible and replace any trees moved from the project area			
	Restrict operation activities outside the monofill			
	Maintain perimeter security fencing regularly			
Increased levels of emissions	Maintain and monitor the installed gas collection system and leachate collection system.		SPC/ Third Part Assessor (SGS, RSS)	MWI MOENV
	Collect, vent, or incinerate excess amount of gases		SPC	
	Regulate and maintain used vehicles		SPC/ Department of Traffic / General Directorate of Civil Defense	
	Immediately report fires to local fire-fighting offices			

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Contamination of soil and water resources	Monitor surface and groundwater	Log of water quality	SPC/Third Part Assessor (SGS, RSS)	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 channel – run-on diversion channel should be encouraged			
Changes of visual character	Ensure pleasant appearance of the monofill		SPC	MWI

Table 7-3: EMP during Closure

Impact/ Issue	Mitigation Measure	Monitoring Measure	Implementation Responsibility	Supervision Responsibility
Public and occupational safety accidents	• Placement and maintenance of final monofill cover	Monthly or quarterly for three years	SPC/Third Part Assessor/ MWI	MWI
	• Regular monitoring of monofill settlement and soil cover grading after closure and for several years			
	• Regular monitoring of air quality after closure and for several years			
	• Regular monitoring of surface and groundwater quality after closure and for several years			
	• Restricting public access to the monofill and maintain security fence regularly			
	• Maintain vegetation around the monofill.			

8 CONCLUSION

According to the previous discussions and the outcomes of the PESIA, 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 sludge storage problem at As Samra WWTP will be significant, making the construction of the monofill a necessary mitigation measure to an accumulating problem until other beneficial reuse options for the generated biosolids are implemented. However; the proper implementation of the EMP is essential to ensure that any negative impacts are minimized and that the environmental performance is being monitored throughout the construction, operation and closure phases of the project.

9 REFERENCES

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APPENDIX A – METROLOGICAL DATA FROM THE AS-SAMRA WEATHER STATION

MONTHLY CLIMATOLOGICAL SUMMARY for JAN. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	9.6	15.4	4:00p	4.9	7:00a	8.8	0.0	0.0	0.1	4.9	11:00a	S
2	10.2	17.7	3:00p	3.9	7:30a	8.2	0.0	0.0	0.0	2.2	4:30p	NNE
3	9.9	17.3	4:00p	3.9	9:00a	8.4	0.0	0.0	0.0	3.1	11:30a	SSE
4	9.4	16.8	4:00p	3.1	8:00a	8.9	0.0	0.0	0.1	5.4	12:30p	SE
5	9.7	13.5	12:30p	8.2	8:00a	8.6	0.0	-686.7	0.4	8.5	4:30p	NNW
6	10.3	11.7	4:30p	8.2	5:00a	8.1	0.0	0.0	2.2	11.6	3:00p	WNW
7	8.6	11.2	1:00a	7.0	10:30a	9.7	0.0	0.5	6.6	13.4	10:00a	WNW
8	7.9	11.1	3:00p	5.1	11:30p	10.4	0.0	0.3	5.5	13.4	3:30p	NW
9	3.4	6.4	4:00p	0.6	10:30p	14.9	0.0	0.3	2.6	12.5	4:30p	NNW
10	2.9	5.5	1:00p	0.7	6:00a	15.4	0.0	0.0	0.9	11.6	2:00a	NNW
11	3.9	9.4	4:00p	0.2	7:30a	14.4	0.0	0.0	0.0	5.4	3:30p	SSE
12	4.4	9.3	4:30p	0.5	3:30a	13.9	0.0	0.0	0.4	11.2	11:30a	S
13	5.6	11.4	3:30p	1.2	8:00a	12.8	0.0	0.0	0.0	4.0	12:00p	S
14	6.4	13.9	3:30p	0.5	7:00a	11.9	0.0	0.0	0.0	0.9	1:00p	SSE
15	6.4	13.7	4:00p	0.6	8:00a	11.9	0.0	0.0	0.2	6.3	12:00p	S
16	7.6	13.7	4:30p	0.7	7:30a	10.8	0.0	0.0	0.8	8.9	10:00a	S
17	10.8	18.5	5:00p	6.7	7:30a	7.6	0.0	0.0	0.1	5.8	2:30a	SSE
18	10.5	18.6	3:30p	2.8	9:00a	7.8	0.0	0.0	0.1	6.3	12:30p	S
19	9.7	17.0	3:00p	3.1	8:00a	8.6	0.0	0.0	0.0	4.5	3:30p	N
20	10.3	16.8	4:00p	4.7	7:00a	8.0	0.0	0.0	0.0	4.5	1:30p	N
21	10.6	18.6	4:30p	3.1	7:00a	7.8	0.0	0.0	0.2	6.3	1:30p	S
22	12.1	20.8	4:30p	6.7	3:30a	6.4	0.2	0.0	0.1	5.4	4:30a	S
23	11.2	15.9	3:30p	7.2	7:00a	7.1	0.0	0.0	0.4	6.7	4:30p	NNW
24	11.4	17.7	4:00p	6.6	6:00a	6.9	0.0	0.0	0.1	5.8	2:30p	SSW
25	13.7	20.1	2:00p	9.4	4:00a	4.8	0.2	0.0	0.1	4.9	9:30a	N
26	13.9	22.7	3:30p	5.8	7:30a	5.3	0.9	0.0	0.0	4.9	12:30p	W
27	13.2	17.2	2:30p	10.2	12:00m	5.2	0.0	11.4	0.4	7.2	3:30p	N
28	10.9	15.9	3:30p	8.4	2:30a	7.4	0.0	0.0	0.1	4.9	7:00p	N
29	9.4	11.2	2:00p	7.8	4:00a	8.9	0.0	0.0	1.6	9.4	1:30p	NNW
30	9.6	14.4	2:00p	7.1	12:00m	8.8	0.0	0.0	0.4	9.4	6:00p	W
31	6.7	8.2	3:00p	5.3	11:00a	11.6	0.0	0.0	1.1	10.7	5:00p	NNW
	9.0	22.7	26	0.2	11	289.5	1.2	-674.3	0.8	13.4	7	NNW

Max >= 32.0: 0
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 11.43 ON 27/01/13
Days of Rain: 4 (> .2 mm) 1 (> 2 mm) 0 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for FEB. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	8.2	10.3	4:00p	6.8	12:30a	10.1	0.0	0.0	0.3	6.7	12:30p	W
2	9.8	13.3	3:00p	7.2	7:30a	8.6	0.0	0.0	0.7	8.5	2:00p	NNW
3	9.6	17.8	4:30p	3.0	8:30a	8.7	0.0	0.0	0.1	4.5	11:00a	S
4	11.6	19.2	4:30p	5.7	7:30a	6.7	0.1	0.0	0.4	8.0	1:00p	S
5	11.7	15.9	3:30p	7.8	7:30a	6.6	0.0	0.0	0.3	8.0	4:00a	S
6	11.5	14.8	1:00p	9.0	12:00m	6.8	0.0	0.3	0.8	10.3	11:00p	NNW
7	11.7	16.6	3:30p	8.1	4:30a	6.6	0.0	0.0	0.0	4.0	11:30p	SSE
8	11.4	17.2	3:30p	5.8	8:00a	6.9	0.0	0.0	0.7	8.9	12:30p	S
9	12.9	19.2	12:30p	8.1	8:00a	5.4	0.1	0.0	0.0	4.0	3:00p	ENE
10	12.6	21.0	4:00p	6.2	7:30a	6.1	0.3	0.0	0.1	5.4	6:30p	SSE
11	10.8	14.4	2:00p	8.4	12:00m	7.5	0.0	0.0	1.1	9.8	2:00p	NNW
12	10.2	13.9	4:00p	7.3	12:00m	8.1	0.0	0.0	0.6	8.0	2:00p	NNW
13	10.7	18.5	4:00p	3.6	6:00a	7.6	0.0	0.0	0.5	8.5	12:00p	SSE
14	13.9	19.0	4:00p	9.5	1:30a	4.4	0.1	0.0	1.0	9.8	11:00a	S
15	11.0	15.7	2:00p	7.7	7:00a	7.3	0.0	0.0	1.7	12.1	3:00p	NNW
16	9.7	12.4	2:00p	7.1	2:30a	8.7	0.0	0.0	0.8	8.0	11:00a	NNW
17	10.6	14.8	4:30p	7.9	6:00a	7.7	0.0	0.0	0.3	5.8	4:00p	NNW
18	9.8	15.6	3:00p	4.1	6:30a	8.5	0.0	0.0	0.3	6.7	5:00p	NNW
19	10.4	14.6	2:30p	7.5	5:30a	7.9	0.0	0.0	0.4	7.2	2:30p	NNW
20	9.7	15.4	3:30p	3.9	6:30a	8.6	0.0	0.0	0.2	5.4	3:00p	N
21	11.5	19.7	4:30p	3.7	7:30a	6.9	0.1	0.0	0.0	4.0	10:30a	S
22	14.6	22.2	3:00p	6.5	8:30a	4.4	0.7	0.0	0.4	8.9	12:30p	S
23	12.9	16.9	3:00p	9.4	5:00a	5.4	0.0	0.0	0.9	8.9	2:30p	NNW
24	13.2	17.4	4:00p	10.1	5:30a	5.1	0.0	0.0	0.4	8.5	2:00p	NNW
25	14.8	22.6	4:30p	6.6	7:30a	4.2	0.7	0.0	1.0	9.4	10:30p	S
26	16.7	25.7	4:30p	9.8	5:30a	3.3	1.7	0.0	0.1	6.7	12:00p	S
27	15.8	23.9	2:00p	9.5	7:30a	3.6	1.1	0.0	0.4	8.9	4:30p	NNW
28	12.1	16.7	4:00p	8.3	7:30a	6.2	0.0	0.0	1.6	10.7	4:30p	NNW
	11.8	25.7	26	3.0	3	188.1	4.7	0.3	0.5	12.1	15	NNW

Max >= 32.0: 0
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 0.25 ON 06/02/13
Days of Rain: 1 (> .2 mm) 0 (> 2 mm) 0 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for MAR. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	11.4	15.4	2:30p	8.5	11:30p	6.9	0.0	0.0	0.9	7.2	1:00p	NNW
2	12.4	20.8	4:30p	5.1	7:00a	6.2	0.3	0.0	0.0	3.1	11:30a	SSE
3	17.2	26.2	2:00p	9.3	5:30a	3.1	1.9	0.0	0.7	11.2	2:30p	NNW
4	13.9	17.7	12:30a	11.4	11:00p	4.4	0.0	0.0	2.4	11.2	1:00p	NNW
5	12.0	15.6	4:00p	9.4	12:00m	6.3	0.0	0.0	2.1	11.2	12:00p	NNW
6	9.1	12.9	12:30p	6.7	7:30a	5.0	0.0	0.0	0.1	5.8	1:00p	N
7												
8												
9												
10												
11												
12												
13												
14	25.2	30.1	3:30p	18.3	12:00m	0.0	3.0	0.0	0.7	7.2	3:30p	NW
15	23.1	32.6	3:30p	12.3	6:00a	1.4	6.2	0.0	1.4	12.1	2:00p	WSW
16	16.6	26.2	12:30a	10.3	11:30p	2.9	1.2	0.0	2.0	10.3	4:00a	NNW
17	10.9	13.4	11:30a	9.2	12:00m	7.4	0.0	340.6	2.4	11.2	6:00p	NNW
18	11.0	15.4	4:00p	8.2	7:30a	7.3	0.0	0.0	0.9	8.5	2:00p	N
19	12.7	19.1	4:30p	6.3	8:00a	5.7	0.0	0.0	0.4	8.0	4:00p	S
20	15.2	23.7	4:00p	8.2	7:00a	4.1	0.9	0.0	0.1	5.8	4:30p	N
21	17.5	25.7	6:00p	7.9	7:00a	3.1	2.3	0.0	0.0	4.5	11:30p	SSE
22	17.9	29.0	2:00p	12.7	12:00m	2.3	1.9	0.0	3.0	13.4	3:00p	S
23	12.6	16.1	3:30p	10.3	12:00m	5.7	0.0	0.0	3.9	11.6	3:30p	NNW
24	12.4	17.6	4:00p	8.3	7:00a	5.9	0.0	0.0	0.5	7.2	3:30p	NNW
25	15.8	24.9	4:30p	6.2	6:00a	4.2	1.7	0.0	0.4	8.5	12:00p	S
26	19.3	29.1	4:00p	10.1	6:30a	2.4	3.4	0.0	1.0	9.8	12:00p	S
27	14.6	19.1	4:00p	10.8	12:00m	3.8	0.1	0.0	1.6	9.4	12:30p	NNW
28	15.3	22.7	4:00p	7.4	6:30a	4.0	0.9	0.0	0.7	8.0	5:00p	NNE
29	17.3	25.0	4:30p	10.4	6:00a	2.7	1.7	0.0	0.1	4.9	5:00p	NE
30	20.0	27.9	5:00p	11.1	5:30a	2.0	3.6	0.0	0.0	5.8	2:30p	SSE
31	23.1	29.9	5:30p	16.9	4:00a	0.2	4.7	0.0	0.9	11.6	11:00a	S
	15.7	32.6	15	5.1	2	97.1	33.6	340.6	1.1	13.4	22	NNW

Max >= 32.0: 1
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 340.61 ON 17/03/13
Days of Rain: 1 (> .2 mm) 1 (> 2 mm) 1 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for APR. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	22.9	28.8	4:00p	17.9	8:00a	0.0	4.7	0.0	1.3	10.7	1:00a	S
2	17.0	23.1	4:30p	11.5	8:30a	2.3	1.0	0.0	1.2	8.9	2:30p	NNE
3	17.4	26.3	5:30p	8.8	7:30a	3.2	2.3	0.0	0.1	5.4	6:30p	SE
4	15.5	19.6	1:30p	11.7	7:00a	2.9	0.1	0.0	3.4	13.4	1:30p	NNW
5	13.4	17.6	3:30p	10.9	4:30a	4.9	0.0	492.3	4.1	13.0	4:00p	NNW
6	16.0	24.8	5:30p	8.8	8:30a	3.8	1.5	0.0	0.2	5.8	4:30p	N
7	21.2	32.1	6:30p	10.0	7:00a	2.2	5.0	0.0	0.2	8.5	3:30p	SSW
8	18.4	27.5	1:30p	12.0	8:00a	1.9	2.0	0.0	1.7	10.7	4:30p	N
9	14.5	19.1	3:30p	11.1	5:30a	3.9	0.0	0.0	2.3	9.8	5:00p	NNW
10	14.2	18.4	3:30p	11.4	5:00a	4.2	0.0	0.0	1.4	9.8	5:30p	NNW
11	14.4	20.6	3:30p	8.2	5:30a	4.2	0.3	0.0	0.1	4.9	12:00p	NNE
12	16.4	25.4	4:00p	8.4	7:30a	3.6	1.7	0.0	0.5	6.7	6:30p	N
13	17.4	25.1	3:30p	10.8	7:00a	2.7	1.7	0.0	0.6	7.2	6:00p	N
14	18.3	25.7	5:30p	11.2	7:30a	2.3	2.3	442.5	0.3	6.3	5:30p	N
15	17.1	25.5	3:30p	9.5	7:30a	2.3	1.3	0.0	0.3	6.7	5:30p	N
16	14.9	19.4	1:00p	11.7	11:30p	3.4	0.0	0.0	2.2	11.6	12:00p	NNW
17	12.4	14.3	2:30p	11.3	1:00a	5.9	0.0	303.0	0.4	8.5	3:00p	NNW
18	14.0	19.3	5:30p	9.1	7:00a	4.4	0.1	0.0	0.3	5.4	3:00p	NNW
19	13.7	19.5	2:30p	9.1	5:30a	4.7	0.1	0.0	1.7	10.7	1:00p	NNW
20	10.7	16.3	12:30p	6.0	6:30a	7.6	0.0	620.5	1.4	11.2	12:30p	NNW
21	12.0	16.1	3:00p	9.4	1:00a	6.3	0.0	202.4	1.3	8.9	4:00p	NNW
22	12.6	17.0	1:30p	9.4	3:30a	5.7	0.0	0.0	1.3	8.9	1:00p	NNW
23	15.1	22.0	3:30p	8.4	2:30a	3.9	0.7	0.0	0.1	5.8	4:00p	N
24	17.9	26.8	5:00p	10.5	5:00a	2.2	1.9	0.0	0.1	6.7	10:30a	ENE
25	20.9	28.1	3:00p	12.3	6:00a	1.1	3.7	0.0	0.2	7.2	11:00a	SSE
26	21.9	29.3	3:30p	13.6	6:00a	0.7	4.3	0.0	0.4	9.8	10:30a	SE
27	23.7	30.7	3:00p	15.3	6:00a	0.4	5.8	0.0	0.6	9.8	11:00p	SE
28	24.4	30.9	3:30p	17.8	6:30a	0.0	6.1	0.0	0.6	8.5	3:30p	S
29	23.6	32.1	3:30p	14.1	6:00a	0.6	4.4	0.0	0.3	5.8	11:30a	ENE
30	29.8	33.8	3:30p	24.9	11:30p	0.0	5.9	0.0	0.3	21.9	5:00p	NE
	17.4	33.8	30	6.0	20	91.4	56.8	2060.7	1.0	21.9	30	NNW

Max >= 32.0: 3
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 620.52 ON 20/04/13
Days of Rain: 5 (> .2 mm) 5 (> 2 mm) 5 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for MAY. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	26.2	32.9	2:00p	19.9	5:00a	0.0	7.9	0.0	0.5	13.9	5:00p	S
2	24.1	31.8	2:30p	18.5	7:00a	0.0	5.8	24.4	0.9	12.1	5:00p	N
3	23.7	31.6	1:00p	17.0	7:00a	0.1	5.4	0.0	0.4	9.4	3:30p	SE
4	24.0	32.5	1:30p	15.6	6:00a	0.4	6.1	0.0	0.4	9.8	3:30p	NNE
5	24.0	30.8	2:00p	16.4	7:00a	0.2	5.8	0.0	0.9	10.3	1:00p	N
6	23.2	29.7	2:30p	15.7	5:30a	0.2	5.1	0.0	1.3	9.8	4:00p	NNW
7	23.2	30.8	1:00p	17.1	5:00a	0.2	5.0	0.0	0.4	9.4	2:30p	N
8	23.9	30.9	3:30p	15.2	6:30a	0.3	5.9	0.0	0.4	7.2	2:00p	N
9	24.2	29.4	4:30p	18.9	6:00a	0.0	5.8	0.0	0.6	7.2	12:30p	NNE
10	23.8	30.9	5:00p	15.9	5:30a	0.3	5.8	0.0	0.6	10.3	4:30p	NW
11	22.0	26.7	2:00p	17.4	12:00m	0.1	3.7	0.0	1.5	12.1	12:30p	NNW
12	18.3	23.8	3:00p	14.4	6:00a	1.2	1.2	121.4	0.8	8.9	4:30p	N
13	19.2	25.8	4:30p	13.1	6:00a	1.6	2.4	363.0	1.1	10.3	5:00p	NNW
14	18.4	24.2	4:00p	14.1	5:00a	1.3	1.3	514.3	1.1	10.7	5:00p	N
15	16.5	20.4	4:00p	11.3	5:30a	2.2	0.3	0.0	1.5	10.3	11:00a	N
16	18.1	24.3	4:00p	13.2	6:00a	1.8	1.5	0.0	1.2	8.9	4:30p	NNW
17	20.3	28.7	5:00p	12.6	6:30a	1.6	3.6	0.0	0.0	4.9	7:00p	NNE
18	24.4	33.7	4:30p	15.2	6:30a	0.3	6.4	0.0	0.4	7.2	5:30p	NNW
19	25.9	31.5	12:30p	18.9	6:30a	0.0	7.6	0.0	0.8	8.5	5:00p	NNW
20	24.3	27.9	3:30p	19.1	12:00m	0.0	6.0	0.0	2.0	11.2	1:00p	NNW
21	23.2	31.2	1:00p	15.8	6:30a	0.4	5.3	0.0	0.6	7.2	4:30p	N
22	25.3	32.3	3:00p	16.7	5:00a	0.1	7.1	0.0	0.2	7.2	3:30p	SSE
23	27.7	36.7	4:30p	18.0	6:30a	0.0	9.4	0.0	0.2	5.8	2:00p	NE
24	30.3	39.3	2:00p	22.1	6:30a	0.0	11.9	0.0	0.4	7.2	3:30p	N
25	25.8	30.4	1:00p	19.3	12:00m	0.0	7.5	0.0	1.6	10.7	3:30p	NNW
26	20.4	27.0	3:30p	14.8	6:00a	0.8	2.8	0.0	1.9	11.2	4:30p	N
27	20.8	27.4	4:00p	13.4	5:30a	1.1	3.6	0.0	1.6	9.8	2:00p	NNW
28	22.2	28.2	4:30p	16.6	6:00a	0.2	4.1	0.0	2.0	12.1	2:30p	NNW
29	24.1	32.6	5:00p	12.8	5:30a	0.8	6.7	0.0	0.0	4.5	2:30p	N
30	27.2	37.1	1:30p	18.9	6:30a	0.0	8.8	0.0	2.1	12.1	3:30p	NNW
31	25.3	33.5	3:30p	15.8	6:00a	0.3	7.2	0.0	0.8	8.9	2:30p	NNW
	23.2	39.3	24	11.3	15	15.3	167.0	1023.1	0.9	13.9	1	NNW

Max >= 32.0: 9
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 514.35 ON 14/05/13
Days of Rain: 4 (> .2 mm) 4 (> 2 mm) 4 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for JUN. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	26.7	33.9	2:00p	19.4	5:30a	0.0	8.3	0.0	1.7	11.2	4:30p	N
2	29.1	37.7	4:30p	20.9	4:00a	0.0	10.7	0.0	0.1	6.7	3:30p	N
3	27.2	34.5	2:30p	20.0	12:00m	0.0	8.8	0.0	2.0	10.3	2:30p	NNW
4	21.9	28.3	3:30p	16.3	6:00a	0.3	3.8	0.0	1.3	9.8	3:00p	NNW
5	21.9	29.1	2:30p	14.7	5:30a	0.7	4.3	0.0	0.9	9.4	2:30p	N
6	23.3	30.4	3:00p	14.8	6:00a	0.6	5.6	0.0	1.4	10.3	2:00p	NE
7	23.1	29.7	1:00p	15.7	6:00a	0.3	5.1	0.0	1.7	11.2	4:00p	NNW
8	25.0	34.4	3:00p	15.3	5:30a	0.6	7.3	0.0	0.3	7.2	4:30p	N
9	24.5	30.1	1:30p	19.8	12:00m	0.0	6.2	0.0	2.0	12.5	1:00p	N
10	22.4	28.2	4:00p	17.8	5:30a	0.1	4.2	0.0	1.9	10.3	5:00p	NNW
11	23.2	31.1	4:00p	15.3	6:00a	0.5	5.4	0.0	0.6	9.4	3:30p	N
12	26.3	33.7	4:30p	17.9	6:30a	0.0	7.9	0.0	0.5	7.2	3:00p	N
13	22.8	28.5	5:00p	18.6	12:00m	0.0	4.4	0.0	1.5	10.3	4:00p	N
14	21.8	28.7	4:00p	15.6	6:00a	0.4	3.9	0.0	1.5	9.4	4:00p	NNW
15	21.3	27.6	4:00p	16.1	6:00a	0.4	3.4	0.0	1.6	8.9	3:30p	NNE
16	21.3	27.5	3:30p	15.8	6:00a	0.5	3.5	0.0	1.6	10.7	1:30p	NNW
17	22.6	29.4	2:30p	15.8	4:00a	0.4	4.7	0.0	1.4	10.7	4:00p	NNW
18	24.2	30.4	4:00p	18.1	6:00a	0.0	5.9	0.0	2.2	11.6	2:00p	NNW
19	25.3	31.8	2:30p	18.6	6:00a	0.0	7.0	0.0	1.3	10.7	3:00p	N
20	26.3	33.2	3:00p	19.4	6:00a	0.0	7.9	0.0	1.0	8.9	5:30p	NNW
21	26.7	32.7	4:30p	19.7	5:30a	0.0	8.3	0.0	1.5	9.8	2:30p	NNW
22	27.4	34.2	4:00p	19.4	6:00a	0.0	9.1	0.0	0.8	9.8	4:00p	N
23	27.6	33.2	2:00p	21.8	6:00a	0.0	9.2	0.0	0.9	9.8	3:00p	N
24	25.8	31.2	3:30p	19.6	6:00a	0.0	7.4	0.0	1.7	10.7	2:30p	N
25	26.1	32.4	3:00p	18.7	6:00a	0.0	7.7	0.0	1.3	10.3	2:30p	N
26	26.6	34.3	2:30p	18.8	6:00a	0.0	8.2	0.0	1.1	10.3	4:30p	N
27	26.7	33.3	3:30p	19.1	6:00a	0.0	8.4	0.0	1.3	9.4	3:00p	NNW
28	26.4	33.3	2:30p	20.1	6:30a	0.0	8.1	0.0	1.8	10.7	3:30p	N
29	25.8	33.4	3:00p	19.2	6:00a	0.0	7.5	0.0	1.5	11.2	4:30p	N
30	25.2	32.4	3:00p	19.1	6:30a	0.0	6.8	0.0	1.9	9.4	5:00p	NNW
	24.8	37.7	2	14.7	5	4.6	199.2	0.0	1.3	12.5	9	N

Max >= 32.0: 15
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 0.00 ON 01/06/13
Days of Rain: 0 (> .2 mm) 0 (> 2 mm) 0 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for JUL. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	23.0	29.7	4:00p	17.0	5:30a	0.1	4.8	0.0	2.0	11.2	4:00p	NNW
2	23.2	29.9	4:00p	18.3	5:30a	0.0	4.9	0.0	1.7	9.8	5:00p	N
3	24.4	32.0	3:30p	16.4	6:00a	0.2	6.2	0.0	0.7	6.7	4:30p	NNW
4	25.3	32.8	3:30p	17.9	6:00a	0.0	7.0	0.0	0.9	8.5	4:00p	NNW
5	25.9	33.5	2:30p	18.1	6:00a	0.0	7.6	0.0	1.1	8.5	3:30p	NNW
6	25.9	33.7	4:00p	17.6	6:00a	0.1	7.6	0.0	0.8	7.2	4:30p	N
7	26.8	35.6	3:00p	17.9	5:30a	0.0	8.4	0.0	0.4	6.3	3:00p	N
8	26.6	34.9	4:30p	18.8	6:00a	0.0	8.2	0.0	0.8	6.7	5:00p	N
9	25.0	31.8	3:30p	18.4	6:00a	0.0	6.7	0.0	2.3	9.8	4:00p	NNW
10	24.3	31.0	3:30p	18.7	3:30a	0.0	5.9	0.0	2.1	10.7	6:30p	NNE
11	24.4	31.1	3:30p	19.3	6:00a	0.0	6.1	0.0	2.1	9.8	3:30p	N
12	24.7	31.9	4:30p	18.8	5:00a	0.0	6.3	0.0	1.4	8.9	6:00p	N
13	26.4	36.2	3:30p	18.2	6:00a	0.0	8.1	0.0	0.6	6.7	5:30p	NNW
14	26.2	33.7	3:30p	19.3	6:30a	0.0	7.8	0.0	1.2	7.2	12:30p	NNW
15	26.7	35.6	4:00p	18.8	6:30a	0.0	8.3	0.0	0.4	5.8	4:30p	N
16	27.2	33.9	3:00p	20.7	6:00a	0.0	8.8	0.0	1.1	8.5	4:30p	NNW
17	25.3	31.4	4:00p	19.6	6:30a	0.0	6.9	0.0	1.3	8.9	3:30p	NNW
18	23.7	29.9	4:30p	18.7	5:00a	0.0	5.4	0.0	1.8	9.4	4:00p	NNW
19	23.8	29.9	4:00p	18.2	6:00a	0.0	5.5	0.0	1.4	9.4	3:30p	NNW
20	25.4	31.4	2:30p	20.9	1:30a	0.0	7.1	0.0	1.5	9.4	2:30p	N
21	24.6	30.6	4:00p	19.6	6:30a	0.0	6.2	0.0	1.9	10.3	3:30p	NNW
22	24.6	31.2	3:30p	19.0	3:30a	0.0	6.2	0.0	1.6	9.8	3:30p	NNW
23	26.2	32.9	3:30p	18.7	6:00a	0.0	7.8	0.0	0.9	8.9	3:30p	N
24	27.2	34.0	3:00p	20.3	5:30a	0.0	8.9	0.0	1.2	8.9	3:30p	N
25	26.5	32.1	2:00p	21.3	6:30a	0.0	8.2	0.0	1.6	11.6	4:30p	NNW
26	26.1	32.9	2:30p	19.2	6:30a	0.0	7.7	0.0	1.4	10.3	4:30p	NNW
27	25.8	31.6	4:30p	19.8	7:00a	0.0	7.4	0.0	1.8	11.2	3:00p	NNW
28	26.6	33.0	2:30p	20.6	6:00a	0.0	8.3	0.0	1.0	9.8	3:30p	NNW
29	26.2	33.2	3:30p	19.2	6:30a	0.0	7.9	0.0	1.1	9.4	4:30p	N
30	25.6	31.7	3:00p	19.1	5:00a	0.0	7.2	0.0	1.5	10.3	4:00p	NNW
31	25.5	32.1	3:30p	18.1	6:30a	0.0	7.2	0.0	1.4	10.3	6:00p	NNW
	25.4	36.2	13	16.4	3	0.3	220.8	0.0	1.3	11.6	25	NNW

Max >= 32.0: 17
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 0.00 ON 01/07/13
Days of Rain: 0 (> .2 mm) 0 (> 2 mm) 0 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for AUG. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	26.1	32.4	3:00p	19.5	6:00a	0.0	7.8	0.0	1.6	10.3	5:30p	NNW
2	27.6	33.9	2:30p	20.1	6:30a	0.0	9.2	0.0	1.4	9.8	4:00p	N
3	26.8	32.9	5:00p	19.8	5:30a	0.0	8.5	0.0	1.4	10.3	3:00p	NNW
4	24.8	31.3	4:00p	18.5	6:30a	0.0	6.5	0.0	1.6	10.7	1:30p	NNW
5	26.0	33.6	3:30p	19.2	7:00a	0.0	7.7	0.0	0.7	8.9	4:30p	N
6	26.2	33.4	3:00p	18.9	6:30a	0.0	7.9	0.0	0.8	8.9	2:30p	N
7	26.2	32.7	3:30p	18.7	6:00a	0.0	7.8	0.0	1.3	8.9	2:30p	N
8	25.7	32.3	2:00p	19.1	6:30a	0.0	7.3	0.0	1.4	9.8	4:30p	N
9	25.8	31.7	4:00p	20.6	6:30a	0.0	7.5	0.0	1.3	9.8	2:30p	NNW
10	25.7	32.5	2:30p	19.6	6:30a	0.0	7.4	0.0	1.0	9.4	5:30p	NNW
11	26.0	32.3	3:00p	19.9	6:30a	0.0	7.7	0.0	1.0	9.8	6:30p	NNW
12	25.0	31.5	4:30p	18.9	6:30a	0.0	6.7	0.0	0.8	8.0	1:30p	NNW
13	26.4	34.6	4:00p	19.6	6:30a	0.0	8.1	0.0	0.4	6.3	6:30p	N
14	28.3	38.6	3:00p	19.4	7:00a	0.0	9.9	0.0	0.1	4.9	5:00p	N
15	28.5	36.3	2:00p	21.6	6:30a	0.0	10.2	0.0	1.0	8.9	3:30p	N
16	27.8	34.8	3:30p	21.7	6:00a	0.0	9.5	0.0	1.2	9.4	4:00p	N
17	27.9	35.7	2:30p	20.9	6:30a	0.0	9.6	0.0	1.2	9.4	12:30p	N
18	26.9	33.1	2:30p	20.8	7:00a	0.0	8.6	0.0	1.2	10.7	4:00p	NNW
19	25.3	33.1	4:00p	18.1	7:30a	0.0	7.0	0.0	0.5	6.7	4:00p	N
20	26.0	34.7	3:30p	18.5	7:00a	0.0	7.7	0.0	0.8	8.9	5:00p	N
21	26.1	32.7	2:30p	19.4	6:30a	0.0	7.7	0.0	1.0	9.8	3:30p	NNW
22	25.6	31.9	4:00p	19.0	6:30a	0.0	7.3	0.0	1.0	8.5	1:30p	NNW
23	25.2	31.7	3:30p	18.9	6:30a	0.0	6.8	0.0	1.0	9.4	4:30p	N
24	23.9	29.3	3:30p	19.2	6:30a	0.0	5.6	0.0	1.5	9.4	4:00p	N
25	24.3	31.3	4:30p	18.4	5:30a	0.0	6.0	0.0	0.7	8.0	4:00p	NNW
26	25.4	33.3	4:30p	19.1	6:00a	0.0	7.1	0.0	0.7	7.2	4:00p	N
27	26.2	33.9	2:30p	19.4	7:00a	0.0	7.9	0.0	0.5	6.3	4:30p	N
28	26.9	34.8	3:00p	19.2	7:00a	0.0	8.6	0.0	0.6	8.0	5:30p	N
29	27.6	34.6	3:00p	20.7	7:00a	0.0	9.3	0.0	0.9	8.9	4:00p	NNW
30	28.2	35.6	2:30p	21.8	7:00a	0.0	9.8	0.0	0.7	8.9	4:00p	N
31	27.2	34.6	3:00p	20.3	4:00a	0.0	8.8	0.0	0.5	8.0	3:30p	N
	26.3	38.6	14	18.1	19	0.0	247.5	0.0	1.0	10.7	4	N

Max >= 32.0: 24
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 0.00 ON 01/08/13
Days of Rain: 0 (> .2 mm) 0 (> 2 mm) 0 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for SEP. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	25.8	33.1	4:00p	19.1	6:00a	0.0	7.5	0.0	0.5	6.3	5:00p	NNW
2	27.2	35.7	3:00p	20.3	6:30a	0.0	8.8	0.0	0.4	6.3	5:00p	NNE
3	26.2	33.4	3:00p	20.7	7:00a	0.0	7.8	0.0	1.0	8.9	4:00p	N
4	24.2	30.1	3:00p	19.2	7:00a	0.0	5.8	0.0	1.2	8.9	4:30p	N
5	24.5	31.2	3:00p	20.0	6:30a	0.0	6.2	0.0	0.7	11.6	2:00p	N
6	24.1	31.7	3:30p	16.3	6:00a	0.2	5.9	0.0	0.4	8.0	4:30p	N
7	23.6	30.7	2:30p	17.9	6:30a	0.0	5.2	0.0	0.7	8.5	4:30p	NNW
8	23.1	30.1	3:30p	17.3	6:00a	0.1	4.8	0.0	0.7	8.5	5:30p	NNW
9	23.2	30.6	4:00p	16.1	6:00a	0.3	5.2	0.0	0.4	6.7	6:30p	N
10	24.9	33.1	4:00p	17.4	6:00a	0.1	6.6	0.0	0.2	5.8	5:00p	N
11	27.3	35.9	4:30p	19.8	4:30a	0.0	8.9	0.0	0.1	5.8	6:00p	NE
12	28.8	37.8	4:30p	19.7	8:00a	0.0	10.5	0.0	0.1	6.3	7:00p	SE
13	29.5	39.1	3:00p	21.1	7:00a	0.0	11.2	0.0	0.1	4.9	4:00p	N
14	28.6	36.7	2:30p	20.7	6:30a	0.0	9.8	0.0	0.5	8.0	3:30p	N
15	25.8	32.1	1:00p	20.4	7:00a	0.0	7.5	0.0	0.8	9.4	2:00p	NNW
16	22.7	28.6	3:00p	18.7	7:00a	0.0	4.4	0.0	1.3	8.5	2:00p	NNW
17	22.1	28.4	3:30p	15.7	6:00a	0.4	4.2	0.0	1.1	9.8	3:00p	NNW
18	23.0	29.6	3:30p	16.2	7:00a	0.2	4.9	0.0	1.5	9.4	11:30a	NNW
19	24.2	30.8	3:00p	17.0	7:00a	0.1	6.0	0.0	0.5	8.0	3:30p	N
20	24.7	29.4	3:00p	20.6	12:00m	0.0	6.3	0.0	1.6	10.3	11:30a	NNW
21	22.4	27.7	3:30p	18.2	6:30a	0.0	4.1	0.0	2.0	10.3	3:00p	NNW
22	22.4	27.2	3:00p	18.8	7:00a	0.0	4.1	0.0	1.7	9.8	3:30p	NNW
23	21.3	27.2	3:00p	15.8	6:30a	0.3	3.3	0.0	1.5	9.8	3:00p	NNW
24	20.9	25.9	4:00p	18.0	4:00a	0.0	2.6	0.0	1.7	9.8	1:30p	NNW
25	20.3	25.9	4:30p	15.5	6:00a	0.6	2.6	0.0	0.8	8.0	4:30p	NNW
26	21.8	30.4	4:00p	13.7	6:30a	0.9	4.4	437.1	0.0	4.0	2:00p	SE
27	22.9	32.3	2:30p	15.5	7:30a	0.3	4.9	0.0	0.3	6.3	5:00p	NNW
28	20.6	26.2	4:00p	15.9	6:30a	0.4	2.8	0.0	0.8	8.5	1:00p	N
29	20.8	27.6	4:30p	14.6	5:00a	0.9	3.3	0.0	0.1	4.9	3:00p	N
30	22.4	31.5	4:30p	14.4	6:30a	0.7	4.8	0.0	0.1	4.5	5:30p	N
	24.0	39.1	13	13.7	26	5.6	174.4	437.1	0.8	11.6	5	NNW

Max >= 32.0: 10
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 437.13 ON 26/09/13
Days of Rain: 1 (> .2 mm) 1 (> 2 mm) 1 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for OCT. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	24.2	33.2	4:30p	17.3	7:00a	0.1	5.9	0.0	0.3	6.7	7:00p	N
2	22.5	28.2	2:30p	16.1	7:00a	0.3	4.5	0.0	0.6	8.0	3:00p	N
3	21.9	27.7	3:30p	16.7	7:00a	0.1	3.7	0.0	1.1	9.4	4:30p	N
4	19.8	24.7	3:00p	16.4	12:00m	0.4	1.9	0.0	1.6	10.3	3:00p	N
5	18.1	22.7	3:30p	14.8	12:00m	1.3	1.1	0.0	1.0	8.5	3:30p	NNW
6	16.7	21.8	3:30p	13.1	12:00m	2.3	0.7	0.0	1.3	9.4	3:00p	NNW
7	15.6	21.8	4:30p	8.3	7:00a	3.4	0.7	0.0	0.1	6.3	2:30p	NNE
8	17.5	25.0	4:00p	9.6	7:30a	2.7	1.9	0.0	0.2	6.3	12:30p	SSE
9	18.5	26.1	5:00p	10.7	7:30a	2.2	2.4	0.0	0.3	8.0	1:00p	S
10	20.1	29.3	4:00p	10.8	7:00a	2.0	3.7	0.0	0.0	4.9	12:00p	S
11	21.3	31.3	3:00p	12.3	7:00a	1.3	4.3	0.0	0.1	5.4	4:00p	N
12	20.2	28.2	2:00p	12.4	7:30a	1.3	3.1	0.0	0.4	6.3	3:30p	N
13	19.0	26.4	3:00p	11.7	7:00a	1.8	2.4	0.0	0.6	8.0	4:30p	N
14	19.3	26.1	3:30p	12.6	7:00a	1.4	2.3	318.5	0.6	8.0	4:00p	N
15	20.2	28.5	3:30p	12.4	7:00a	1.3	3.2	0.0	0.0	4.5	4:00p	N
16	21.3	29.9	3:00p	12.5	7:00a	1.1	4.1	0.0	0.0	4.9	12:30p	SSW
17	21.7	31.2	3:30p	12.8	7:30a	0.9	4.3	0.0	0.2	5.8	5:00p	N
18	19.3	26.6	2:30p	12.2	7:30a	1.1	2.1	0.0	1.6	12.1	2:30p	N
19	18.3	22.4	3:30p	15.2	7:00a	1.1	1.0	0.0	1.2	8.9	2:30p	N
20	17.4	24.1	4:00p	11.3	5:30a	2.3	1.4	230.9	0.0	4.5	11:30a	SSE
21	17.9	24.7	3:30p	11.5	7:30a	2.1	1.7	0.0	0.4	8.9	1:00p	S
22	19.3	26.8	3:30p	12.5	7:30a	1.7	2.6	0.0	0.4	8.0	4:00p	SSE
23	19.4	27.1	3:00p	12.0	7:30a	1.6	2.7	0.0	0.3	6.3	3:00p	NNW
24	18.4	26.4	3:00p	10.8	8:00a	2.2	2.3	0.0	0.3	6.3	4:30p	NNW
25	16.9	25.3	3:30p	9.5	5:30a	2.9	1.5	0.0	0.3	6.3	5:00p	N
26	16.9	24.5	3:30p	8.5	7:00a	2.9	1.4	0.0	0.1	4.5	4:30p	N
27	17.2	25.1	2:00p	9.3	6:30a	2.8	1.7	0.0	0.1	5.8	3:30p	N
28	17.1	25.3	3:00p	8.6	6:00a	3.1	1.8	0.0	0.0	3.6	11:00a	S
29	19.0	26.5	2:00p	10.2	6:00a	2.2	2.8	0.0	0.4	8.9	2:30p	S
30	20.2	24.9	2:00p	15.6	6:30a	0.3	2.2	0.0	0.6	9.8	11:00a	SSE
31	17.0	20.8	3:30p	13.7	6:30a	1.6	0.2	88.4	0.9	10.3	11:30a	SSE
	19.1	33.2	1	8.3	7	51.7	75.8	637.8	0.5	12.1	18	N

Max >= 32.0: 1
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 318.52 ON 14/10/13
Days of Rain: 3 (> .2 mm) 3 (> 2 mm) 3 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for NOV. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	17.1	23.4	12:30p	13.4	7:00a	1.8	0.5	25.7	0.0	6.3	1:00p	SSE
2	16.5	22.7	1:00p	11.7	6:30a	2.5	0.7	-632.9	0.0	5.4	6:00p	SSE
3	17.1	23.3	2:30p	11.3	6:00a	2.5	1.3	-328.8	0.0	5.4	11:30a	SW
4	17.3	23.6	2:00p	10.9	6:30a	2.4	1.4	0.0	0.4	8.0	2:30p	S
5	19.1	26.2	2:30p	13.6	1:30a	1.5	2.2	0.0	0.2	8.9	11:30a	S
6	19.6	27.7	2:00p	12.1	7:00a	1.6	2.8	0.0	0.0	4.0	3:30p	SSE
7	19.2	26.6	12:00p	12.1	6:30a	1.4	2.3	0.0	0.1	6.3	1:30p	N
8	20.0	25.5	3:00p	15.9	12:00m	0.5	2.2	0.0	0.0	4.5	7:00p	SSE
9	17.4	22.6	3:00p	12.4	4:30a	1.9	1.0	0.0	0.0	4.9	9:30a	SSE
10	17.9	24.2	2:30p	12.4	6:30a	2.0	1.5	0.0	0.0	4.5	2:00p	S
11	17.7	22.6	3:00p	13.5	6:30a	1.6	1.0	0.0	0.2	6.3	10:30a	S
12	17.8	22.0	2:00p	14.8	12:00m	1.3	0.7	0.0	0.3	6.3	12:30p	SSW
13	17.3	23.4	2:00p	11.8	6:00a	2.2	1.1	0.0	0.0	3.6	12:00p	SSW
14	16.7	24.1	1:30p	10.7	5:30a	2.9	1.3	0.0	0.0	5.4	2:00p	SSE
15	16.8	24.3	2:30p	10.3	6:30a	2.7	1.2	0.0	0.0	3.6	5:00p	N
16	15.9	22.7	1:00p	10.4	6:30a	3.2	0.8	0.0	0.0	4.0	3:30p	N
17	14.9	20.8	12:00p	9.7	6:00a	3.7	0.3	0.0	0.0	4.0	1:00p	SSE
18	13.8	18.6	12:30p	9.3	6:30a	4.6	0.0	150.4	0.1	8.5	7:00p	SSE
19	14.3	19.1	12:00p	10.2	7:30a	4.1	0.0	0.0	0.5	8.0	2:00p	SE
20	14.6	20.1	2:00p	9.8	6:30a	4.0	0.2	0.0	0.3	6.7	3:30p	N
21	14.8	21.2	2:00p	9.1	7:00a	4.0	0.4	85.1	0.1	5.4	3:30p	N
22	15.3	24.0	3:00p	7.3	6:30a	4.1	1.1	40.1	0.0	4.0	12:00m	SSE
23	16.1	21.8	1:30p	9.9	8:00a	2.9	0.7	0.0	0.0	5.4	12:30a	SSE
24	15.6	20.7	1:30p	9.3	6:30a	3.2	0.4	0.0	0.0	0.9	1:30p	N
25	16.4	24.4	2:30p	9.2	6:30a	3.2	1.4	0.0	0.0	3.1	10:30a	SSE
26	18.6	29.2	3:00p	11.1	7:00a	2.4	2.6	0.0	0.1	5.4	12:00p	S
27	19.4	26.3	3:30p	11.7	7:30a	1.7	2.7	0.0	0.0	5.4	2:00a	SSE
28	19.4	25.4	1:30p	14.1	12:00m	0.8	1.9	0.0	0.3	6.3	11:00a	N
29	14.1	17.8	12:00p	10.3	12:00m	4.3	0.0	0.0	0.8	8.5	1:00p	NNW
30	13.2	19.8	3:00p	6.9	6:30a	5.3	0.2	0.0	0.0	4.9	1:00p	S
	16.8	29.2	26	6.9	30	80.1	33.7	-660.5	0.1	8.9	5	SSE

Max >= 32.0: 0
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 150.37 ON 18/11/13
Days of Rain: 4 (> .2 mm) 4 (> 2 mm) 4 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for DEC. 2013

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	15.1	19.2	3:30p	9.9	1:00a	3.3	0.1	0.0	1.3	10.7	10:30a	S
2	14.6	19.6	3:00p	11.1	12:00m	3.8	0.1	0.0	0.1	4.9	1:30a	S
3	14.6	20.1	3:00p	7.6	5:00a	4.1	0.3	0.0	0.0	4.0	11:00p	SSE
4	15.8	20.7	1:00p	12.0	7:00a	2.9	0.3	5.1	0.2	5.8	2:30p	NNW
5	12.2	13.8	12:30a	10.6	8:30a	6.2	0.0	-809.0	0.3	9.4	1:00p	NNW
6	12.3	14.6	1:00p	10.1	7:00a	6.0	0.0	290.6	0.0	2.2	4:30a	W
7	11.2	16.3	1:00p	6.0	6:30a	7.1	0.0	0.0	0.0	3.6	3:30p	N
8	11.2	14.9	1:00p	8.4	2:30a	7.1	0.0	645.0	0.2	7.2	1:00p	NNW
9	9.6	12.9	2:30p	4.7	12:00m	8.8	0.0	0.0	0.1	5.8	10:30a	NNW
10	6.7	11.7	12:30p	1.2	7:00a	11.6	0.0	0.0	0.0	4.9	3:00p	SSW
11	7.9	9.5	7:30a	4.7	12:00m	10.4	0.0	445.1	3.1	13.0	9:00p	NW
12	4.0	5.3	1:30p	2.8	4:30a	14.3	0.0	0.0	0.7	11.2	9:30p	NNW
13	3.9	6.6	2:00p	1.9	7:30p	14.4	0.0	117.4	4.3	13.4	3:30p	NW
14	3.8	5.4	1:00p	2.1	6:30a	14.5	0.0	0.0	1.0	11.2	1:00a	NNW
15	3.6	9.3	4:00p	-0.2	9:00a	14.8	0.0	0.0	0.0	0.4	3:30a	SSW
16	4.2	10.6	2:30p	-0.2	7:00a	14.1	0.0	0.0	0.0	4.0	11:30a	SSE
17	5.1	10.9	2:30p	-0.6	7:00a	13.3	0.0	0.0	0.0	4.9	12:00p	SSW
18	7.7	14.3	3:30p	2.3	8:00a	10.6	0.0	0.0	0.0	0.9	12:30p	S
19	7.1	14.9	3:00p	1.6	7:00a	11.3	0.0	0.0	0.0	0.4	1:30a	SSE
20	7.0	13.9	2:30p	1.1	6:30a	11.3	0.0	0.0	0.0	4.0	2:30p	SSE
21	7.7	15.3	3:00p	1.6	6:30a	10.7	0.0	0.0	0.0	0.4	2:00p	SW
22	7.8	16.8	2:30p	1.6	7:00a	10.5	0.0	0.0	0.0	0.4	12:00p	SSE
23	7.0	15.5	2:00p	1.2	4:00a	11.3	0.0	0.0	0.0	4.9	1:00p	SSW
24	6.3	13.5	3:00p	0.6	7:00a	12.1	0.0	0.0	0.3	7.2	4:00p	S
25	7.2	13.4	3:30p	1.7	8:00a	11.2	0.0	0.0	0.6	10.3	11:30a	S
26	7.8	10.6	2:30p	5.4	12:00m	10.6	0.0	0.0	0.1	7.2	11:30a	SSW
27	9.9	17.9	3:00p	2.3	5:00a	8.4	0.0	0.0	0.2	8.0	12:00m	S
28	12.4	17.7	3:30p	6.5	7:30a	5.9	0.0	59.7	0.2	6.3	11:00a	S
29	9.8	13.2	1:00p	6.4	12:00m	8.6	0.0	0.0	0.1	5.8	4:00p	NNE
30	8.5	13.6	3:00p	1.6	7:30a	9.8	0.0	0.0	0.0	0.9	1:00p	W
31	9.7	14.1	1:00p	5.7	12:00m	8.6	0.0	0.0	0.0	4.0	3:30p	N
	8.8	20.7	4	-0.6	17	297.6	0.7	753.9	0.4	13.4	13	S

Max >= 32.0: 0
Max <= 0.0: 0
Min <= 0.0: 3
Min <= -18.0: 0
Max Rain: 645.01 ON 08/12/13
Days of Rain: 6 (> .2 mm) 6 (> 2 mm) 5 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for JAN. 2014

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	8.1	13.5	3:00p	4.3	2:00a	10.2	0.0	0.3	0.0	1.8	1:00p	W
2	8.3	14.6	3:00p	2.3	7:00a	10.0	0.0	0.0	0.0	5.4	1:30p	SSW
3	9.8	15.1	3:00p	5.7	7:00a	8.6	0.0	0.0	0.2	6.3	10:30a	SSE
4	9.9	15.1	2:30p	4.9	7:00a	8.4	0.0	0.0	0.3	6.7	11:30a	S
5	8.3	13.2	2:30p	4.4	8:00a	10.0	0.0	0.0	0.0	4.9	11:00a	S
6	7.1	13.8	3:00p	0.6	7:00a	11.2	0.0	0.0	0.0	0.9	11:00a	S
7	6.5	13.8	4:00p	-0.4	7:30a	11.8	0.0	0.0	0.1	4.9	2:00p	SSW
8	6.1	12.7	3:00p	-0.6	6:00a	12.2	0.0	0.0	0.3	6.7	12:30p	S
9	7.9	13.0	2:00p	3.5	4:00a	10.4	0.0	68.1	0.2	6.3	11:00a	S
10	7.3	9.5	2:00p	5.3	3:30a	11.1	0.0	0.0	0.0	4.0	11:30a	NNE
11	9.6	14.3	2:30p	7.3	3:00a	8.7	0.0	0.0	0.1	5.8	3:00p	N
12	10.4	15.2	2:00p	6.4	5:00a	7.9	0.0	0.0	0.1	4.9	2:30p	N
13	12.4	17.6	1:30p	8.8	6:30a	5.9	0.0	0.0	0.0	2.2	8:30p	ENE
14	11.6	16.1	3:30p	7.9	7:00a	6.7	0.0	0.0	0.4	6.7	12:00p	S
15	10.9	18.2	4:00p	4.6	7:00a	7.4	0.0	0.0	0.0	3.6	8:30p	S
16	10.4	14.6	3:00p	7.4	5:00a	7.9	0.0	0.0	0.6	9.8	1:30p	S
17	10.5	16.5	2:00p	5.4	5:30a	7.8	0.0	0.0	0.4	7.2	2:30p	NNW
18	9.6	16.7	4:00p	4.8	7:00a	8.8	0.0	578.1	0.0	0.9	6:00p	N
19	10.0	18.2	2:30p	2.9	7:30a	8.3	0.0	0.0	0.0	0.9	2:30p	N
20	10.5	19.6	3:30p	3.1	6:30a	7.9	0.1	0.0	0.0	0.0	---	---
21	10.9	20.7	3:00p	3.6	5:30a	7.7	0.2	0.0	0.0	0.0	---	---
22	11.3	19.5	2:00p	4.2	7:30a	7.1	0.1	0.0	0.0	2.7	3:00p	N
23	10.7	16.2	3:00p	5.4	5:30a	7.6	0.0	0.0	0.2	6.3	2:30p	NNW
24	11.7	18.1	3:00p	7.4	12:00m	6.6	0.0	139.2	0.0	0.9	10:30p	SSE
25	11.3	19.1	3:30p	3.8	7:00a	7.1	0.1	0.0	0.2	6.3	2:30p	S
26	13.4	17.8	6:30p	7.8	7:00a	4.9	0.0	0.0	0.3	6.7	9:30p	S
27	12.3	16.3	2:00p	8.2	7:00a	6.1	0.0	0.0	0.0	4.5	3:30p	N
28	10.8	14.9	4:00p	7.5	11:30p	7.5	0.0	189.2	1.7	10.7	8:30a	WNW
29	10.7	19.1	3:00p	2.4	7:00a	7.7	0.1	0.0	0.0	5.8	1:00p	W
30	11.0	17.6	1:30p	4.2	6:30a	7.3	0.0	0.0	0.3	6.7	3:00p	N
31	11.7	19.1	4:00p	3.6	6:30a	6.7	0.0	111.4	0.1	8.0	10:30a	S
	10.0	20.7	21	-0.6	8	257.8	0.4	1086.2	0.2	10.7	28	S

Max >= 32.0: 0
Max <= 0.0: 0
Min <= 0.0: 2
Min <= -18.0: 0
Max Rain: 578.10 ON 18/01/14
Days of Rain: 6 (> .2 mm) 5 (> 2 mm) 5 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for FEB. 2014

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	12.6	19.9	2:30p	4.9	7:30a	5.9	0.1	0.0	0.0	5.4	11:00p	S
2	10.2	12.6	2:30p	7.9	11:00p	8.2	0.0	113.0	1.0	8.5	9:30a	S
3	6.9	13.3	1:30p	3.2	12:00m	11.4	0.0	0.0	0.1	5.4	2:30p	S
4	6.4	12.2	1:00p	3.1	12:00m	11.9	0.0	77.0	0.7	7.2	3:00p	NNE
5	4.7	11.0	2:30p	-1.7	7:00a	13.6	0.0	0.0	0.0	4.9	10:30p	S
6	5.8	12.3	1:30p	-1.2	5:30a	12.5	0.0	0.0	0.0	4.5	12:00p	S
7	7.8	14.3	4:00p	0.3	7:00a	10.6	0.0	0.0	0.0	1.8	12:00p	SSE
8	8.9	16.6	2:30p	2.4	7:00a	9.4	0.0	0.0	0.0	2.7	11:00a	SSW
9	9.2	18.1	2:30p	1.3	6:00a	9.2	0.0	0.0	0.0	5.4	11:30a	S
10	9.8	18.9	1:00p	2.3	7:00a	8.5	0.0	0.0	0.0	4.9	3:00p	NNW
11	10.5	19.0	3:00p	2.0	7:00a	7.8	0.0	0.0	0.0	1.8	2:00p	N
12	12.0	18.8	3:30p	4.3	5:30a	6.4	0.0	0.0	0.4	6.7	11:30a	SSW
13	12.9	22.0	4:00p	4.3	7:00a	5.9	0.5	0.0	0.8	8.9	10:30a	S
14	13.4	22.1	2:30p	7.7	6:30a	5.3	0.4	0.0	0.5	8.0	4:30p	S
15	11.4	15.1	1:30p	8.4	6:00a	6.9	0.0	84.3	1.1	9.8	10:30a	NW
16	10.2	13.5	2:30p	7.5	12:00m	8.2	0.0	181.4	0.1	5.4	5:00p	N
17	9.9	15.6	3:30p	4.4	7:00a	8.4	0.0	-717.1	0.1	5.4	1:30p	N
18	11.4	19.4	3:00p	4.3	6:00a	6.9	0.1	0.0	0.0	0.4	11:30a	N
19	13.2	22.4	3:30p	4.3	7:30a	5.8	0.7	0.0	0.0	3.1	12:30p	S
20	14.5	24.6	4:30p	4.9	6:30a	5.2	1.3	0.0	0.0	5.8	1:30p	SSW
21	15.3	24.9	3:00p	5.8	6:30a	4.6	1.5	0.0	0.0	6.3	3:00p	S
22	15.9	25.2	1:30p	7.3	7:00a	4.0	1.6	0.0	0.2	8.5	2:30p	NNW
23	14.8	21.2	3:00p	9.1	7:30a	3.8	0.4	0.0	0.0	3.1	10:00a	NNW
24	15.3	24.4	4:00p	8.3	7:00a	4.2	1.1	0.0	0.3	10.3	3:00p	N
25	12.2	15.6	1:30p	9.3	12:00m	6.1	0.0	0.0	0.9	8.0	11:30a	NNW
26	11.4	16.4	3:30p	7.8	6:00a	6.9	0.0	0.0	0.2	6.3	12:30p	NNW
27	10.6	16.2	2:30p	5.2	7:30a	7.8	0.0	0.0	0.5	8.0	4:30p	N
28	11.7	18.9	4:30p	4.3	7:00a	6.6	0.1	0.0	0.0	2.2	10:30a	ENE
	11.0	25.2	22	-1.7	5	212.1	7.7	-261.4	0.3	10.3	24	S

Max >= 32.0: 0
Max <= 0.0: 0
Min <= 0.0: 2
Min <= -18.0: 0
Max Rain: 181.36 ON 16/02/14
Days of Rain: 4 (> .2 mm) 4 (> 2 mm) 4 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for MAR. 2014

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	14.8	24.3	3:00p	5.2	6:30a	4.8	1.3	0.0	0.2	5.8	8:30p	S
2	16.9	25.5	2:00p	11.4	5:30a	2.6	1.2	0.0	0.3	5.8	12:30a	S
3	17.0	24.4	3:30p	10.7	7:00a	2.7	1.4	0.0	0.0	4.5	4:30p	N
4	15.6	20.6	1:00p	10.4	12:00m	3.2	0.4	0.0	1.1	10.7	1:00p	N
5	15.7	23.6	3:00p	6.9	7:00a	4.0	1.3	0.0	0.0	4.9	4:00p	S
6	17.7	25.8	2:30p	10.7	6:00a	2.7	2.1	0.0	0.3	7.2	1:00p	N
7	19.8	28.3	4:00p	10.4	6:00a	2.2	3.6	0.0	0.7	8.5	1:30p	SSW
8	17.3	23.3	3:00p	13.1	4:00a	1.8	0.8	21.1	0.6	8.5	8:00a	S
9	15.7	20.6	11:00a	13.2	11:00p	2.9	0.3	-624.0	0.1	5.8	11:00a	SSW
10	12.4	15.5	12:30p	9.7	12:00m	5.9	0.0	806.7	0.5	8.9	2:30p	N
11	11.7	16.6	2:30p	6.9	6:30a	6.7	0.0	0.0	0.1	9.4	8:30p	N
12	9.5	12.2	2:30p	7.7	11:30p	8.8	0.0	-145.9	1.4	11.2	2:30p	NNW
13	8.5	10.6	2:30p	6.8	4:30a	9.8	0.0	17.3	0.3	8.5	1:00a	NNW
14	7.7	10.3	2:30p	5.4	4:00a	10.4	0.0	0.0	0.8	8.9	2:30p	NNW
15	16.4	24.4	1:30a	10.8	4:30p	2.7	0.8	0.0	0.0	5.4	3:00a	N
16	15.9	24.6	11:30p	9.3	4:00p	3.6	1.2	0.0	0.0	4.9	9:30p	N
17	18.3	27.4	12:00m	11.0	3:00p	2.3	2.3	0.0	0.1	8.0	9:00p	SSE
18	20.3	27.2	1:00a	16.7	12:30p	0.4	2.4	0.0	0.3	6.3	8:00p	S
19	19.4	26.2	1:00a	14.6	4:30p	1.1	2.1	0.0	0.0	5.8	4:30a	S
20	14.9	23.6	12:30a	9.2	4:00p	4.1	0.6	0.0	0.1	8.0	12:00m	N
21	14.6	22.7	12:00m	7.1	4:30p	4.4	0.7	0.0	0.4	8.0	2:30a	NNW
22	16.4	27.4	12:00m	6.8	4:00p	3.8	1.8	0.0	0.0	3.1	12:30a	NNW
23	19.2	27.9	1:30a	9.7	3:00p	2.2	3.1	0.0	0.2	8.9	11:30p	N
24	16.5	25.7	12:30a	11.3	4:00p	2.9	1.1	0.0	3.4	12.5	10:00p	NNW
25	10.4	18.9	12:00m	3.9	4:00p	7.9	0.0	0.0	1.3	12.5	12:30a	N
26	14.9	22.6	12:00m	9.6	4:00p	3.9	0.5	0.0	0.2	8.5	9:00p	SSE
27	16.7	24.0	1:30a	10.8	4:00p	2.4	0.8	0.0	0.3	8.5	11:30p	N
28	13.7	20.5	12:00m	8.2	3:30p	4.8	0.2	0.0	0.6	8.5	1:00a	N
29	13.7	20.7	11:00p	7.9	4:00p	4.9	0.3	0.0	0.6	8.5	1:30a	NNE
30	15.6	24.1	11:30p	9.2	5:00p	3.6	0.9	0.0	0.2	6.3	11:00p	N
31	20.2	29.6	12:00m	11.7	5:00p	1.6	3.4	0.0	0.4	8.0	1:30a	S
	15.4	29.6	31	3.9	25	125.2	34.7	75.1	0.5	12.5	24	NNW

Max >= 32.0: 0
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 806.70 ON 10/03/14
Days of Rain: 3 (> .2 mm) 3 (> 2 mm) 2 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for APR. 2014

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	22.8	31.0	3:30a	13.9	5:30p	0.6	5.1	0.0	0.0	5.4	12:30a	N
2	18.3	28.9	12:30a	10.7	5:30p	2.3	2.3	0.0	0.8	8.5	2:30a	NNW
3	17.8	23.8	11:30p	10.8	5:00p	2.2	1.7	0.0	0.5	8.9	1:00a	N
4	15.8	23.8	12:30a	10.4	5:30p	3.3	0.7	0.0	1.0	8.0	1:30a	NNW
5	15.3	24.6	12:00m	8.7	4:30p	3.8	0.8	0.0	0.4	8.0	1:30a	NNW
6	19.7	26.3	3:00a	13.0	4:30p	1.1	2.4	0.0	0.2	8.9	12:00m	NNW
7	15.6	22.3	1:00a	9.9	4:00p	3.4	0.6	0.0	0.7	9.8	1:00a	NNW
8	15.7	23.4	12:00m	8.4	4:30p	3.6	0.9	0.0	0.2	5.8	1:00a	NNW
9	17.7	25.8	11:30p	11.4	5:00p	2.5	1.8	0.0	0.3	6.7	3:00a	NNW
10	21.1	27.5	12:00m	13.6	5:00p	0.8	3.6	0.0	0.6	10.7	1:30a	NW
11	22.6	28.2	3:00a	17.1	3:00p	0.1	4.3	0.0	0.7	8.9	12:00m	N
12	19.2	26.2	12:30a	12.9	5:00p	1.3	2.2	0.0	1.4	9.4	3:00a	NNW
13	21.8	32.2	12:00m	13.9	4:00p	0.9	4.3	0.0	1.2	12.1	11:00p	S
14	27.0	33.4	2:00a	22.6	4:30p	0.0	8.7	0.0	1.5	12.1	10:00p	S
15	21.1	30.4	1:30a	14.8	4:30p	0.8	3.6	0.0	0.8	10.3	1:30a	N
16	17.2	25.1	12:00m	11.2	5:00p	2.6	1.4	0.0	0.8	8.5	1:30a	NNW
17	20.1	29.5	12:00m	12.8	4:30p	1.3	3.0	0.0	0.2	6.7	2:30a	N
18	23.9	32.3	12:00m	15.9	4:30p	0.2	5.8	0.0	0.1	8.0	1:00a	S
19	26.6	33.7	3:00a	19.1	5:00p	0.0	8.2	0.0	0.1	6.3	12:30a	S
20	23.8	34.2	2:00a	15.6	4:30p	0.2	5.7	0.0	0.6	7.2	2:00a	N
21	19.3	30.3	12:00m	11.4	5:00p	2.0	3.0	0.0	0.7	7.2	2:30a	NNW
22	21.9	31.3	2:00a	13.2	5:30p	1.2	4.7	0.0	0.1	8.0	12:00m	N
23	22.4	29.1	1:30a	14.1	5:00p	0.4	4.4	0.0	0.5	8.5	3:00a	N
24	21.1	28.1	11:30p	13.2	5:00p	0.8	3.6	0.0	0.4	8.5	12:30a	N
25	21.5	29.2	12:00m	13.2	5:00p	0.9	4.1	0.0	0.4	9.4	12:00m	NNW
26	22.7	29.4	1:00a	16.8	4:30p	0.2	4.6	0.0	0.8	10.3	1:00a	N
27	19.2	29.4	12:00m	12.6	4:00p	1.8	2.7	0.0	1.1	9.4	12:30a	NNW
28	24.3	34.1	11:30p	15.1	4:00p	0.3	6.3	0.0	0.7	9.8	1:00a	NNW
29	27.2	34.2	1:30a	18.5	4:30p	0.0	8.9	0.0	0.5	10.7	11:00p	SW
30	27.5	34.6	1:30a	22.8	3:00p	0.0	9.2	0.0	0.4	10.3	12:30a	N
	21.0	34.6	30	8.4	8	38.7	118.6	0.0	0.6	12.1	13	NNW

Max >= 32.0: 8
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 0.00 ON 01/04/14
Days of Rain: 0 (> .2 mm) 0 (> 2 mm) 0 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for MAY. 2014

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	24.8	30.9	11:30p	20.0	5:00p	0.0	6.5	0.0	0.1	5.8	12:30a	SSE
2	20.3	32.5	1:30a	15.1	8:00p	0.7	2.8	772.9	0.2	11.6	5:00a	N
3	17.4	21.6	12:00m	13.3	4:00p	1.6	0.7	0.0	0.2	8.9	11:00p	N
4	17.9	24.3	12:00m	11.7	4:00p	1.9	1.6	0.0	0.2	8.0	1:00a	N
5	19.9	25.3	1:30a	13.8	5:00p	0.9	2.4	0.0	0.2	7.2	6:30a	N
6	18.4	25.1	2:00a	13.3	4:00p	1.5	1.6	0.0	0.3	8.0	11:30p	N
7	17.6	22.4	2:00a	13.3	3:30p	1.8	1.1	0.0	0.9	9.4	11:00p	N
8	18.2	25.2	12:00m	12.9	4:30p	1.8	1.6	0.0	0.7	9.8	1:30a	N
9	20.1	29.7	11:30p	12.8	3:30p	1.4	3.2	0.0	0.4	8.5	4:00a	NNW
10	23.3	30.6	12:00m	15.1	3:30p	0.5	5.4	0.0	0.0	4.5	3:30a	N
11	24.6	30.9	12:30a	17.1	4:00p	0.1	6.4	0.0	0.1	6.7	11:30p	N
12	20.8	30.5	12:30a	14.0	4:30p	1.1	3.5	0.0	0.5	8.0	1:00a	NNW
13	18.1	24.9	2:00a	13.5	4:00p	1.8	1.5	0.0	0.6	8.9	3:00a	NNW
14	18.3	25.9	12:00m	12.9	3:30p	1.8	1.8	0.0	0.3	8.0	2:00a	N
15	22.1	30.5	11:30p	16.2	5:00p	0.2	3.9	0.0	0.5	8.9	1:30a	NNW
16	23.3	31.7	2:00a	17.4	5:00p	0.1	5.0	0.0	0.3	9.4	5:00a	N
17	22.3	27.8	1:00a	15.9	4:30p	0.3	4.4	0.0	0.0	4.5	2:00a	N
18	21.7	27.9	2:00a	15.2	4:00p	0.5	3.8	0.0	0.3	6.7	11:30p	N
19	21.9	28.4	12:00m	15.5	4:30p	0.4	3.9	0.0	0.3	8.5	1:30a	N
20	21.7	28.8	1:30a	14.3	3:00p	0.7	4.1	0.0	0.3	6.7	3:30a	N
21	22.5	30.0	12:00m	15.6	4:30p	0.3	4.5	0.0	0.7	8.9	1:00a	NNW
22	25.7	33.5	11:30p	18.4	3:30p	0.0	7.4	0.0	0.7	10.3	12:00m	NNW
23	24.5	33.0	12:30a	18.6	4:00p	0.0	6.2	0.0	0.7	8.9	2:00a	N
24	24.3	34.8	12:00m	16.6	4:00p	0.1	6.1	0.0	0.3	8.5	1:30a	N
25	28.8	36.8	1:00a	20.2	5:00p	0.0	10.4	0.0	0.1	8.0	11:00p	N
26	21.3	31.3	12:30a	15.7	3:30p	0.6	3.5	0.0	0.7	8.9	3:00a	N
27	19.6	24.8	2:30a	15.3	4:00p	0.8	2.1	0.0	0.8	8.9	1:00a	N
28	19.9	27.3	12:00m	14.3	4:00p	0.9	2.6	0.0	0.6	9.4	1:00a	N
29	24.4	34.3	12:00m	17.9	4:30p	0.0	6.1	0.0	0.4	8.9	2:30a	NNW
30	29.6	36.4	2:30a	23.8	4:00p	0.0	11.3	0.0	0.3	10.3	11:30p	SSW
31	21.0	27.7	1:30a	16.9	4:00p	0.3	2.9	0.0	1.3	10.7	2:00a	NNW
	21.8	36.8	25	11.7	4	22.2	128.3	772.9	0.4	11.6	2	N

Max >= 32.0: 7
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 772.92 ON 02/05/14
Days of Rain: 1 (> .2 mm) 1 (> 2 mm) 1 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

MONTHLY CLIMATOLOGICAL SUMMARY for JUN. 2014

NAME: As-Samra CITY: STATE:
ELEV: 590 m LAT: 32° 00' 00" N LONG: 36° 00' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	19.9	25.6	1:30a	14.7	4:00p	0.9	2.4	0.0	0.5	8.9	2:00a	N
2	20.9	28.0	12:00m	14.9	4:00p	0.7	3.2	0.0	0.2	6.7	12:30a	N
3	23.4	31.4	11:30p	16.5	5:00p	0.2	5.3	0.0	0.0	5.4	2:30a	N
4	24.2	31.7	12:30a	17.2	4:30p	0.1	5.9	0.0	0.2	8.0	12:00m	N
5	21.8	28.8	1:00a	16.4	3:30p	0.3	3.7	0.0	0.9	10.3	11:30p	NNW
6	21.1	27.3	1:30a	15.2	3:30p	0.5	3.2	0.0	0.8	11.2	12:00m	NNW
7	21.3	27.7	12:00m	16.2	3:00p	0.4	3.4	0.0	0.6	10.7	1:30a	N
8	23.4	30.0	12:00m	16.8	4:00p	0.2	5.2	0.0	0.1	7.2	1:30a	N
9	24.4	30.9	2:00a	17.4	5:00p	0.1	6.2	0.0	0.2	8.5	12:00m	N
10	23.6	32.3	12:00m	16.2	4:00p	0.2	5.5	0.0	0.5	9.4	12:30a	N
11	26.6	32.8	12:00m	19.1	4:30p	0.0	8.3	0.0	0.7	9.4	12:00m	NNW
12	25.0	32.4	12:30a	18.4	3:30p	0.0	6.7	0.0	1.0	10.3	1:30a	N
13	26.2	33.7	12:00m	19.9	5:00p	0.0	7.9	0.0	0.8	9.8	1:00a	N
14	29.1	34.9	12:00m	23.4	4:30p	0.0	10.7	0.0	0.7	8.9	2:30a	N
15	26.1	34.9	12:30a	19.5	4:00p	0.0	7.7	0.0	0.8	8.9	12:30a	N
16	22.4	29.6	12:00m	16.7	3:30p	0.2	4.3	0.0	0.5	7.2	12:30a	N
17	23.5	31.4	2:30a	15.8	5:00p	0.3	5.4	0.0	0.1	5.8	3:00a	N
18	24.9	33.0	3:00a	17.2	5:00p	0.1	6.6	0.0	0.0	2.2	3:00a	N
19	25.1	32.4	1:00a	19.2	4:30p	0.0	6.7	0.0	0.2	8.0	11:30p	NNW
20	25.0	33.2	12:00m	17.5	4:00p	0.1	6.7	0.0	0.6	9.8	1:30a	N
21	28.6	39.3	11:30p	20.6	3:30p	0.0	10.2	0.0	0.1	5.8	4:30a	N
22	32.3	39.4	2:00a	24.0	4:00p	0.0	14.0	0.0	0.2	7.2	5:00a	N
23	31.5	39.3	11:00p	21.9	4:00p	0.0	13.2	0.0	0.2	7.2	1:30a	N
24	30.4	39.2	12:30a	21.7	4:30p	0.0	12.1	0.0	0.2	8.0	4:00a	N
25	28.9	37.6	1:30a	20.4	4:30p	0.0	10.6	0.0	0.2	9.4	12:00m	N
26	26.4	34.8	12:00m	18.1	4:30p	0.0	8.1	0.0	0.6	8.9	1:00a	NNW
27	27.2	34.6	1:00a	19.8	4:00p	0.0	8.9	0.0	0.9	10.3	1:00a	NNW
28	26.6	33.4	12:30a	19.2	4:30p	0.0	8.2	0.0	0.7	9.8	1:30a	N
29	27.0	32.9	12:30a	20.7	3:00p	0.0	8.7	0.0	0.7	8.9	2:00a	NNW
30	24.8	32.1	1:30a	17.4	4:30p	0.0	6.4	0.0	0.3	7.2	1:00a	N
	25.4	39.4	22	14.7	1	4.1	215.4	0.0	0.5	11.2	6	N

Max >= 32.0: 19
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 0.00 ON 01/06/14
Days of Rain: 0 (> .2 mm) 0 (> 2 mm) 0 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

APPENDIX B – AS-SAMRA MONOFILL SITE TOPOGRAPHIC SURVEY

564.7577
563.5259
559.0412
563.4272
563.3307
563.3901
563
563.4261
560.994
562.5
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561.3996
561.7459
558.9425
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546.111
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554.0199
554.6168
552.4455
557.5
558.844
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542.5
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548.5
555.97
550.5
554.5
553.1937
554.325
564.532
564.3478
562.7032
562.0632
560.97
562.938
556.024
562.92
563.5
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546.5
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544.5
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541.5
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539.323
537.449
557.605
558.552
553.5
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551.482
561.061
562.24
562.434
562.5
562.121
562.099
563.663
563
562.383
564
564.5
567.039
566.5
565.5
565
566
563.457
553.235
561.62