Arab Republic of Egypt

Ministry of Housing, Utilities and Urban Communities

European Investment Bank

L'Agence Française de Développement (AFD)

Construction Authority for Potable Water & Wastewater CAPW

Helwan Wastewater Collection & Treatment Project

Environmental and Social Impact Assessment Report

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Consulting Engineering Office

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List of Abbreviations

AFD	L’Agence Française de Développement
Al	Aluminium
Ar	Arsenic
BOD	Biochemical Oxygen Demand
CAAs	Competent Administrative Authorities
CAPMAS	Central Agency for Public Mobilization and Statistics
CAPW	Construction Authority for Potable Water & Wastewater
Cd	Cadmium
CFU	Colony Forming Units (in 100ml)
CLS	Core Labour Standards
Co	Cobalt
Co3	Carbonate
COD	Chemical Oxygen Demand
Cr	Chromium
Cu	Copper
DO	Dissolved Oxygen
DRI	Drainage Research Institute
DS	Dry Substance Content
EC	Electrical Conductivity
ECS	Effluent Conveyance System
EEAA	Egyptian Environmental Affairs Agency
EIB	European Investment Bank
EMU	Environmental Management Unit
EPADP	Egyptian Public Authority for Drainage Projects
EPAP III	Egyptian Pollution Abatement Programme
ERP	Emergency Response Plan

ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
EU	European Union
FC	Fecal Coliform
Fe	Iron
FGDs	Focus Group Discussions
FS	Feasibility Study
FST	Final Sedimentation Tank
GCWC	Greater Cairo Wastewater Company
GHG	Greenhouse Gas
GOE	Government of Egypt
ha	Hectare (10,000 m^2, 2.5 feddan)
HCO3	Bicarbonate
HCWW	Holding Company for Water and Wastewater
Hg	Mercury
HRI	Hydraulic Research Institute
ID	Inner Diameter
ILO	International Labour Organisation
INFRA	Consulting Office for Infrastructure Engineering
IP	Implementation Plan
m	Meter
m^3/h	Cubic meter per hour
MALR	Ministry of Agriculture and land reclamation
masl	Meter above sea level
MBR	Membrane Bio Reactor
MDF	Mechanical Dewatering Facility
Mg	Magnesium
mg/l	Milligram per litre

MoE	Ministry of Environment
MoHUUC	Ministry of Housing, Utilities and Urban Communities
MP	Monitoring Plan
MWRI	Ministry of Water Resources and Irrigation
NAP	Egyptian National Action Plan
NARSS	National Authority for Remote Sensing and Space Science
NCHR	National Council for Human Rights
ND	Nominal Diameter
Ni	Nickel
NRC	National Research Centre (Cairo)
NTU	Turbidity Unit
NWRC	National Water Research Centre
OP	Operational Safeguard Policy
OSHA	Occupational Safety and Health Administration
PAPs	Project Affected People
Pb	Lead
pe	Population Equivalent
PMU	Project Monitoring Unit
PS	Pump Station
Qd	Daily Flow
RAC	Risk Assessment Code
RDF	Refuse Derived Fuel
RIGW	Research Institute for Groundwater
SAR	Sodium Absorption Ratio
SBR	Sequencing Batch Reactor
SCADA	Supervisory Control and Data Acquisition
SDB	sludge drying beds
SO2	Sulfur Dioxide

TDS	Total Dissolved Solids
THMs	trihalomethanes
TN	Total Nitrogen
ToR	Terms of Reference
TP	Total Phosphorus
TSS	Total Suspended Solids
TVS	Total Volatile Solids
UN	United Nations
USEPA	Environmental Protection Agency - United State
VOCs	volatile organic compounds
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WB	World Bank
WEEE	Waste electrical and electronic equipment
WHO	World Health Organization
WWTP	Wastewater Treatment Plant
Zn	Zinc

Executive summary

Introduction

In Egypt, the gap between water and sanitation coverage has grown, with access to drinking water reaching 96.6% based on CENSUS 2006 for Egypt overall (99.5% in Greater Cairo and 92.9% in rural areas) and access to sanitation 50.5% (94.7% in Greater Cairo and 24.3% in rural areas - according to the Central Agency for Public Mobilization and Statistics (CAPMAS).

The main objective of this Project is to contribute to the improvement of the country's wastewater treatment services in one of the major treatment plants in Cairo that suffer from the exceeded design capacity and to improve the sanitation service level in South of Cairo at Helwan area.

Project rationale: The Project for the ‘Expansion and Extension of Various Wastewater system with Treatment Plant at South Cairo in Arab Abo Sa’ed will be implemented in line with the objective of the Egyptian Government to improve the sanitation conditions of South of Cairo and depollute the Al Saff Irrigation Canal and improve the water quality to suit the agriculture purposes, therefore, this project was selected as a top priority identified by the GoE.

Project goals and objectives: The Project will promote efficient and sustainable wastewater treatment in South Cairo and expands the reclaimed agriculture lands.

ESIA objectives and purpose of the report

Assessment of the environmental and social impacts is a prerequisite for implementing developmental projects both by the Egyptian Environmental Affairs Agency (EEAA) and the EIB. Accordingly this study has been prepared for performing an Environmental and Social Impact Assessment (ESIA), following Terms of Reference (ToRs) prepared by funding institutions, aiming at providing a detailed analysis of the anticipated environmental and social safeguard issues associated with the Helwan WWTP extension project; and to develop an environmental management and monitoring plan to be implemented during the construction and operation of the project.

According to the EIA guidelines and procedures manual published by the Ministry of Environment – EEAA January 2009 (amended in October 2010). The proposed project falls under category C projects, its required full ESIA study. This ESIA report has been compiled as part of the EIA process in accordance with Egyptian environmental Law number 4 for the year 1994 amended by law number 9 for the year 2009 and Law 105 for the year 2015. It has taken into account the environmental regulations and requirements of funding institutions including the EIB safeguard policies. The ESIA report will be submitted to the Egyptian Environmental Affairs Agency (EEAA) after reviewing and acceptance from Construction Authority for Potable Water & Wastewater (CAPW) and the funding institutions in order to seek environmental approval for the proposed project.

The report includes the identification and evaluation of the potential environmental impacts due to the construction and operation of different components of the project. It also includes proposed mitigation and monitoring measures to control/minimize the effects of the identified negative impacts. Also, the CRVA will be performed for the Project (Climate Resiliency and Vulnerability Assessment and Carbon footprint report). The detailed findings included in this ESIA study will provide decision makers with the needed information in order to minimize the unfavorable impacts and maximize the positive impacts.

Summary of the national legislation pertinent to the project

The legislations listed below represent the national legislation pertinent to the project:

Egyptian legislation related to environmental aspects

- Law 4 for Year 1994 for the environmental protection , amended by Law 9/2009 and Law 105/2015
- Executive Regulation(ER) No 338 for Year 1995 and the amended regulation No 1741 for Year 2005, amended with ministerial decree No 1095/2011, ministerial decree No 710/2012, and ministerial decree No 964/2015
- Law No 93 for Year 1962 for discharge on the public sewer network and protection and treatment of wastewater wastes and safe discard methods of the treatment by products, amended with Decree No 44 for Year 2000.
- Law No 48 for Year 1982 for the protection of the Nile river, agricultural drains, ponds and aquifer from pollution, and the ER amended with Decree No 92 for Year 2013.
- Law No 12 for Year 2003 for the protection, occupational health and safety for the workers, which is amending Law 137 for Year 1981 and its executive decrees.
- Law No 102 for Year 1983 for natural habitats.
- Law No 38 for Year 1968 for the public cleanliness, which is amended by Law No 31 for Year 1976.
- Guidelines of Principles and Procedures for "*Environmental Impact Assessment*" 2nd Edition EEAA, January 2009 and its amended Lists in October 2010.

Egyptian legislation related to social aspects

- EEAA guidelines related to the Public Consultation; Guidelines of Principles and Procedures for "Environmental Impact Assessment" 2nd Edition January 2009
    - Paragraph 6.4.3 Requirements for Public Consultation
    - Paragraph 6.4.3.1 Scope of Public Consultation
    - Paragraph 6.4.3.2 Methodology of Public Consultation
    - Paragraph 6.4.3.3 Documentation of the Consultation Results
    - Paragraph 7 Requirement and Scope of the Public Disclosure
- Protection of human rights
- Law no. 94/2003 on establishing the National Council for Human Rights
- Unified structure Law No 119 of year 2008
- Presidential Decree No. 135 of year 2004 related to the establishment of WWHC

International requirements

The EIB Environmental and Social Practices Handbook, last amended in the year 2013 describe the processes and practices of the Bank to ensure that all financing activities are consistent with its environmental policy. Volume I of the handbook outlines 10 standards that may have significance for the ESIA study. With reference to the Helwan WWTP Project, all standards are considered as applicable.

- Standard 1: Assessment and Management of Environmental and Social Impacts and Risks
- Standard 2: Pollution Prevention and Abatement
- Standard 3: Biodiversity and Ecosystems
- Standard 4: Climate-related Standards
- Standard 5: Cultural Heritage
- Standard 6: Involuntary Resettlement
- Standard 7: Rights and Interests of Vulnerable Groups
- Standard 8: Labour Standards
- Standard 9: Occupational and Public Health, Safety and Security
- Standard 10: Stakeholder Engagement

Project description

This proposed project was designed to redistribute the wastewater flows to decrease discharges from existing collectors and divert to the WWTP in Arab Abo Sa'ed through the construction of new collector, pump stations, and force-mains as follows:

- Areas East and West of AUTOSTORAD main road which include (Al Maadi Al Gedida, 70 Feddan (Al Hadabah Al Wosta), Sobhi Hessien, Maadi Al Sarayat Al Sharqia, and Zahraa Al Maadi) will be diverted to Ahmed Zaki collector in Cairo project with force-main of diameter 1200 mm by CAPW. This modification will lead to decrease discharges on the collector of contract No. (4) of diameter 2000/2150 mm (horse shape) and decrease discharges on the existing screw pump station No. (4) (Maasarah).
- A new collector will be constructed to divert some discharges from the Helwan zone to a new pump station No. (3A) in existing land near from the existing station No. (3), and a force-main to 15th May pump station No. (2A).
- The wastewater flows from 15th of May City will be diverted directly to the WWTP by a force-main from new pump station No. (2A) in the same location of the non-working WWTP in 15th of May City in addition to receive the flows from the new pumping station No. (3A).
- Construction of new booster pumping station (1A) in the midway from the 15th of May City pumping station to the new WWTP in El-Kurimat and will serve in future the extension of 15th of May City that is currently planned.
- Construction of new force-mains to deliver discharges from 15th of May P.S No. (2A) directly to the Arab Abo Sa'ed WWTP (phase 1), and another new force-mains to deliver future wastewater discharges from 15th of May P.S No. (2A) to a new booster pump station No.(1A), then directly to El-Kurimat WWTP (phase 2).
- As Alternative I, an expansion for the WWTP of capacity 250,000 m3/day in the same Area of the existing Arab Abo Sa'ed WWTP (phase 1).
- As Alternative II, design of new WWTP of capacity 800,000 m3/day in the new area of the El- Kurimat as (3) modules, and build the first module of 250,000 m3/day and two modules 275,000 m3/day for future expansion of the proposed project.
- Develop all the Abo Sa'ed WWTP to be an advanced treatment to allow the safe irrigation reuse in the El-Saff irrigation canal to substitute the fresh water extracted from the River Nile Pumping Stations, Ghamaza I at km 25 and Ghamaza II at km 50 of the El-Saff irrigation canal. This will save an amount of 500,000 m3/day taken daily from the River Nile that will be used later in the Delta to substitute the deficiency of water at the north part of the Delta.
- These modifications will lead to decrease discharges on the existing collectors, screw pump stations, and force-mains from existing screw pump No. (3) down to P.S. No. (1), and force-mains to the Arab Abo Sa'ed WWTP and relief these collectors to allow the start of cleaning process for the sediments to restore to the original cross section and design capacity. **Error! Not a valid bookmark self-reference.** presents the proposed projects.

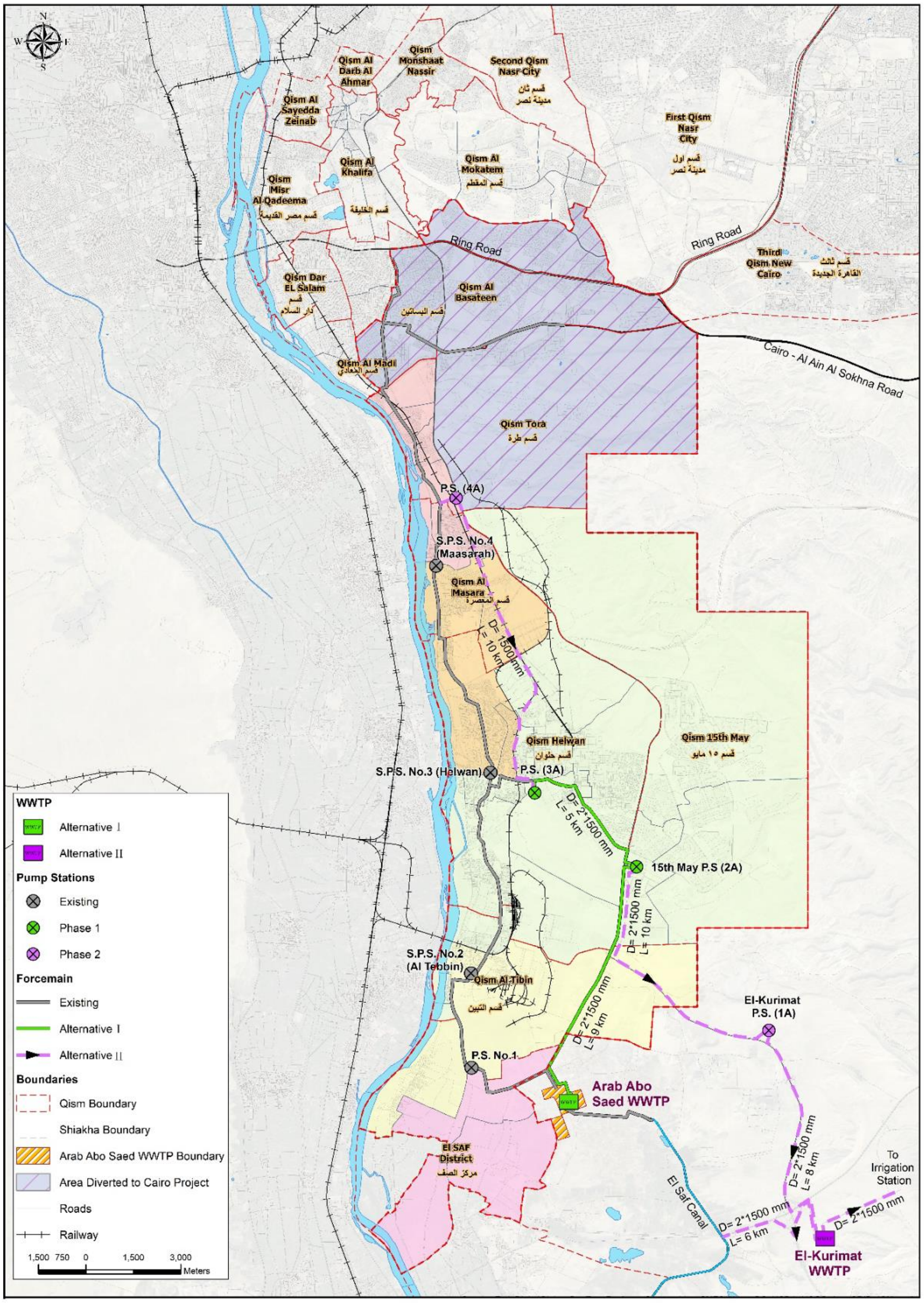


Figure 0-1: Proposed Helwan Wastewater Project (Modifications and projects required)

Baseline conditions

Environmental and Social Baseline conditions were studied in the project different areas. The following sections provide the main characteristics of the environmental and social conditions.

Topography and Soil Permeability

The topography of the region varies from one location to another, as it consists of non-flat plateaus and semi-mountainous areas whose levels descend west towards the Nile from about 80 meters above sea level in the east to about 30 meters above sea level in the west where the ancient agricultural lands then descend towards the west until the river. The Nile is irregular slopes, and there are some internal depressions and ponds in the region. The most important of these ponds are the reef and steel plant pool and the national company pool.

There is no an impermeable layer at depths of more than 10 meters below the soil surface. According to its levels, the impermeable layer descended from the south towards the north.

Water Supply and Sanitation facilities

Helwan WWTP project is designed and implemented to serve the southern part of Greater Cairo, which starts from Al-Maadi and extends southward for a distance of 30 km, to serve residential areas. Industrial areas, including iron and steel factories, coke factories, forgings, cement factories, the Nasr Company for Cars, many military factories in the region, in addition to the residential areas and industrial areas covered by the wastewater project. It also serves Helwan University and many military and security sites, including Helwan Airport, Tora Prisons, security forces in Tora, Police Trustees Institute in Tora, Helwan Air Force Secondary School, entertainment and commercial areas. (Source: Feasibility study report for Helwan, 2015; Pre-feasibility study for Helwan, 2020).

There are main five water treatment plants are in operation serving the project catchment including Tebben, Kafr El Alo, North Helwan, Maadi, and Fusttat with total capacity of around 1.97 million m3/day. No shortage of water is reported from the served area over the year except few hours for maintenance and repairing broken or leakage from water supply pipeline.

Helwan (Arab Abo Sa'ed) WWTP is currently serving a population of about 1.6 million capita. The data for population was obtained from the official Egyptian source of Statistics, Central Agency for Public Mobilization and Statistics, CAPMAS 2017. The population will increase to reach 2,368,584 capita by year 2037, and 3,328,645 capita by year 2052.

Demography

Helwan Zone includes Helwan city, with its three districts: Ain Helwan, El-Maasara and 15th of May; El-Maady City, with its two districts: El-Maady and Tourah; Markas Atfieh; Markaz Es-Saff; Tebbin City. The total area of the -Helwan area covers 903.471 km2, representing 0.09% of the Republic's area.

The area encompasses 2 marakez, 4 cities, 34 districts, 11 rural local units annexed by 43 villages, and 106 Kafrs & Ezbets. According to the preliminary results of the 20016 census, is 70.6% of population live in urban areas, and 29.4% in rural areas and population natural growth rate has reached 19.3 per thousand. Besides being an agricultural area, Helwan is also considered an industrial one as it hosts many industries such as: Iron & Steel, Cement, basic metals, engineering and electronics, as well as mining. Moreover, the project area hosts three industrial zones; one of them is located in Tebbin and has big industrial companies. The other two zones are located at Maady and Helwan. In addition to that, the area hosts many new projects such as the under construction new Tebbin power plant of capacity 2x350 MWe.

Employment and the Labor Market

The labor force of Helwan is around 448,362, i.e. 26.17% of total population, with unemployment, including job losers, at around 10% in 2009.

This labor pool is comprised of employees of industrial activities (chemicals, building and construction, Iron & Steel, Cement, textiles, basic metals products, wood, wooden products & upholstery, spinning, weaving, garments & leather, paper products and food products), employees of small industry and small business operators. Around 58% of the total labor pool can be categorized as skilled, having been trained as industrial technicians.

The proposals outlined in the Giza & the Helwan Region Master Scheme 2015, which corresponds to the Government of Egypt's development program for the country, are likely to offer thousands of employment opportunities through the construction and operation of the proposed businesses as well as industrial and commercial developments in the entire area.

Education

The educational status of the Helwan population is partially classified yet and the Giza Governorate data, which incorporates southern area of Es-Saff and Atfieh, is given by Tables 5-98 through 5-112. The educational facilities (governmental) available within the Helwan include 8,332 classrooms for Nursery (ages under 6), Elementary schools (age 6-12) for both boys and girls, Preparatory (ages 12-15) and Secondary (ages 15-18) schools, in addition to 12 Vocational Education Centers. Table 5-101 gives more details on the undergraduate education in Ex- Helwan Governorate. Tables 5-102 & 5-103 give data on technical and vocational education in Helwan Governorate.

Health

Main medical facilities in the Helwan consist of 8 public and central hospitals, 2 hospitals belong to the Ministry of Health, One University Hospital, 4 Police and Prison Hospitals and one specialized hospital. The hospitals collectively support approximately 2,368 beds, they are well equipped for most types of surgery and convalescence and are staffed by more than 889 physicians, 261 dentists and 1,495 nurses covering all medical specializations. Many other private hospitals, clinics, kidney washing facilities and physical therapy units are distributed over the Helwan area. Additional health care services in the

Helwan include, also, 63 private sector hospitals, 46 emergency centers and points, 44 ambulances, 39 urban health units, 57 health care units, 80 family planning units/centers, 37 child care centers and 15 health outreach offices.

Climate

In Helwan area, the summers are long, hot, humid, arid, and clear and the winters are short, cool, dry, and mostly clear. Over the course of the year, the temperature typically varies from 10°C to 35°C and is rarely below 8°C or above 39°C.

Figure 0-2 shows a climate summary for Helwan along the year.

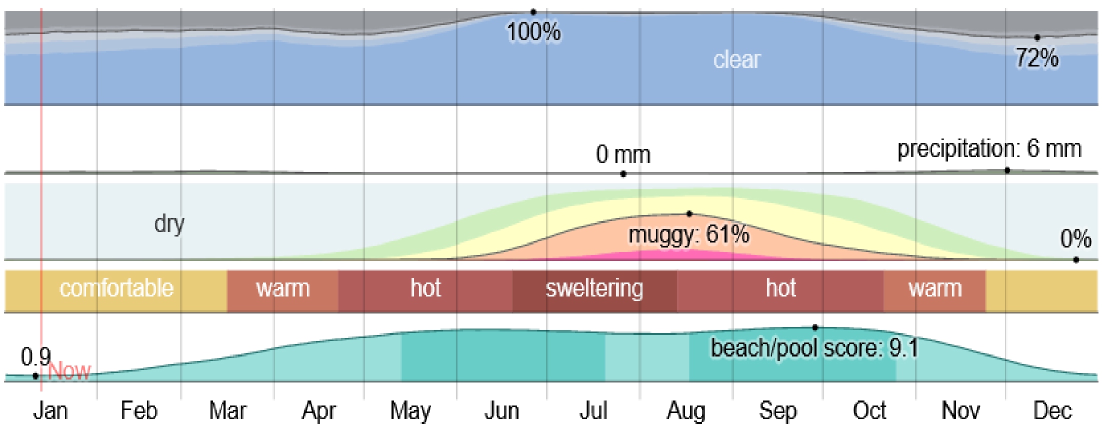


Figure 0-2: Climate summary in Helwan

Temperature

The hot season lasts for 4.7 months, from May 12 to October 2, with an average daily high temperature above 32°C. The hottest day of the year is June 27, with an average high of 35°C and low of 23°C.

The cool season lasts for 3.0 months, from December 3 to March 2, with an average daily high temperature below 22°C. The coldest day of the year is January 20, with an average low of 10°C and high of 19°C. Figure 0-3 below shows the daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

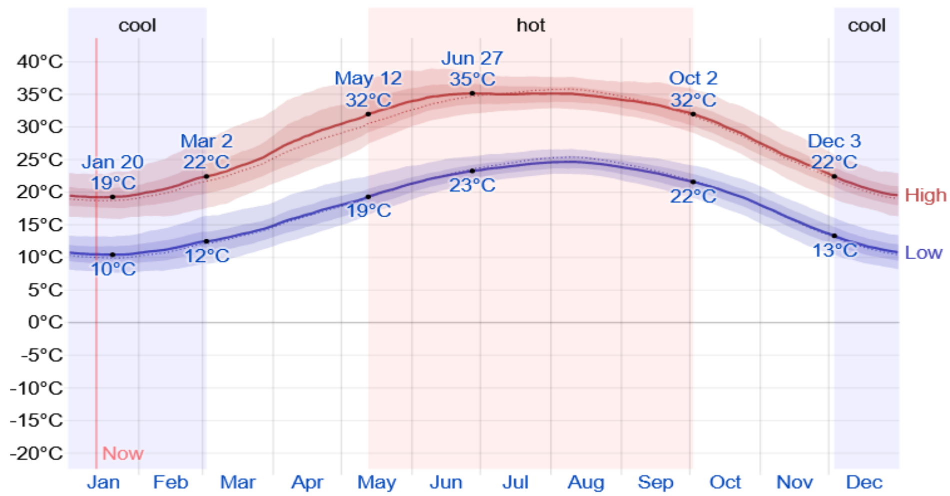


Figure 0-3: Average High and Low Temperature in Helwan

Figure 0-4 below shows you a compact characterization of the entire year of hourly average temperatures. The horizontal axis is the day of the year, the vertical axis is the hour of the day, and the color is the average temperature for that hour and day.

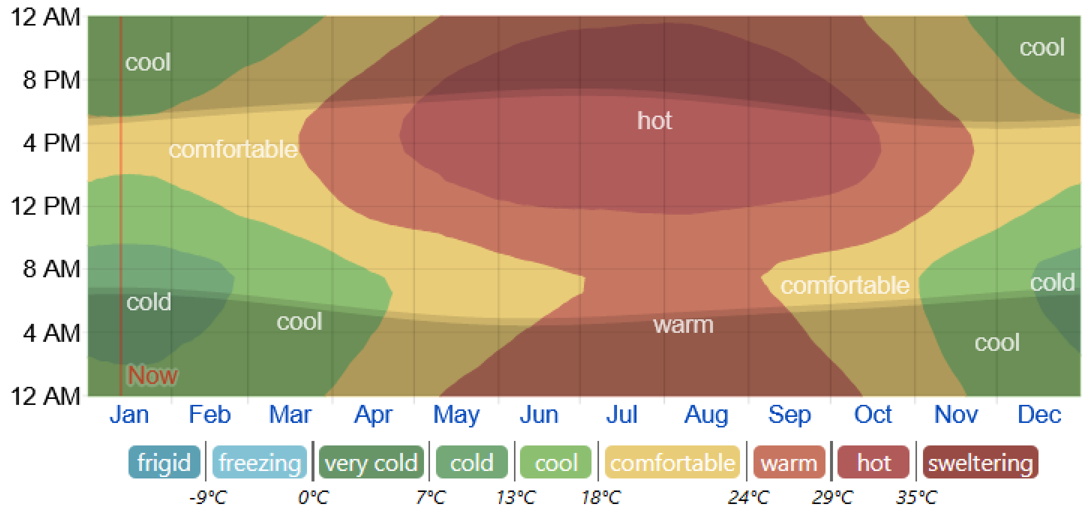


Figure 0-4: Average Hourly Temperature in Helwan

Rainfall

The sliding 31-day quantity of rainfall in Helwan does not vary significantly over the course of the year, staying within 3 millimeters of 3 millimeters throughout.

Figure 0-5 below shows the average rainfall (solid line) accumulated over the course of a sliding 31-day period centered on the day in question, with 25th to 75th and 10th to 90th percentile bands.

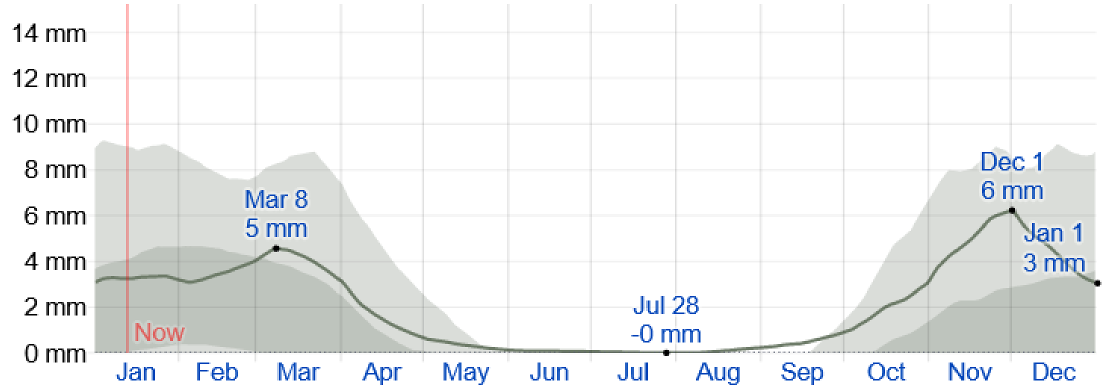


Figure 0-5: Average Monthly Rainfall in Helwan

Wind

The windier part of the year lasts for 4.6 months, from March 15 to August 1, with average wind speeds of more than 14.8 kilometers per hour. The windiest day of the year is June 9, with an average hourly wind speed of 16.9 kilometers per hour. The calmer time of year lasts for 7.4 months, from August 1 to March 15. The calmest day of the year is January 5, with an average hourly wind speed of 12.7 kilometers per hour. Figure 0-6 shows the average mean hourly wind speed.

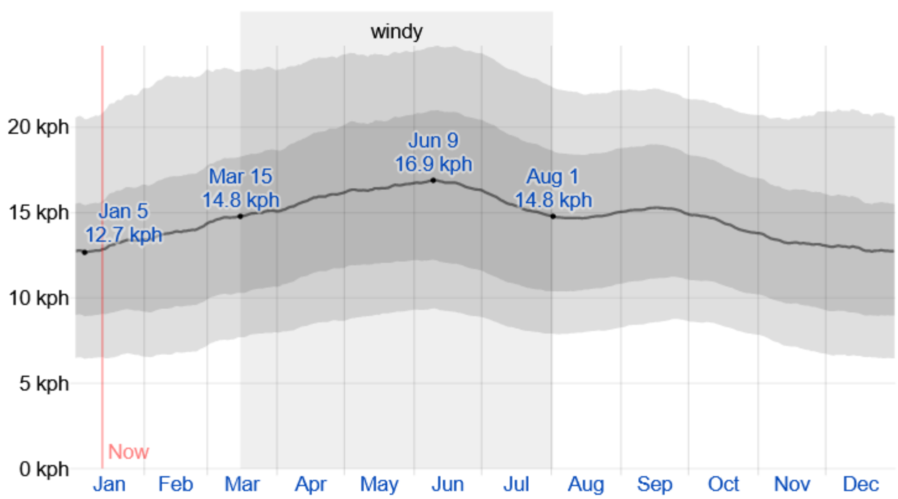


Figure 0-6: The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.

The predominant average hourly wind direction in Helwan varies throughout the year. The wind is most often from the west for 1.2 months, from January 9 to February 15, with a peak percentage of 37% on January 31. The wind is most often from the north for 11 months, from February 15 to January 9, with a peak percentage of 33% on January 1.Figure 0-7 shows the percentage of hours and their corresponding mean wind direction.

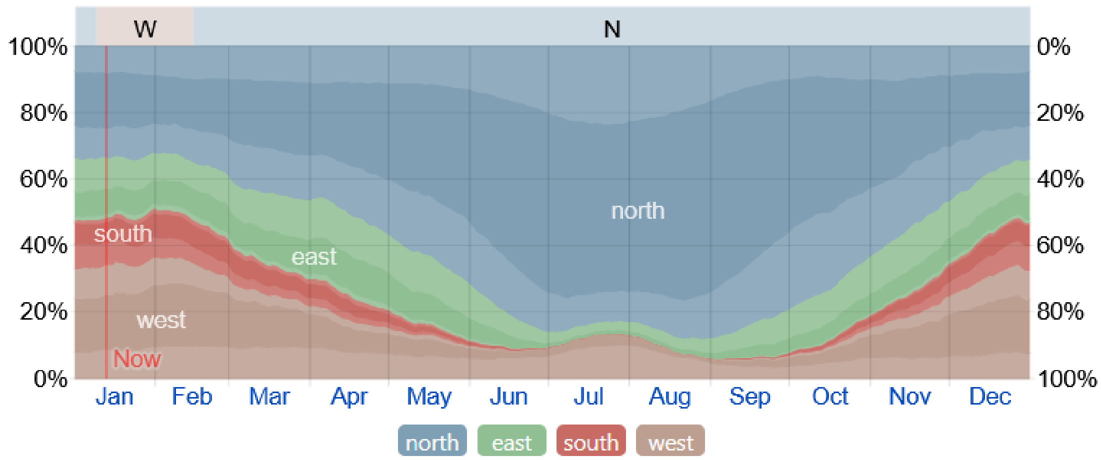


Figure 0-7: The percentage of hours in which the mean wind direction

The percentage of hours in which the mean wind direction is from each of the four cardinal wind directions, excluding hours in which the mean wind speed is less than 1.6 kph. The lightly tinted areas at the boundaries are the percentage of hours spent in the implied intermediate directions (northeast, southeast, southwest, and northwest)

Analysis of alternatives

The objective of analysing different project alternatives is to evaluate the project options, which have been considered for Helwan WWTP extension project, from the environmental perspective. This analysis of alternatives shall help in reaching/confirming optimum options for the project design from both the economic, social and environmental points of view.

No Project Alternative

Helwan WWTP extension project is expected to result in significant environmental improvement in the project areas. The existing situation, in which target areas are deprived from sanitation services, leads to major environmental and health problems to inhabitants. Even though there are some impacts associated with Helwan WWTP extension project construction and operation, however the overall environmental impacts are expected to be positive.

The situation of the existing sanitation scheme makes the improvement of the sanitation facilities a necessity for achieving better hygienic for residents and environmental conditions of the present use including houses, buildings condition and agriculture land in the project area.

Project's Alternatives

There are two main alternatives for the general scheme of this project as followings:

- Alternative (1) scheme is mainly to construct a new expansion to the existing Arab Abo Sa'ed WWTP.
- While alternative (2) scheme is to construct the required expansion in a new site at the Al Kurimat- Al Zafarana Desert Road.

Prefeasibility study of the project concluded that Alternative (1) offers many enhancements and allows for maximum efficient use of existing resources with lower investment needs than alternative (2), and with well-established plan, which serves many environmental and economic aspects such as effluent water quality of unrestricted irrigation into Al Saff canal, which is in a need for these resources. Hence, it is an optimum short/medium term solution for the WWT issue in the area. On another perspective, alternative (1) does not nullify alternative (2), it can be considered an efficient stepping stone on the short/medium term, while the area of the new Al-Kurimat WWTP can be clearer in the future (long term) with the population expansion and hence clearer decision making can be done.

Environmental and Social impact assessment

Environmental impacts of the different components of the Helwan WWTP extension project in Arab Abu Sa'ed - Giza governorate during both the construction and operation phases covers components including:

1. Extension of existed Helwan WWTP;
2. New pumping stations 2A and 3A.
3. FMs
4. El Saff canal

The construction and operation of some/all of the components of the project listed above will also create additional activities/processes such as:

1. Solid hazardous and non-hazardous waste generation during both construction and operation phases.
2. Liquid waste generation during construction and treated effluent discharge during operation.
3. Sludge generation, handling, storage and disposal/reuse, during operation of WWTPs.
4. Development of on-site workers/staff workshops, offices and housing units during construction.

The key receptors have considered include:-

- Air (air quality and ambient noise);
- Soil (soil quality, erosion, landscape);
- Water (water quality and resource consumption);
- Biological environment (Flora and Fauna);
- Human environment (Occupational health & safety, Community safety, Visual impacts, traffic impacts and the Socio-economic and Health impacts).

Environmental and Social impact during Construction phase

Positive Impacts

- Creating job opportunities for skilled and unskilled during construction of the project different components (around 600 Labourers Staff and 150 Technical & Administration Staff).
- Creating opportunities for companies working in contracting and construction of sewage networks.
- Reviving economic activities for shops supplying construction materials in the area, due to selling necessary construction material.

Negative impacts:

- Dust generated during excavation may have some health impacts especially on individuals who suffer from allergy
- Noise generated during construction may have an inconvenient impact on the surrounding populations, especially that some plots are located near some sensitive receptors such as primary schools, youth centres and mosques as well as other residential areas.
- Storing of construction materials and excavation waste on the streets may affect the traffic.
- Risks that accidents may occur as a result of failure to adhere to the safety and occupational health requirements among workers
- Traffic jams in force mains routes areas.

Environmental and Social impact during Operation phase

Positive Impacts

- Improve living conditions and sanitation facilities within project area severed
- Creating job opportunities for some engineers, labours and skilled workers at the PSs and WWTP (around 150 manpower)
- Stop the untreated wastewater disposal into Al-Saff Canal,
- Significantly reduce the current pollution levels in the first reach of Al-Saff canal and improve the water quality in Al-Saff Canal, shown in Table 0-1.

Table 0-1: Pollutants reduction loads in effluent before and after the extension of Helwan WWTP

Parameters	Before extension	After extension	Pollutants load reduction %
BOD (ton/day)	129.5	48.0	62.9%
COD (ton/day)	207.5	64.0	69.2%
TSS (ton/day)	148.0	40.0	73.0%

- Presents advanced treated water quality to the farmers in the first reach of the canal,
- Reduce health risk of residents, famers and crop consumers.

- Provide more good quality water in the canal which shall reduce the pressure on fresh water from the Nile River (about 800 m^3/day).
- Efficiently treat and utilize the sludge with anaerobic digestion to produce electricity to cover up to half of the electricity consumption of the WWTP.
- Utilize the stabilized treated sludge in agricultural and farming purposes.
- Reduce the greenhouse gases emissions from the wastewater and sludge treatment which shall reduce the impact on climate change.

One important positive impact of this project is the improvement potential in the carbon footprint of Helwan WWT system. The carbon footprint study showed that the indirect emissions due to energy use from the grid are the major constitute of the carbon footprint. The three scenarios of the sludge digestion were compared with the current status and the more sludge digested, the more autonomous Arab Abu Sa'ed WWTP is and the less the carbon footprint will become, where the energy savings range are 17% (scenario 1) and 51% (scenario 2, 3) of the WWTP consumption (without irrigation PS.), Figure 0-8. Demolition of the sludge drying beds will significantly decrease the direct emissions from the plant. Furthermore, the shift from secondary treatment to tertiary treatment will significantly decrease the emissions from the effluent discharge of the plant. In total, the project scenarios allow the decrease in emissions per capita served significantly; decreasing both direct and indirect emissions by varying figures depending on chosen scenario. Figure 0-9 shows the decrease in total emissions in ton CO2 equivalent per capita served for Arab Abu Sa'ed WWTP.

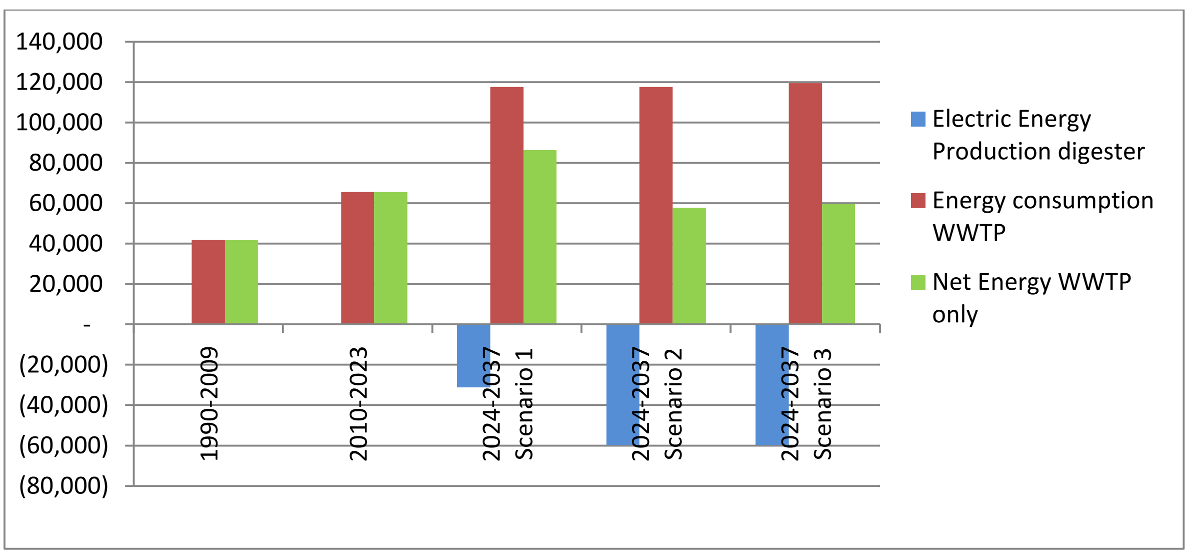


Figure 0-8: Indirect emissions due to electric energy consumption and production in the WWTP only and net electric energy

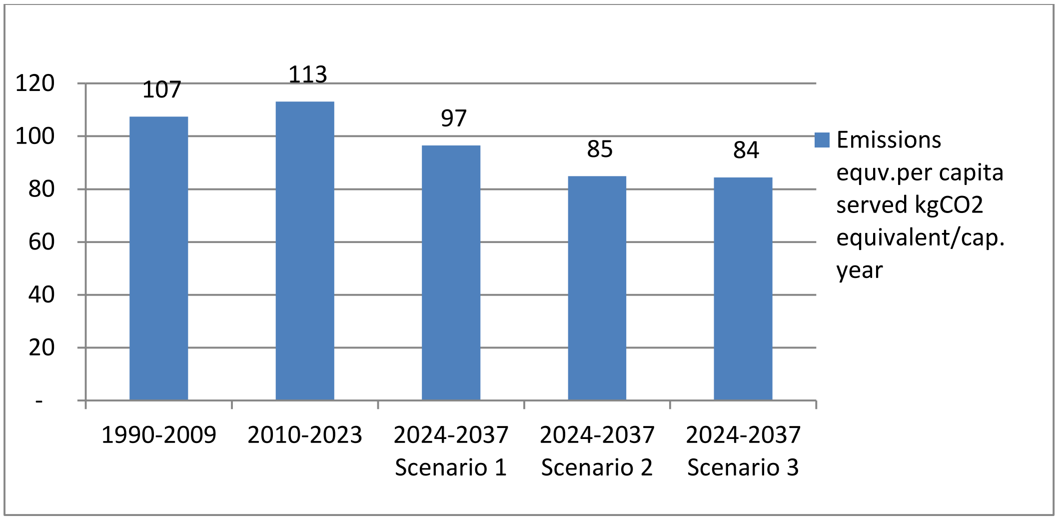


Figure 0-9: Emissions per capita served of Arab Abu Sa'ed WWTP present and future plans

The project has a very strong potential when it comes to climate resiliency and vulnerability as, all the proposed project outputs and components may be considered as a reduction to the vulnerability to climate change as the project will:

- Increase the wastewater conveyance network capacity, which will help contain more intense rainfall and storms/floods.
- Supply unrestricted irrigation water quality with additional 800,000 m^3/day, which would have otherwise been extracted from the Nile. This will help compact droughts and shortage of water resources and agricultural water stress.
- Will improve wastewater treatment quality to compact the climate change impacts.
- Compact the damage and halt in service due to power cutoffs by depending less on the national grid by utilizing energy recovery in sludge digestion.
- Decreasing the carbon footprint per capita served by utilizing energy recovery and tertiary treatment.
- Increasing the WWTP capacity along with upgrading to tertiary treatment will allow for more containment to the peak average daily water consumption increase as temperatures increase.

Negative impacts:

- Spread of some foul odours to the surrounding residential areas
- Noise related to the operation of the PSs
- Hydraulic capacity of al Saff canal should be increased to accommodate the new WWTP effluent of 800,000 m^3/day. As seen in the following Figure 0-10 that the predicted water level will be overflow the canal bank in case of introduced the new flow 800,000 m^3/day.

- Implement the proposed subsurface drainage network (Studied by Drainage Research Institute and to be implemented by Egyptian Public Authority for Drainage Projects) comprises 6 drains.

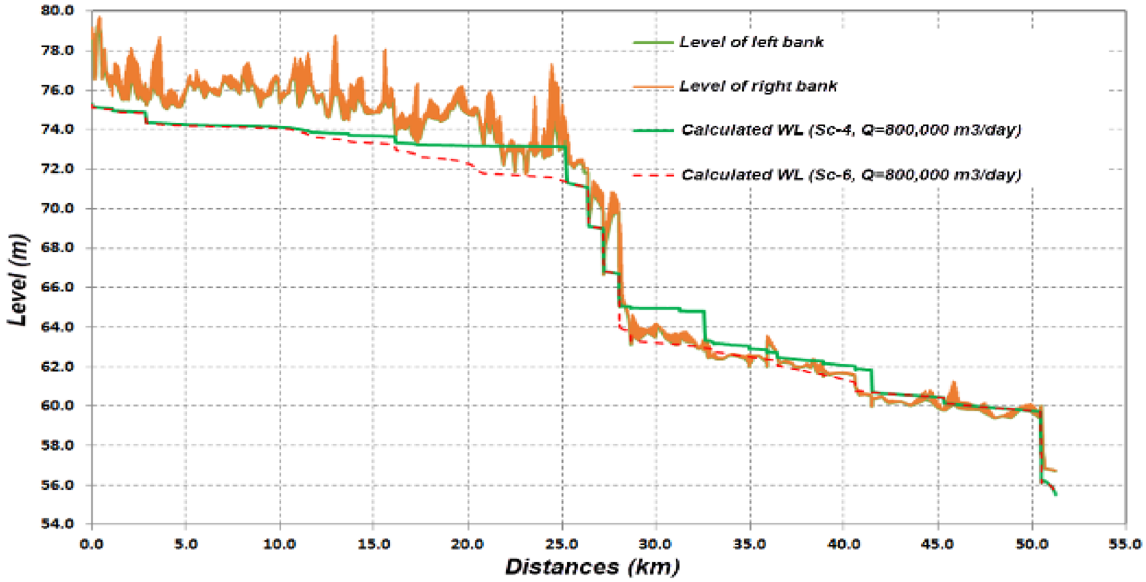


Figure 0-10: The water level results to Al-Saff old canal in model

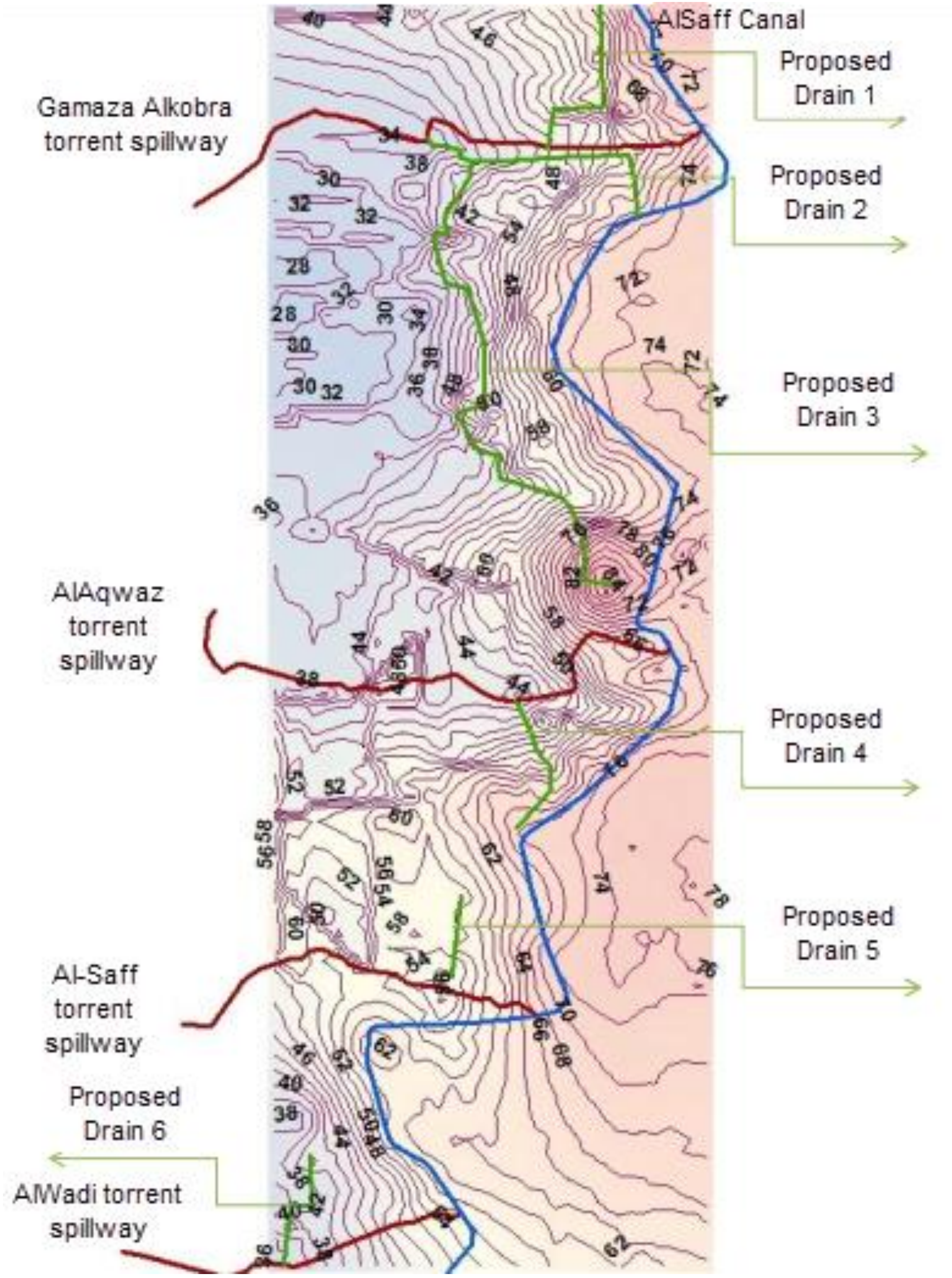


Figure 0-11: Al-Saff canal and the locations of the proposed drains to serve Al-Saff area

Environmental and Social Management Plan

The Environmental and Social Management Plan (ESMP) presented in this section reflects the implementation procedures and mechanisms as well as the roles and responsibilities for the implementation of the mitigation measures and monitoring activities for the expected impacts.

The effectiveness of the proposed mitigation measures and environmental management plan will be monitored throughout the construction and operation phases of the project. Monitoring will be performed using calibrated equipment (where relevant) and standard techniques in order to ensure accuracy of the results. These results will be stored in an easy to access database and will be analysed and corrective/additional actions shall be undertaken as necessary.

Table 02- and Table 04-provide summary of the potential impact during construction and operation phases respectively.

Table 02-: Summary of Impacts assessment during Construction Phase

Activities causing the impact	Overall Impact Significance									
	Dust and Air Emission	Noise	Land and Soil	Water Resources	Waste Generation and Disposal	Flora and Fauna	Visual Impacts	Health and Safety Impact Assessment	Traffic Impact	Community Health and Safety	Socioeconomic
Construction of Helwan WWTP extension	Minor	Minor	Minor	Minor	Moderate	**Insignificant**	Minor	Moderate	Minor	Minor	Positive
Construction of PSs including all sub components	Moderate	Moderate	Minor	Minor	Moderate	**Insignificant**	Minor	Moderate	Minor	Minor	Positive
Construction of FMs	Moderate	Moderate	Moderate	Minor	Moderate	**Insignificant**	Minor	Moderate	Major	Moderate	Positive

Table 03-: Summary of Impacts assessment during Construction Phase (considering mitigation measures)

Activities causing the impact	Overall Impact Significance									
	Dust and Air Emission	Noise	Land and Soil	Water Resources	Waste Generation and Disposal	Flora and Fauna	Visual Impacts	Health and Safety Impact Assessment	Traffic Impact	Community Health and Safety	Socioeconomic
Construction of Helwan WWTP extension	**Insignificant**	**Insignificant**	**Insignificant**	**Insignificant**	Minor	**Insignificant**	**Insignificant**	Minor	**Insignificant**	**Insignificant**	Positive
Construction of PSs including all sub components	Minor	Minor	**Insignificant**	**Insignificant**	Minor	**Insignificant**	**Insignificant**	Minor	**Insignificant**	**Insignificant**	Positive
Construction of FMs	Minor	Minor	Minor	**Insignificant**	Minor	**Insignificant**	**Insignificant**	Minor	Moderate	Minor	Positive

Table 04-: Summary of Impacts assessment during Operation Phase

Activities causing the impact	Overall Impact Significance										
	Air Emissions, Dust and Odour	Carbon footprint & Climate Change	Noise Impact	Land and Soil	Water Resources	Wastes	Visual impacts	Health and Safety Impact Assessment	Traffic Impact	Community Health and Safety	Socioeconomic
Operation of Helwan WWTP extension	Minor	Positive	Minor	Minor	Positive	Moderate	Minor	Major	Minor	Positive	Positive
Operation of PSs including all sub components	Minor	Insignificant	Moderate	Minor	Positive	Moderate	Minor	Moderate	Minor	Positive	Positive
Operation of FMs	Minor	N/A	Insignificant	Moderate	Minor	Insignificant	Moderate	Minor	Minor	N/A	Positive

Table 05-: Summary of Impacts assessment during Operation Phase (considering mitigation measures)

Activities causing the impact	Overall Impact Significance									
	Air Emissions, Dust and Odour	Carbon footprint & Climate Change	Noise Impact	Land and Soil	Water Resources	Wastes	Visual impacts	Health and Safety Impact Assessment	Traffic Impact	Community Health and Safety	Socioeconomic
Operation of Helwan WWTP extension	Minor	Positive	Minor	Insignificant	Positive	Minor	Minor	Moderate	Insignificant	Positive	Positive
Operation of PSs including all sub components	Minor	Insignificant	Minor	Insignificant	Positive	Minor	Minor	Minor	Insignificant	Positive	Positive
Operation of FMs	Insignificant	N/A	Insignificant	Insignificant	Insignificant	Insignificant	Minor	Minor	Insignificant	N/A	Positive

CHAPTER 1

Introduction, Approach and Methodology

1. Introduction, Approach and Methodology

1.1 Background

In Egypt, the gap between water and sanitation coverage has grown, with access to drinking water reaching 96.6% based on CENSUS 2006 for Egypt overall (99.5% in Greater Cairo and 92.9% in rural areas) and access to sanitation 50.5% (94.7% in Greater Cairo and 24.3% in rural areas - according to the Central Agency for Public Mobilization and Statistics (CAPMAS).

This gap and the related pollution concerns are prompting the Government to adopt more aggressive strategies to extend the relevant infrastructure. In particular, according to the Memorandum of Information distributed previously to potential bidders for the 6th of October wastewater treatment plant, the government of Egypt aims to expand wastewater capacities from 60% of the cities covered at present, to 100%.

In that perspective, the government envisages to substantially increase its investment in the water sector, while, in parallel, seeking to scale up private sector participation in the financing, design, construction, operation and maintenance of wastewater treatment plant projects, such as this one.

The initial Helwan Wastewater Project including Helwan Wastewater Treatment Plant is considered as one of the four largest wastewater projects established in Egypt during the eighties of the last century. Helwan Wastewater treatment plant has a capacity of 550,000 m^3/day.

The project of Helwan is designed and implemented to serve the southern part of Greater Cairo as shown in Figure 1-1, which starts from Al-Maadi and extends southward for a distance of 30 km, to serve residential areas. Industrial areas, including iron and steel factories, coke factories, forgings, cement factories, the Nasr Company for Cars, many military factories in the region, in addition to the residential areas and industrial areas covered by the wastewater project. It also serves Helwan University and many military and security sites, including Helwan Airport, Tora Prisons, and security forces in Tora, Police Trustees Institute in Tora, Helwan Air Force Secondary School, entertainment and commercial areas.

The proposed project Upgrade and Extension of Helwan Wastewater Treatment Plant (WWTP) from secondary treatment of 550,000 m3 per day to advanced treatment and expand the total capacity of the plant to 800,000 m3 per day (additional 250,000 m3/day as first phase at year 2037). The project will dispose the 800,000 m3/day advanced treated water to Al-Saff Canal to utilize the treated water in irrigation and supplement the water deficit in the region. After completing the treatment of wastewater in WWTP in Abu Sa'ed, the treated effluent is discharged by gravity to the irrigation station located in the WWTP's site, which in turn lifts the water to the source of "Al Saff" Canal, located 3.5 km away from WWTP.

Besides the upgrade and extension of the existing Helwan WWTP, the project shall also include: Construction of new collectors; Construction of new wastewater pumping stations WWPSs, screw PS, and WWPS in the same location as 15th of May WWTP to divert the wastewater from 15th of May City to Helwan WWTP. The available treated excess water shall provide an additional source of water, thus improving the economic situation for farmers and agricultural activities in the area. Also, this project will improve the health and environmental situation of the population living in the southern part of Cairo Governorate.

Figure 1-1: Project location

1.2 Project Justification

The proposed project of upgrade and extension of Helwan WWTP is included as one of the projects in the National Action Plan of Egypt (NAP) 2015 and is a top priority of the Government of Egypt. It contributes towards an efficient and sustainable water resources management in Egypt as well as to the Egyptian climate protection efforts.

The proposed project of upgrading and extension of Helwan (Arab Abo Sa'ed) WWTP from 550,000 m^3/day second treatment to 800,000 m^3/day Advanced Treatment shall:

- Stop the untreated wastewater disposal into Al-Saff Canal,
- Significantly reduce the current pollution levels in the first reach of Al-Saff canal and improve the water quality in Al-Saff Canal,
- Presents advanced treated water quality to the farmers in the first reach of the canal,
- Provide more excellent quality water in the canal which shall reduce the abstraction of fresh water from the Nile River.
- Efficiently treat and utilize the sludge with anaerobic digestion to produce electricity to cover up to half of the electricity consumption of the WWTP.
- Utilize the stabilized treated sludge in agricultural and farming purposes.
- Reduce the greenhouse gases emissions from the wastewater and sludge treatment which shall reduce the impact on climate change

The project will support the depollution of Southern region of Greater Cairo and Al-Saff Canal and provide an additional source of water and thus improve the economic situation for agriculture. The project will improve the health and environmental situation of the people living in the Governorate of Cairo. The project will contribute to the environmental sound disposal/utilization of effluent and sludge as well as energetically optimized and environmental sound sludge treatment.

If the project is not executed in case of "No Project Alternative", Helwan WWTP shall not be able to receive and handle the future flows. The high level of pollution due to un-proper level of treatment of wastewater received by the WWTP as well as the current sludge treatment and handling shall increase and consequently the level of pollution reaches the Al-Saff Canal and ultimately reaches the land and farmers shall also increase. This level of pollution shall affect the human health as well as the limited available water resources.

Considering the serious environmental and socio-economic currently attributed by the poor treatment efficiency of the WWTP the upgrade and extension project is essential, especially with view of improvements in human health, water resources and energy efficiency.

1.3 ESIA Objectives and Purpose of the Report

A feasibility study, initially funded by the African Development Bank in 2015, was updated by the EU delegation in Cairo (conducted by Atkins-Chemonics). This study was the base for the required tasks of this assessment as it was required from the consultant to focus on the rational and findings of the said updated study. The current ESIA assignment also aimed at completing the existing study in order to support the respective appraisal processes of AFD and EIB to ensure that both agencies have access to the required information to mobilize financing for the Project at key steps in their evaluation of the Project.

Moreover, assessment of the environmental and social impacts for the proposed upgrade and extension of the Helwan (Arab Abo Sa'ed) WWTP is a prerequisite for implementing developmental projects both by financing agencies (EIB and AFD) and the Egyptian Environmental Affairs Agency (EEAA). Accordingly this study has been prepared for performing an Environmental and Social Impact Assessment (ESIA), following Terms of Reference (TORs, aiming at providing a detailed analysis of the anticipated environmental and social safeguard issues associated with proposed project; and to develop an environmental management and monitoring plan to be implemented during the construction and operation of the project.

The Ministry of Environment is engaged as a key stakeholder so as to inform the content of the ESIA, ensure Egyptian requirements are met and that the ESIA can be used for environmental permitting for construction and operation of the upgrade and extension of the WWTP. The ESIA will be for the benefit of the Government of Egypt.

According to the ESIA guidelines and procedures of EIB and AFD environmental and social requirements and by the Ministry of Environment – EEAA January 2009 (amended in October 2010), the project falls under Category C projects.

This ESIA report has been compiled as part of the ESIA process in accordance with Egyptian environmental Law number 4 for the year 1994 amended by law number 9 for the year 2009 and Law 105 for the year 2015. It has taken into account the environmental regulations and requirements of funding institutions including the EIB and AFD safeguard policies.

The report includes the identification and evaluation of the potential environmental impacts due to the construction and operation of different components of the project. It also includes proposed mitigation and monitoring measures to control/minimize the effects of the identified negative impacts. In general, the objectives of the ESIA study were to:

- The description of the project: location, site, design, size; the physical characteristics of the project (including any demolition or land-use requirements); technical capacity and characteristics of the operational phase.
- Identify the various elements that may affect human health and safety as well as have an impact on different ecosystems;
- The description of the baseline scenario – adequate and appropriate quantitative and qualitative, primary and secondary data on the relevant aspects of the existing state of the environment and social context and the likely evolution thereof without implementation of the project, paying attention to any area of particular environmental and social importance and the use of natural resources. In doing so, the Consultant shall specify the quality of surface and groundwater within the Project's area of influence.

- Highlight and review the legislations under which the project will be implemented; Current knowledge and methods of assessment, as well as the applicable laws and regulations of the jurisdictions of Egypt that relate to environmental and social matters.
- Determine the social and environmental impacts in a quantitative manner whenever possible taking into account different projects activities at various stages (planning, construction, operation and decommissioning) and their impact on environmental and social issues;
- Perform a preliminary carbon footprint assessment, including both construction and a 20 year-operation period. As the detailed design for the WWTP is not available yet, different assumptions for energy produced by bio-digesters may be drawn from comparable projects.
- Assessment of the likely significant effects of the proposed project on environmental and social aspects, including biodiversity, population, human health, land (e.g. land take), soil (e.g. organic matter, erosion, compaction, sealing), water (e.g. hydro morphological changes, quantity and quality), air, climate (e.g. GHG emissions, impacts relevant to adaptation), landscape, material assets, human rights resulting from inter alia:
    - the existence of the project,
    - the use of natural resources,
    - the emissions of pollutants, noise, vibration, light, heat and radiation,
    - the risks to human well-being, cultural heritage or the environment,
    - the technologies and substances used,
    - the accumulation of effects with other projects and/or activities.
- The description should cover the direct effects and any direct, secondary, cumulative, trans-boundary, short-, medium- and long-term, permanent and temporary, positive and negative effects of the project.
- In particular the review of the draft ESIA should include:
    - Analysis of the physio-chemical, biological and socio-economic conditions at the level of the Al Saff canal and the anticipated environmental and social impacts of the discharge of treated water and the expansion activities of the canal over 25 km;
    - Analysis of social risks associated with the installation of sewer collectors and backups and permanent access to the network;
    - Description of the management and treatment of industrial wastewater (types of Discharges, internal treatment method, discharge agreement, etc.)
    - Description of current practices in E&S management of the WWTP.
- The description of the reasonable alternatives (for example in terms of project design, technology, location size and scale) to the proposed project and an indication of the main reasons for selecting the chosen option, including a comparison of the environmental effects. Analyze and select the most appropriate alternatives based upon the analysis and evaluation of environmental and social concerns;
- Prepare the environmental and social management plan (ESMP) to mitigate adverse impacts (social and environmental). The ESMP includes performance indicators and monitoring

requirements for the impacts in accordance with relevant environmental and social laws and regulations.

- Develop a monitoring program in order to identify; 1) any unexpected cases which may appear during the project's implementation; and 2) the effectiveness of the identified mitigation measures during implementation;
- Comprehensive and context-specific stakeholder identification and analysis, including identification of individuals and communities actually and potentially impacted by the project, in particular vulnerable individuals or groups, as well as other relevant stakeholders. Description of the precise public engagement and consultation activities undertaken with different groups of impacted individuals, communities and other relevant stakeholders. The Consultant shall be particularly attentive in integrating gender-sensitive measures in the stakeholder engagement process.
- Arrangements for grievance mechanisms and for steps that will be taken to ensure effective access to remedy for affected stakeholders.
- Public consultation ensuring participation by stakeholders such as women and farmers. To be noted that one public consultation meeting has already been held.
- Description of information sharing, reporting and disclosure undertaken as part of the impact assessment and details on how feedback was taken into consideration in the identification and assessment of impacts, design of project alternatives, impact mitigation and monitoring.
- Assessment of the natural, man-made disaster and accidental risks to which the project could be vulnerable and, where appropriate, descriptions of the measures foreseen to prevent such risks, as well as measures regarding preparedness for and response to emergencies, to be included as part of the ESMP.
- Confirmation that the project does not involve involuntary resettlement, impacts on vulnerable groups, Indigenous Peoples, minorities and/or cultural heritage. Should the Project be found to include any of the above, additional assessments will be required.
- Risk assessment and identification of people and physical assets in the vicinity of the WWTP
- A non-technical summary of the information provided under the above-mentioned headings.
- A final ESIA report ready for submission to the relevant authority for approval

The findings included in this ESIA study will provide decision makers with the needed information in order to minimize the unfavorable impacts and develop the best compensation strategy, if needed.

1.4 Report Structure

The ESIA consists of Executive Summary, (8) chapters and Annexes, which provide a concise and stepped approach to the ESIA study for the construction and operation of proposed project. A description of report contents is briefed in Table 1-1 below:

Table 1-1: ESIA report structure

Chapter	Contents
Executive Summary	A non-technical summary of the information provided under the eight chapters mentioned below
Chapter 1 Introduction, approach and methodology	Contains project justification, a brief description of the proposed activity and an outline of the report structure. Outlines the approach to the ESIA study and summarizes the process undertaken for the project to date.
Chapter2 Project Description	Includes a detailed description of the proposed activities.
Chapter 3 Regulatory Framework	Outlines the legislative, policy and administrative requirements applicable to the proposed development.
Chapter 4 Environmental and Social Baseline	Describes the environmental and social baseline conditions in the project region.
Chapter 5 Stakeholder Engagement and Consultation Activities	Aims at highlighting the key consultation and community engagement activities and their outcomes, in addition to outlining the validity and reliability of the collected data.
Chapter6 Environmental and Social Impact Assessment	Describes and assesses the potential environmental and socio-economic impacts of the proposed project on different receptors and describes relevant mitigation measures.
Chapter 7 Analysis of Project Alternatives	Describes and assesses the project alternatives and recommend the viable options
Chapter 8 Environmental and Social Management Plan	Describes the identified mitigation measures in the environmental management and monitoring plan
Annexes	1. List of participants 2. Climate Resiliency and Vulnerability Assessment 3. Climate change assessment, Carbon Footprint 4. (a) Helwan WWTP - Influent flow 2019/2020

Chapter	Contents
	Wastewater Quality laboratory data (July –October 2020) (b) Sludge samples lab. results for heavy metals and E. coli of Helwan WWTP Nov. 2020 5. English Summary, Hydraulic Study Hydraulic Capacity of Al-Saff Canal after increase the existing capacity of wastewater treatment plant in Arab Abo-Sa'ed from 550,000 m^3/day to be 800,000 m3/day 6. English Summary, Hydraulic Capacity Study Hydraulic Capacity of Al-Saff drains after increase the existing capacity of wastewater treatment plant in Arab Abo-Sa'ed from 550,000 m^3/day to be 800,000 m^3/day

1.5 Approach and Methodology

The ESIA is a systematic process where the potential negative and positive impacts of the project on the bio-physical and socio-economic environment are identified, assessed and – if avoidance is not feasible -mitigated. The following sections include the methodologies that were adopted by the Consultant during the different stages of the ESIA process.

1.5.1 Environmental Impact Assessment phase

Each potential impact resulting directly or indirectly from the project is categorized based on the Basic Impact Index and the Receptor Sensitivity. Based on these two parameters, the Impact Significance is evaluated. The significance of each potential impact will depend on the project activities and the potential impacts on the environmental receptor. Basic Impact Index: The criteria for defining the basic impact index includes assessing the following parameters, see Figure 1-2.

- Magnitude: describes the quantity of the resource (or receptor) potentially affected by the activity.
- Spatial extent: the geographical area over which the impact is experienced.
- Duration: the length of time over which the impact will be experienced. An impact may be present only while an activity is active, or it could persist long after the activity has ceased, in which case the duration may be regarded as the time the receptor needs to recover from the effect.

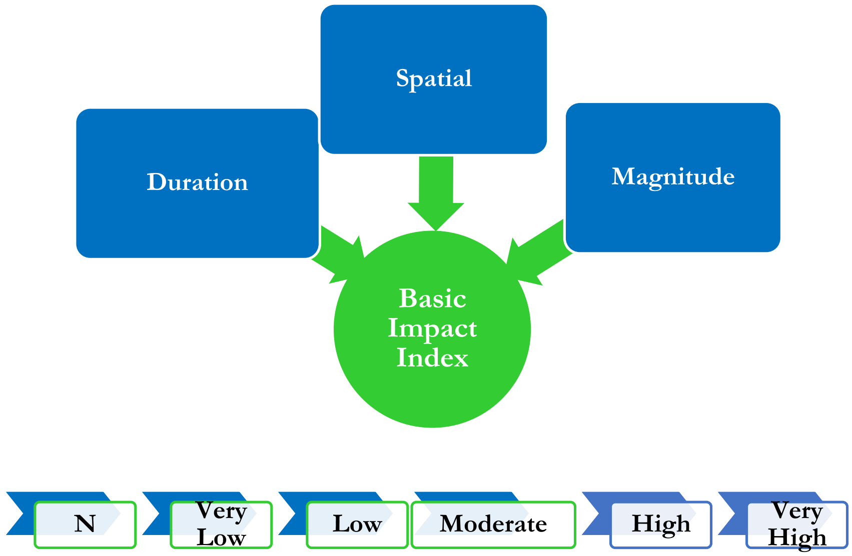


Figure 1-2: Basic Impact Index Assessment

Each potential impact should be evaluated by applying descriptors to each of the above criteria, based on qualitative or, to the extent possible, quantitative evaluation, as follows.

The magnitude of impact is allocated one of the following categories:

- Very Low (1): A very small proportion of the receptor is affected.
- Low (2): A small proportion of the receptor is affected.
- Moderate (3): A moderate proportion of the receptor is affected.
- High (4): A large proportion of the receptor is affected.
- Very High (5): A very large proportion or all of the receptor is affected.

The spatial extent of impact is allocated one of the following categories:

- N (0): No effect.
- Very Low (1): Local scale impact in the immediate area of the activity.
- Low (2): Local impact in the study area.
- Moderate (3): Regional scale impact.
- High (4): National scale impact.
- Very High (5): Global scale impact.

Duration of impact is described by one of the following categories:

- N (0): No effect.
- Very Low (1): Less than one year.

- Low (2): One to five years.
- Moderate (3): Five to ten years.
- High (4): Greater than ten years.
- Very High (5): Irreversible.

The relative importance of each criterion, as illustrated in will be evaluated on a scale from zero to five, and expressed as follows: Nil (N), Very Low (VL), Low (L), Moderate (M), High (H), and Very High (VH). The highest figure is assigned to an impact when there is uncertainty about the criteria, so as to reduce the chance of underestimating an impact; thereby minimizing risk. The Basic Impact Index, see Table 1-2, is obtained by the weighted average of these three values, to obtain a whole number between 0 and 5. The magnitude's weight is twice that for spatial extent and duration.

Table 1-2: Basic Impact Index

Basic Impact Index	N	VL	L	M	H	VH
Magnitude	0	1	2	3	4	5
Spatial Extent	0	1	2	3	4	5
Duration	0	1	2	3	4	5

Receptor Categorization: is based on the relationship between the respective project activities and the present baseline environment (the receptor). It is assessed based on the vulnerability of the receptor, including the surrounding population and environment. To illustrate, if the effect of an impact on a receptor is more readily absorbed and easily mitigated, it is less sensitive. On the other hand, as an impact is more challenging to mitigate and cannot be absorbed by the population and/or environment it becomes more sensitive and requires an extensive management plan.

The sensitivity of the receptor is assessed as:

- Low: High capacity to absorb/mitigate impact
- Medium: Limited capacity to absorb/mitigate impact
- High: No capacity to absorb/mitigate impact

Impact Significance: The final impact significance is the result of the combination of the Basic Impact Index and the Receptor Categorization, as shown in Table 1-3, where impact significance may result in one of the following classes: Insignificant (IN), Minor (MI), Moderate (MO) or Major (MA).

Table 1-3: Impact Significance

Receptor Categorization	Basic Impact Index						
	Negative /Adverse						Beneficial
	N	VL	L	M	H	VH	
L	IN	IN	IN	MI	MO	MA	Positive
M	IN	IN	MI	MO	MA	MA	
H	IN	MI	MO	MA	MA	MA	

Environmental impacts are caused by environmental aspects and can have a direct impact on the environment, contribute indirectly to a larger environmental change, or be cumulative. Those impacts rated as Minor, Moderate or major are considered to require mitigation measures in order to eliminate the impact or, where this is not possible, to reduce their significance ranking to Minor or Insignificant.

Wherever possible, the impact assessment is based on a quantifiable analysis, in order to compare the expected impacts with relevant and applicable laws and standards, as detailed in Chapter 3 of this report.

<u>The potential impacts are assessed under the assumption that the planned pollution control measures described in Chapter 6 of this report will be implemented.</u>

Each impact's significance is determined based on its effluence on resources and/or receptors, as well as the area's sensitivity and the implied magnitude of change, see Figure 1-3.

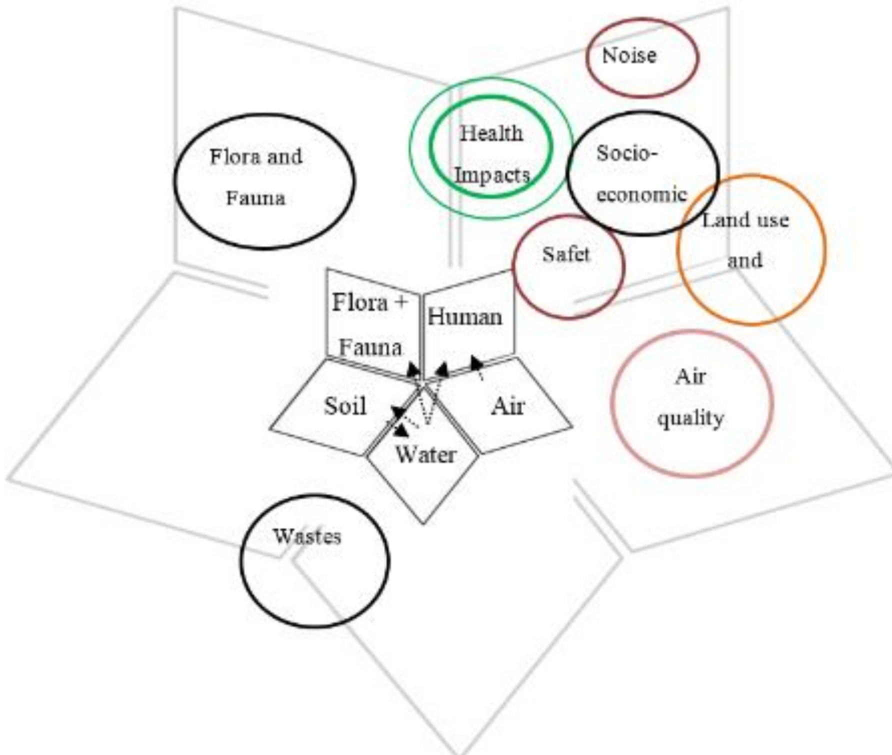


Figure 1-3: Potential environmental and social impacts versus sensitive receptors

1.5.2 Social Impact Assessment Data Collection Methodology

The consultant has adopted a multistage analysis strategy, several data collection methods and tools were applied using the Participatory Rapid Appraisal approach. This approach ensures that local community groups participated to the study. Data was collected in coordination with relevant stakeholders.

A number of qualitative data collection tools were applied to ensure balanced representation of different beneficiary groups. The consultant has also reviewed relevant secondary data sources such as: project technical studies, relevant reports and previous literature. The research team has conducted several field visits to assess the baseline conditions. The applied methodology in the social impact assessment can be summarized as follows in Figure 1-4:

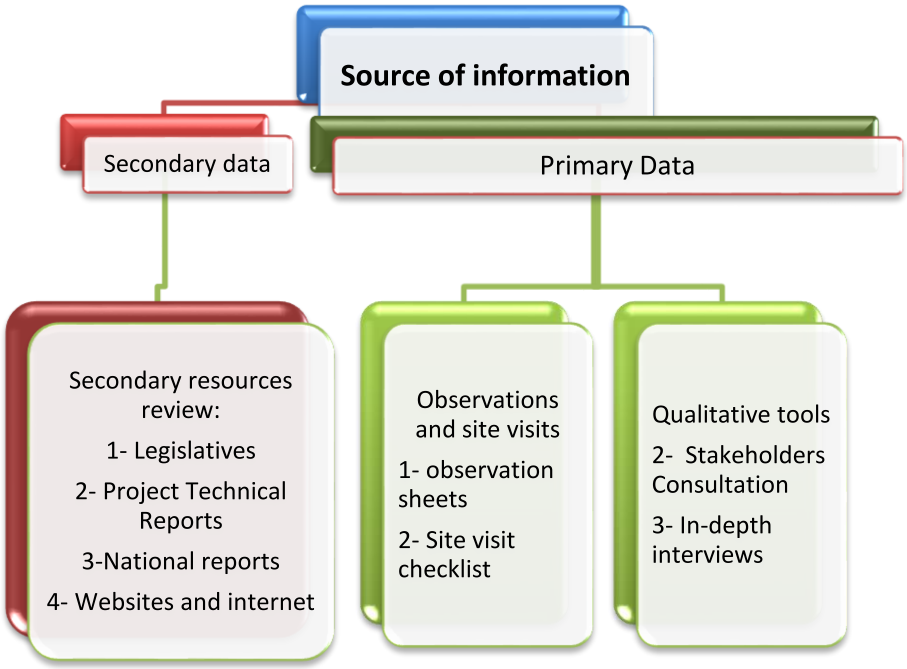


Figure 1-4: Methodology and Data collection tools

CHAPTER 2

Project Description including Alternatives

2. Project Description including Alternatives

2.1 Project background

Cairo wastewater system was initiated in 1914, and it was shallow sewers and pneumatic ejectors. Such system went out of efficient service 60 years later due to increased population, and emergency projects needed to be done to save the situation especially after severe flooding of Cairo in the period between 1964 till 1966. This required a new perspective on Cairo's wastewater system; where a joint fund was signed by the British and American funds to completely renew the wastewater collection system on both banks of the River Nile in Cairo. Such system depended on gravity main collectors and deep culverts, and divided Cairo catchment areas into generally four major parts: North east, south east, North west and South west of Cairo, each of these major catchments were to be served by a big scale wastewater treatment plant.

The North part of Greater Cairo East Bank wastewater is collected through tunnels and culverts that convey the collected wastewater to both Gabal Asfar WWTP and Berka WWTP. The Third WWTP constructed at the Northern part of the East Bank is Shoubra Al-Khemah WWTP with capacity of 600,000 m^3/day. The Southern part of Cairo is depending on a separate collection and treatment system, starting from the south of Maadi district. Wastewater is collected and delivered through culverts and in-series screw pump stations further south to Helwan.

Due to the long length of the served area at the East Bank of Cairo, the collection system was divided into two main directions. The first direction which collects the wastewater and converts it to the north direction started from the south part of Cairo at Maadi area and passes through the East Bank districts collecting sewage water until it reaches to the North of Cairo at Amirya pump station. The second direction of wastewater collection was to the south where it also started from a matching line at Maadi area and started diverting sewage to the southern direction at Helwan via a series of collectors, trunk mains and sires of pump stations up to Helwan WWTP at Arab Abo Sa'ed area.

The catchment zone of Helwan project extends from the Cairo ring road on the north direction down to the rural area of Arab Abu-Sa'ed in the south direction, and from Kattamia on the East side to the Nile Cornish on the West side . In addition , the current wastewater and treatment system of Helwan receives wastewater from the areas of Mokattam middle knoll, Almeerage and Sakr Koreach, Wadi Digla, Al Autostrad, Zahraa Al Maady and parts of New Cairo, Tura(s), Al Maasara(s), Al Teben and Helwan areas up to Arab Abu-Sa'ed and the new regional ring road to the south of Cairo.

Since the first Master Plan of Helwan General Wastewater Project, which was prepared and construction supervised by the German Consultant "Dorsch Consult", many demographic changes have been introduced and many additional residential areas have been added to the catchment areas of the southern zone of Cairo. Those include the extended population increase and additional development areas at the districts of Al Maadi, Helwan and 15th of May city. In addition new settlements on the eastern direction of the autostrad up to New Cairo have been developed and its generated sewage was transferred to the collection system of Helwan project that ends by Helwan WWTP at Arab Abo Sa'ed.

The original project was divided to several contracts and funded by the European International Development Agencies together with the local component of the project budget. The master plan and the project designs were completed in 1978 based on constructing two stages; the first up to 1992 and the second stage up to the year 2000. The first stage of Helwan wastewater treatment plant has a design capacity of 350,000 m3/day to serve approximately one million inhabitants. The plant capacity was increased to 550,000 m3/day by the Arab-Contractors company to serve approximately 1.5 million inhabitants. The plant expansion was completed and set into operation in 2010. However, It should be noted that the plant has seen sever discussions before it was finally handed over to GCWC for operation due to technical problems in the performance of the plat, the effluent quality that was not matching with the contract conditions/ Egyptian laws, and the operation/maintenance conditions of different electromechanical equipment. The operator (Arab contractors for operation & maintenance received a huge penalty deducted from its invoices. The location of both Helwan and 15th May WWTPs is shown in Figure 2-1 below.

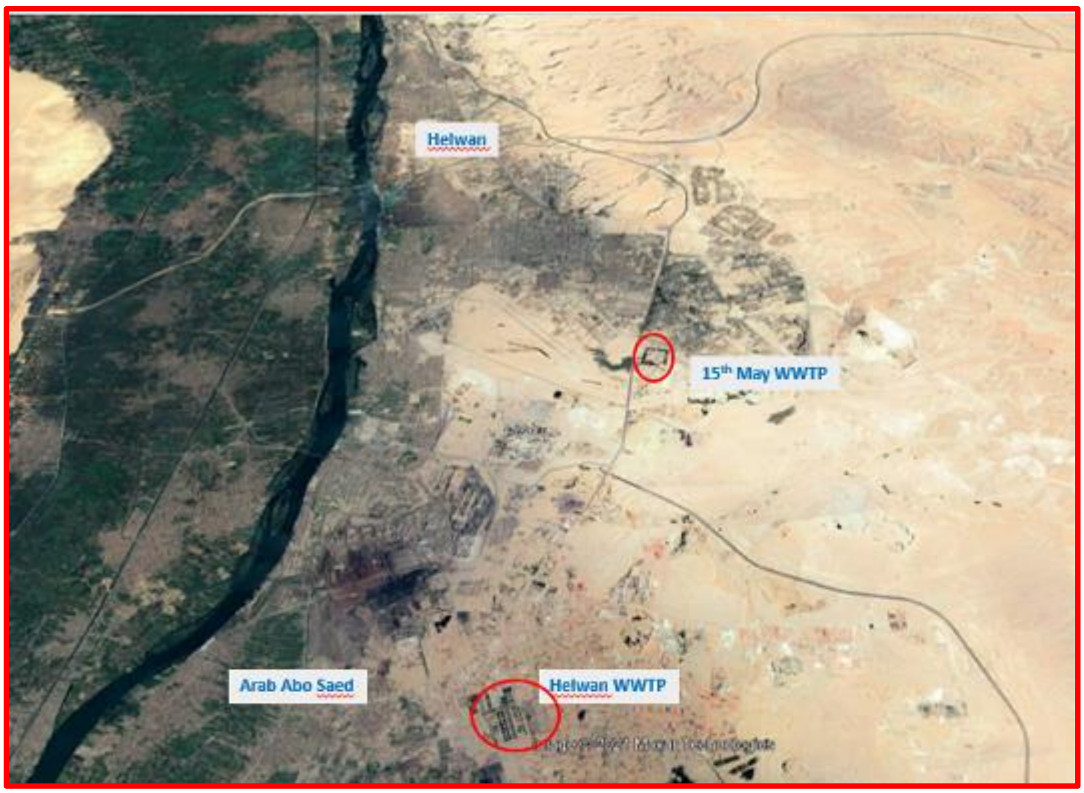


Figure 2-1: Location of Helwan and 15th May WWTPs

The treated wastewater from this plant is pumped to a ground reservoir with a size of 550,000 m^3 at Arab Abu-Sa'ed canal to irrigate new reclaimed rural areas. The irrigation pump station current efficiency is not more than 60% due to technical problems in the pumps and the automatic control system.

In addition to Helwan wastewater treatment plant, the city of 15th of May has its own tertiary treatment plant of 30,000 m^3/day design capacity which is over loaded at the moment with more than double of its original capacity and is currently under rehabilitation. The excess flow is directed to Helwan Arab abo sa'ed WWTP, its general layout is shown in Figure 2-2. However, the tertiary treatment in 15th May WWTP was mainly planned to re-use the treated effluent for irrigation of the green areas and parks of the city.

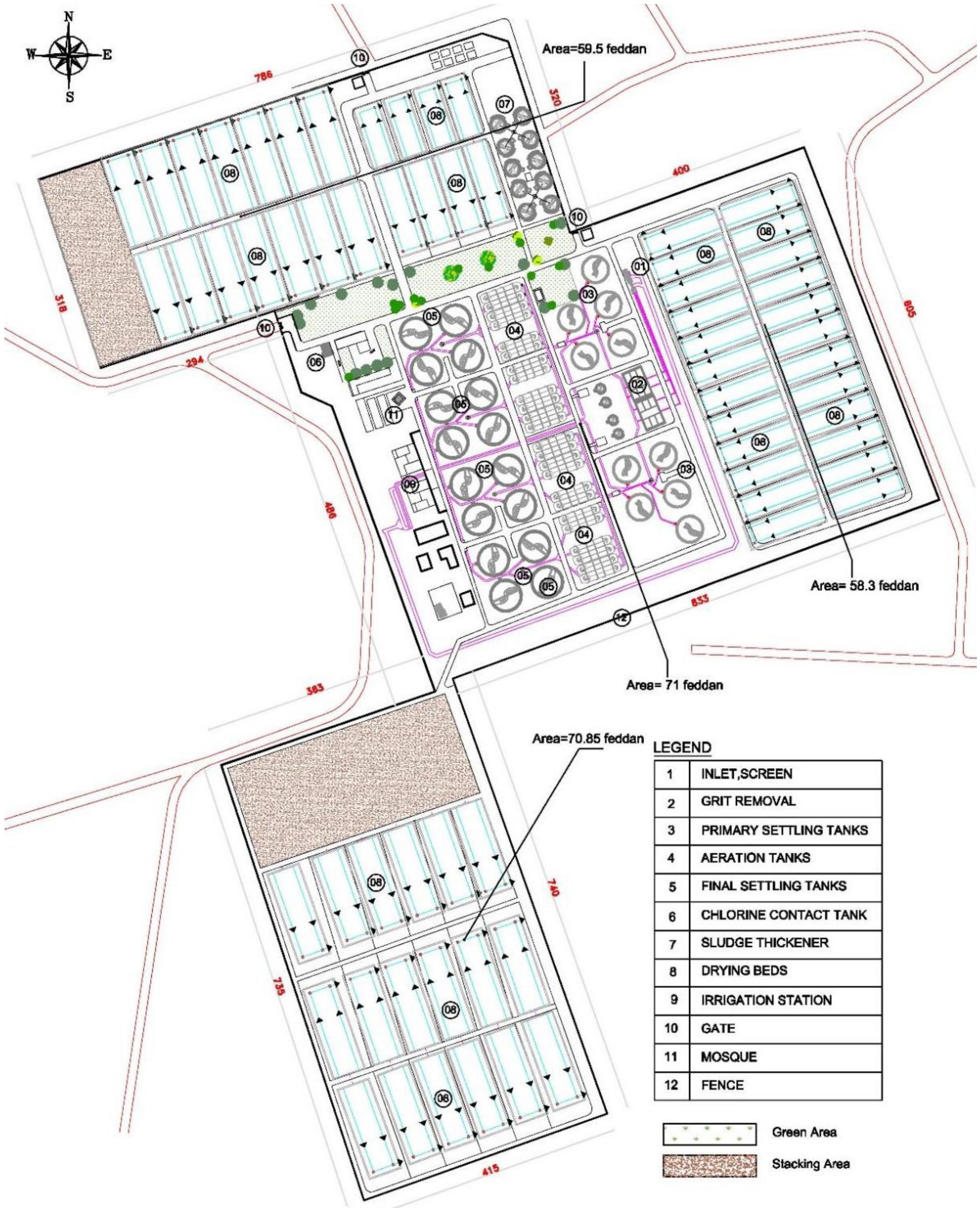


Figure 2-2: Current General lay out of Helwan (Arab Abu Sa'ed WWTP)[1]

[1] COWI-ATKINS- "Rehabilitation & Extension of Various WTPs-WWTPs Prefeasibility Study" Aug 2020 -Helwan Wastewater Expansion Project

2.2 Project Rational

The economic benefits of investment in infrastructure projects in general, and water and sanitation projects, in particular, are much higher than the cost of the funds invested in them. Water supply and sanitation projects have several impacts, including effects on health, education, gender and social inclusion, and on income and consumption. In addition, the water shortage problem in Egypt and shortage of irrigation water are serious issues. The current per capita share of water is below the water poverty limit of 1,000 m3/capita/year (An Egyptian person's water share is 650 m3/capita/year as per the National Water Resources Plan 2017 and the Sustainable Development Strategy – Egypt's Vision 2030).

The existing Helwan (Arab Abo Sa'ed) WWTP is currently serving a population of about 1.6 million capita within different areas starting from the Ring road at Maadi to Helwan and El-Tebeen in the south of Cairo. Initially designed with a capacity of 550,000 m^3/day, it is now overloaded as the current average wastewater generation is about 587,874 m3/day, and reaches 700,000 m3/ day in summer – resulting in the intermittent discharge of untreated wastewater flows into Al Saff irrigation Canal. Moreover, the estimated wastewater generation is expected to increase up to 1,167,925 m^3/day by 2052, so that the addition of new treatment capacities up to 250,000 m3/day as a first stage is urgently required.

Furthermore, Improving the existing wastewater facilities in South of Cairo through the diversion of wastewater flows from the flooded main collectors (culverts) and pumping stations will enhance the standard of living at Helwan area and overcome the negative health and diseases effect generated by the flood of raw sewage at the walkways and streets of Helwan catchment zone due to insufficient capacity of both the collection and treatment facilities.

Contributing to increased coverage of improved sanitation and clean environment for the nearly 2.25 million population living in this area, by the completion of the collection system and treatment facilities with the additional treatment capacity of 250,000 m3/day as a first phase is urgent priority and a first objective of this project

One of the main objectives of the project also is to improve the quality of treated wastewater discharged into the Al Saff canal. Where, Irrigation water presents approximately 78% of water demand in Egypt; therefore, establishment of new water resources is strongly required by treating the wastewater inflow all over Egypt in general and specially inflow to Helwan WWTP. Currently, the effluent from Helwan WWTP is mixed with untreated over capacity wastewater and consequently does not meet the standards of the irrigation water quality.

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

1. **Promote efficient and sustainable wastewater treatment in South of Cairo Governorate:** where the Project will allow accommodating the area's demographic growth, ensuring that the targeted population of approximately 2,000,000 (by year 2037) benefits from a safely managed wastewater service.
2. **Reduce wastewater related pollution in the Al Saff Irrigation Canal and promote the use of unconventional water resources:** The Project will allow Helwan WWTP to achieve the regulatory

thresholds in terms of water discharged into the Canal, and allow for the safe reuse of at least 500,000m^3/day of treated wastewater for unrestricted irrigation agricultural purposes.

3. **Promote a climate change-friendly growth:** besides its benefits in terms of adaptation to the growing climate change-driven water stress, the Project will allow Helwan WWTP to be autonomous for a significant percentage of its electricity needs depending on the share of sludge anaerobic digestion and energy recovery that will be decided for this project. This will also enhance Operation and maintenance costs and reduce the reliance on the power from the National Grid.

2.3 Current Wastewater treatment scheme project components

2.3.1 Service Catchment Area of Helwan WWTP

The sanitation project in Helwan is designed with capacity of the treatment plant of 550,000 m^3/day (first and second stages). The project is designed to accommodate the residential, service and industrial discharges for the service area, which starts from the south of Maadi (area in the north of the project) to the Arab Abu Sa'ed area in the south (area in the south of the project). There is another WWTP along this scheme, which is 15th of May treatment plant of design capacity 30,000 m^3/day. Even though it was constructed in the Eighties, few years later the plant became over loaded and additional capacity is urgently needed to accommodate the excess flows arriving at plant inlet. Currently 15th Mayo plant is under rehabilitation and the flows are diverted to Helwan WWTP facilities.

The service area of the Helwan WWTP is highly developed and the only opportunity to extend the site would be to extend the plant within the site itself. The service area of Helwan WWTP, shown in Figure 2-3, includes:

1. Qism Tora, which consists of (Tora Al-Hajar, Tora Al-Balad, Tora Al-Heit, Tora Al-Cement, Manshiyat Al-Masry, Zahraa Al-Maadi).
2. Qism Helwan, which consists of (economic residences, Helwan Al-Bahariya, Helwan Al-Balad, Eastern, Tribal, and Western Helwan, Kafr Al-Alu, Ain Helwan).
3. Qism Al-Maasarah, which consists of (Al-Maasarah Al-Balad, Al-Maasarah Al-Mahatah, Hadaek Helwaan, Wadi Hoaf).
4. Qism 15th May, which consists of (first, second and third Sheyakhah).
5. Qism Al-Tebbin, which consists of (Al-Tebbin Al-Qibliah, Al-Tebbin Al-Bahariyah, Hekr Al Tebbin, Madinet Al Solb, Masakn Al Tebbin).
6. Qism Al Basateen, which consists of (New Maadi).
7. Qism Al-Maadi, which consists of (Maadi Al Sarayat Al Sharqia).
8. Qism Al Mokatem (70 Feddan (Al Hadabah Al Wosta), Sobhi Hessien).
9. Qism El-Saf consists of (Al Shorfa & Al Atiaat, Al Ekhsas, Al Shobak Al Sharqi, Al Meniah).
10. Industrial areas, including iron and steel factories, coke factories, forgings, cement factories, the Nasr Company for Cars, and many military factories in the region.

11. Helwan University and many military and security sites, including Helwan Airport, Tora Prisons, security forces in Tora, Police Trustees Institute in Tora, Helwan Air Force Secondary School, entertainment and commercial areas.

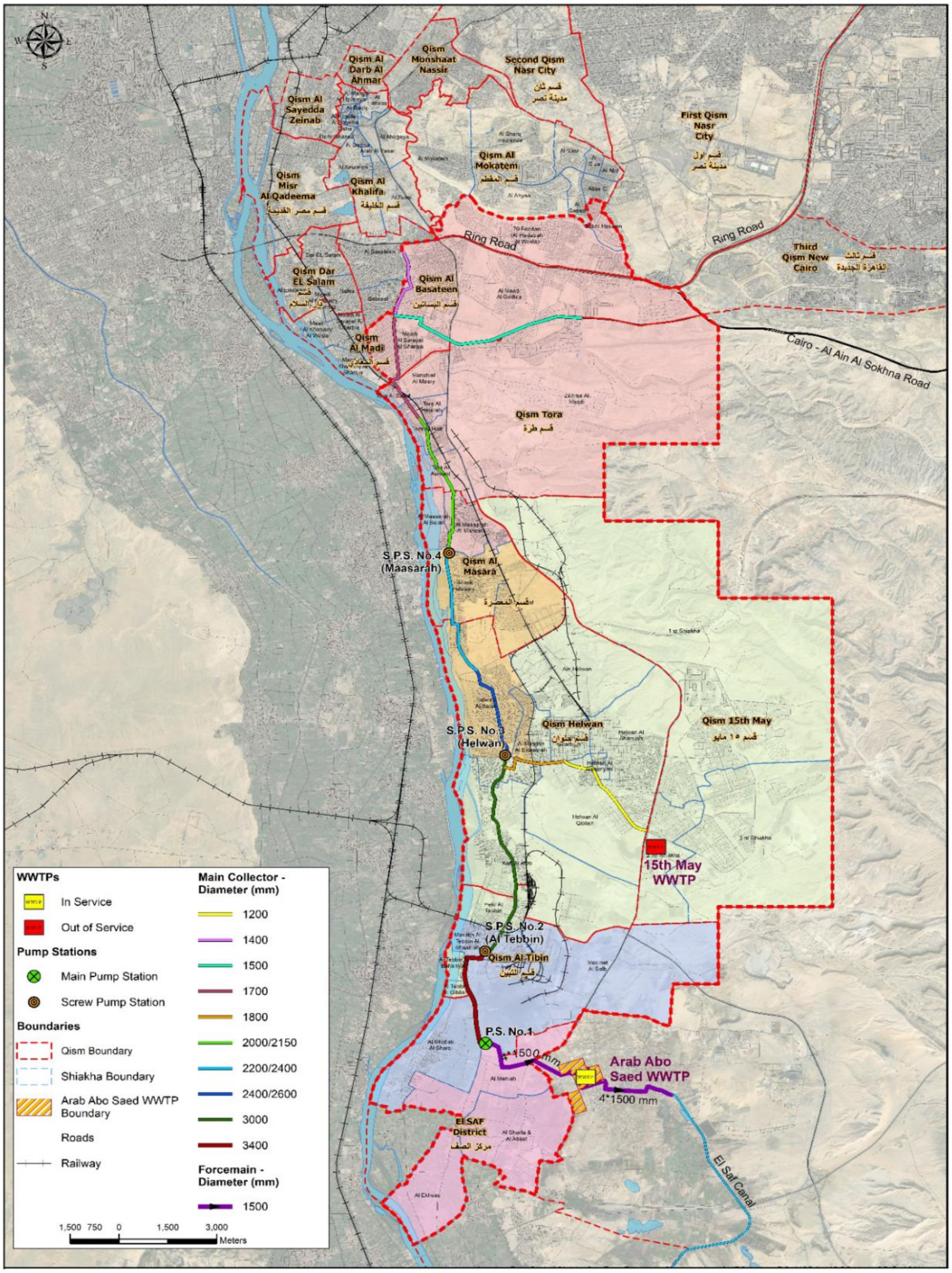


Figure 2-3: Service Catchment Area of Helwan WWTP

2.3.2 Added area served to Helwan Wastewater collection system

The new added areas, shown in Figure 2-4, are located in a higher ground level from the original catchment area as those are allocated towards the Eastern direction of Cairo on more than 60 to 100 meters elevation.

Most of the flooded areas are located in the lower level directions near to the valley. The wastewater collection system is facing over flows capacities in several areas mainly between Maadi – Torrah up to P.S4 at Massarah.

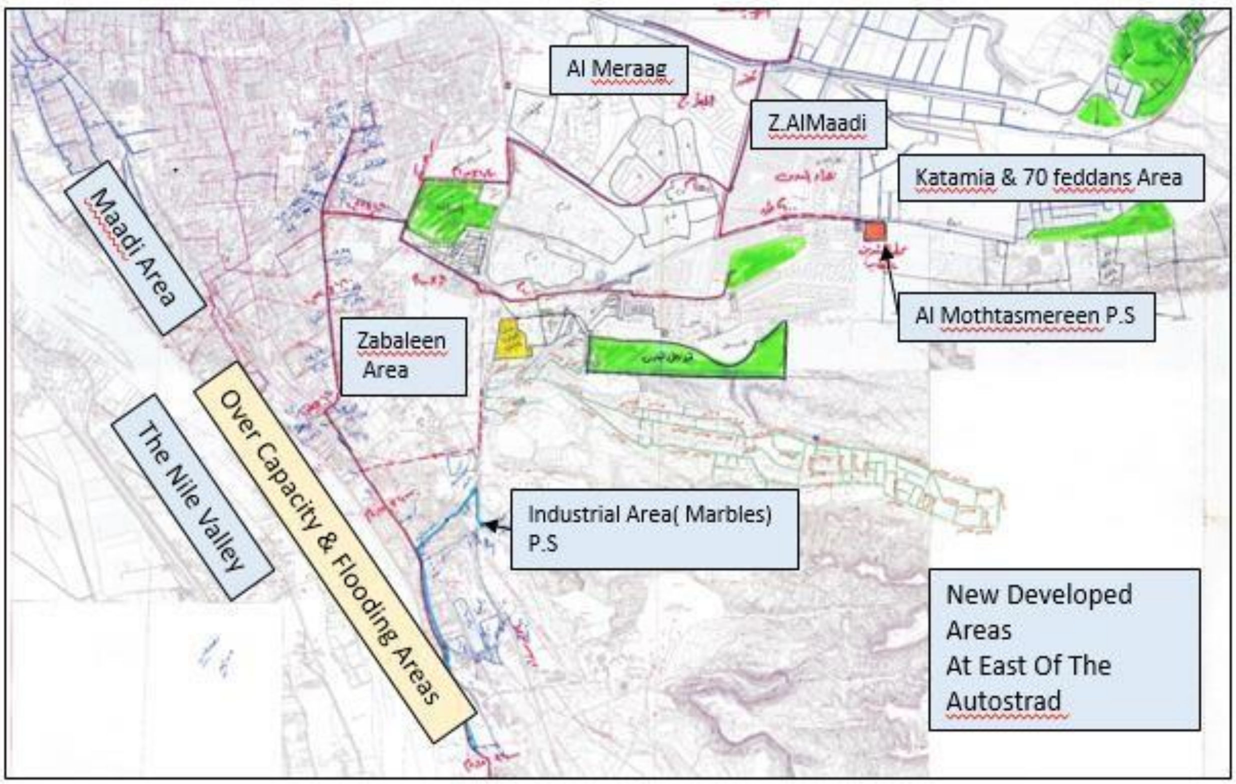


Figure 2-4: Location of additional catchment areas from east Autostrad discharging to Helwan

This over capacity can be seen through the flooding areas around pump stations or even at certain cross sections of the sewer networks.

As per the data of the pumps operation hours at the current pump stations P.S 1,2,3,4 it can be seen that P.S. 4 is already over loaded, the main sewer collectors arriving at the pump station is flooding in several locations (Contract 11). GCWC has already started construction of a new urgent pump station some 4,1 km prior to the inlet manhole of P.S 4 to divert the flows from the flooding reach at Torrah al Balad to the inlet manhole of the pump station. Figure 2-5 shows the new urgent P.S and the delivery force main of diameter 700 mm and length of 4,100 km. the expected flow for this additional P.S is 50,000 m^3/day.

In addition GCWC has confirmed that the new development areas at the Eastern part of the Autostrad are served via two pump stations as follows:

- Al Mothtasmereen P.S that delivers about 50,000 m^3/day as per the operation hours of the pumps, and this discharges into Contract 21 serving Mokatem and Basateen Area.
- Industrial Marble Zone (Shak Al Thobaan) P.S (called P.S 4b) diverting to main sewer line of contract 11 reaching to P.S 4 of Helwan collection system. (6 small pump stations are diverting generated wastewater at the industrial area as well as new development housing areas to the called P.S 4b Industrial).
- Main Sewer line of diameter 1000 mm connected to the very high loaded area of contract 21 at Maadi.

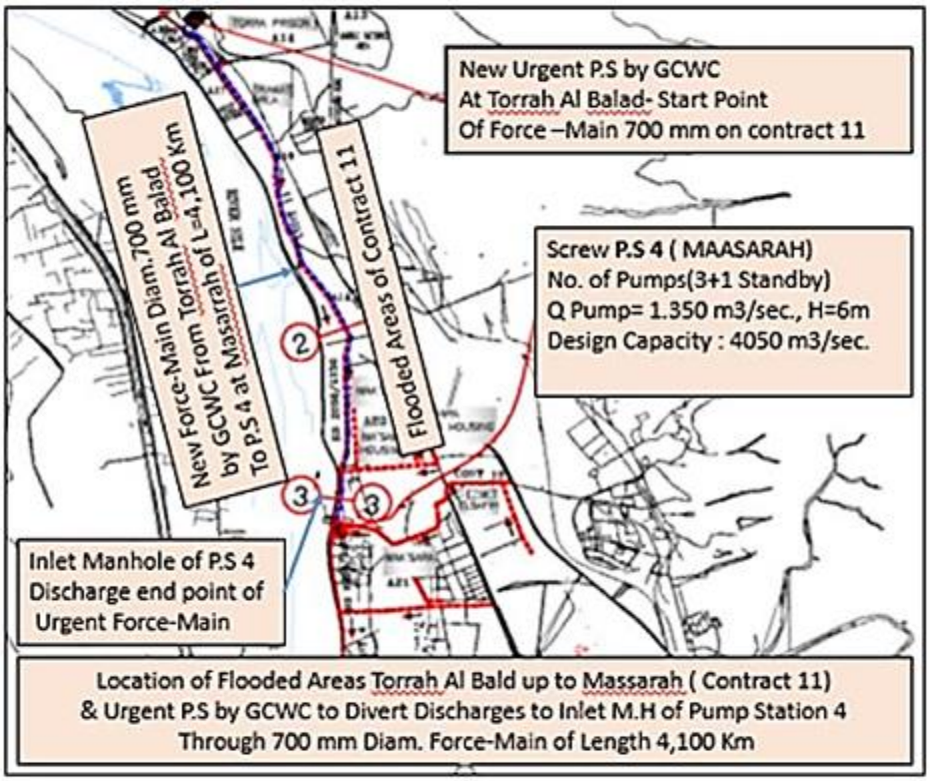


Figure 2-5: Urgent Project by GCWC to Overcome Flooding of Contract 11

As shown in Figure 2-5, 9 sections were selected for check and verification of the capacity of the main collectors of Helwan wastewater system, percentage of maximum occupation (Q/Qmax) showed the overloading of some of the mentioned sections that confirms the overload of some main collectors of the system

Accordingly, GCWC has taken several measures to face the operational problems of the collection system. Most important project was the construction of an urgent pump station on the sewer line of contract 11 at the area of Torah al balad with a force main 700 mm diameter of 4,100 km up to the inlet manhole of P.S 4 at Massarah as mentioned above. This project relieved the flooded area of Contract 11 at this distance from a flow of 50,000 m^3/day and diverted them directly to P.S 4. inlet manhole. Figure 2-6 and Figure 2-7 shows PS 2 and 3 respectively.

Figure 2-6: Pump Station No.2

Figure 2-7: Pump Station No.3

2.3.3 Quantity of Municipal discharge

Helwan (Arab Abo Sa'ed) WWTP is currently serving a population of about 1.6 million capita. The data for population was obtained from the official Egyptian source of Statistics, Central Agency for Public Mobilization and Statistics, CAPMAS 2017. The population will increase to reach 2,368,584 capita by year 2037 and 3,328,645 capita by year 2052. The following Table 2-1 illustrates catchment zone corrected population for the major pumping stations discharging to Arab Abu Sa'ed WWTP. The estimated discharge to Arab Abu Sa'ed WWTP is illustrated in Table 2-2.

Table 2-1: Catchment Zone population capita for the major pumping stations discharging to Arab Abu Sa'ed WWTP

Pump Stations & WWTP	Catchment Zone population capita			
	2017	2020	2037	2052
Pump Station No.4	532,140	588,855	864,510	1,251,792
Pump Station No.3	692,500	737,837	1,058,978	1,461089
P.S No.3 (Including Pop. Served by P.S 4)	1,224,640	1,326692	1,923,488	2,712,881
Pump Station No.2	107,522	114,104	159,772	215,032
P.S No.2 (Including Pop. Served by P.S 3,4)	1,332,162	1,440,796	2,083,260	2,927,913
Pump Station No.1	80,306	99,490	176,079	249,219
P.S No.1 (Including Pop. Served by P.S 2,3,4)	1,418,468	1,540,284	2,259,339	3,177,133
Direct Zones to WWTP	65,250	71,639	109,245	151,512
Pop. Served by WWTP	**1,483,718**	**1,611,923**	**2,368,584**	**3,328,645**

Table 2-2: The estimated discharge to Arab Abu Sa'ed WWTP

Served Zone	Generated Design WW (m^3/ day)		
	2020	**2037**	**2052**
Served Zone of P.S 1 (including P.S 4,3,2)	632,809	908,997	1,260,053
Direct to WWTP (Menya Rural Areas, Al Ekhsas & Al Shorfa & Al Atiaat)	29,014	44,244	61,362
Total to WWTP	**661,822**	**953,241**	**1,321,416**

From the estimates of the population expansion and the consequent flows, some conclusions and recommendations must be considered:

- Immediate need for increasing the capacity of P.S.3
- Expansion of P.S.4 in the midway of 2020 to 2037 and extension of P.S 4 capacity should take place not later than 2025.
- Immediate need for extension of Helwan WWTP to meet the requirement of 2020 that is confirmed by the current flow measurement in summer that reaches up to 700,000 m^3/day and that will reach to 953,241 m^3/day in 2037.

2.3.4 Quantity of Industrial Discharges

The number of industrial facilities within the existing service area is about 65 facilities. Their total discharge reaches 671,811 m3/month with an average of 22,394 m3/day. In addition to that, the service area of 15th of May City will be linked to the treatment plant directly. This area counts for another 58 industrial facilities. Their total discharge sums up to 47,293 m3/month with an average of 1,596 m3/day.

The total daily discharge from the industrial zone therefore is around 23,970 m3/day. Comparing the discharge estimated by the Utilities Consulting Office (which supposedly reaches 137,440 m3/day) with the actual discharges to the network in year 2014 (which is 23,970 m3/day) a big difference becomes obvious. The actual discharges represent only 17.5% of the estimated ones. It seems that the estimated discharge is highly exaggerated. One reason may be that many companies have installed their own treatment units through which water is treated and recycled. Table 2-3 shows the revised quantities of industrial discharges for the periods 2012, 2017, 2022, and 2037.

Table 2-3: Revised Quantities of Industrial Discharges

Year	2012	2017	2022	2037
Quantity of industrial discharge (m^3/day/hectare)	35,000	40,000	45,000	55,000

2.3.5 Main Components of the Current Helwan Wastewater System

Helwan (Arab Abo Sa'ed) WWTP treatment works receives wastewater from the catchment area previously mentioned via a series of culverts and pumping stations forming a wastewater conveyance system. Following treatment at Arab Abo Sa'ed, the chlorinated final effluent is discharged into Al Saff Canal for re-use in agriculture purposes. Figure 2-8 and Figure 2-9 Show the general scheme of the project.

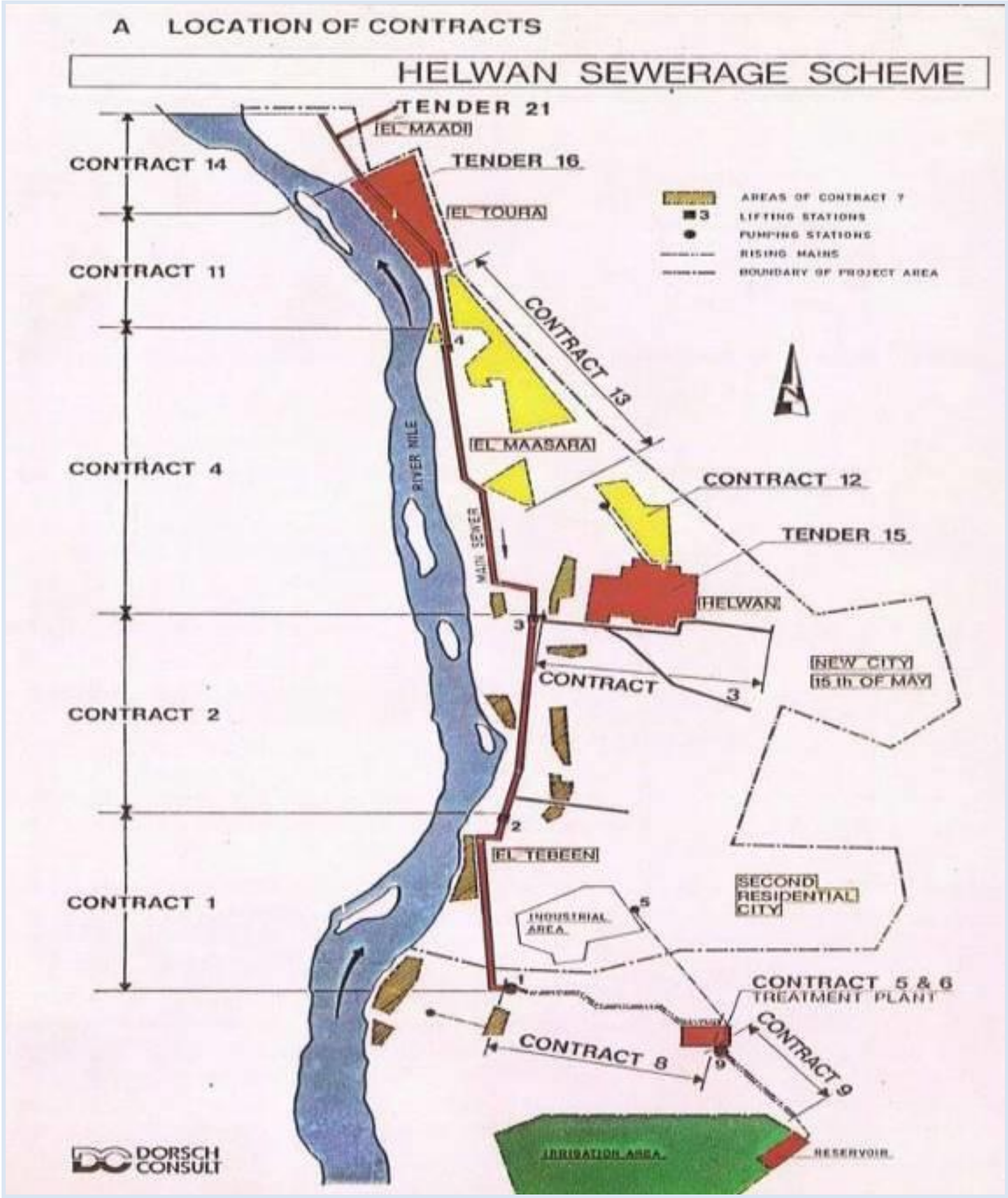


Figure 2-8: Helwan Wastewater Collection & Treatment MP (by Dorsch Consult)

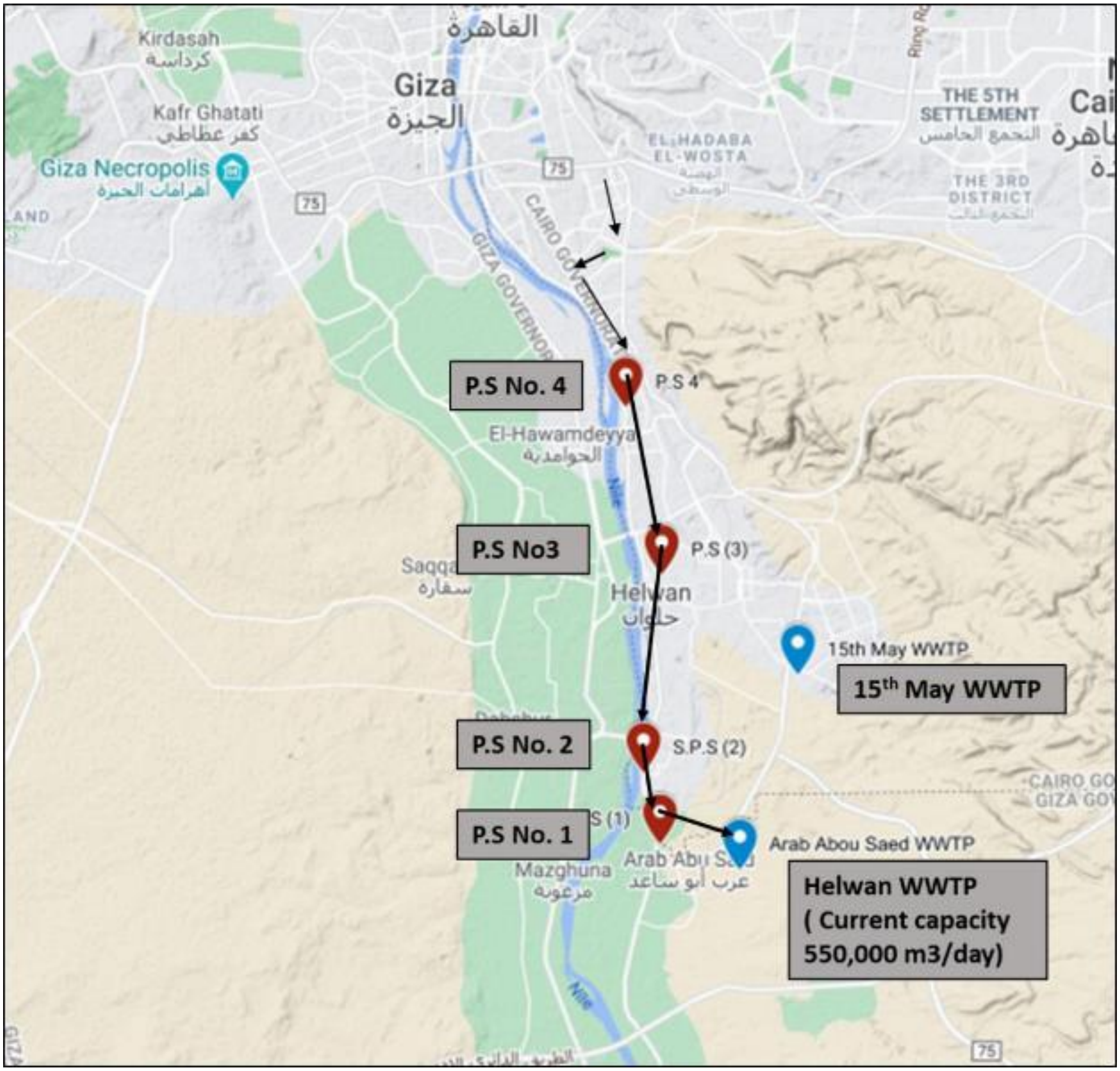


Figure 2-9: Current Scheme of Helwan Wastewater Collection and Treatment

The existing project includes the following main facilities:

- 6 main collectors included in Contracts (1, 2, 4, 11, 14, 21).
- 2 main sewer lines (No. 3, 12).
- 4 contracts for sub sewer lines contracts (7, 13, 15, and 16).
- 3 screw pump stations, numbers (2, 3, 4), and one main pump station (station No. 1).
- Treatment plant with a capacity of 350,000 m3/day in first stage, and expanded to 550,000 m3/day in second stage.
- Irrigation station and equalization tank with a capacity of 550,000 m3.

Table 2-4 below illustrates the main Components of the Current Helwan Wastewater System in further details:

Table 2-4: The main Components of the Current Helwan Wastewater System

Contract No.	Shape and Description	Service Area
Contract 14	Main gravity collector of reinforced concrete casted on site in the form of a horseshoe shape with dimensions 1,600 – 2,000mm and capacity 216,800 m3/day	Sakr Koreach west, the new housing communities on the south side of the ring road, west of autostrad road, Al gazaier street & its extension in new Maadi and the Basateen automated slaughter house.
Contract 21	Main gravity collector of reinforced concrete casted on site in form of a horseshoe shape with dimensions 1,600 – 1,720mm and capacity 172,800 m3/day	Mokattam middle knoll, Sakr Koreach east, Almeerage and Zahraa Al Maady
Contract 11	Main gravity collector of reinforced concrete casted on site in the form of a horseshoe shape with dimensions 2,000 – 2,150mm	This collector receives the flows of the last two collectors in addition to the flows from Tura(s) (Albalad, Alasmant, Alhegara and Alheet), Al Maasara(s) (Almhatta, Albalad, Cement factory and Factory 45 geometrical industries).
Contract 4	Main gravity collector of reinforced concrete casted on site in the form of a horseshoe shape with dimensions 2,200 – 2,400mm and 2,400 – 2,600mm	This collector receives the discharge of pump station 4 in addition to the flows from Ezbet Kamel Sidky (north & south), Ezbet Alsafeeh, Ezbet Alhagana, Ezbet AlOmda, Ezbet Alwalda, Arab Ghuneem, Alzelzal Housing & Hadaeik Holwan
Part of Contract 4	Screw Lifting Station No. 4 of capacity 233,000 m^3/day. The station contains 3 operating screw pumps and 1 standby pump. The static head of the station is 6m.	receives the flows of the last collector (contract 11)
Contract 2	Screw Lifting pump Station No. 3 with a capacity of 488,000 m^3/day. The screw lifting pump station No. 3 contains Three operating screw pumps and 1 standby pump with static head of 6 m (only six). Main gravity collector is circular type from reinforced concrete with a diameter of 3,000mm and capacity of 670,000 m3/day.	The pump station No.3 receives the flows of Contract No.4 and discharges into the said collector. The collector of Contract No.2 also receives the flows of Manshiat Gamal Abdel Nasir, Holwan Albalad, Ezabet Rashid, Ezbet Albagor, Kafr Al Elw, Al Teben Al Balad and Al Hekr north and south

Contract 1	Screw Lifting Station No. 2 with a station capacity of 640,000 m^3/day. The station contains 4 operating screw pumps and 2 standby pumps. The static head of the station is 6m. circular type Main gravity collector (contract 1) from reinforced concrete with a diameter of 3,400mm	P.S No.2 receives the flows of the collector of Contract No.2 and discharges into this collector. The collector also receives flows from Al Teben industrial area and parts of its housing units. This collector extends to the Main Pumping Station No.1.
Contract 8	The Main Pumping Station No.1 and its Force Mains. The current capacity of the station is 690,000 m3/day after expansion woks. It has 4 force mains of pre-stressed reinforced concrete pipes each of 1,500 mm diameter and 3.5 km length. Pump Station No.1 seven (7) operating centrifugal pumping units and 2 standby pumps each is of 40m total head.	The station receives the flows of the main collector of contract No.1 in addition to the flows from Almenia and Al Shobak areas, those areas are connected to the collector at the entrance to the station where the generated wastewater from the catchment area is pumped to Arab Abo sa'ed WWTP
Contracts 5 and 6	This contract comprises the design, construction, commissioning / start-up of Helwan Wastewater Treatment Plant (WWTP of conventional activated sludge process with a design capacity 550,000 m3/day constructed on two stages); the first stage (1990) is 350,000 m^3/day and the second stage (2005) is 200,000 m3/day.	All catchment areas mentioned above that includes Southern part of Maadi, part of Al Basateen, Mokattam middle knoll, East Autostrad settlements, Torra's, Massarah, Helwan, Teben, Excess flow of 15th May WWTP and direct dischages from surrounding villages of the area of Arab Abo Sa'ed (Menya El Shorafa, Al Khasas, Al Shobak)
Contract 9	The Irrigation Pumping Station pumps the effluent of the treatment plant, via 4 force mains each of 1,500mm, to a ground reservoir at the reuse area in Arab Abu Sa'ed. The current capacity of the station is 550,000 m^3/day after completion of expansion works.	
Additional Main Collector constructed by CAPW & GCWC	In addition to Helwan wastewater treatment plant, the 15th of May treatment plant of design capacity 30,000 m^3/day was constructed at the eighties, however in few years the plant became over loaded and additional capacity is urgently needed to accommodate the excessive flows arriving at plant inlet. Currently the overflows are diverted to Helwan WWTP facilities.	Serve the city of 15th May
contract 3	Several gravity pipeline of 800, 900, 1,200 and 1,800mm diameters. The gravity collector	This collector receives at the moment part of 15th of May city

	starts at the autostrad road just in front of 15th of May city and discharge at the main collector of contract No. 2	flows, portion of Helwan city flows, Al Ezba kibliya, Al Ezba Bahariya and the flows of the gravity sewers of contract 12.
contract 12	Main and branch gravity pipelines of GRP with diameters ranging between 500 and 1,000mm.	This network serves Helwan industrial area (east of the Metro), Ein Helwan and receives the discharge of Ein Helwan pumping station that serves Helwan University and the residential area. This network flows to the end of contract 3 sewer in front of Zo-Alfiqar street.
contracts 7 and 13	Branch sewers of GRP with diameters ranging between 300 and 900mm	Serves parts of Masara, Arab Ghoneem, Ezbet Al Walda, AlTeben, Almenia and Al Shobak.
contract 15	Branch gravity sewers of diameters ranging between 225 and 1,200mm in addition to the house connections	These pipelines serve the areas of al Maasara, Manshiat Gamal Abdel Nasir, Helwan Albalad, Ezabet Rashid, Ezbet Albagor, Kafr Al Elw and the areas adjacent to Tura cement factory in the north up to Kafr Al Elw to the south.
contract 16	Branch gravity sewers of diameters ranging between 175 and 1,000mm in addition to the house connections	These pipelines serve the areas of Tura Al Balad, Tura Al Asmant, Tura Al Hegara and Tura Al Heet. These sewer ends to main collector of contract 11.

2.4 Arab Abu Sa'ed (Helwan) WWTP

2.4.1 General layout

In the early eighties, Helwan (Arab Abo Sa'ed) WWTP was designed to treat all municipal wastewater generated within Helwan catchment area, in accordance with the master plan, in two stages with the following flows and loads in Table 2-5:

Table 2-5: Flows and loads for the two stages

Item	Unit	Stage 1	Stage 2
Average Flow (Q24)	m^3/d	350,000	555,610
Average hourly Flow (Q24/24)	m^3/hr (m^3/s)	14,583 (4.05)	23,150 (6.43)
Peak hourly Flow (Q24/18)	m^3/hr (m^3/s)	19,444 (5.40)	27,781 (7.70)
Max Peak flow	m^3/s		8.5
BOD5 load	kg/d	60,000	95,516
Population equivalent	pe	1,000,000	1,591,933
Effluent BOD5	mg/l	=<40	=<40
Effluent Chlorine Residual	mg/l	>=0.5	**>=0.5**

The general layout of the Helwan WWTP in Figure 2-10 shows how the arrangement of the WWTP treatment units was made with a provision for construction of the additional units of Stage 2 so that the WWTP after extension to 550,000 m3/day looks like a plant of one stage. The total plant area is estimated at about 259.65 feddans and it receives water from the main pump station No. (1), through (4) forcemains with a diameter of 1500 mm in addition to the force main coming from the service of three villages in Qism El-Saf. The area of the existing plant is divided into three plots, as following:

- The first plot with an area of 129.3 feddans contains the main units of the plant (entrance, screens and grit removal chambers), primary sedimentation basins, aeration basins of activated sludge biological treatment, final sedimentation basins, chlorination mixing basins, the main irrigation pumping station that pumps treated water to the El-Saf canal through (4) force mains with a diameter of 1500 mm. There are drying basins for sludge that can be used with the built-in area for future plant expansion.
- The second plot, with an area of 59.5 feddans, contains sludge thickener basins, drying basins, and sludge stacking areas.

- The third plot, with an area of 70.85 feddans, contains drying beds and sludge stacking areas.

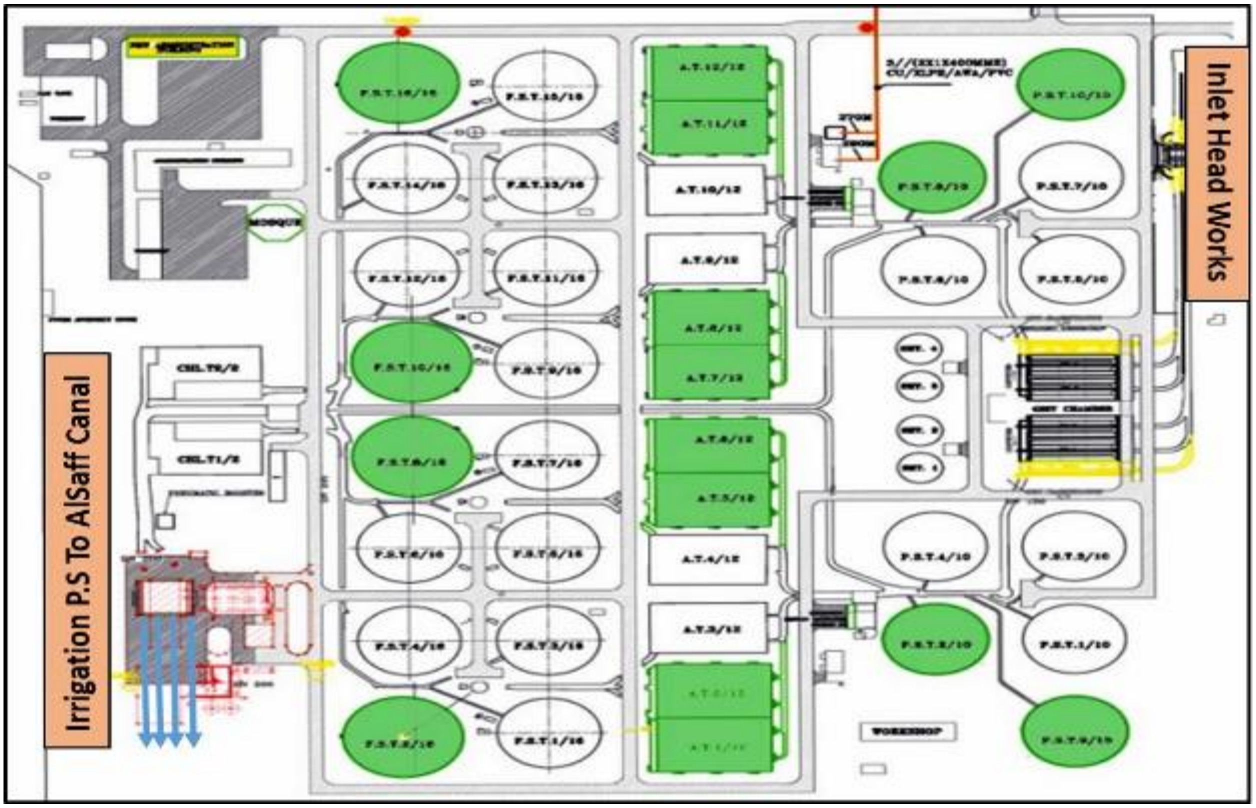


Figure 2-10: Helwan WWTP 550,000m^3/day capacity layout

Construction of Stage 1 was completed and came into operation in 1990. Since then, flows arriving at the WWTP have increased to over 500,000 m3/d, while construction of the second phase started by 2005 when Arab Contractors company/ Dorsch Consult was appointed by CAPW as contractor to design and build Stage 2 including the Irrigation (effluent) PS and pipelines in addition to renovation of the existing Stage 1 plant.

After starting operation of the first stage, it was not possible to ignore that higher wastewater loads were occasionally and intermittently received at the WWTP which were not taken into account within the design parameters of stage1. Several analyses programs were carried out for adaptation of the design parameters so that the consultant at that time can take the exact loads into account and that stage 2 design parameters would handle those higher concentrations as well as taking this into consideration the required integration of stage 1 into the same design parameters. Hence the WWTP of capacity 550,000 m3/day was full adapted to the new design figures.

At that time, the BOD loads consistently exceeded the original design value of 172 mg/l, (Stage 1) averaging at 290 mg/l in 2005. With the increased flows, this represents almost 100% overload on stage 1 treatment units. Confirmations were also given by the increase in TSS levels to similar ratios. The impact of this was as follows:

- The aeration tanks were severely overloaded and the BOD removal efficiency is significantly reduced.
- The sludge production (primary and waste activated) exceeded the capacity of the gravity thickeners and sludge drying beds.

The design figures were then updated and concluded as follows in Table 2-6:

Table 2-6: The updated design figures for Helwan WWTP

Parameter	Unit	Value
Daily Average Flow	m^3/day	**550,000**
Peak Factor	-	**1.25**
Max Process Flow	m^3/s (m^3/hr)	**7.96** **(28,650)**
Max Hydraulic Flow Rate	m^3/s	**8.5**
TSS	mg/l	**800**
TSS (avg.)	mg/l	**500**
BOD5	mg/l	**370**
BOD5 (avg.)	mg/l	**290**
Intermittent Peak BOD5	mg/l	**450**
COD	**mg/l**	**800**

2.4.2 Produced sludge at the existing WWTP

Three main components for sludge treatment are defined:

- Sludge storage and thickening of Waste Activated Sludge (WAS)
- Sludge storage and thickening of Primary Sludge (PS)
- Drying all of the sludge production in the Drying Beds

Figure 2-11 illustrates sludge treatment line in Arab Abu sa'ed WWTP. The original design of stage 1 that has been adapted during the re calculation of process design of Stage 2 has ended with the following sludge volumes in Table 2-7:

Table 2-7: Sludge Production daily rate

Sludge Sources & Production Rate/day				
Design Temperatures		**T=18C^o**	**T=23C^o**	**T=28C^o**
Primary sludge				
Primary sludge Flow Before	m3/day	5,658	5,658	**5,658**
Primary sludge Flow Before	m3/day	3,600	3,600	**3,600**
Waste Activated				

WAS Flow before Thickening	m3/day	10,912	10,232	**9,549**
WAS Flow before Thickening	m3/day	2,723	2,554	**2,383**
Total Dry solids Load	Kg/day	293,340	287,395	**281,432**
Total Organic Dry solids load	Kg/day	246,250	241,187	**235,627**
Total Sludge Flow after Thickening	**m3/day**	**6323,8**	**6154,0**	**5983,6**

In addition to the overload on the water line at that time, the sludge treatment had been a subject of exhaustive studies to improve the efficiency of the sludge drying beds. To conclude, the expected efficiency of the sludge drying beds was not achieved. Efforts to produce thicker sludge to reduce the volume passed to the drying beds caused problems with the dewatering systems. This has been given particular attention to ensure that the new project has a sludge processing system that can fully cope with the expected sludge generation.

While the design flow capacity was increased by 65% to 550,000 m3/d, the sludge design loads were increased by 350%, which had a great effect on the biological and sludge treatment, requiring additional capacity in the aeration tanks and final settling tanks.

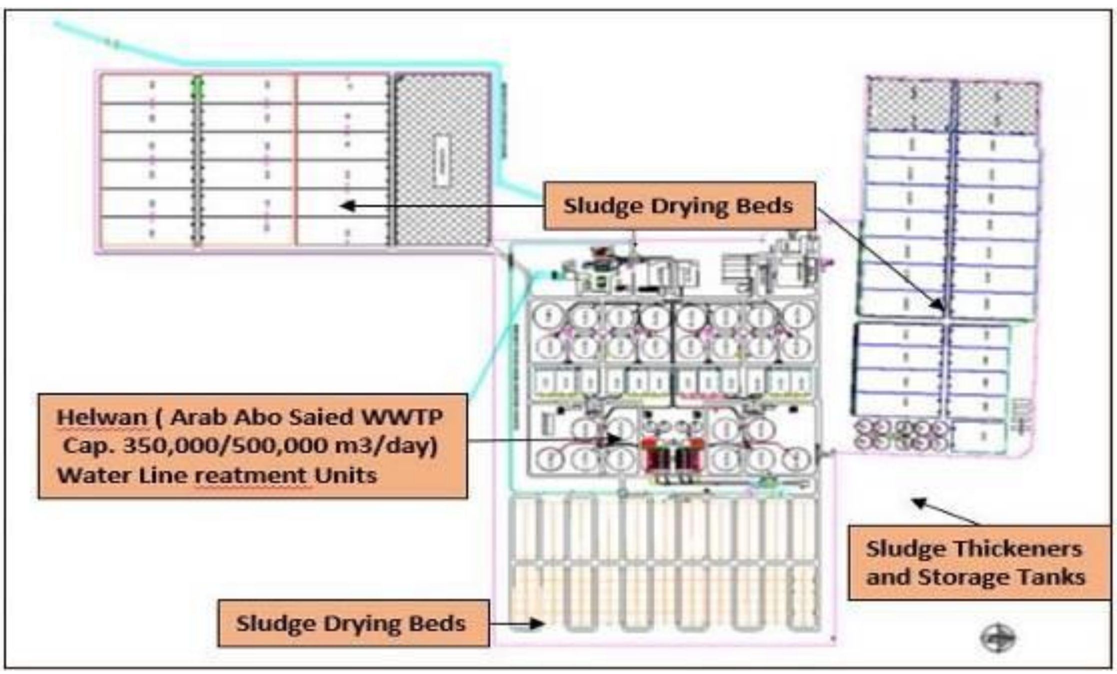


Figure 2-11: Sludge treatment facilitates

Thickening of Primary Sludge

Four Circular tanks each 28m diameter and 4.22m deep are used, the volume of each is 2,600m³. Dry Solids Surface Loading is less than 80 kg/m²/d. The supernatant flow is about 2100 m³/d, which is forwarded to the plant inlet. The thickened sludge (55 kg/m³) is pumped to the Sludge Holding Tanks and then to the drying beds.

Thickening of Waste Activated Sludge

Also4 tanks are used each of 28m diameter identical to the primary sludge thickeners and can be operationally switched or used to thickened mixed primary and WAS sludge. However, the sludge is thickened separately and then mixed in pump station to the Sludge Holding Tanks. The supernatant is almost 8200 m^3/d, which is forwarded to the plant inlet.

The total sludge to be dried at that plant is currently matching with the design figures as per the information handed over during the site visit.

Sludge Holding Tanks

The idea behind the sludge holding tanks is that the sludge thickeners were designed to operate at constant level, with nearly constant outflow however the designer (Dorsch consult) took into account risk measures for cases were the sludge is not pumped at night time the transfer of thickened sludge to the sludge drying beds is controlled manually. Also, t if there is no sufficient space in the active SDB, there will be a need for a storage tank. Two tanks each of volume 5542 m3, diameter 28m, depth 4.5 m and retention time of one day are available on site, however as per the site visit, they are not used.

Existing sludge drying beds and operation protocol

Sludge drying beds are allocated on three different locations. Sludge is pumped to each location from the sludge pumping station at thickeners; the daily volume pumped is almost 6300 m^3/day. The drying beds are filled with sludge of depth of 0.8m. More than 190 feddans are occupied with sludge drying beds. As shown in previous Figure 2-11 there are three areas of drying beds, A1= 59,5 Feddan, A2= 58,3 feddan and A3= 70,85 Feddans. The existing study by ATKINS –Alternative 1 was based on demolishing of area A2 of the sludge drying beds which represents almost one third of the total area of the drying beds. This has to be taken into consideration on two levels:

- How to subsidies the decrease in number and area of the demolished drying beds.
- Written confirmation from GCWC for the demolishing of the above-mentioned drying beds.

As a conclusion, a volume of 2100 m^3/day of sludge has to be added to the sludge treatment of the new extension of Helwan WWTP.

2.4.3 The Irrigation Pump Station

A typical view of the layout of the WWTP and the connecting line to Al Saff canal can be seen in Figure 2-12. The existing irrigation pump station has seen deterioration in operational conditions due to lake in maintenance especially from 2013 to 2016. In addition, as per the design criteria, the retention time at the irrigation pump station was limited to only 5 minutes after which the sump starts flooding. Operational conditions sometimes specially when the WWTP is operating at 700,000 m^3/day while the maximum capacity of the irrigation pump station was limited at 550,000 m^3/day caused severe problems, accordingly, CAPW together with GCWC has decided to construct an addition irrigation pump station that can act as stand by or to act in parallel in emergency case. The New Irrigation pump station as shown in Figure 2-13, which is currently under construction, shall pump treated wastewater driven from a dry pump house through vertical pumps discharging into a connecting force main of diameter 1500 mm to the four existing force mains up to Al Saff canal start point reservoir. The station shall be furnished with five pumping units complete with all accessories driven by electric motors through cardan shafts. The tender documents of the new pump station stated clearly that the new pumps shall be considered as an emergency to the existing pumps at old irrigation pump station and that the total pumping capacity of both old and new pumping stations shall not exceed 550,000 m^3/day. The new pump stations comprise of Five pumps (3 in duty + 2 stand-by) each of capacity 1500 lit./sec. of total capacity with 388,000 m^3/day at duty point 46 m head.

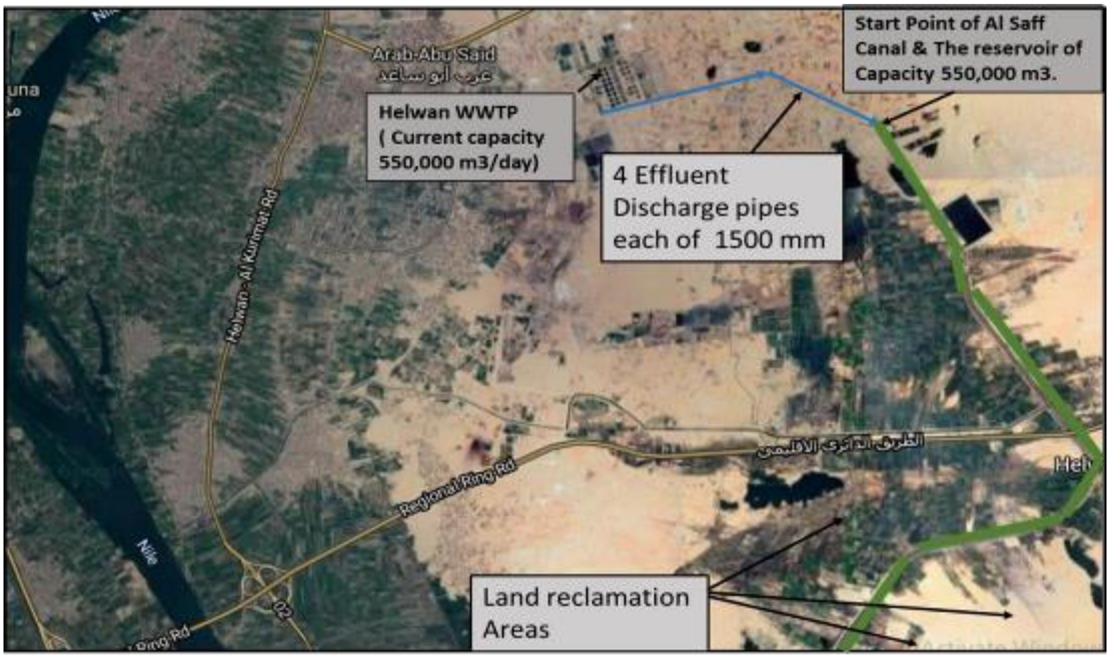


Figure 2-12: Irrigation P.S and Force Mains up to Al Saff canal

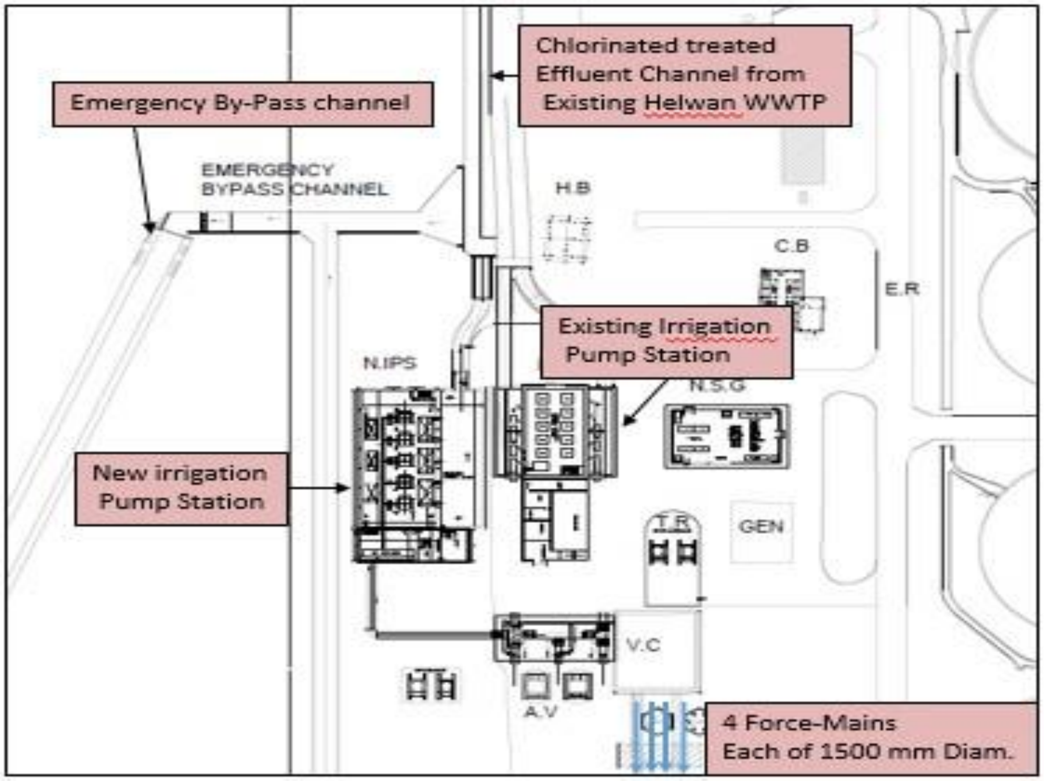


Figure 2-13: location of The New Irrigation Pump station (Under Construction)

2.5 Proposed Upgrade and Extension Works

2.5.1 Proposed Alternatives for development of Helwan wastewater collection and treatment facilities

The Existing study aimed at proposing an alternative to accommodate the future generated wastewater flows to the year 2052. The civil works Consultant in coordination with CAPW and Cairo Wastewater Company officials discussed the previous studies as well as the findings of the above assessment to overcome the excessive loading on gravity collectors, pumping stations, and the treatment plant capacity. The civil works Consultant created two alternatives for the new project schemes stated as Alternative 1, and Alternative 2 where a conclusion together with coordination with CAPW and GCWC was reached to consider Alternative 1 as an immediate urgent requirement.

The main feature of Alternative (1) is the construction of the new expansion in the existing Arab Abo Sa’ed WWTP site, while Alternative (2) is for the construction of the required expansion in a new site at Al Kurimat- Al Zafarana Desert Road. Figure 2-14 shows the layout of the two alternatives.

This proposed project was designed to redistribute the wastewater flows to decrease discharges from existing collectors and divert to the WWTP in Arab Abo Sa’ed or the new WWTP in Kuraimat through the construction of new collector, pump stations, and force-mains as follows:

- Areas East and West of AUTOSTORAD main road which include (Al Maadi Al Gedida, 70 Feddan (Al Hadabah Al Wosta), Sobhi Hessien, Maadi Al Sarayat Al Sharqia, and Zahraa Al Maadi) will be diverted to Ahmed Zaki collector in Cairo project with force-main of diameter 1200 mm by CAPW. This modification will lead to decrease discharges on the collector of contract No. (4) of diameter 2000/2150 mm (horse shape) and decrease discharges on the existing screw pump station No. (4) (Maasarah).
- A new collector will be constructed to divert some discharges from the Helwan zone to a new pump station No. (3A) in existing land near from the existing station No. (3), and a force-main to 15th May pump station No. (2A).
- The wastewater flows from 15th of May City will be diverted directly to the WWTP by a force-main from new pump station No. (2A) in the same location of the non-working WWTP in 15th of May City in addition to receive the flows from the new pumping station No. (3A).
- Construction of new booster pumping station (1A) in the midway from the 15th of May City pumping station to the new WWTP in El-Kurimat and will serve in future the extension of 15th of May City that is currently planned.
- Construction of new force-mains to deliver discharges from 15th of May P.S No. (2A) directly to the Arab Abo Sa’ed WWTP (phase 1), and another new force-mains to deliver future wastewater discharges from 15th of May P.S No. (2A) to a new booster pump station No.(1A), then directly to El-Kurimat WWTP (phase 2).
- **As Alternative 1**, an expansion for the WWTP of capacity 250,000 m^3/day in the same Area of the existing Arab Abo Sa’ed WWTP (phase 1).

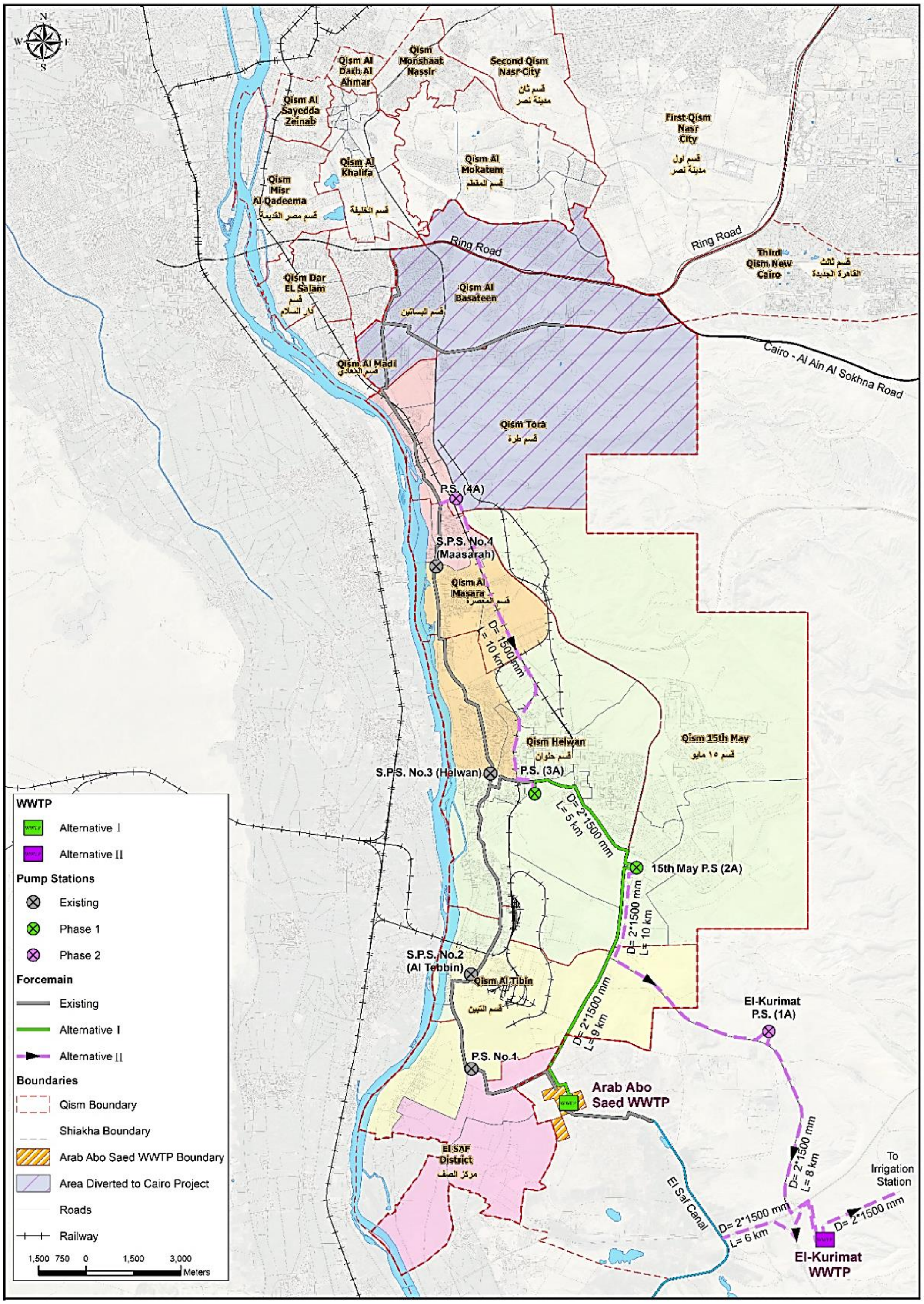


Figure 2-14: General layout of Alternative (1) and Alternative (2) and the existing WWT system

- **Alternative 2**, design of new WWTP of capacity 800,000 m^3/day in the new area of the El- Kurimat as (3) modules, and build the first module of 250,000 m^3/day and two modules 275,000 m^3/day for future expansion of the proposed project.
- Develop all Abo Sa'ed WWTP to be an advanced treatment to allow the safe irrigation reuse in the El-Saff irrigation canal to substitute the fresh water extracted from the River Nile Pumping Stations, Ghamaza I at km 25 and Ghamaza II at km 50 of the El-Saff irrigation canal. This will save an amount of 500,000 m^3/day taken daily from the River Nile that will be used later in the Delta to substitute the deficiency of water at the north part of the Delta.

These modifications will lead to decrease discharges on the existing collectors, screw pump stations, and force-mains from existing screw pump No. (3) down to P.S. No. (1), and force-mains to the Arab Abo Sa'ed WWTP and relief these collectors to allow the start of cleaning process for the sediments to restore to the original cross section and design capacity.

2.5.2 Alternative (2)

As mentioned before, the main feature of Alternative (2) is the construction of the required expansion in a new site at the Al Kurimat- Al Zafarana Desert Road as shown in Figure 2-15.

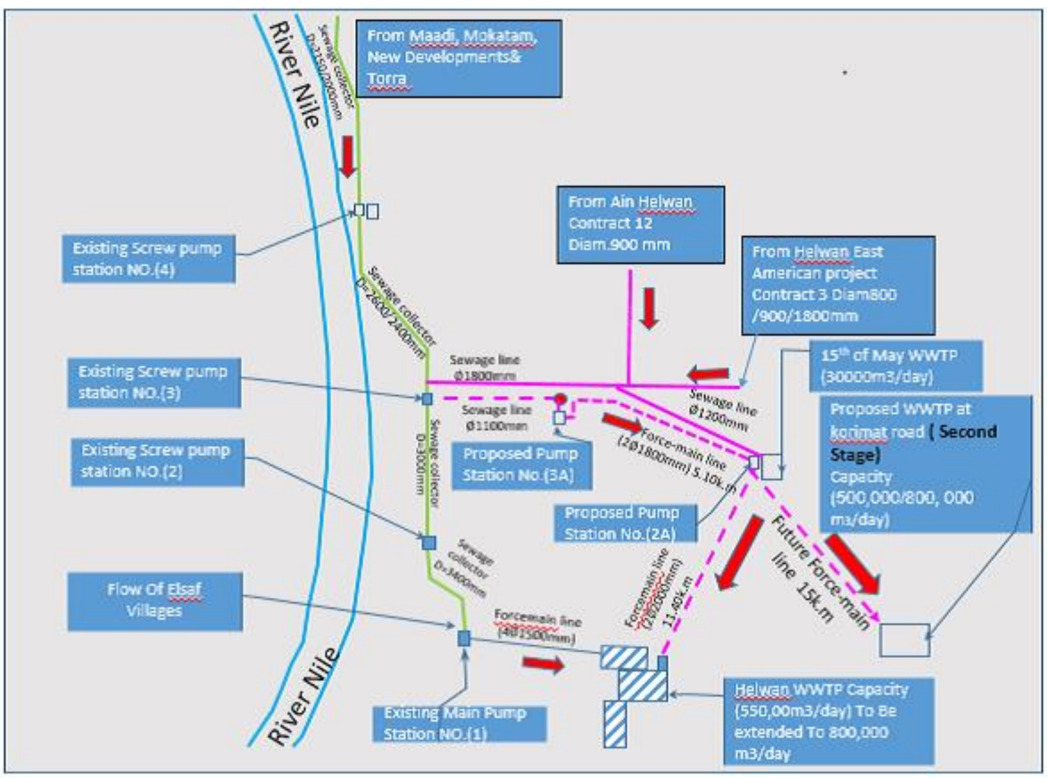


Figure 2-15: Proposed Alternative No.1 by the existing study as well as the Future requirements of new WWTP at Al-Kurimat road (alternative 2)

This alternative like alternative (1) depends on decreasing discharges on the existing collectors, pump stations, and WWTP by diverting some Areas, but with an alternative location of the treatment plant at Al Kurimat – Al Zafrana Desert Road, and the works will be as follows:

- Areas East and West of AUTOSTORAD main road will be diverted to Ahmed Zaki collector in cairo project with forcemain of diameter 1200 mm by CAPW. This modification will lead to decrease discharges on the collector of contract No. (4) and decrease discharges on the existing screw pump station No. (4) (Maasarah) which suffers from a persistent overflow.
- Constructing a new pumping station No. (3A) in Helwan City to divert the wastewater flows from reaching pumping station No. (3), through a flow diversion from the existing gravity collector in Omar Ebn Abdel Aziz Street to P.S. No. (3A) by constructing new collector, and new force-mains to divert discharges from P.S. No. (3A) to a new pumping station No. (2A) in the same location of under rehabilitation WWTP of 15th May city.
- The wastewater flows of the 15th May City will be diverted directly to the Al Kurimat new WWTP by constructing new pumping station No. (2A) in the same location of the non-working WWTP in 15th May City, and a new forcemains to discharge in a new booster (1A) at the Al Kurimat Desert Road, and then at Al-Kurimat new WWTP. This modification will lead to decrease discharges on the collector of diameter 3000 mm (circular) from screw P.S. No. (3) to screw P.S. No. (2), and decrease discharges on the existing screw pump station No. (2).
- These diversion works will lead to decrease the wastewater flows and discharges in the collector of diameter from the screw pumping station No.(3) to the screw pumping station No. (2), and decrease discharges on the existing screw pumping station No. (2) at Al Tebbin.
- These works will allow Cairo Wastewater Company to implement the required sewer cleaning to restore the collector original design capacity to sustain the future flows.
- Yet, so far, Alternative (2) is not the favorable alternative for the immediate stage, but is generally considered a strategic plan for further future expansions, as there is an urgent need currently to save the situation in Arab Abu Sa’ed WWTP. Implementing alternative (1) then alternative (2) can be considered as fully utilizing and reaching maximum efficiency and capacity of existing WWTP and resources before expanding into new projects.

2.5.3 Alternative (1)

The project as agreed with CAPW and Greater Cairo Wastewater Company was studied as two alternatives. The first alternative includes the expansion of existing WWTP in Arab Abo Sa’ed Site with extra design capacity of 250,000 m^3/ day, while the second alternative is to construct a new treatment plant at the El-Kurimat Desert Road site with an initial capacity of 250,000 m^3/ day.

It should be noted that, the selected Helwan wastewater project shall be the first alternative which is construction of 250,000 m^3/day advanced treatment in Arab Abo Sa’ed existing site. The current ESIA shall focus only on the new construction works of the 250,000 m^3/day advanced treatment in Arab Abo Sa’ed location and the operation of the whole Arab Abo Sa’ed Plant (the existing 550,000 m^3/day after upgrade to advanced treatment and the new 250,000 m^3/day advanced treatment). Proposed general layout of Arab Abu Sa’ed WWTP is shown in Figure 2-16.

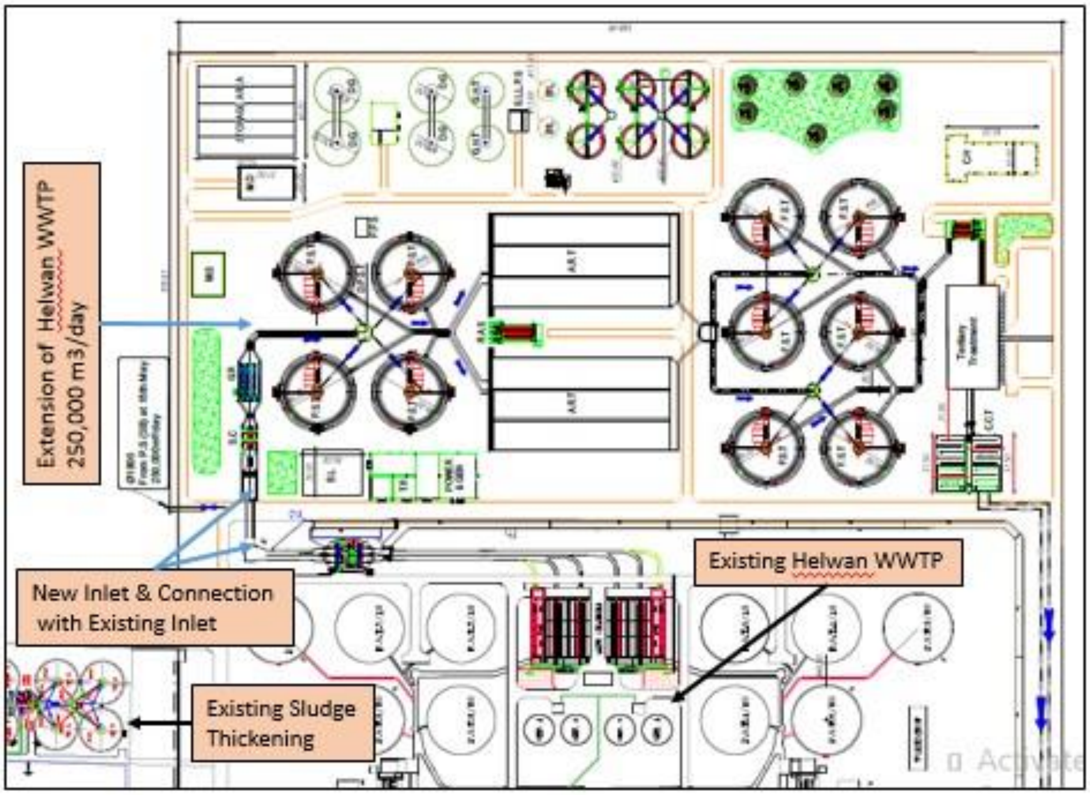


Figure 2-16: Proposed general layout of Arab Abu Sa'ed WWTP

Details components are listed below:

- Construction of Collector of diameter 1800 mm with 100 m length to take water from the existing collector in Omar Ebn Abdel Aziz street to a new pump station No. (3A) in Helwan.
- Construction of civil works for new Pumping Station No. (3A) of capacity (400,000 m3/day), including Electro-mechanical works of the first phase (capacity 200,000 m3/d) including five (3+2) pumps, pump capacity 1,000 L/sec and 60.0 m head.
- Construction of two Forcemain of diameter 1500 mm and length of 5 km from the new P.S. No. (3A) to 15th May P.S (2A).
- Construction of new 15th of May Pumping Station (2A) civil works of capacity 550,000 m3/d including electromechanical works of capacity (250,000 m3/day) with five (3+2) pumps for phase (1), pump capacity 1,500 L/sec and 25 m head.
- Construction of two forcemains each of diameter 1500 mm and length of 9.00 km from the new 15th May P.S. (2A) to Arab Abo Sa'ed existing WWTP.
- An expansion for the existing WWTP of capacity 250,000 m3/day (provided with mechanical dewatering of sludge) in the same Area of the existing Arab Abo Sa'ed WWTP. It also includes an advanced treatment unit (DynaSand) for the whole plant capacity (800,000 m3/ day).
- Anaerobic digesters for Arab Abo Sa'ed WWTP with a total capacity 250,000 m3/day.

- Rehabilitation and Expansion of the first part of Al Saff Irrigation Canal of 25 km length starting from km 0 to km 25).

2.5.4 Design Flows of Stage III

The design capacity of the required extension to serve up to 2037 was set to be 250,000. However, the calculated figure for the WWTP is 847,525 m3/day meaning that the extension should be of capacity 297,525 (say 300,000) m3/day provided that the current capacity is 550,000 m3/day. The proposed extension would be sufficient for treatment of the collected wastewater reaching at the WWTP up to some years before 2037. The capacity of the treatment extension was based on a Peak factor of 1.5 from the annual average water consumption after application of a ratio of 0.85 as generated wastewater. Figure 2-17 illustrates the influent flow records at Arab Abu Sa'ed WWTP.

QWWTP = design flow for wastewater treatment plants = 1.5 * Qavg (m3/day)

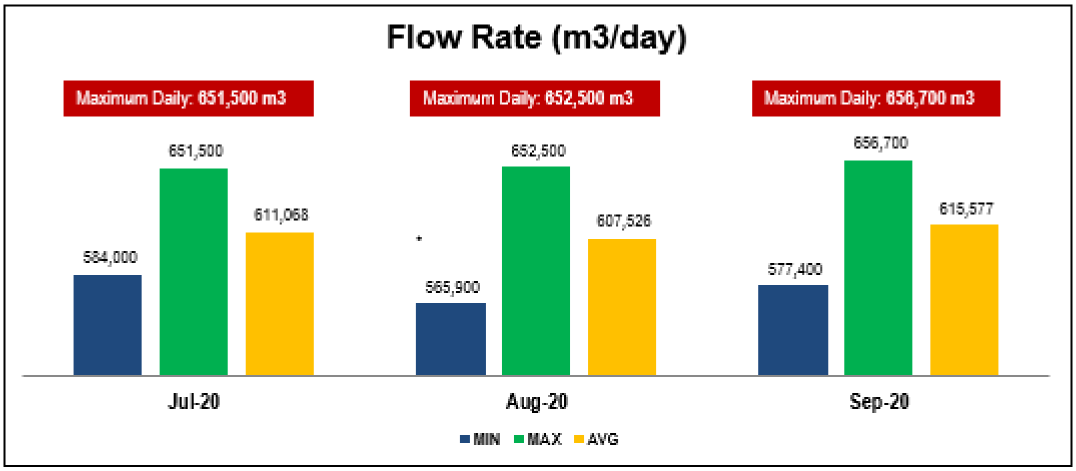


Figure 2-17: Influent Flows Recorded at the Existing Helwan WWTP (July2020-Sep.2020)

For the effluent quality and since the existing study recommended the tertiary treatment to guarantee the best quality of treated effluent for Re- use in agriculture especially that restricted irrigation would not be applicable for different reasons, the effluent quality of both Stage1,2 and the new extension of 250,000 m3/day had to be adapted. Effluent of 10 mg/l TSS, 10 mg/l BOD and 20 mg/l COD will be requested. Table 2-8 summarizes the design criteria from the proposed scheme.

Table 2-8: Design criteria for the proposed Scheme

Parameter	Unit	Design Figure	Effluent Requirement
BOD	mg/L	335	**10**
COD	mg/L	670	**30**
TSS	mg/L	450	**10**
Sludge Dry Solids	**%**	**21**	

2.5.5 Wastewater Treatment Methods

The proposed wastewater treatment technologies which shall be discussed and assessed in the Concept Design Report are for secondary treatment with Disinfection and filtration processes (advanced treatment) since the required effluent standards for Helwan WWTP is required to be at this level of treatment as required by the MWRI and its conditional approval for disposal to Al-Saff Canal.

The existing facilities will be retained as far as possible; inlet works, grit removal, primary settlement, sludge dewatering. The following basic options are identified for appraisal in concept development. This list is not exhaustive and may be developed further during the appraisal. Proposed Wastewater Treatment Options at Helwan WWTP:

- Activated Sludge (with air diffusers)
- Sequential Batch Reactors (SBR) Sludge Treatment
- Gravity thickeners, digesters and CHP
- Disinfection using one of the common methods of disinfection include ozone, chlorine, ultraviolet light, or sodium hypochlorite

Also, according to Alternative 1 of the existing study, one third from the existing operating sludge drying beds will be demolished for making available area for the construction of the 2550,000 m3/day extension. Furthermore, Discussions with CAPW and GCWC also preferred the application of sludge anaerobic digestion for the full plant on a partial application for only 250,000 m3/day of 800,000 m3/day of full capacity. Those discussions also showed deep interest with high potential to replace the process of the current sludge drying through drying beds by mechanical dewatering. This matches with CAPW's strategy in implementation of anaerobic digestion and mechanical dewatering for big size wastewater treatment plants. GCEC demonstrated the huge complication dealing with more than 180 Feddans of drying beds and it took quit a long time to reach a stage where they can sell a stable treated sludge.

2.6 Proposed Wastewater Effluent Disposal and Reuse

The current design capacity of Helwan (Arab Abo Sa'ed) is 550,000 m^3/day and it receives an actual flow of 700,000 m3/day. Therefore, there is an overloading on the WWTP which reduces the quality of the treated effluent disposed into Al-Saff Canal in its first region (the first 25 km of the canal). Sometimes, this excess influent water is bypassed without treatment to Al-Saff Canal which causes drastic deterioration of the water quality available for Farmers from the canal for irrigation and farming in its first 25 km of the canal length. Following this first reach of the canal (25km), fresh water is pumped from the Nile River to supplement the deficit of the water in the canal.

Having in mind that, Helwan Wastewater Treatment Plant is producing now 550,000 m3/day and after upgrade and extension it shall produce 800,000 m3/day advanced treated wastewater, this produced advanced treated wastewater is very suitable for agricultural reuse. Since the plant is located far from the Nile River, as shown in Figure 2-18, it is planned to dispose the advanced treated wastewater into Al-Saff Canal (Figure 2-19), which is currently receiving the treated effluent under Law 48/1982. The WWTP could not comply with these standards with the current treatment. However, a special dispensation under a presidential decree for the discharge of primary treated effluent on condition that the WWTP are to be upgraded at some stage to advanced treatment for compliance with the discharge standards.

The second branch of Al-Saff canal shall be rehabilitated so that it can receive the flow of the extension of Helwan WWTP 250,000 m3/day. This shall help the farmers to utilize this advanced treated wastewater as a source for irrigation water with good quality suitable for irrigation and it shall replace and save water to be abstracted from the Nile River for farmers for irrigation.

Figure 2-18: Location of Helwan WWTP with respect to River Nile and Arab Abo Sa'ed Village

Figure 2-19: Al-Saff Canal Main branch and Second Branch

2.7 Sludge Treatment Options and Disposal

The sludge treatment shall be performed by thickening process followed by anaerobic digestion. Then, the sludge shall be dewatered mechanically and then the sludge shall be composted to be used for agricultural usage.

This proposed treatment process is the same process as followed in El-Gabal El-Asfar WWTP (the largest WWTP in Egypt) which proved to be the most efficient sludge treatment process for large Wastewater Treatment Plants in Egypt. It worth here mentioning that, the current upgrading process of Abo Rawash WWTP (the second largest WWTP in Egypt) shall follow the same treatment methodology. Lessons learned from sludge treatment of these two largest WWTP in Egypt shall be utilized in the proposed sludge treatment methodology for Helwan (Arab Abo Sa'ed) WWTP. The bio-gas generated from the anaerobic digestion process shall be utilized to generated electricity which can cover up to half of the WWTP electricity consumption.

The stabilized treated dried sludge shall have high quality and shall be converted to compost and sold to farmers for agricultural usage purposes for reasonable price following all environmental and health regulation and restrictions in handling and transporting process. With reference to the quantity of dried sludge to be supplied a volume of approximately 150-200 m³/day.

The previously described sludge treatment methodology adopted for large WWTPs in Egypt helps to reduce the greenhouse gases developed during sludge treatment process which shall definitely help to minimize the effect on the climate change. This effect shall be discussed in details in the detailed ESIA during detailed design phase.

The current wide application of mechanical dewatering across the country and especially for the big size treatment plants led to the suggest of having the following scenarios as a development of Alternative 1

- **Scenario 1**: Anaerobic Digestion for only 250,000 m3/day, mechanical dewatering for sludge produced from the extension of 250,000 m3/day + one third of the mixed sludge produced from the existing WWTP (550,000 m3/day)
- **Scenario 2**: Anaerobic Digestion for 800,000 m3/day, mechanical dewatering for sludge produced from the extension of 250,000 m3/day + one third of the mixed sludge produced from the existing thickeners of the current WWTP (550,000 m3/day)
- **Scenario 3**: Anaerobic Digestion for 800,000 m3/day, mechanical dewatering for sludge produced from the extension of 250,000 m3/day+ all mixed sludge produced from the existing thickeners of the current WWTP (550,000 m3/day)

2.8 Land Availability for Upgrade and Extension

The extension of the Arab Abo Sa'ed WWTP 250,000 m3/day advanced treatment shall be in the same premises of the existing Arab Abo Sa'ed WWTP. The site is supplied with all existing utilities which are also expected to minimize the environmental impacts during the construction phase. Also, the upgrade and extension of the Helwan WWTP shall be in the same location of the WWTP in Arab Abu Sa'ed. Hence, no land acquisition is required for the extension.

As for the two new pump stations 3A and 2A:

- 3A: will be constructed in the existing land near the existing station No. (3) in Helwan, within the premises of the site of the old Helwan plant.
- 2A: will be constructed within the premises of 15th May WWTP which is currently under rehabilitation.
- The force mains will be buried under roads, as by the Egyptian codes.

Hence, no land acquisition is needed for any element of the total project.

2.9 Construction processes

2.9.1 Pump stations and Pipelines

The construction activities of the PSs will involve conventional activities related to the construction of reinforced concrete components. The activities will involve digging down to the foundation level, construction of needed isolated footings, and construction of the main cesspit, guard room warehouse and fence. The activities will also involve the installment of pipelines and pumps, special pieces and valves, connection welding, and completing all the electrical work needed. The construction activities will be located within the allocated site. Sensitive receptors around the PS site have been identified and will be presented in details in Chapters 4 and 5.

It is therefore expected that during the construction of the PS, the following activities will take place:

- Storage of the raw materials such as pipelines (maximum 6 layers high separated by timber blocks) pumps, masonry, Portland cement sacks, sand, and gravel, wood plates (to mold the concrete and for the windows and door frames), fuel and water.
- Concrete mixing and pouring; water will be added to the cement- sand -gravel mix
- Steel reinforcement storage, welding, and bending
- Spoil storage and transport/disposal of excess spoil.

2.9.2 Expansion the existing WWTP

The construction activities of the WWTP will involve conventional activities related to the construction of reinforced concrete components. The activities will involve digging down to the foundation level, construction of needed isolated footings, and other needed civic works. The activities will also involve the installment of pipelines and pumps, special pieces and valves, connection welding, and completing all the electrical work needed. The construction activities will be located within the allocated site. It is expected that during the construction of the WWTP, the following activities will take place:

- Storage of the raw materials such as pipelines (maximum 6 layers high separated by timber blocks) , pumps, masonry, Portland cement sacks, sand, and gravel, wood plates (to mold the concrete and for the windows and door frames), fuel and water
- Concrete mixing and pouring; water will be added to the cement- sand -gravel mix
- Steel reinforcement storage, welding, and bending
- Spoil storage and transport/disposal of excess spoil.

2.10 Equipment and Raw Material Requirements

Equipment, machinery and raw materials to be used in construction would include the several items presented in the following Table 2-9 and Table 2-10.The list of equipment was estimated through consultation and interview and previous experience.

Table 2-9: Tentative list of equipment and machinery for construction

SL No.	Equipment/Machinery Type	Numbers
1.	Mobile Crane	04
2.	JCB	08
3.	Air Compressor	04
4.	Hilti Breaker	10
5.	Pick-up	03
6.	Mobile Pump	04
7.	Bobcat	07
8.	Water pump	05
9.	Vibrators	06
10.	Wood Cutting Machine	05
11.	Steel Cutting Machine	04
12.	Hilti Drilling Machine	10
13.	Boom loader	04

14.	Mixer Machine	04
15.	Block cutter	02
16.	Steel cutter	02
17.	Power floating machine	02
18.	Shovel	10
19.	Excavator	08
20.	Water Tanker, 5000 Gallon	01
21.	Water Tanker, 1500 Gallon	01
22.	Wheel Loader	17
23.	Trailer	06
24.	Travel Mixer	10
25.	Grader	02

Table 2-10: List of raw materials

Material	Source
Borrow materials	**Locally acquired**
Gravel	**Locally acquired**
Aggregate	**Locally acquired**
Sand	**Locally acquired**
Road {rip rap material} and Stone Block	**Locally acquired**
Clean Water for Concrete	**Locally acquired**
Other Water for Compaction	**Locally acquired**
Reinforcing bar	**Manufactured Local**
Cement	**Locally Manufactured**
Steel beams	**Regionally Manufactured/Local**
Steel Rails	**Imported Manufactured/ Local**

All the access roads to Helwan WWTP site are wide enough to transport all required material and the only issue is that the access road is unpaved road and need to be paved.

2.11 Manpower Required

The following Table 2-11 illustrates tentatively the required manpower for construction phases of the project in terms of technical, administration, skilled and non-skilled labors.

The manpower was estimated through consultation and interview with the contractors during site visits.

Table 2-11: Manpower required for construction

Technical & Administration Staff	
Category	**Numbers**
Project Management	7
Construction Manager (Civil)	6
Construction Manager (MEP)	04
Construction Manager (Roads)	01
Control Engineer	06
QA/QC Engineer	06
Safety Engineer	06
Site Engineer (Civil & MEP)	14
Site Supervisor	06
Foremen	10
Quantity Surveyor	06
Project Clerk	06
Secretary & Document Controller	02
Project Clerk	02
Draughtsman (Civil & MEP)	02
Storekeeper	06
Logistic Assistant	06
Timekeeper	02
Office Boy	04
Surveyors	12
Sub-total	114
Labourers Staff	
Category	**Numbers**
Skilled Labour	150
Un-skilled Labour	300
Mechanics	20
Electrician	16
Other Staff	20
Sub-total	486
Total	600

Yet, there is no clear figure about the estimated manpower required for the operation phase. However, tentatively, the total required manpower for operation phases of the project in terms of technical, administration, labors and animals keepers can be estimated as presented in the following Table 2-12.

Table 2-12: Tentative figure for required manpower, operation phase

Type	Number
Existing	400
Additional after full operation with Alternative 1	150
Total	650

2.12 Construction Program and Risk

The completing time of the project phases including design, mobilization and construction is outlined in Table 2-13.

There are some factors that might cause a delay in the project's construction progress including but not limited to:

- Natural factors: Such as sandstorms, hot waves, flood storms, heavy rain, and summer and Ramadan working hours;
- Technical and management factors: Introducing new arrangement& procedures, appointing new contractors, changing scope of works, introduce new activities of variation orders and change some of design option.
- Engineering value considerations: Changing project phases and activities, optimizing cost and redesigning some of the activities
- Construction Logistic requirements such as of delaying in importing some of the construction materials

2.13 Health, Safety and Environmental Policies

All work on site will be carried out in accordance with the Egyptian Conditions of Contract, which specify compliance with the appropriate health and safety and environmental policies. In addition, clauses have been inserted into the conditions of contract for the works to require the contractor to comply with the mitigation actions, which have been identified in this report, and this compliance will be monitored by the Resident Engineer and his staff. Details of mitigation measures and management plan presented in chapters six (impact assessment) and eight (ESMP).

Table 2-13: Tentative project implementation schedule

Work Packages & Activities	2021		2022				2023				2024				2025				2026				2027	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Consultancy Services																								
Environmental Permitting	■																							
Tender Documents Preparation	■																							
Bid Evaluation & Contract Award		■																						
Construction Supervision			■	■	■	■	■	■	■	■	■	■	■	■	■	■								
Supervision on O&M																	■	■	■	■				
Pump Station 3A with Forcemain 1,500 mm for 4,650 km																								
Site Mobilization					■																			
Civil Works for Pump Stations					■	■	■	■	■	■	■	■	■	■										
Electromechanical Works											■	■	■	■										
Pressure line & Forcemain activities							■	■	■	■	■	■	■											
Commissioning & Start of Guarantee Period (1 year)															■	■	■	■						
Pump Station 2A - Forcemain 1,500 mm for 9,00 km																								
Site Mobilization					■																			
Civil Works for Pump Stations					■	■	■	■	■	■	■	■	■	■										
Electromechanical Works											■	■	■	■										
Pressure line & Forcemain activities							■	■	■	■	■	■	■											
Commissioning & Start of Guarantee Period (1year)															■	■	■	■						
Extension of Arab ASa'ed (250,000 m3/day)																								
Detailed Design / Construction / shop drawing development			■	■																				
Mobilization				■																				
Civil Works					■	■	■	■	■	■	■	■	■	■	■	■								
Electromechanical Works											■	■	■	■	■	■								
Commissioning & Start-up																■								
Liability Guarantee and O&M contract (2 years)																	■	■	■	■	■	■	■	■
Additional Works for Existing Plant (Tertiary treatment, tertiary P.S, mechanical dewatering, electricity buildings)																								
Detailed Design / Construction & shop drawing development			■	■																				
Mobilization				■																				
Civil Works					■	■	■	■	■	■	■	■	■	■										
Electromechanical Works											■	■	■	■										
Commissioning & Start-up														■										
Liability Guarantee and O&M contract (1 year)															■	■	■	■						
Al saf Canal																								
Irrigation Rehabilitation structures for the first 25 km					■	■	■	■	■	■	■	■	■	■	■									
Forcemain (3.2 km) 1,500 mm Irrigation P.S																								
Mobilization								■																
Construction (civil works)								■	■	■	■	■	■											

CHAPTER 3

LEGAL FRAMEWORK

3 Legal Framework

This Chapter describes the legal and administrative framework for the proposed project. It lists the national laws and international requirements pertinent to the project. Following an overview of the requirements of international institutions and international conventions, the requirements of Egyptian legislation are compared with those of the EIB Environmental and Social Policy, and presented in a tabular form of gap analysis.

3.1 National Administrative and Legal Framework

The following is a description of the different national authorities and institutions of relevance to this project.

The Egyptian Environmental Affairs Agency (EEAA) is an authorized state body regulating environmental management issues. Egyptian laws identify three main roles of the EEAA:

- It has a regulatory and coordinating role in most activities, as well as an executive role restricted to the management of natural protectorates and pilot projects.
- The agency is responsible for formulating the environmental management (EM) policy framework, setting the required action plans to protect the environment and following-up their execution in coordination with Competent Administrative Authorities (CAAs).
- EEAA is responsible for the review and approval of the environmental impact assessment studies as for new projects/expansions undertaken.

The Environmental Management Unit (EMU) at the governorate and district level is responsible for the environmental performance of all projects/facilities within the governorates premises. The governorate has established EMUs at both the governorate and city/district level. The EMUs are responsible for the protection of the environment within the governorate boundaries and thus are mandated to undertake both environmental planning and operation-oriented activities. The EMU is mandated to:

- Follow-up on the environmental performance of the projects within the governorate during both construction and operations to ensure the project abides by laws and regulations as well as mitigation measures included in its EIA approval. Investigate any environmental complaints filed against projects within the governorate
- The EMUs are affiliated administratively to the governorate yet technically to EEAA. The EMUs submit monthly reports to EEAA with their achievements and inspection results.
- The governorate has a solid waste management unit at the governorate and district level. The units are responsible for the supervision of solid waste management contracts.

Law 4/1994 stipulates that applications for a license from an individual, company, organization or authority, subject to certain conditions, require an assessment of the likely environmental impacts.

The Competent Administrative Authorities (CAAs) are the entities responsible for issuing licenses for project construction and operation. The EIA is considered one of the requirements of licensing. The CAAs are thus responsible for receiving the EIA studies, check the information included in the documents concerning the location, suitability of the location to the project activity and ensure that the activity does not contradict with the surrounding activities and that the location does not contradict with the ministerial decrees related to the activity. The CAA forwards the documents to EEAA for review. They are the main interface with the project proponents in the EIA system. The CAA is mandated to:

- Provide technical assistance to Project Proponents
- Ensure the approval of the Project Site
- Receive EIA Documents and forward it to EEAA
- Follow-up the implementation of the EIA requirements during post construction field investigation (before the operation license)

After submission of an ESIA for review, the EEAA may request revisions in the ESIA report within 30 days, including additional mitigation measures, before issuing the approval of the report. In case of disapproval, CAPW will have the right to issue an appeal within 30 days from its receipt of the EEAA's decision. It should be noted that once the ESIA has been approved, the ESMP as will be presented in the report, will be considered an integral part of the project; and the CAPW will be legally responsible for the implementation of that plan, depending on their involvement in the construction or operation process. It is therefore worth mentioning that the CAPW must ensure that all mitigation measures and environmental requirements described in the ESMP will be clearly referred to in the tender documents for the construction works, the construction contracts, and have been respected. CAPW will follow-up on the construction contractor to ensure that the ESMP is adequately implemented in the construction phase. See Figure 3-1 demonstrates the EIA process procedures.

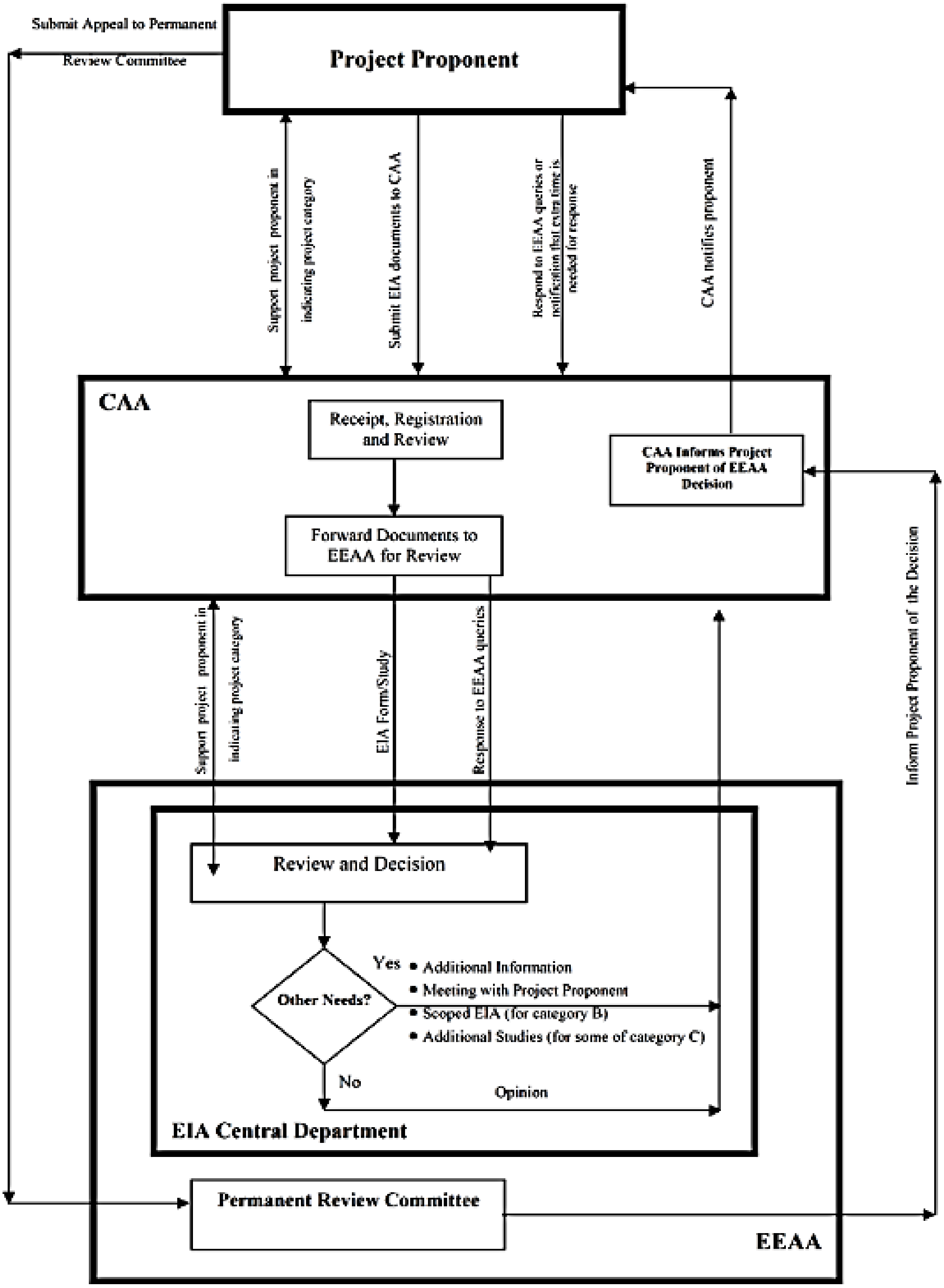


Figure 3-1: EIA Procedure overview

3.2 Summary of the National Legislation Pertinent to the Project

The legislations listed below and described in more details in the following sections represent the national legislation pertinent to the project:

3.2.1 Egyptian legislation related to social aspects

- EEAA guidelines related to the Public Consultation; Guidelines of Principles and Procedures for "Environmental Impact Assessment" 2nd Edition January 2009
  - Paragraph 6.4.3 Requirements for Public Consultation
  - Paragraph 6.4.3.1 Scope of Public Consultation
  - Paragraph 6.4.3.2 Methodology of Public Consultation
  - Paragraph 6.4.3.3 Documentation of the Consultation Results
  - Paragraph 7 Requirement and Scope of the Public Disclosure
- Land acquisition and involuntary resettlement **(The project will not result in resettlement activities)**
  - Law 94/2003 on the National Council for Human Rights (NCHR)
  - The Constitution (1971, amended in year 1980)
  - The Constitution (2014, articles 33 and 35)
  - Law 10/1990 on property expropriation for public benefit and its amendments by law number 1/2015.
  - Other laws governing expropriation
- Protection of human rights
- Unified structure Law No 119 of year 2008
- Presidential Decree No. 135 of year 2004 related to the esablishment of WWHC

3.2.2 Egyptian legislation related to protection of Antiquities, archaeology and cultural heritage

- Law 117/1983

3.2.3 Egyptian legislation related to environmental aspects

- Law 4 for Year 1994 for the environmental protection , amended by Law 9/2009 and law 105 for the year 2015
- Executive Regulation(ER) No 338 for Year 1995 and the amended regulation No 1741 for Year 2005, amended with ministerial decree No 1095/2011, ministerial decree No 710/2012, and ministerial decree No 964/2015
- Law No 93 for Year 1962 for discharge on the public sewer network and protection and treatment of wastewater wastes and safe discard methods of the treatment by products, amended with Decree No 44 for Year 2000.
- Law No 48 for Year 1982 for the protection of the Nile River, agricultural drains, ponds and aquifer from pollution, and the ER amended with Decree No 92 for Year 2013.
- Law No 12 for Year 2003 for the protection, occupational health and safety for the workers, which is amending Law 137 for Year 1981 and its executive decrees.
- Law No 102 for Year 1983 for natural habitats.

- Law No 38 for Year 1968 for the public cleanliness, which is amended by Law No 31 for Year 1976.
- Guidelines of Principles and Procedures for "Environmental Impact Assessment" 2nd Edition EEAA, January 2009 and its amended Lists in October 2010.

3.3 International Requirements

International funding agencies, such as the WB require that the projects they finance to be in compliance with both the country's national standards as well as their own environmental and social policies. Therefore, in addition to the national regulations, the project aims at complying with the EIB safeguard policies and guidelines. The policies help to ensure the environmental and social soundness and sustainability of investment projects. They also support integration of environmental and social aspects of projects into the decision-making process. In addition, the policies promote environmentally sustainable development by supporting the protection, conservation, maintenance, and rehabilitation of natural habitats. Helwan WWTP project is classified as category C project by EEAA, which requires mandatory Environmental Impact Assessment as it may have moderate implications on the environment. The project is classified as Category B according to the WB classification criteria.

The EIB has identified ten environmental and social safeguard policies that should be considered in its financed projects. The objective of these policies is to prevent and mitigate undue harm to people and their environment in the development process.

The EIB Environmental and Social Practices Handbook, last amended in the year 2013 describe the processes and practices of the Bank to ensure that all financing activities are consistent with its environmental policy. Volume I of the handbook outlines 10 standards that may have significance for the ESIA study. With reference to the Helwan WWTP Project all standards are considered as applicable.

Standard 1: Assessment and Management of Environmental and Social Impacts and Risks

The overall objective of this Standard is to outline the promoter's responsibilities in the process of assessing, managing and monitoring environmental and social impacts and risks associated with the operations.

Standard 2: Pollution Prevention and Abatement

The objectives of this Standard are:

- Avoidance of any deterioration in the quality of human health or the environment, and any loss of biodiversity, by avoiding, reducing and, if possible, compensating/remedying significant adverse effects of projects supported by the EIB;
- Support to the EU aims of reducing greenhouse gas emissions and enhancing resource efficiency, that will ease pressures on the environment and bring increased competitiveness through cost savings from improved efficiency, commercialization of innovations and better management of resources over their whole life cycle; and,

- Promotion of an integrated approach to prevention and control of emissions into air, water and soil, to waste management, to energy efficiency and to accident prevention for the protection of the environment as a whole and therefore, avoiding the shift of pollution from one environmental medium to another.

Standard 3: Biodiversity and Ecosystems

Standard 4: Climate-related Standards

Standard 5: Cultural Heritage

The objective of this Standard is to outline the promoter's responsibilities in terms of cultural heritage management, involving the actions taken to identify, assess, decide and enact decisions regarding the impact on cultural heritage associated with operations supported by the EIB.

Standard 6: Involuntary Resettlement

The objectives of this Standard are:

- Avoid or, at least minimize, project-induced resettlement whenever feasible by exploring alternative project designs;
- Avoid and/or prevent forced evictions and provide effective remedy to minimize their negative impacts should prevention fail;
- Ensure that any eviction which may be exceptionally required is carried out lawfully, respects the rights to life, dignity, liberty and security of those affected who must have access to an effective remedy against arbitrary evictions;
- Respect individuals', groups' and communities' right to adequate housing and to an adequate standard of living, as well as other rights that may be impacted by resettlement;
- Respect right to property of all affected people and communities and mitigate any adverse impacts arising from their loss of assets, or access to assets and/or restrictions of land use, whether temporary or permanent, direct or indirect, partial or in their totality. Assist all displaced persons to improve, or at least restore, their former livelihoods and living standards and adequately compensate for incurred losses, regardless of the character of existing land tenure arrangements (including title holders and those without the title) or income-earning and subsistence strategies;
- Uphold the right to adequate housing, promoting security of tenure at resettlement sites;
- Ensure that resettlement measures are designed and implemented through the informed and meaningful consultation and participation of the project-affected people throughout the resettlement process; and
- Give particular attention to vulnerable groups, including women and minorities, who may require special assistance and whose participation should be vigilantly promoted.

Standard 7: Rights and Interests of Vulnerable Groups

Standard sets out to avoid or minimize, or otherwise mitigate and remedy potential harmful effects of EIB operations to vulnerable individuals and groups whilst seeking that these populations duly benefit from such operations. As a means to foster those project outcomes, Standard 7 proposes a framework and tools to address inequalities and other factors contributing to vulnerability, and, as appropriate, to allow for equal access to and enjoyment of project benefits for those individuals and groups.

Standard 8: Labour Standards

With the present standards, the responsibilities of the promoter are defined to ensure that the project embraces the principles of International Labor Standards.

Standard 9: Occupational and Public Health, Safety and Security

In compliance with ILO's Guidelines on occupational safety and health management systems the EU's decent work agenda the OSH Framework Directive as well as the UN Guidelines on Business and Human Rights, the EIB stresses the employers' duty of care towards project workers and society, in safeguarding occupational and public health, safety and wellbeing within the area of influence of their operations and at associated facilities.

Standard 10: Stakeholder Engagement

As a public institution, the EIB actively promotes the right to access to information, as well as public consultation and participation; the right to access to remedy, including through grievance resolution, is equally acknowledged and actively promoted by the EIB. Standard 10 affirms the EIB's expectation that promoters uphold an open, transparent and accountable dialogue with all relevant stakeholders at the local level targeted by its EIB operations. This Standard stresses the value of public participation in the decision-making process throughout the preparation, implementation and monitoring phases of a project.

Core Labour Standards (CLS) of the International Labour Organisation

The International Labour Organisation (ILO) is a tripartite organisation consisting of trade unions, governments and companies, and is part of the United Nations system. In 1998, the ILO produced the Declaration on Fundamental Principles and Rights at Work. In the Declaration, ILO member states agreed that they should all respect, promote, and realise Core Labour Standards (whether or not they have ratified them).

The core labour standards consist of four standards, laid out in eight conventions:

- Freedom of association and the effective recognition of the right to collective bargaining (Convention No. 87 & No. 98).
- The elimination of all forms of forced and compulsory labour (Convention No. 29 & No. 105).
- The effective abolition of child labour (Convention No. 138 & No. 182).
- The elimination of discrimination in respect of employment and occupation (Convention No. 100 & No. 111).

Today all International Financing Institutions including EIB have fully adopted CLS in their activities. Egypt has ratified all core labour standards mentioned before and set into force.

3.4 International Conventions and Agreements

Egypt has signed and ratified a number of international conventions that commit the country to conservation of environmental resources. The following is a list of the key conventions:

- International Plant Protection Convention (Rome 1951)
- African convention on the conservation of nature and natural resources (Algeria 1968)
- UNESCO Convention for the protection of the world cultural and natural heritage (Paris, 16 November 1972)
- Convention on International Trade In Endangered Species Of Wild Fauna And Flora (CITES) (Washington 1973)
- Basel Convention on the control of trans-boundary movements of hazardous wastes and their disposal (1989)
- United Nations framework convention on climate change (New York 1992). The convention covers measures to control greenhouse gas emissions from different sources including transportation.
- United Nations Framework Convention on climate change and Kyoto Protocol (Kyoto 1997)
- Convention on biological diversity (Rio de Janeiro 1992), which covers the
- Conservation of habitats, animal and plant species, and intraspecific diversity.
- Convention for the protection of the ozone layer (Vienna 1985)
- Convention for the prevention and control of occupational hazards caused by carcinogenic substances and agents (Geneva 1974)
- Convention for the protection of workers against occupational hazards in the working environment due to air pollution, noise and vibration (Geneva 1977).
- ILO core labor standards: core labor standards are to be adhered to/reached during the project implementation. Egypt has been a member state of the ILO since 1936, and has ratified 64 conventions that regulate the labor standards and work conditions. In 1988, Egypt has ratified the Occupational Safety and Health Convention of 1979 (No 152).

3.5 Detailed Description of National Legislation Related to Environmental and Social Aspects

3.5.1. Water Quality

Egyptian Code for Reuse of Treated Sewage water in irrigation and Use of Sludge in agriculture 501/2015

This Code allows the direct usage of treated wastewater into irrigation networks but not to open drains and waterways. The law which concerns the disposal of treated wastewater effluent to open waterways is Law 48/1982 (issued by Ministry of Water Resources and Irrigation). Table 3- shows effluent quality for treated wastewater as per Code 501/2015.

Three categories of treated waste – that from public treatment facilities, from private treatment facilities and lastly where the effluent is from an industrial source. A range of conditions and criteria are set and a permit is required from the Ministry of Health prior to application. The receiving land shall not be within 3 km from built up areas and there are constraints on the types of agriculture for which the effluent can be used.

Table 3-1: Effluent quality for treated wastewater as per Code 501/2015

Parameter	Class A	Class B	Class C	Class D
TSS (mg/l)	15	30	50	300
Turbidity (NTU)	5	Undefined	Undefined	Undefined
BOD (mg/l)	15	30	80	350
E.Coli Count (Org/100ml)	20	100	1000	Undefined
Nematodes (no. of cells or eggs/l)	1	Undefined	Undefined	Undefined

Standards and Limits for the drains' water quality to be discharged into watercourses

According to Article 51 of the ER of Law 48/1982 amended by Decree 402/2009

Parameter	Standards&Limits (mg/l)
Total dissolved solids TSS	1000≤
Temperature	Maximum difference of 3°C as compared with the receiving watercourse
Dissolved Oxygen	5≥
pH	min 6.5 and max 8.5
BOD	≤30
COD	≤50
Total Nitrogen (TN)	15
TotalP (TP)	3
Oil&Grease	≤3
Mercury	≤0.001

Parameter	Standards&Limits (mg/l)
Fe	≤3
Mn	≤2
Cu	≤1
Zn	≤2
Phenol	≤0.05
As	≤0.01
Cd	≤0.03
Cr	≤0.05
Free Cyanide	≤0.01
Pb	≤0.1
Ni	0.1
Se	0.01
Coliform 100 cm^3	5000

Standards and Limits for discharging Treated Sanitary effluent into drains

Parameter	Standards and Limits (mg/l)
Temperature	Does not exceed the temperature of the receiving receptor by more than 3
pH	6-9
BOD	60
COD	80
Dissolved Oxygen	≥4
Oil & Grease	10
Total Dissolved Solids	Does not exceed 2000
Total Suspended Solids	50
H2S	1
Free Cianides	0.1
Total P	-
NH3	-
TN	-
Phenol	0.05
Mercury	0.01
Pb	0.1
Cd	0.003
Arsenic	0.05
Se	0.1
Cr	0.1
Cu	0.5
Ni	0.5
Zn	2
Fe	3.5
Total Coliform (100cm3)	5000

3.5.2. Sludge and Sludge/sediment assessment Methodology

Reuse Code for Treated Sludge (based on total metals form)

Over the past few decades, Egypt has been focused on sanitation-related services, especially constructing new sewerage networks and wastewater treatment facilities, with a little attention given to the management of excess sludge produced from municipal wastewater treatment. This is reflected in the national legislations that often simply depend on regulations of industrialized or more advanced countries without real to adapt it to local situations.

Law 48/1982 and ministerial decree 44/2000 regulates the sludge reuse in agricultural purposes only. For sludge reuse, the regulations are only considered heavy metals and pathogenic (or potentially-pathogenic) organisms as the only sources for contaminations. The law (as well as ministerial decree) obligates the end user to dispose sludge before land applications by storing for 6 months. However, the highly-contaminated sludge with heavy metals or pathogenic organisms have to be landfilled properly.

Egyptian Code for Reuse of Treated Sewage water in irrigation and Sludge in agriculture[2] covers the safe usage and controls the use of sludge resulting from the treatment process including all relevant aspects to this process (production and usage/disposal of sludge including the safe production of sludge (including the establishment of limits of various heavy metals), sludge production control, handling and sites not to be utilized and the need for producers and carriers of the sludge to obtain an appropriate license).

The decree was followed and updated by the Ministerial Decrees 288/2000 and 329/2001 through issue of an Egyptian Code for Reuse of Treated Sewage water in irrigation and Use of Sludge in agriculture.

The decree provides a definition of sludge according to wastewater treatment and refers to US Environmental Protection Agency (EPA) criteria as the basis for determining safe use without referring to any particular standards. It provides recommendations for the periodic follow up and analysis to prevent build-up of heavy metals and sets limits for heavy metal content (total metals form) in sludge as shown in Table 3.

[2] (Ministry of Housing, Utilities and New communities: Ministerial decree 288/2000 and 329/2001)

Table 3-2: Permissible Limits of safe use of treated sludge in agricultural applications

Parameter	Allowable limit (mg/kg ds)	Parameter	Allowable limit (mg/m^3)
Zinc (Zn)	2800	Mercury (Hg)	17
Copper (Cu)	1500	Chromium (Cr)	1200
Nickel (Ni)	420	Molybdenum (Mo)	18
Cadmium (Cd)	39	Selenium (Se)	36
Lead (Pb)	300	Arsenic (As)	41

Assessment Technique (based on bioavailability forms)

In the sludge/sediment assessment, metal speciation is recommended to separate the bioavailability forms (Exchangeable and Carbonate) of heavy metals to evaluate the environmental risk of metals in sludge/sediment. The heavy metals bioavailability form and portion depends on many factors[3] [4]included but not limited to:

- Sludge/sediment type
- Sludge/sediment salinity
- Sludge/sediment alkalinity
- Oxidation
- Yield history and sludge/sludge/sediment layer position (top or bottom)

The "Risk Assessment Code- RAC "is a flexible and realistic assessment method"[5] [6] [7] [8]which assesses the risk connected with the presence of metals in an aquatic environment. The metals in the sludge/sediments are bound to fractions with different strengths which give in turn an indication of the sludge/sediment reactivity. The application of the well-known "RAC" practice is important to define/classify the level of the associated risks (e.g. high, medium, low and no risks) and to investigate the proper management strategy to be applied including potential recycling options. Moreover, the produced sludge will be classified into several zones. The natural sources are dominated by parent rocks and metallic minerals, while the main anthropogenic sources are agricultural activities, where fertilizers, animal manures, and pesticides containing heavy metals are widely used, as well as industrial effluent discharges.

3 Singh, S.P.; Tack, F.M.G.; Verloo, M. "Extractability and bioavailability of heavy metals in dredged sediment derived surface soils", Laboratory of Analytical Chemistry and Applied Ecochemistry, Coupure-Links 653, B-9000 Gent, Belgium, Chemical Speciation and Bioavailability Journal 8:105-110, 1996

4 Riba, E. García-Luque, J. Blasco & T. A. DelValls "Bioavailability of heavy metals bound to estuarine sediments as a function of pH and salinity values", Chemical Speciation & Bioavailability, 15:4, 101-114, DOI, 2003: 10.3184/095422903782775163. To link to this article: https://doi.org/10.3184/095422903782775163

5 USEPA, "Framework for Metals Risk Assessment", Office of the Science Advisor Risk Assessment Forum U.S. Environmental Protection Agency Washington, DC 20460, March, 2007

6 Sanja Sakan and others" Geochemical Fractionation and Risk Assessment of Potentially Toxic Elements in Sediments from Kupa River, Croatia", MDPI, the United Nations Global Compact, Water Journal, Switzerland July 2020

7 Guangliang Zhang and others, Heavy metal fractions and ecological risk assessment in sediments from urban, rural and reclamation-affected rivers of the Pearl River Estuary, China, ELSEVIER Journal, Volume 184 Pages 278-288, October 2017.

8 Maha Ahmed and others, "Mobility and risk assessment of heavy metals by sequential extraction in coastal sediment south Mediterranean Sea, Egypt", Marine Systems & Ocean Technology ISSN 1679-396X Volume 14 Number 1, April 2019

Heavy metals enter the water system through a variety of sources other than antifouling products. Heavy metals in the sludge are usually having orders of magnitude higher than the overlying water column due to their tendency to adsorb onto particulate matter (Stark, 19989; Danis et al, 200410). They are known to bio-accumulate in water organisms. This may lead to a permanent ban on the consumption of fish in water streams.

Several efforts have been undertaken to develop standard procedures and criteria for the assessment of environmental impacts on sludge/sediments; but until now, there are few accepted guidelines for sludge/sediment quality (Larsen, B. and Jensen, A. 198911). There are several recommended guidelines for assessing the metals pollution in the sludge/sediments including:

- Canadian environmental quality guidelines (2002)
- Dutchtarget Adopted from Gruiz et al. (1998)
- Germain Claussen et al. (2000)
- GAFs Global average for fluvial sludge/sediments (Malm et al., 1989)

To study the bioavailability of the metals in sludge/sediment several extraction techniques with different chemical extractants in single step and/or in sequence have been developed[12]. Chemical partition of sludge/sediments is used also to deduce the source and pathways by which natural and anthropogenic heavy metals have entered the Environment. In this Metal speciation will be used to separate the bioavailability forms (Exchangeable and Carbonate) of heavy metals to evaluate the environmental risk of metals in bottom sludge/sediment. Sludge/sediment released in exchangeable and carbonate fractions less than 1% of the total metal and can be considered safe for the environment. On the contrary a sludge/sediment releasing in the same fractions more than 50% of the metal has to be considered highly dangerous and the metal can easily enter the food chain[13]. The following Table 3-3 describes the risk assessment code percentage.

Table 3-3: Risk Assessment Code (RAC) classification[14]

Risk	Metal in Carbonate and Exchangeable Fraction
No Risk	<1%
Very Low to Low Risk	1-10%
Medium Risk	11-30%
High Risk	31-50%
Very High Risk	75%

[9] Stark L (1998) Heavy metal pollution and macrobenthic assemblages in soft sediments in two Sydney estuaries, Australia. Marine and Freshwater Research 49, 533-40.

[10] Danis B, Wantier P, Dutrieux S, Flammang R, Dubois P, Warnau M (2004) Contaminant levels in sediment and asteroids (Asterias rubens L., Echinodermata) from the Belgian coast and Scheldt estuary: polychlorinated biphenyls and heavy metals. Science of the Total Environment 333, 149-165.

11 Geochemistry and Health 19, 63-66.Larsen, B. and Jensen, A. (1989): Evaluation of The Sensitivity Of Sediment Monitoring Stationary In Pollution Monitoring. Mar pollut Bull 20:556-60.

[12] Houba, V.J.G., Lexmond, Th.M., Novozamsky, I. & V a n d e r Lee, J.J. (1996) State of the art and future developments in soil analysis for bioavailability assessment. – Sci. Total Environ. 178, 21.

[13] Perin, G., Craboledda, L., Lucchese, M., Cirillo, R., Dotta, L., Zanette, M. L. and Orio, A. A., (1985) "Heavy metal speciation in the sediments of Northern Adriatic Sea. A New approach for environmental toxicity determination, in Lckkas, T.D. (cd). Heavy metals in the environment" vol. 2, CEP Consultants, Edinburgh.

[14] Houba, V.J.G., Lexmond, Th.M., Novozamsky, I. & V a n d e r Lee, J.J. (1996) State of the art and future developments in soil analysis for bioavailability assessment. – Sci. Total Environ. 178, 21.

While the following Table 3- presents the typical output from RAC analysis & assessment for bottom sludge/sediment layer.

Table 3-4: Typical output from RAC analysis and assessment for a sludge/sediment layer

Metals	Station 1	Station 2	Station 3
Cadmium (Cd)	Very Low Risk	No Risk	Very Low Risk
Chromium (Cr)	Very Low Risk	No Risk	Very Low Risk
Cobalt (Co)	Very Low Risk	Low Risk	Low Risk
Copper (Cu)	Low Risk	Low Risk	Low Risk
Lead (Pb)	No Risk	No Risk	No Risk
Nickel (Ni)	No Risk	No Risk	No Risk
Zinc (Zn)	Very Low Risk	No Risk	Very Low Risk
Arsenic (Ar)	No Risk	No Risk	No Risk
Mercury (Hg)	No Risk	No Risk	No Risk
Aluminum (Al)	No Risk	No Risk	No Risk
Silver (Ag)	Very Low Risk	No Risk	Very Low Risk
Iron (Fe)	No Risk	No Risk	No Risk

3.5.3. Involuntary resettlement and the compensation of affected persons

The WB's policy on involuntary resettlement and the compensation of affected persons is clearly spelled out under the Bank's operational safeguard policy (OP) # 4.12.

"For sector investment operations that may involve involuntary resettlement, the Bank requires that the project implementing agency screen sub-projects to be financed by the Bank to ensure their consistency with [OP 4.12]. For these operations, the borrower submits, prior to appraisal, a resettlement policy framework that conforms to this [OP 4.12]. The framework also estimates, to the extent feasible, the total population to be displaced and the overall resettlement costs."

While the right of squatters is not addressed in the Egyptian law, the World Bank's policy OP 4.12 requires squatters including illegal farming and light building to be provided with resettlement assistance when their residences are affected by projects financed by the Bank, but no compensation for the land the squatters are occupying.

Egyptian legislation does not recognize the rights of squatters. There have been resettlement cases in which the Egyptian Government compensated squatters because of political sensitivity rather than provisions in the law or in compliance with the Bank's policy.

Egyptian previous practice in dealing with squatters 'right reflects the political pressure and considers the social dimension. The Government has been forced to provide an alternative option for groups of households either in terms of alternative shelter or cash and crop compensation in case of crops damage.

The Egyptian law makes no provision to provide resettlement assistance to project affected people, whereas OP 4.12 offers support for a transition period. The OP 4.12 further requires that the cost of this assistance should be included in the overall resettlement plan.

Without equivalent practices between Egyptian law and the Bank's OP 4.12, it would be difficult to provide assistance to Project Affected People (PAPs) at their new resettlement site. It would be hard to ensure opportunities for PAPs to restore or improve their income and as well as being provided temporary income support if required. Table 3- below presents a more detailed description of the Egyptian legislation related to the social aspects.

Table 3-5: detailed description of the Egyptian legislation related to the social aspects

Title of legislation	Summary and how this legislation applies to this project	Year
EEAA ESIA guidelines related to the Public Consultation		
Based on Law number 4/1994 on Environmental Protection	Consultation of the community people and concerned parties with the needed information about the project. All stakeholders should be invited. Paragraph 6.4.3 of Law 4/1994 on Environmental Protection provides detailed information on the scope of public consultation, methodology and documentation **Paragraph 6.4.3 Requirements for Public Consultation in the EEAA ESIA Guidelines**[15] Paragraph 6.4.3.1 Scope of Public Consultation Paragraph 6.4.3.2 Methodology of Public Consultation Paragraph 6.4.3.3 Documentation of the Consultation Results Paragraph 7 Requirement and Scope of the Public Disclosure	1994
Land acquisition and involuntary resettlement (The project will not result in resettlement activities)		
Law 10/1990	On Property Expropriation for Public Benefit. It describes acquisition procedures as follows: 1. Expropriation procedures start with the declaration of public benefit based on the relevant presidential decree. The decree includes a memorandum explaining the project including a complete plan for the project and expected construction (Law 59/1979 & Law 3/1982 provided that the Prime Minister issues the decree); 2. The decree and the accompanying memorandum must be published in the official newspapers; • A copy of the decree should	1990

[15]EEAA (2009) Guidelines and Foundations for the Procedures of ESIA.Arabic publication, second edition.

	be published at the main offices of the relevant local Government unit. This law has specified, through Article 6, the composition of the valuation committee. The committee is formed at the Governorate level, and is composed of a representative from the relevant Ministry's Surveying Body (as President), a representative of the Agricultural Directorate, a representative of the Housing and Utilities Directorate, and a representative of the Real Estate Taxes Directorate in the Governorate. The compensation shall be estimated according to the prevailing market prices at the time of the issuance of the Decree for Expropriation. Amendments in 2015 has specified the period allowed for submitting a grievance to be 15 days and allowed additional 30 days to submit all relevant documents	
Law 577/1954	**Law 577/54**, which was later amended by Law 252/60 and Law 13/162, and establishes the provisions pertaining to the expropriation of real estate property for public benefit and improvement.	1954
Law 27/ 1956	**Law No. 27 of 1956**, which stipulates the provisions for expropriation of districts for re-planning, upgrading, and improvement, and the amended and comprehensive Law No.10 of 1990 on the Expropriation of Real estate for Public Interest. The first article of Law No. 27 of 1956 allows for the expropriation of districts for their improvement, upgrading, re-planning, and reconstruction. Article 24 of Law 577/54 also stipulates that in case only partial expropriation of real estate property is required, and the remaining un-expropriated part will not be of benefit to the owner; the owner shall be given the right to submit a request within 30 days (beginning from the date of final disclosure of the list of the expropriated property) for the purchase of the entire area. It should be noted, that the new law has not restricted the right to request the purchase of the remaining un-expropriated portion of real estate regardless whether it is a building or land.	1956
Civil code 131/1948	**Articles 802-805 acknowledge the right for private ownership**. • Article 802 states that the owner, according to this law, has the sole right of using and/or disposing his property. • Article 803 defines what is meant by land property Article 805 states that no one may be deprived of his property except in cases prescribed by Law and would take place with fair compensation.	1948
Protection of communities Human Rights Laws		
Law no. 94/2003	The Law on Establishing the National Council for Human Rights (NCHR) aims to promote, ensure respect, set values, raise awareness and ensure adherence with human rights. At the forefront of these rights and freedoms are the right to life and security of individuals, freedom of belief and expression, the right to private property, the right to resort to courts of law, and the right to fair investigation and trial when charged with an offence.	2003

3.6 Detailed Description and Gap Analysis of National Environmental Requirements and WB Requirements

Whenever there is a discrepancy between national requirements and international requirements, the `most strict requirements shall be adopted.

3.6.1 Air Quality

Regulations

Table 3-6: Comparing Egyptian Legislation to the requirements of the World Bank for Air Quality

Issue	Requirements of Egyptian legislation		Requirements of WB	
	Reference	***Inflections***	***Reference***	***Inflections***
Air Quality	**Article 34 of Law 4/1994** amended by law 9/2009, 105/2015 and **Article 34** of its Executive Regulation (ERs), and Decree 710/2012 Annex 5 of the ERs	Standards for ambient air quality	OP 4.01 WBG GENERAL EHS GUIDELINES	Ensure the environmental sustainability of investment projects Air Emissions and ambient air quality (Section 1.1, WHO Ambient Air Quality Guidelines)

Standards and limits

Table 3-7: Comparing Egyptian Legislation to the World Bank for Air Quality standards and limits

Issue			Requirements of Egyptian legislations					Requirements of WB			
	Ambient air parameters		***Ambient air pollutants threshold (Egyptian)***					***Ambient air pollutants threshold According to WHO***			
	Exposure period		1 hr	8 hr	24 hr	1 year		1 hr	8 hr	24 hr	1 year
	Carbon monoxide CO mg/m^3		**30**	**10**	N/A	N/A		N/A	N/A	N/A	N/A
	Sulfur dioxide SO_2 $\mu g/m^3$		**350**	N/A	150	**60**		N/A	N/A	**125**	N/A
	Nitrogen oxides NO_x $\mu g/m^3$		300	N/A	**150**	60		**200**	N/A	N/A	**40**
	Particulates PM_{10} $\mu g/m^3$		N/A	N/A	**150**	**70**		N/A	N/A	150	70
	Particulates $PM_{2.5}$ $\mu g/m^3$		N/A	N/A	80	50		N/A	N/A	**75**	**35**
	TSP $\mu g/m^3$		N/A	N/A	**230**	**125**		N/A	N/A	N/A	N/A

	Ozone		**180**	**120**	N/A	N/A		N/A	160	N/A	N/A

All parameters are in (µg/m^3) unless otherwise noted.

N/A = not applicable; (Highlighted Vales shall be followed by the project)

3.6.2 Noise

Regulations

Table 3-8: Comparing Egyptian Legislation to the World Bank for Noise Regulations

	(Egyptian requirements)		(WB requirements)	
Noise	***Reference***	***Inflections***	***Reference***	***Inflections***
	Article 42 of Law 4/1994 amended by law 9/2009 and **Article44** of ERs (amended by Decree 1095/2011 amended by Decree 710/2012).	Maximum allowable limits for ambient noise intensity Maximum exposure duration	OP 4.01	Ensure the environmental sustainability of investment projects
			WB GENERAL EHS GUIDELINES Table 1.7.1 Table 2.3.1	Presents Noise Level Guidelines Identify maximum increase in background noise levels at the nearest receptor location off-site. Presents noise limits for different working environments

Standards and Limits for Ambient Noise

Table 3-9: Comparing Egyptian Legislation to the World Bank for Ambient Noise standards and limits

	Egyptian Law 4 Requirements				Requirements of WB (Table 1.7.1 of the WBG General EHS Guidelines)		
Noise		Permissible limit for noise intensity decibel			Receptor	One hour L_{Aeq} (dBA)	
	TYPE OF AREA	DAY 7 a.m. to 10 p.m.	NIGHT 10 p.m. to 7 a.m.			Day time 07:00 – 20:00	Night time 22:00 - 07:00
	Sensitive Areas (schools- hospitals- public parks- rural areas)	50	40		Residential; Institutional; educational	55	45
	Residential areas in with limited traffic and public services are available	55	45		Industrial; commercial	70	70
	Residential areas in the city where commercial activities are available	60	50				
	Residential areas located adjacent to roads which width is less than 12m, and workshops or commercial or entertainments activities are found	65	55				
	Areas located adjacent to roads which width is 12m or more, or light industrial areas.	70	60				
	Industrial areas (heavy industries)	70	70				

Standards and Limits for Noise Levels in the Work Environment

Table 3-10: Comparing Egyptian Legislation to the World Bank for Noise Levels in the work Environment Standards and Limits

	Egyptian Law 4 Requirements			Requirements of WB (Table 2.3.1 of the WBG General EHS Guidelines)		
Noise	TYPE OF PLACE AND ACTIVITY	Maximum Permissible Noise [Level Equivalent To Decibel (A)] At The Beginning of 2014		Location /Activity	Equivalent level LAeq,8h	Maximum LAmax, fast
	Work place with up to 8 hour shifts and aiming to limit noise hazards on sense of hearing*	85		Heavy Industry (no demand or oral communication	85 dB(A)	110 dB(A)
	Hospitals, clinics, public offices, etc	80		Light industry (decreasing demand for oral communicatio)	50-65 dB(A)	110 dB(A)
	Administrative offices – control rooms	65		Open offices, control rooms, service counters or similar	45-50 dB(A)	N/A
	Work rooms for computers, typwriters or similar equipment	70		Individual offices (no disturbing noise)	40-45 dB(A)	N/A
	Work rooms for activities requiring routine mental concentration	60		Hospitals	30-35 dB(A)	40 dB(A)

*: If the measured noise at the workplace increased over the maximum allowable limit by 3 dBA, the exposure period shall be reduced to half of the exposure period. In addition, wearing proper ear muffs is a must.
Noise level at any time at the work place shall not exceed 135 dBA

Noise shall be measured inside working environment in LAeq unit in accordance with ISO 9612/ ISO 1996 or Egyptian standards Depending on the activity as demonstrated in the above table.

3.6.3 Water Quality

According to WBG EHS general guidelines, limits for discharging treated wastewater to surface water is subject to the compliance with national standards for sanitary wastewater discharges.

Regulations

Table 3-11: Comparing Egyptian Legislation to the World Bank regulations discharging treated wastewater

Issue	Requirements of Egyptian legislations		Requirements of WB	
	Reference	*Inflections*	*Reference*	*Inflections*
Water Quality	**Article 51,** The Executive Regulations of Law 48 for the year 1982 amended with Ministerial Decree 402 / 2009 and Ministerial Decree 92/2013	Drains Ambient water quality before reaching main watercourse	OP 4.01	Ensure the environmental sustainability of investment projects
	Article 52, The Executive Regulations of Law 48 for the year 1982 amended in 2013 and Ministerial Decree 92/2013	Maximum limits for discharging treated sanitary wastewater into drains	WB GENERAL EHS GUIDELINES	Discharges of process wastewater, sanitary wastewater, wastewater from utility operations or storm water to surface water should not result in contaminant concentrations in excess of local ambient water quality criteria
	Ministerial Decree No. 44/2000 amending Law 93/1962	Controlling the discharge of wastewater into the sewage system and public network,	WB GENERAL EHS GUIDELINES	Discharges of industrial wastewater, sanitary wastewater into public or private wastewater treatment systems should meet the pretreatment and monitoring requirements of the sewer treatment system into which it discharges.
	Ministerial Decree No. 44/2000 amending Law 93/1962	Standards for reuse of treated wastewater in irrigation of tree forests		
	Ministerial Decree No. 44/2000 amending Law 93/1962	It encompasses this statement: "Wastewater discharge licenses must be acquired from the concerned authorities during the		

Issue	Requirements of Egyptian legislations		Requirements of WB	
		construction and operation phase”		
	Law 38/1967 and its executive regulations (decree 134/1968)	Concerning cleanliness and sanitation and also regulates the collection, transportation, storage and disposal of solid waste.		

Standards and Limits for Water Quality

Table 3-12: Comparing Egyptian Legislation to the World Bank water quality standards and limits

	ER of Egyptian Law 48/1982 amended by Decree 402/2009	**IFC / WB guidelines for wastewater and ambient water quality.**
Parameter	**Standards&Limits (mg/l)**	
Total dissolved solids TSS	1000≤	
Temperature	Maximum difference of 3°C as compared with the receiving watercourse	
Dissolved Oxygen	5≥	
pH	min 6.5 and max 8.5	6 - 9
BOD	≤30	30
COD	≤50	125
Total Nitrogen (TN)	15	10
TotalP (TP)	3	2
Oil&Grease	≤3	10
Mercury	≤0.001	
Fe	≤3	
Mn	≤2	
Cu	≤1	
Zn	≤2	
Phenol	≤0.05	
As	≤0.01	
Cd	≤0.03	
Cr	≤0.05	
Free Cyanide	≤0.01	
Pb	≤0.1	
Ni	0.1	

	ER of Egyptian Law 48/1982 amended by Decree 402/2009	IFC / WB guidelines for wastewater and ambient water quality.
Parameter	**Standards&Limits (mg/l)**	
Se	0.01	
Coliform 100 cm^3	5000	400

CHAPTER 4

ENVIRONMENTAL AND SOCIAL BASELINE CONDITIONS

4 Environmental and Social Baseline Conditions

4.1 Project Location

Helwan area is on the East bank of the Nile, opposite to the ruins of Memphis, Originally a southern suburb of Cairo. The project as agreed with CAPW and Greater Cairo Wastewater Company was studied as two alternatives. Figure 4-1 to Figure 4-4 present the maps of the current project location and the two alternatives, and Table 4-1 illustrates the geographic location of different project elements. The first alternative includes the expansion of existing WWTP in Arab Abo Sa'ed Site with an additional design capacity 250,000 m3/ day, while the second alternative is to construct a new treatment plant at the El-Kurimat Desert Road site with a capacity of 250,000 m^3/ day. The project extends through Torah city, 15th of May, Helwan, Al Tebin, and Al Saff.

Figure 4-1: Project location in Helwan area

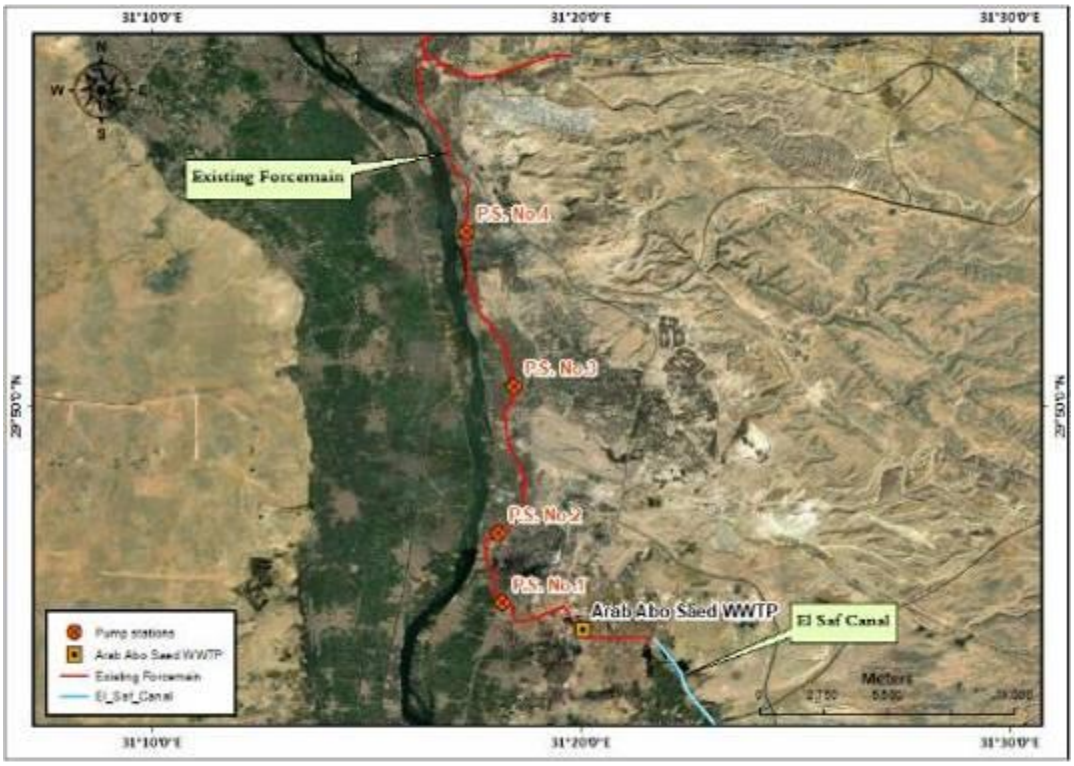


Figure 4-2: location of the current project components

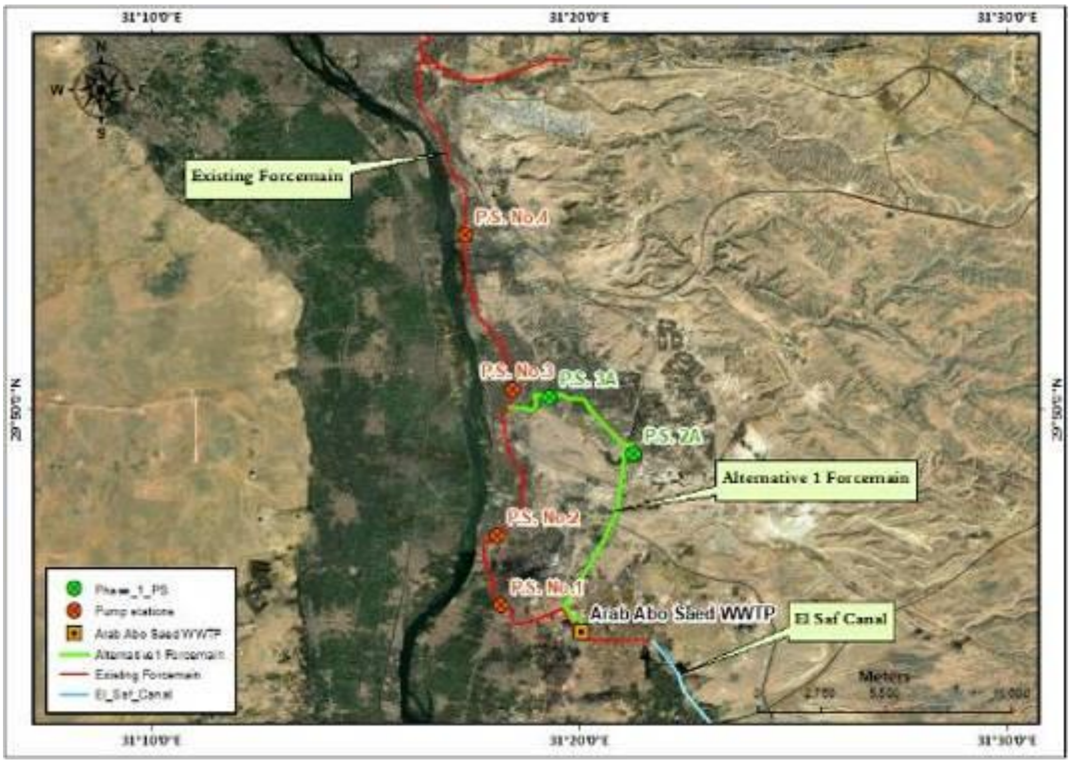


Figure 4-3: location of alternative 1 project components

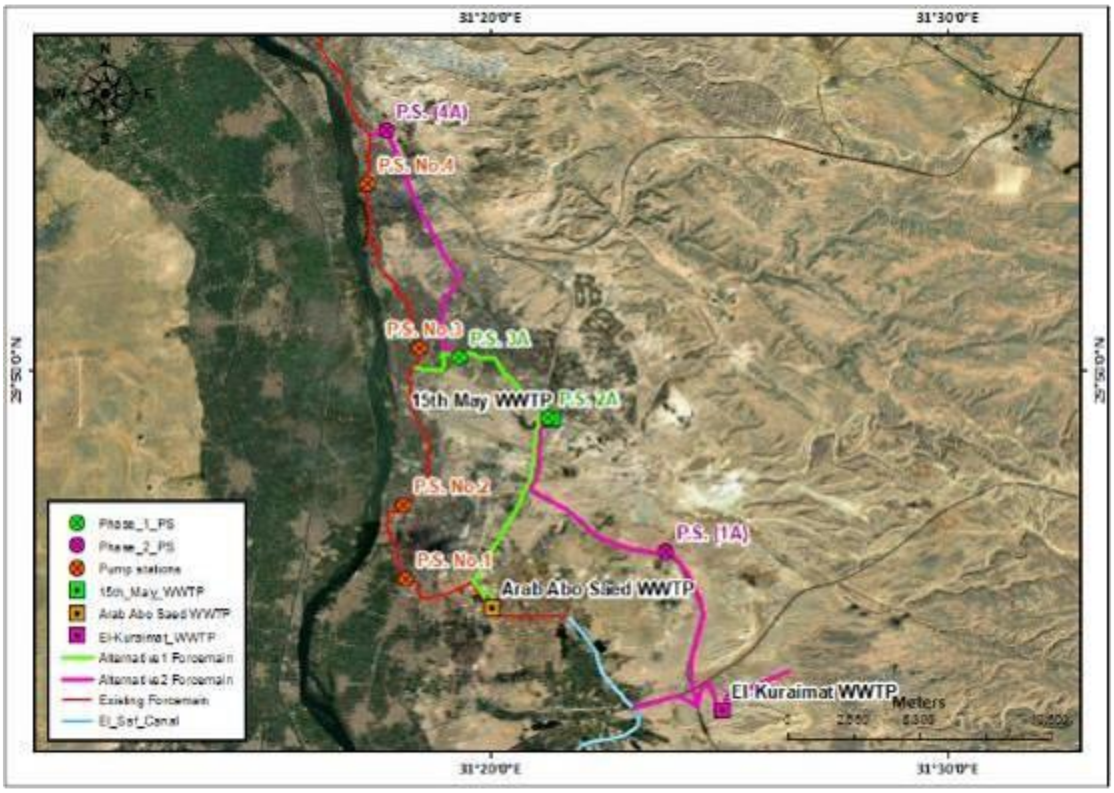


Figure 4-4: location of alternative 2 components

Table 4-1: Geographic location of different project components

#	Component	X	Y
1	Arab Abo Sa'ed WWTP	31.33374	29.74671
2	15th May WWTP	31.35573	29.81535
3	15th May WWTP	31.35573	29.81535
4	El-Kuraimat WWTP	31.41758	29.70923
5	P.S. No.1	31.30262	29.75715
6	P.S. No.2	31.30137	29.78434
7	P.S. No.3	31.30740	29.84123
8	P.S. No.4	31.28863	29.90129
9	P.S. 1A	31.39728	29.76712
10	P.S. 2A	31.35445	29.81600
11	P.S. 3A	31.32176	29.83815
12	P.S. 4A	31.29551	29.92084

4.2 Helwan WWTP Reuse Scheme, Al Saff Project

4.2.1 Background

Al-Saff Canal project is considered one of the major projects implemented by Ministry of Agriculture and land reclamation (MALR) with 42,000 feddans to be reclaimed in the east of Markaz Al Saff, Irrigated by the treated effluent from Helwan WWTP though Al Saff canal with 52.0 km length since 1983 .

With the continued irrigation of these lands and the absence of a surface or covered drainage system serving the Al-Saf lands, salt leaching problems began to appear in many parts, especially those lands adjacent to Al-Saf canal and formation of ponds in addition to the rise in groundwater levels in the old western agricultural lands adjacent to the Nile River and the rise in ground water levels within residential areas Existing in the area due to the infiltration of water inside the top soil and the direction of water to the old, low lands, where the levels of ground water have risen, which poses a real threat to the crop productivity of these lands in the future. Therefore the necessity of finding an appropriate solution to solve these problems and improve the drainage situation aroused. Study was conducted by Drainage Research Institute (DRI, October 2019)[16]

4.2.2 Topography

It became clear that the topography of the region, shown in Figure 4-5, varies from one location to another, as it consists of non-flat plateaus and semi-mountainous areas whose levels descend west towards the Nile from about 80 meters above sea level in the east to about 30 meters above sea level in the west where the ancient agricultural lands then descend towards the west until the river The Nile is irregular slopes, and there are some internal depressions and ponds in the region. The most important of these ponds are the reef and steel plant pool and the national company pool.

4.2.3 Soil Permeability

The permeability of the soil was measured at several sites in the study area as shown in Figure 4-6. Figure 4-6 presents the distribution contour lines of the soil permeability values shows that that the soil permeability is high and ranges from 0.98 to 1.57 m / day with an average of 1.08 m / day, which is proportional to the soil texture Prevailing in the area.

There is no an impermeable layer at depths of more than 10 meters below the soil surface. According to its levels, the impermeable layer descended from the south towards the north.

4.2.4 Water Table

From the above it is clear that the depths of the surface ground water, which is shown in Figure 4-7, rises in the east and south of the region, where the path of Al-Saff canal and slopes westward with low natural levels of land, forming some small ponds.

4.2.5 Subsurface water Salinity

The salinity level of groundwater was also measured in the sites. Values show that the degree of salinity of groundwater in the monitoring wells of Drains No. 1 and 2 to north ranged between 1.2 dS/m and 13 dS/m. With drain 3, it ranged between 9 dS/m and 30 dS/m. With drain 4 to south, it

[16] Drainage Research Institute, Technical final report of the design the open drainage system study for Al-Saf area, October 2019 submitted to Egyptian Public Authority for Drainage Projects, EPADP- MWRI

ranged between 5 dS/m and 100 dS/m. While in Drains 5 and 6 to further south, it ranged between 3.8 dS/m and 24 dS/m. The high degree of salinity of the groundwater is due to the fact that the study area is a semi-arid area and water logging in which the temperature rises and the rate of rainfall decreases, and this increases the amounts of evaporation, which helps to collect salts in the soil sector and increase the degree of salinity of the soil solution. Also, the absence of a draining system in the study area led to a rise in the groundwater level and the accumulation of salts in the surface layers of the soil, and thus the salinity of the soil solution.

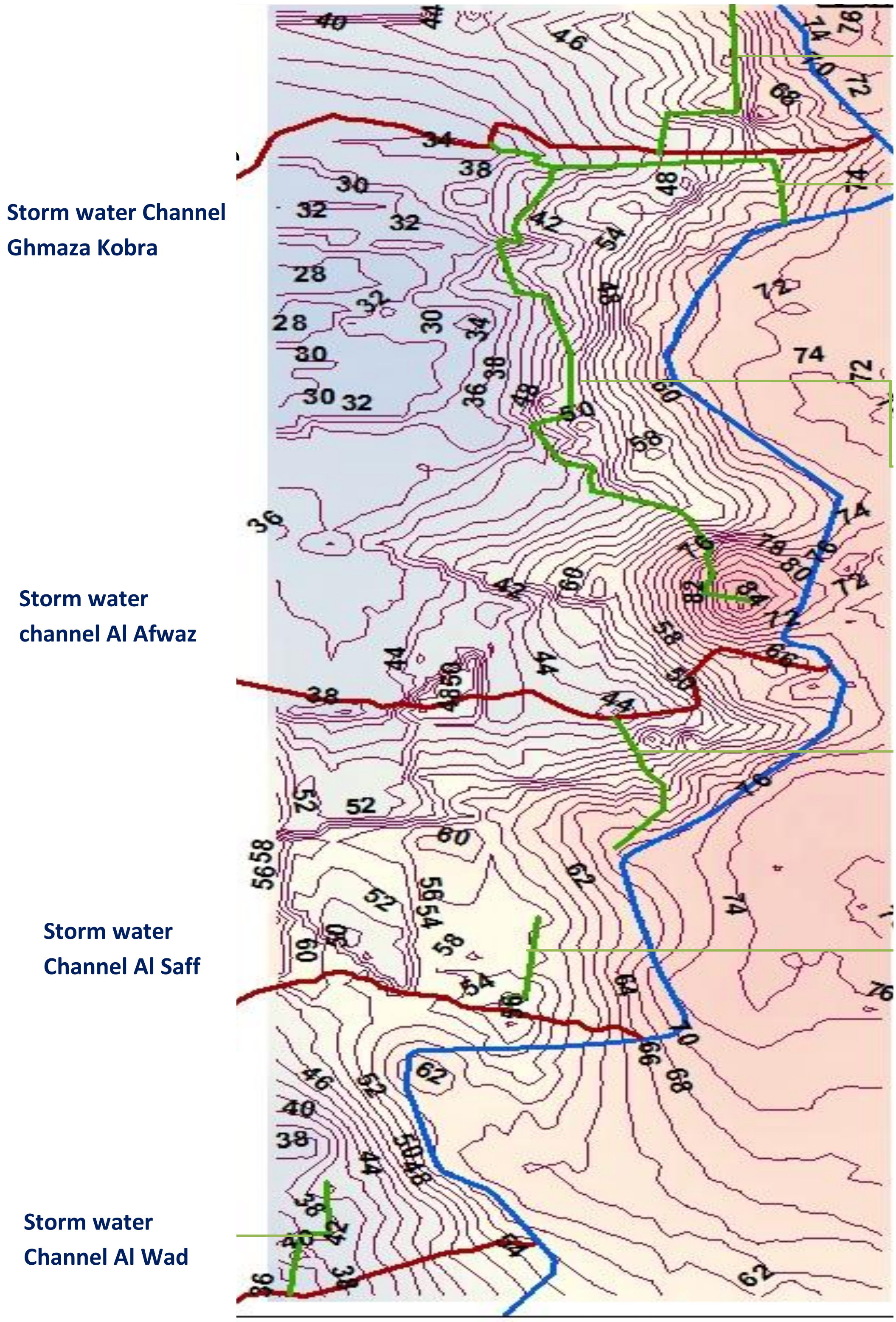


Figure 4-5: Topography map of Al-Saff agriculture area[17]

[17] Drainage Research Institute, Technical final report of the design the open drainage system study for Al-Saff area, October 2019 submitted to Egyptian Public Authority for Drainage Projects, EPADP- MWRI

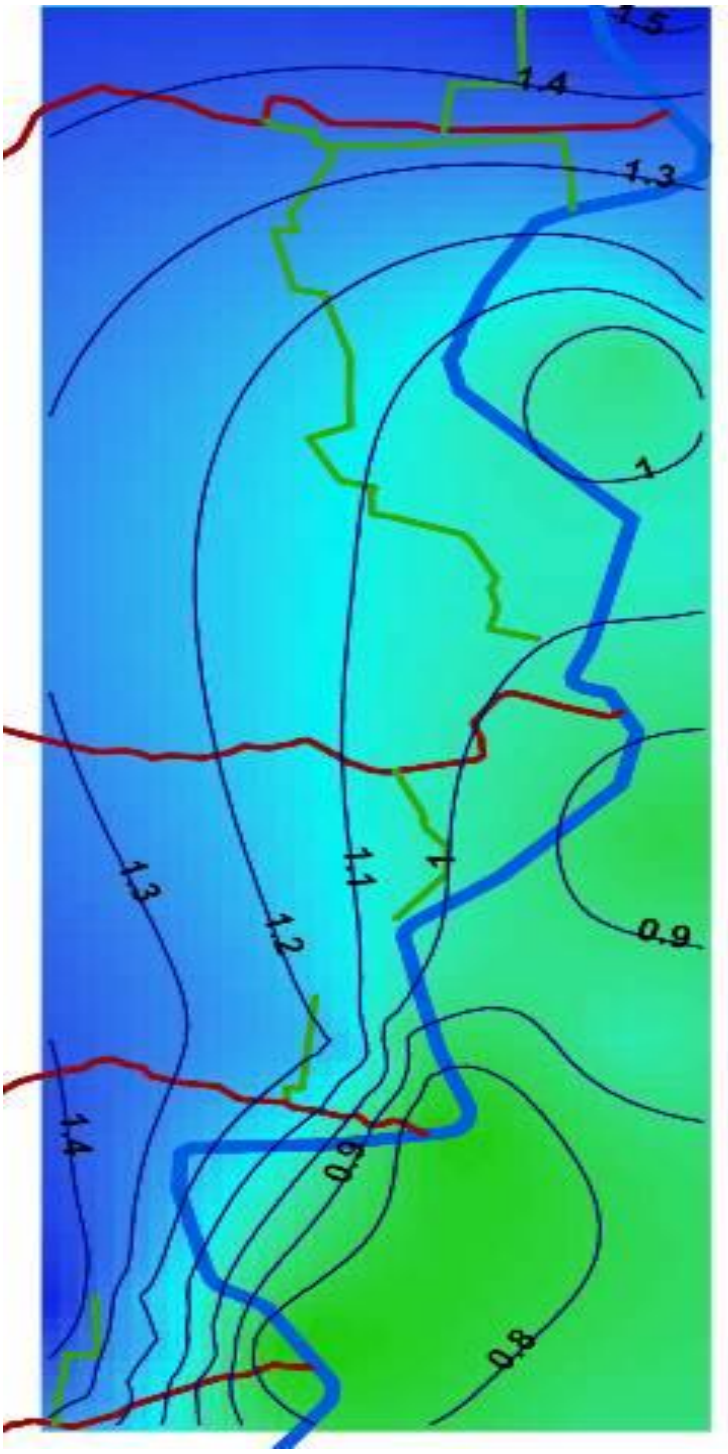


Figure 4-6: Distribution contour lines of soil permeability values (m/day)[18]

[18] Drainage Research Institute, Technical final report of the design the open drainage system study for Al-Saff area, October 2019 submitted to Egyptian Public Authority for Drainage Projects, EPADP- MWRI

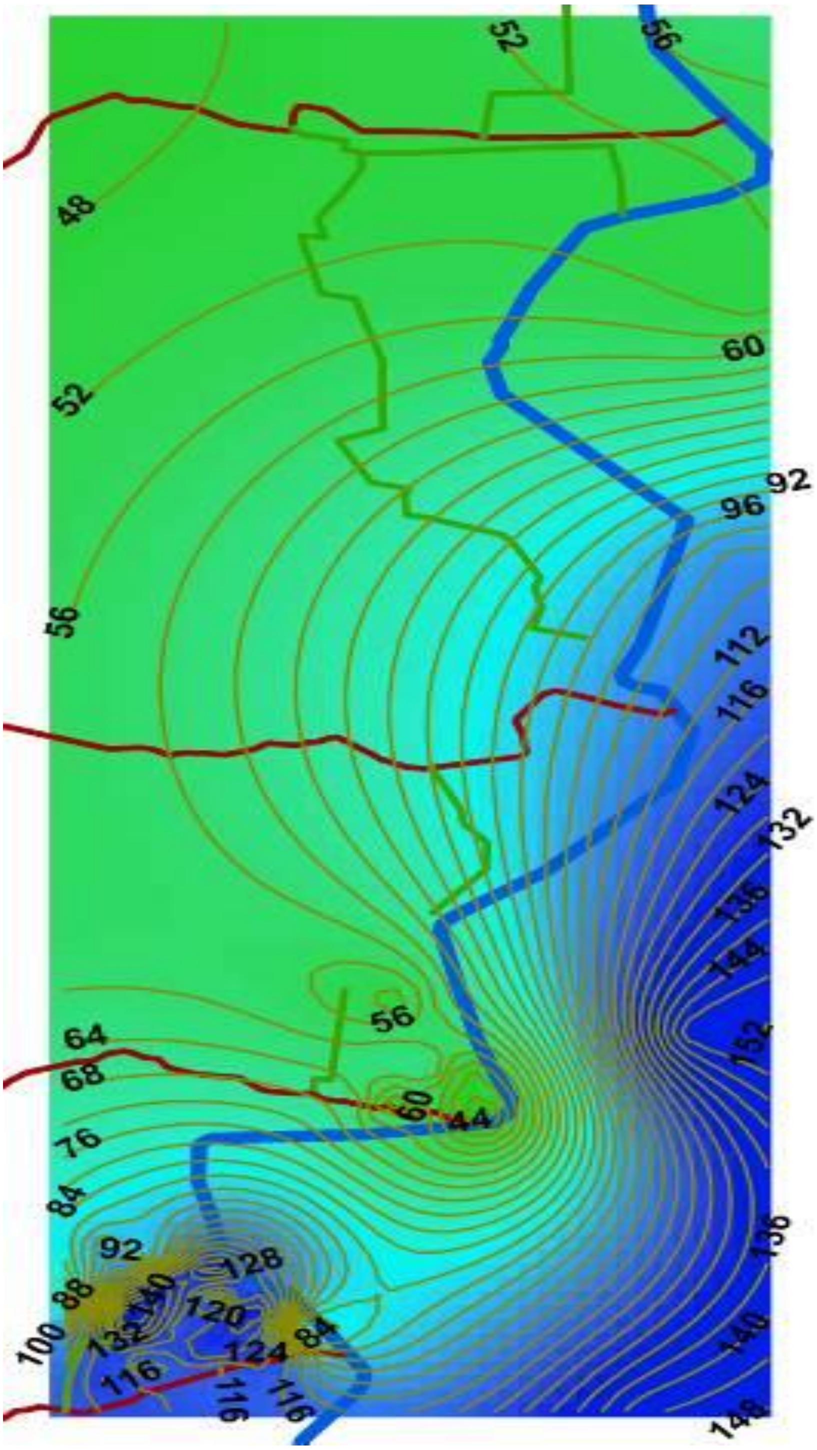


Figure 4-7: Distribution contour lines of the average depths (cm) of the groundwater in Al-Saff area[19]

[19] Drainage Research Institute, Technical final report of the design the open drainage system study for Al-Saff area, October 2019 submitted to Egyptian Public Authority for Drainage Projects, EPADP- MWRI

4.2.6 Al Saff Canal Water Quality

The study of the quality of irrigation water in the Al-Saff canal representing the canal reaches as presented in Table 4-3 where the results indicate the following:

- Total alkalinity within the permissible percentage in Article 60 of Law 48 of 1982 for all samples (between 6 to 9)
- Total dissolved Oxygen within the permissible percentage in Article 60 of Law 48 of 1982 for all samples (over 4 mg/l)
- The percentage of dissolved solids does not exceed the permissible percentage in Article 60 of Law 48 of 1982 (Below 2000 mg/l).
- The percentage of total suspended solids exceeded the permissible percentage in Article 66 of Law 48 of 1982 for samples from all samples.
- The relative increase in Biological Oxygen Demand BOD and the number of total and fecal coliform bacteria and its increase from the maximum, as the percentage of fecal bacteria exceeded the standard specifications for most of the samples

Table 4-2: Water quality results analysis along Al-Saff Canal, DRI, 2019

Parameter	Km 1.0	Km 5.0	Km 10.0	Km 15.0	Law 48
pH	7.45	7.76	7.58	7.37	6 to 9
Dissolved Oxygen _DO	5.32	4.13	5.22	5.45	> 4
Turbidity	197	265	224	188	
Carbonte_Co3	0	0	0	0	
Bicarbonate HCO3	276	281.5	283.5	287.3	
Total Alkalinity	276	281.5	283.5	287.3	
Electrical Conductivity_Ec	1.49	1.46	1.56	1.47	
Total Phosphorus (T_P)	0.89	0.91	1.28	0.96	
Total Volatile (TVS)	23	34	33	24	
Total dissolved Solids (TDS)	970	962	1043	974	2000

4.2.7 Cultivated cropping Pattern

The results of surveying the actually crops grown within Al-Saff area served during the study period (DRI, 2019) , it was found that the cultivated areas currently within the proposed drains area served are estimated at about 8155 Feddans, Table 4-3 shows the actual crop pattern, of a total of about 11 thousand feddans and their distribution is as follows:

- The areas of cultivated lands around Proposed Drain No. 1 1450 feddans,
- The areas of cultivated lands around the proposed bank No. 2 1050 feddans,
- The areas of cultivated lands around the proposed bank No. 3 2550 feddans,
- The areas of cultivated lands around the proposed bank No. 4 1250 feddans,
- The areas of cultivated lands around the proposed bank No. 5 1200 feddans,
- The cultivated lands around the proposed bank No. 6, 950 feddans

Table 4-3: Actual crops pattern grown within Al-Saff area

Season	Crop type	% cultivated land
Winter season	Clover	30%
	Wheat	30%
	Potato	20%
	Barley	10%
	Feeds	10%
Summer season	Sesame	30%
	corn	40%
	Feeds	10%
	Fallow land	20%

4.2.8 Problems threaten Al-Saff Canal Agriculture Area Served

The study conducted by Drainage Research Institute in 2019 showed many problems threaten the agriculture practice within Al-Saff canal area served as listed below and illustrated in the following Figure 4-8 to Figure 4-12 :

- There is basic problem from the starting of the project in the typical crack canal lining and collapse up to km 22.0 due to quality of the implementation and soil type (loamy type in some area).
- There are around 38 official openings along the canal for irrigation where there are around 106 illegal irrigation openings established by breaking the lining of the canal lead to more leakage and drainage problem.
- More drainage and seepage problem due to the water level of Al-Saff canal is higher than the level of agricultural lands, as well as residential areas, by more than about 40 m, and due to the nature of the geological structure of the area from fissured rocks and sandy loamy soil.
- Absence of open drainage system and using the storm water channels for drainage purpose.
- The irrigation system used in most of the agriculture lands is flood irrigation leading to a lot of water losses and drainage rate.

Figure 4-8: Water logging due to excessive leakage in low land area.

Figure 4-9: Surface water run off increase drainage water problem in project area

Figure 4-10: Drainage water problem causing ponds in project area

Figure 4-11: Crop damage and loss due to drainage problem in Al-Saff project area

Figure 4-12: Cracks in side bank lining in Al-Saff Canal

4.3 Water Supply and Sanitation facilities

The general project of Helwan is designed and implemented to serve the southern part of Greater Cairo, which starts from Al-Maadi and extends southward for a distance of 30 km, to serve residential areas. Industrial areas, including iron and steel factories, coke factories, forgings, cement factories, the Nasr Company for Cars, many military factories in the region, in addition to the residential areas and industrial areas covered by the wastewater project. It also serves Helwan University and many military and security sites, including Helwan Airport, Tora Prisons, security forces in Tora, Police Trustees Institute in Tora, Helwan Air Force Secondary School, entertainment and commercial areas. (Source: Feasibility study report for Helwan, 2015; Pre-feasibility study for Helwan, 2020).

Here are main five water treatment plant are in operation serving the project catchment including Tebben, Kafr El Alo, North Helwan, Maadi, and Fusttat with total capacity of around 1.97 million m3/day, Table 4-4 shows water supply capacity. No shortage of water is reported from the served area over the year except few hours for maintenance and repairing broken or leakage from water supply pipeline.

Table 4-4: Water supply capacity in the project area[20]

WTP	capacity 1000 m^3/day			Time for extension in operation
	Current	**Extension**	**Total**	
Tebben	280	100	380	2022
Kafr El Alo	70	400	470	60% progress
North Helwan	300	200	500	Ready for operation
Maadi	320	-	320	-
Fusttat	300		300	-
Total	**1270**	**700**	**1970**	

Helwan (Arab Abo Sa'ed) WWTP treatment works receives wastewater from the catchment area previously mentioned via a series of culverts and pumping stations forming a wastewater conveyance system. Following treatment at Arab Abo Sa'ed, the chlorinated final effluent is discharged into Al Saff Canal for re-use in agriculture purposes. Chapter 3 Shows a general scheme and details of the project. The main components of the original Helwan project were illustrated by Atkins Study as shown in Table 4-5.

[20] Hand-out, INFRA Engineering, January 2021

Table 4-5: Key Data of the Existing Wastewater Project in Helwan[21]

Item	Sanitation project in Helwan
Design capacity of the treatment plant (m^3/day)	First stage: 350,000 m^3/day starting from year 1990 Second stage: 200,000 m^3/day starting from year 2000
Starting operation date	End of 1989/Start of 1990
Units in the Treatment plant	Wastewater units in Arab Abu Sa'ed WWTP: ▪ Conventional activated sludge (primary sedimentation tank, aeration tank, final sedimentation tank, and chlorination tank). ▪ Sludge units: Gravity thickener and drying beds.
Service area	The southern part of Greater Cairo (North of Maadi to the South of Al-Tebbin). 15th of May District- all residential areas surrounding the Autostrad - the industrial zone of Helwan, Al-Tebbin, and the 15th of May. Military areas (Helwan Airport, Tora Prisons, Security Forces, Police Trustees Institute). Commercial and recreational areas, clubs, etc.
Population	One million Capita (First stage)./ 1.5 million Capita (Second stage).
Project components	Major collectors start from Al-Maadi, passing by Al-Tarwat and Kafr Al-Alwi, to Arab Abu Sa'ed. ▪ Three screw pump stations (Station No. 4 in Al Maasarah - Station No. 3 in Helwan - Station No. 2 in Al-Tebbin) ▪ Main pump station No. 1. ▪ Four force mains, each with a diameter of 1500 mm (2 first stages, 2 second stages) from pump station No. 1 to the entrance of the treatment plant. ▪ Treatment plant using aeration system. ▪ The irrigation pumping station inside the treatment plant, which receives the treated water from the plant and pumps it to the entrance of El-Saff canal at distance 3.5 km from the plant.

There are some reporting regarding overflow during summer season from 3:00 PM to 11:00 PM from manholes of some zones within the served area including:

- Tora Prison (A) area in the Corniche - Cairo Prison area in the Corniche - Prisons General Stores;
- Extension of Ekhaa
- Tora al-Madbah
- The land of the association and the land of praise butrah
- Kotsika tunnel
- Alma'sara area

[21] COWI-ATKINS-Chemonics "Rehabilitation & Extension of Various WTPs-WWTPs Prefeasibility Study" June 2020 -Helwan Wastewater Expansion Project

The following Figure 4-13 illustrates typical impacted area by wastewater overflow in project area and flushing the blocking solid waste by maintenance staff.

Figure 4-13: Typical overflow from manholes within the served area and flushing the blocking solid waste

4.4 Socioeconomic

4.4.1 Population

Helwan (Arab Abo Sa'ed) WWTP is currently serving a population of about 1.6 million capita. The data for population was obtained from the official Egyptian source of Statistics, Central Agency for Public Mobilization and Statistics, CAPMAS 2017. The population will increase to reach 2,368,584 capita by year 2037 and 3,328,645 capita by year 2052 as presented in the following Table 4-6.

Table 4-6: Estimated population for the service area by each pump station up to year 2052[22]

No.	Area's Name		Population, capita			
			2017	2020	2037	2052
Screw Pump Station No.4 (Maasarah)						
1	Al Maadi Al Gedida	المعادى الجديدة	90.409	95.943	134.343	180.808
2	70 Feddan (Al Hadabah Al Wosta)	ال 70 فدان (الهضبة الوسطى)	47.943	50.877	71.241	95.881
3	Sobhi Hessien	صبحى حسين	19.389	20.576	28.811	38.776
4	Maadi Al Sarayat Al Sharqia	معادى السرايات الشرقية	25.177	26.718	37.412	50.351
5	Zahraa Al Maadi	الزهراء(زهراء المعادى)	28.187	30.801	50.909	79.314
6	Tora Al Hejarah	طرة الحجارة	22.308	24.377	40.291	62.772
7	Tora Al Balad	طرة البلد	110.072	120.279	198.802	309.727
8	Tora Al Hait	طرة الحيط	53.131	58.058	95.960	149.503
9	Tora Al Asmant	طرة الأسمنت	7.063	7.718	12.757	19.874
10	Manshiet Al Masry	منشية المصرى	9.677	10.574	17.478	27.230
11	Al Maasarah Al Balad	المعصرة البلد	11.799	12.521	17.533	23.597
12	Al Maasarah Al Mahatah	المعصرة المحطة	106.985	130.414	158.974	213.958
Total for Screw P.S. No.4 (Maasarah)			**532.140**	**588.855**	**864.510**	**1.251.792**

[22] COWI-ATKINS-Chemonics "Rehabilitation & Extension of Various WTPs-WWTPs Prefeasibility Study" June 2020 -Helwan Wastewater Expansion Project

No.	Area's Name		Population, capita			
			2017	2020	2037	2052
Screw Pump Station No.3 (Helwan)						
1	Hadaek Helwaan	حدائق حلوان	132.179	140.269	196.411	264.343
2	Wadi Hoaf	وادى حوف	19.069	20.236	28.336	38.136
3	Helwan Al Balad	حلوان البلد	106.302	112.809	157.959	212.592
3	Screw Pump Station No.4 (Maasarah)	المحطة الحلزونية رقم 4	532.140	588.855	864.510	1.251.792
	Total for Screw P.S. No.3 (Helwan)		**789.690**	**862.169**	**1.247.216**	**1.766.863**
Screw Pump Station No.2 (Al Tebbin)						
1	Al Masakn Al Ektsadiah	المساكن الاقتصادية	98.831	104.880	146.858	197.651
2	Helwan Al Bahariyah	حلوان البحرية	13.328	14.144	19.805	26.655
2	Helwan Al Sharqiah	حلوان الشرقية	134.258	142.476	199.500	268.501
3	Helwan Al Gharbiah	حلوان الغربية	44.775	47.516	66.533	89.545
3	Helwan Al Qibliah	حلوان القبلية	15.384	16.326	22.860	30.766
4	Kafr Al Aloo	كفر العلو	73.561	78.064	109.308	147.114
4	Ain Helwan	عين حلوان	34.800	36.930	51.711	69.596
5	Al Tebbin Al Bahariyah	التبين البحرية	5.581	5.923	8.293	11.161
5	Al Tebbin Al Qibliah	التبين القبلية	1.254	1.331	1.863	2.508
6	Hekr Al Tebbin	حكر التبين	27.126	28.786	40.308	54.249
6	Qism 15th May	قسم 15 مايو	93.574	102.251	169.005	263.304
7	Screw Pump Station No.3 (Helwan)	المحطة الحلزونية رقم 3	789.690	862.169	1.247.216	1.766.863
	Total for Screw P.S. No.2 (Al Tebbin)		**1.332.162**	**1.440.794**	**2.083.260**	**2.927.914**
6	Qism 15th May	قسم 15 مايو	93.574	102.251	169.005	263.304
7	Screw Pump Station No.3 (Helwan)	المحطة الحلزونية رقم 3	789.690	862.169	1.247.216	1.766.863
	Total for Screw P.S. No.2 (Al Tebbin)		**1.332.162**	**1.440.794**	**2.083.260**	**2.927.914**
Main Pump Station No.1						
1	Madinet Al Solb	مدينة الصلب	21.205	22.503	31.510	42.408
2	Masakn Al Tebbin Al Shaabiah	مساكن التبين الشعبية	16.874	17.907	25.074	33.746
3	Al Shobak Al Sharqi	الشوبك الشرقي	48.227	59.080	119.496	173.066
4	Screw Pump Station No.2 (Al Tebbin)	المحطة الحلزونية رقم 2	1.332.162	1.440.794	2.083.260	2.927.914
	Total for Main P.S. No.1		**1.418.468**	**1.540.284**	**2.259.339**	**3.177.133**
Direct to the WWTP						
1	Al Meniah	المنيا	20.877	22.155	31.022	41.752
2	Al Ekhsas	الأخصاص	21.186	24.877	43.768	63.389
3	Al Shorfa & Al Atiaat	الشرفا و العطيات	23.187	24.606	34.455	46.371
	Total Direct to the WWTP		**65.250**	**71.639**	**109.245**	**151.512**
	Total for WWTP		**1.483.718**	**1.611.923**	**2.368.584**	**3.328.645**

4.4.2 Demography

Helwan Zone includes Helwan city, with its three districts: Ain Helwan, El-Maasara and 15th of May; El-Maady City, with its two districts: El-Maady and Tourah; Markas Atfieh; Markaz Es-Saff; Tebbin City. The total area of the -Helwan area covers 903.471 km^2, see Table 4-7, representing 0.09% of the Republic's area. The area encompasses 2 marake, 4 cities, 34 districts, 11 rural local units annexed by 43 villages, and 106 Kafrs & Ezbets. According to the preliminary results of the 20016 census, is 70.6% of population lives in urban areas, and 29.4% in rural areas and population natural growth rate has reached 19.3 per thousand. Besides being an agricultural area, Helwan is also considered an industrial one as it hosts many industries such as: Iron & Steel, Cement, basic metals, engineering and electronics, as well as mining. Moreover, the project area hosts three industrial zones; one of them is located in Tebbin and has big industrial companies. The other two zones are located at Maady and Helwan. In addition to that, the area hosts many new projects such as the under construction new Tebbin power plant of capacity 2x350 MWe.

Table 4-7: Surface Area of Helwan area[23]

Item	Unit	Value
Total Area	**Km^2**	**903.471**
Total Populated Area	**Km^2**	**519.5**
Housing and Scattering Areas	Km^2	131.39
Facilities and Cemeteries	Km^2	81.294
Ponds and Fallow	Km^2	85.13
Agricultural Land within Agricultural Borders	Km^2	18.49
Agricultural Land Outside Agricultural Borders	Km^2	44.877
Population Density in the Populated Area	Thousand Persons/Km^2	3.29
Population Density in the Total Area	Thousand Persons/Km^2	1.89
Populated Area (% of Total Area)	%	57.5

4.4.3 Land use

During the period 1955 to 1975 Helwan and its nearby surroundings had developed into a first-order industrial center. Helwan and its surroundings were considered as an important industrial district in Egypt where some large national industrial facilities such as iron and steel, cement, car manufacturing, coal industry as well as red brick factories are present. These industries consume significant amounts of water and return in many cases highly polluted wastewater directly to the environment.

Hence, these activities are considered as an important source of water pollution. Moreover, the area, see Figure 4-14, has some tourism activities due to the presence of mineral and sulfur water springs. The area includes a few small villages or Ezab, for example, Ezbt El-Walda, El Ezba El Baharya, and El-Qeblya, Arab Abu-Sa’ed and others served with old and deteriorated sewerage

[23] Arab Republic of Egypt-The Cabinet Information & Decision Support Center: Egypt's Description by Information 2009, Helwan area

network. Some of the scattered communities and houses dispose their domestic waste either in private septic tanks (latrines) or directly to the El-Khashab canal. [24]

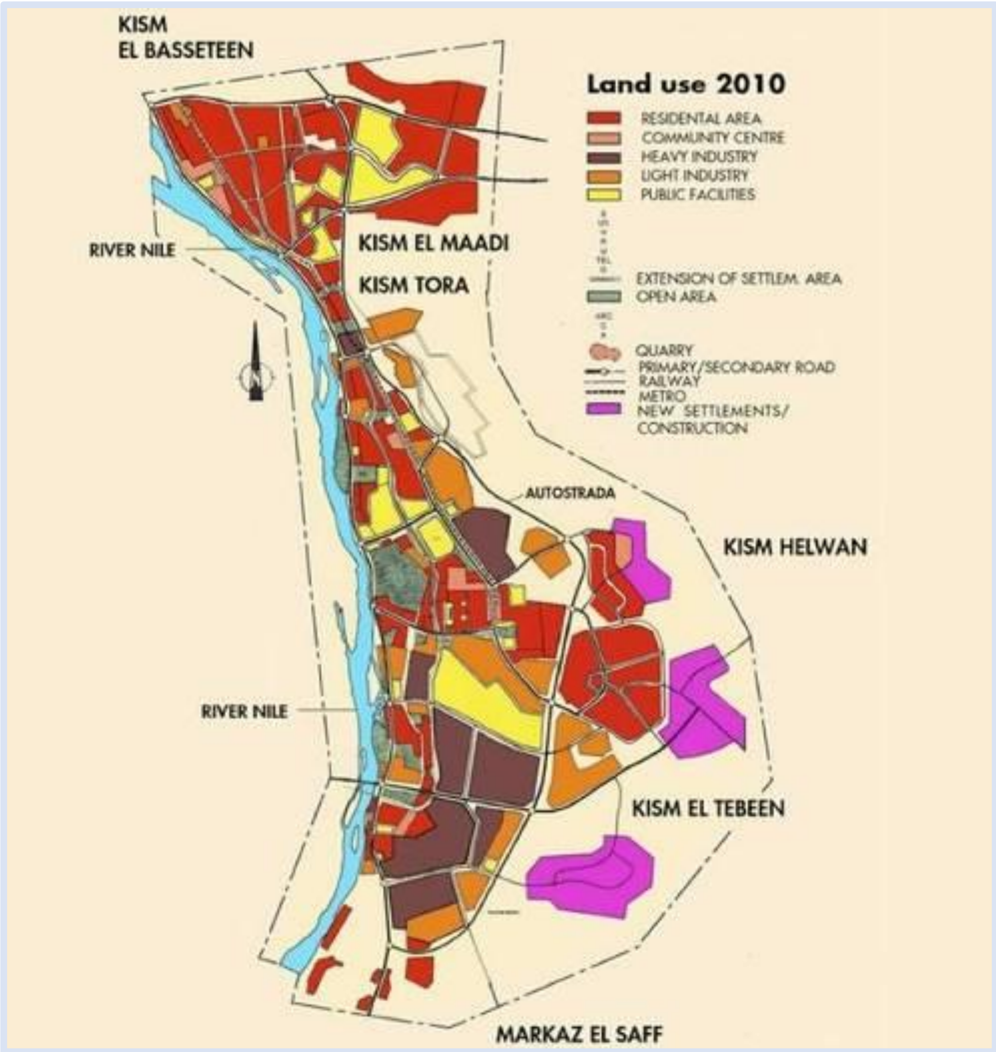


Figure 4-14: Land use of the project area[24]

4.4.4 Employment and the Labor Market

The labor force of Helwan is around 448,362, see Table 4-8 and Table 4-9, i.e. 26.17% of total population, with unemployment, including job looser, at around 10% in 2009. The Atfieh Zone, around 30.6% of the Zone total population forms the active work force, while in the Entire Helwan area this ratio reaches about 26.17%. This labor pool is comprised of employees of industrial activities (chemicals, building and construction, Iron & Steel, Cement, textiles, basic metals products, wood, wooden products & upholstery, spinning, weaving, garments & leather, paper products and food products), employees of small industry and small business operators. Around 58% of the total labor pool can be categorized as skilled, having been trained as industrial

[24] Japan International Cooperation Agency, The strategic urban development master plan study for a sustainable development of the greater Cairo region in the Arab Republic of Egypt, Final Report (Volume 2), 2012

technicians. A considerable portion of the Helwan Zone's economy centers on small businesses which comprise handicraft workshops.

The proposals outlined in the Giza & the Helwan Region Master Scheme 2015, which corresponds to the Government of Egypt's development program for the country, are likely to offer thousands of employment opportunities through the construction and operation of the proposed businesses as well as industrial and commercial developments in the entire area.

Table 4-8: Labor Market in Helwan according to Preliminary Results of Population Census

Item	Unit	Value
Total Labor Force	(1000) persons	1,713,278
No. of Employed Persons	(1000) employed	448,362
No. of Un-employed Persons	(1000) un-employed	176.59
Labor Force (% age of population)	%	26.17
Rate of Un-employment	%	9.7
Growth Rate of Work Force	%	26.27
Females (% age of Work Force)	%	14.2
Un-employment Rate of High Education Graduates	%	15.4
Un-employment Rate of Intermediate & above Intermediate Education Graduates	%	11.3

Table 4-9: Estimates of Employed Persons by Economic Activity and Sex in Giza Governorate[25]

No.	Economic Activity	Males	Females	Total
1	Agriculture & Hunting	158,900	34,100	193,000
2	Mining, Quarrying & Manufacturing	316,900	21,100	338,000
3	Construction & Building	224,900	3,700	228,600
4	Retail & Wholesale Trade & Repair	238,700	18,100	256,800
5	Hotels & Restaurants	48,900	2,300	51,200
6	Transportation, Storage & Communications	157,800	8,700	166,500
7	Education	72,400	48,800	121,200
8	Health & Social Activity	26,000	26,500	52,500
9	Services	149,700	22,400	172,100
10	Others	114,200	44,500	158,500
	Total	**1,508,400**	**230,200**	**1,738,400**

4.4.5 Health and Education

The educational status of the Helwan population is partially classified yet and the Giza Governorate data, which incorporates southern area of Es-Saff and Atfieh, is given by following Tables. The educational facilities (governmental) available within the Helwan include 8,332 classrooms for Nursery (ages under 6), Elementary schools (age 6-12) for both boys and girls,

[25] CAPMAS: Statistical Year Book, Dec. 2009

Preparatory (ages 12-15) and Secondary (ages 15-18) schools, in addition to 12 Vocational Education Centers, see Table 4-10.

Main medical facilities in the Helwan consist of 8 public and central hospitals, 2 hospitals belong to the Ministry of Health, One University Hospital, 4 Police and Prison Hospitals and one specialized hospital. The hospitals collectively support approximately 2,368 beds, they are well equipped for most types of surgery and convalescence and are staffed by more than 889 physicians, 261 dentists and 1,495 nurses covering all medical specializations. Many other private hospitals, clinics, kidney washing facilities and physical therapy units are distributed over the Helwan area. Additional health care services in the Helwan include, also, 63 private sector hospitals, 46 emergency centers and points, 44 ambulances, 39 urban health units, 57 health care units, 80 family planning units/centers, 37 child care centers and 15 health outreach offices, see Table 4-11 and Table 4-12.

Table 4-10: Number and Percent of Population (10 Years & above) in Helwan by Educational Status according to Preliminary Results of Population Census

No.	Educational Status	Number	Ratio %
1	Illiterate	327,600	24.50%
2	Read & Write	142,470	10.65%
3	Illiterate Erase	9,293	0.69%
4	Below Intermediate	288,427	21.56%
5	Intermediate	338,352	25.30%
6	Above Intermediate	40,929	3.06%
7	University Degree	182,868	13.67%
8	Above University Degree	7,027	0.53
9	Not Stated	0.00	0.00
	Total	**1,336,966**	

Table 4-11: University Hospitals, Police & Prison Hospitals, Railway Hospitals, Other Hospitals and Private Sector Hospitals Helwan, 2010[26]

Markaz/City	University Hospitals				Police & Prison Hospitals				Railway Hospitals				Other Hospitals				Private Sector Hospitals			
	No.		Beds		No.		Beds		No.		Beds		No.		Beds		No.		Beds	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Helwan	0	1	0	120	0	0	0	0	0	0	0	0	0	1	0	600	43	42	756	717
El-Maady	0	0	0	0	4	0	240	230	0	0	0	0	0	0	0	0	17	17	485	485
Atfieh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Es-Saff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	51	51
Tebbin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4-12: University, Police & Prison Hospitals, Railway Hospitals, Other Hospitals and Private Sector Hospitals Helwan, 2010

Markaz/City	University Hospitals				Police & Prison Hospitals				Railway Hospitals				Other Hospitals				Private Sector Hospitals			
	No.		Beds		No.		Beds		No.		Beds		No.		Beds		No.		Beds	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Helwan	0	1	0	120	0	0	0	0	0	0	0	0	0	1	0	600	43	42	756	717
El-Maady	0	0	0	0	4	0	240	230	0	0	0	0	0	0	0	0	17	17	485	485
Atfieh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Es-Saff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	51	51
Tebbin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[26] Helwan: Information and Decision Support Center, November 2010

4.5 Topography and geomorphology

The ground level of the eastern plateau to the east of the study area is about 100 m + msl sloping westward in steep to gradational near the bounding cliffs and gentle near the Nile flood plain reaching about 18 m + msl Figure 4-15. The eastern plateau is highly dissected by faulting and drained by a number of wadis (valleys) trending in E-W direction. These eastern parts of the study area are planned for development in the near future for industrial, agricultural and other urbanization projects. The alluvial plains cover the western portions of the study area constituting the old agricultural lands. The most populated areas are Helwan and El-Tabein cities where surface water, groundwater and wastewater treated effluent are the main source of water for agricultural and industrial purposes.

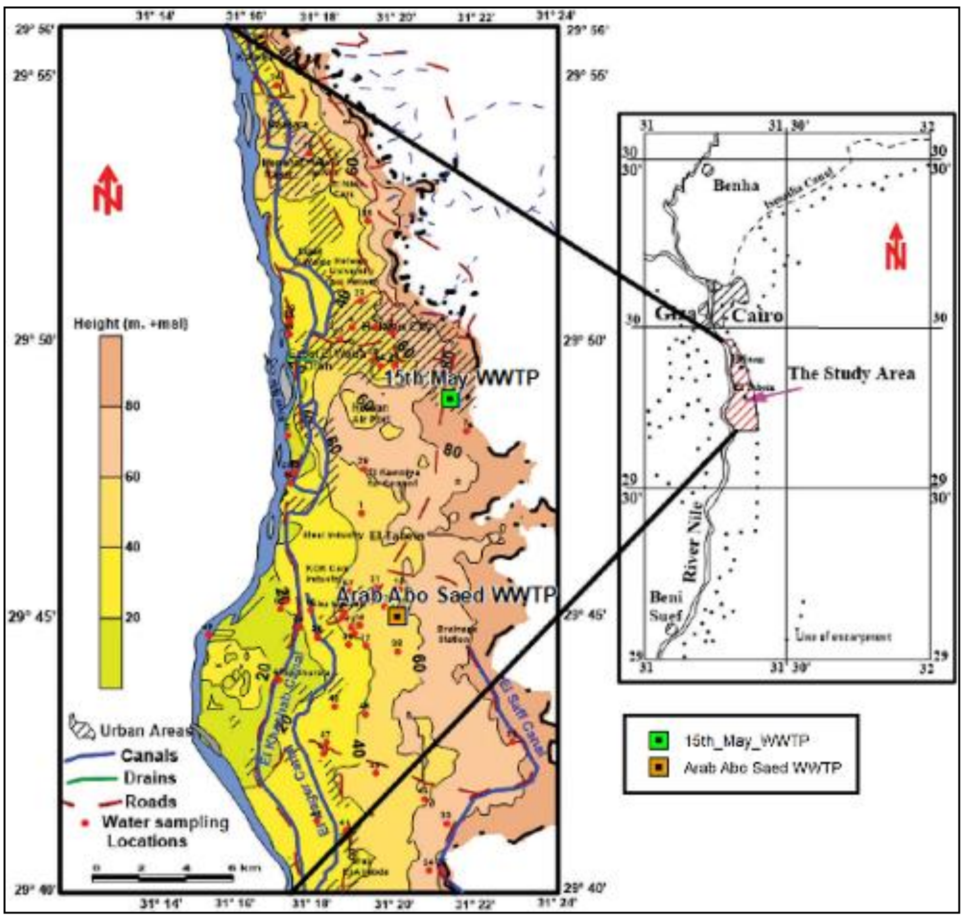


Figure 4-15: Location and topography of the study area[27]

[27] ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/twas20
Samir R. Awad, Groundwater hydrogeology and quality in Helwan area and its vicinities in Egypt, Water Science 2019, VOL. 33, NO. 1, 10–21

4.6 Geology and hydrogeology

The study area is geologically complicated due to great changes in faces and geologic structures as shown in Figure 4-15 and Figure 4-17. The Quaternary aquifer occupies the western part of the area adjacent to the Nile channel. This aquifer consists of Pleistocene sand and gravel sediments with a thickness dominantly about 50 m, may reach about 100 m locally adjacent to the River Nile and usually decreases eastward until vanishing near the eastern fringes. A thin semi-pervious silty clay cap aquitard occasionally covers the Quaternary aquifer near the Nile. The lower part of the Quaternary aquifer constitutes the Pliopleistocene sediments of mixed shale, sand, and gravel (RIGW, 1997[28]; RIGW, IWACO, 1998[29]). Dominantly, thick Eocene carbonate is directly present under the aquifer deposits and crop out in the eastern high lands of the area. The thickness of the carbonate formations is about 1300 m in the area, and the Nubian sandstone aquifer is present deep in the subsurface (Said, 1990[30]).

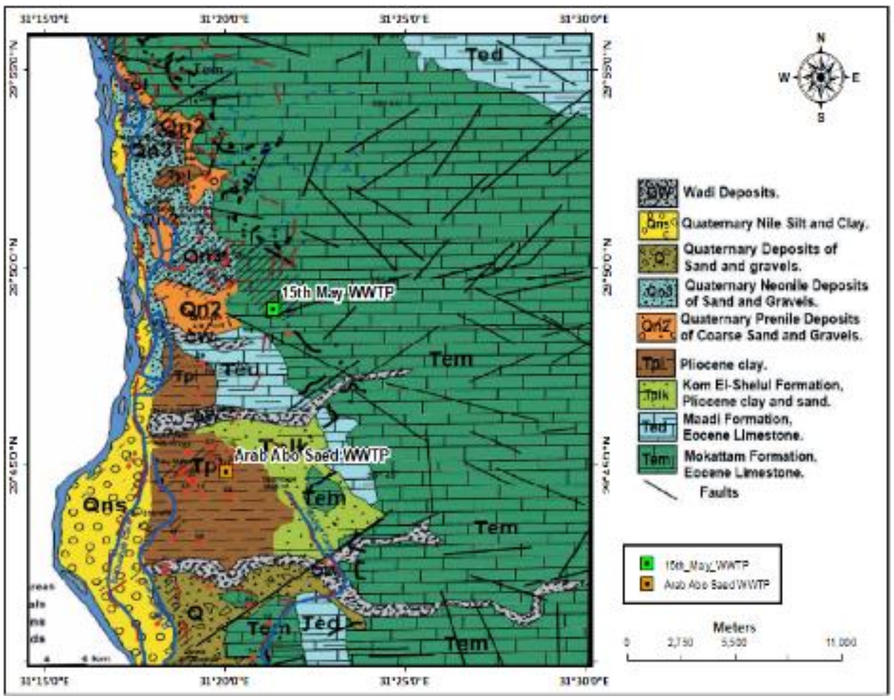


Figure 4-16: Geologic outcrops in the Study Area (RIGW, 1997)

[28] RIGW (1997) Hydrogeological maps of Egypt, scale 1:100,000.Water Research Center, Ministry of Public Works and WaterResources, Egypt

[29] RIGW/IWACO, 1998, 'Environmental management of groundwater resources (EMGR): Identifica-tion, priority setting and selection of area for monitoring groundwater quality', Technical ReportTN/70.00067/WQM/97/20, Research Institute for Groundwater (RIGW), Egypt.

[30] Thorweihe U (1990) Nubian Aquifer System. In: Said R (ed) Thegeology of Egypt, 2nd edn. Balkema, Rotterdam

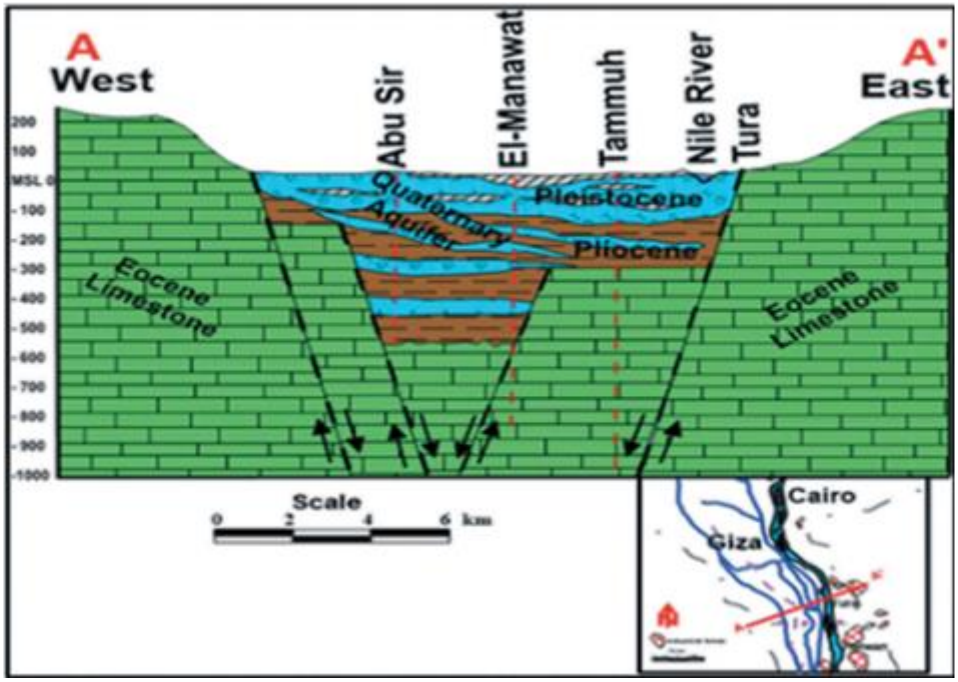


Figure 4-17: Hydrogeological Cross Section through the Study Area[31]

4.7 Water Resources

4.7.1 Nile River

Water samples were collected from one station (Code: NL33 National Water Quality Monitoring Program) of the Nile River at Helwan. The results of this monitoring program over three years during the period are presented and assessed in the following sections[32].

Temperature: Water temperature at project site ranged between 20.5 and 27.8 °C with an overall average and standard deviation equal to 23.8 and 2.99 °C respectively.

Total Dissolved Salts (TDS): Total dissolved salts values at project site varied between 260 and 283 (mg/l) where the absolute maximum value was recorded in Feb. 2012 while the absolute minimum value was measured in Aug. 2013. The overall average and standard deviation equal to 270 and 5.9 mg/l respectively. These results indicate that the TDS levels at the project location were complying with Egyptian quality standards (not more than 500 mg/l - Modified Law 48 issued in 2013 - Article 49).

Hydrogen Ion Concentration (pH): Hydrogen ion concentration values at project varied between 7.8 and 8.1 during the period from February 2010 to August 2013. The absolute maximum value was recorded in Sep. 2010 while the absolute minimum value was measured in Aug. 2013. The overall average and

[31] RIGW, 1997. Hydrogeological Map of Egypt, Scale 1: 500000, Helwan Map Sheet.

standard deviation equal to 7.9 and 0.2 respectively. These results indicate that the pH levels at the monitored location were in alkaline side and complying with Egyptian quality standards for all measurements (between 6.5 and 8.5 - Modified Law 48 issued in 2013 - Article 49).

Dissolved Oxygen (DO): The concentration of dissolved oxygen varied between 8.8 and 9.4 (mg/l) during the period from February 2010 to August 2013, the highest value recorded in Feb 2012, while the lowest value found in Aug 2011, Figure 4-18. These DO results indicate that the River Nile is in very healthy and good quality condition at the project location complying with Egyptian quality standards for all measurements (Not less than 6.0 mg/l - Modified Law 48 issued in 2013 - Article 49).

Ortho-P: Ortho-P concentration values at project varied between 0.025 and 0.072 (mg/l) during the period from February 2010 to August 2013 (Figure 3.22) showing low present of Ortho-P.

Total Suspended Solids (TSS): Total Suspended Solids concentration values at project site station (Asyut: NL21) varied between 9.0 and 17.0 (mg/l) during the period from February 2010 to August, Figure 4-19.

Biological Oxygen Demand (BOD): Biological Oxygen Demand concentration values at project site varied between 3.02 and 5.5 (mg/l) during the period from February 2010 to August 2013, Figure 4-20. These values indicate absence of the industrial, domestic and agriculture pollution. The BOD levels at the project location were complying with Egyptian quality standards for all measurements (not more than 6.0 mg/l - Modified Law 48 issued in 2013 - Article 49).

Fecal Coliform (FC): Fecal Coliform concentration values at project varied between 200 and 310 (MPN/100ml) during the period from February 2010 to August 2013. These values indicate absence of the domestic pollution

Heavy Metals in Water: The means and ranges of heavy metals concentrations from February 2010 to August 2013 in the water samples showed that, the heavy metal concentrations were found within the permissible limits of Egyptian law 48/98). Some the heavy metals parameters (such as Arsenic, Selenium, Tin and Antimony) were below the detection limit. Agricultural and industrial activities are mainly responsible for elevated levels of the measured elements in the water. The mean values of the elements showed Fe to be the most abundant element. Generally, given heavy metals concentrations were relatively higher during winter period, which is due to smaller amounts of discharging water. Most fus compounds in aquatic environments are resulting from the precipitation of Fe in alkaline and oxidizing conditions. These results indicate that the almost all measurements for heavy metals concentrations at the project location were complying with Egyptian quality standards.

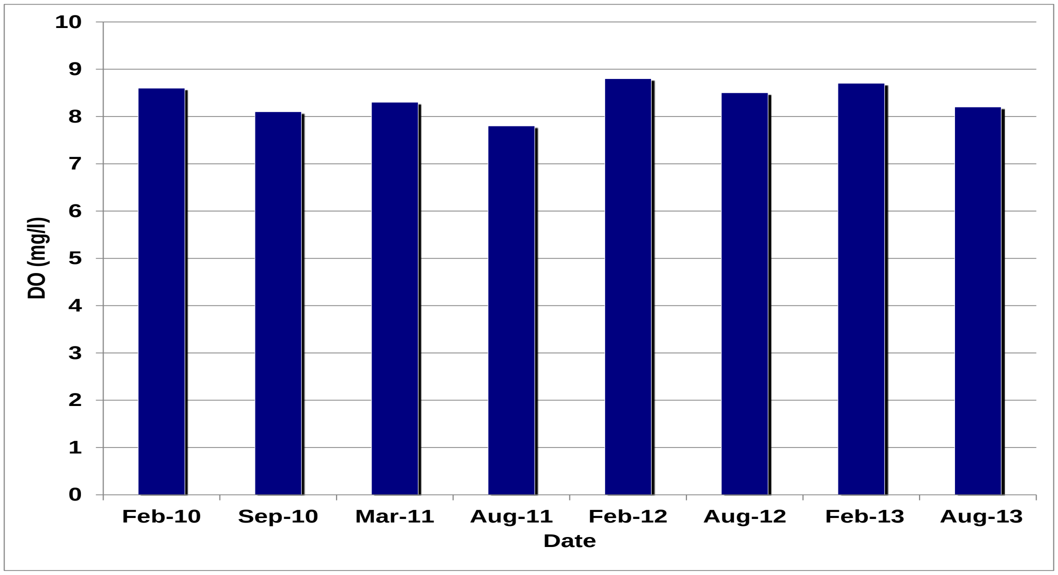


Figure 4-18: DO (mg/l) at project site station at Helwan

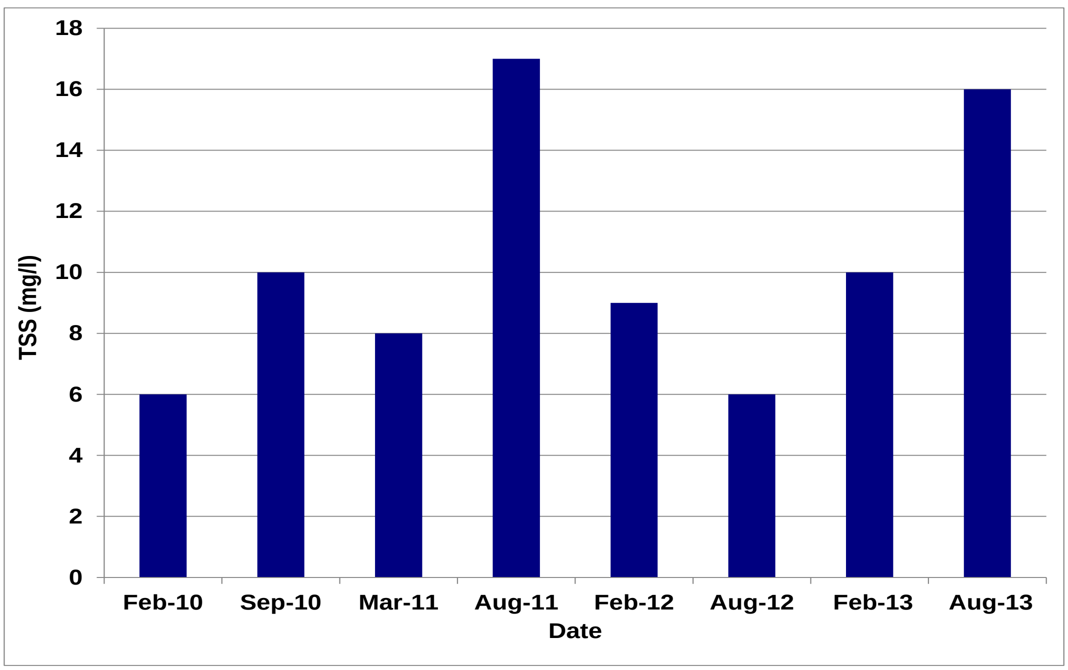


Figure 4-19: TSS (mg/l) at station (Asyut: NL21)

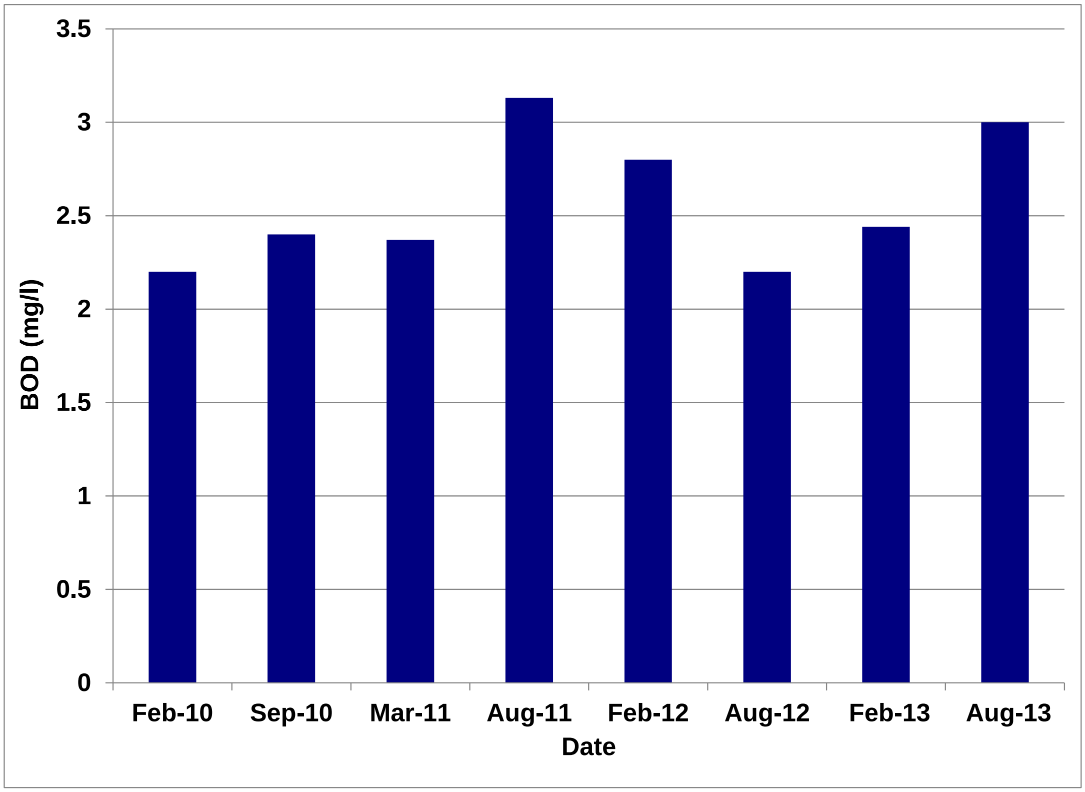


Figure 4-20: BOD (mg/l) at project site station (Asyut: NL21)

4.7.2 Main Canals in the project area

The surface water system in the study area comprises El Khashab El Hagar canals and Al-Saf Canal. The groundwater, on the other hand, is represented by the shallow quaternary aquifer. The major threat for the water resources in the project area is comes from the domesitc and industrail wastewater .

samples were collected from the study area for thirty five (35) sites (Figure 4-21)corresponding to all available water sources included surface water (13 samples) and groundwater (22 wells) in El Saff area were obtained for chemical and biological as well as bacteriological analyses.

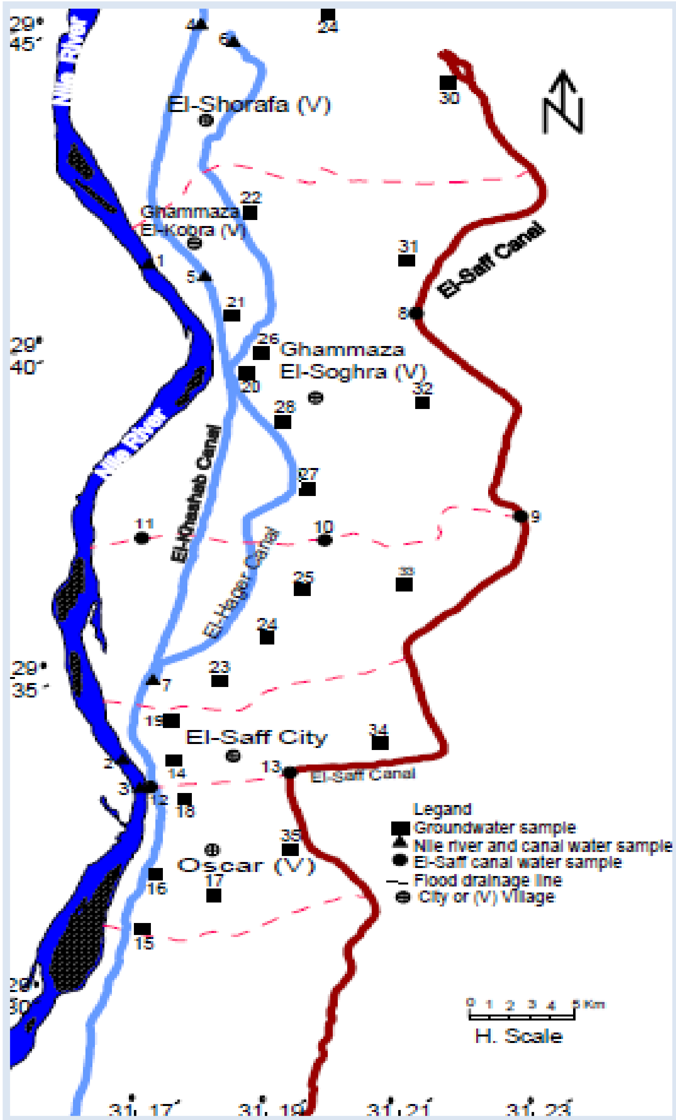


Figure 4-21: Surface water system in the project area and sampling sites [33]

The results revealed that the surface water for El Khashab, El Hagerand and Al-Saf canals) are variably polluted by biological contaminants (BOD5 12 up to 30 mg/l and COD 16 to 50 mg/l). Also some bacteriological pollutants were detected in surface and groundwater samples.

Y.R. Gedamy, A.M. El-Aassar and A.M. Abdel-Gawad, "Pollutants Detection in Water Resources at El Saff Area and Their Impact on Human", International Journal of Environment 1(1): 1-14, 2018, ISSN: 2077-4508

Some samples for El Khashab, El Hagerand and Al-Saf canals are contaminated with Heavy metals as Fe3+ (up to 1,13 mg/l) and Zn2+ ions (up 0.27 mg/l).

4.7.3 Groundwater

Groundwater represents the second source of water at Helwan after surface water. The groundwater levels are more than 60 m + msl in the eastern parts of the area adjacent to the eastern plateau and decrease westward reaching less than 18 m + msl adjacent to the River Nile Figure 4-22. Thus, the groundwater in the area could be recharged from different sources including leakage from canals, excess irrigation water, drained wastewater from the populated and industrial areas and upward flow from groundwater springs from deep Nubian sandstone aquifer recharging the Quaternary aquifer with sulfur water. Descriptive statistics for the concentrations of major elements in groundwater samples are given in Table 4-13. For 47 different samples in the study area of Helwan taken and analyzed by (Awad, 2019)[34].

Referring to the Hydrogeological Map of Egypt (see *Figure 5-13*), the groundwater conditions and the aquifer geometry can be summarizing as in the following:

- ***The Nilotic aquifer system*** (Qena Formation) of semi-confined type is underlain by thick clay beds (Pliocene rock unit) which act as aquiclude. It consists mainly from sands, gravels and silt.
- ***The Quaternary fluviatile and fluvio-marine*** sand and gravel with interbeds of clay and having a thickness of about Most of the shallow water wells are restricted to the top most part of this aquifer.
- ***Fissured Carbonate Aquifer System***: This aquifer is mainly consists of thick fractured limestone and dolomite of the Lower and Middle Eocene rock units. The depth to the water bearing beds ranging from 100 – 150 m. from the ground surface while the water level 1s about 90 m. from the level of the ground surface.

[34] ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/twas20
Samir R. Awad, Groundwater hydrogeology and quality in Helwan area and its vicinities in Egypt, Water Science 2019, VOL. 33, NO. 1, 10–21

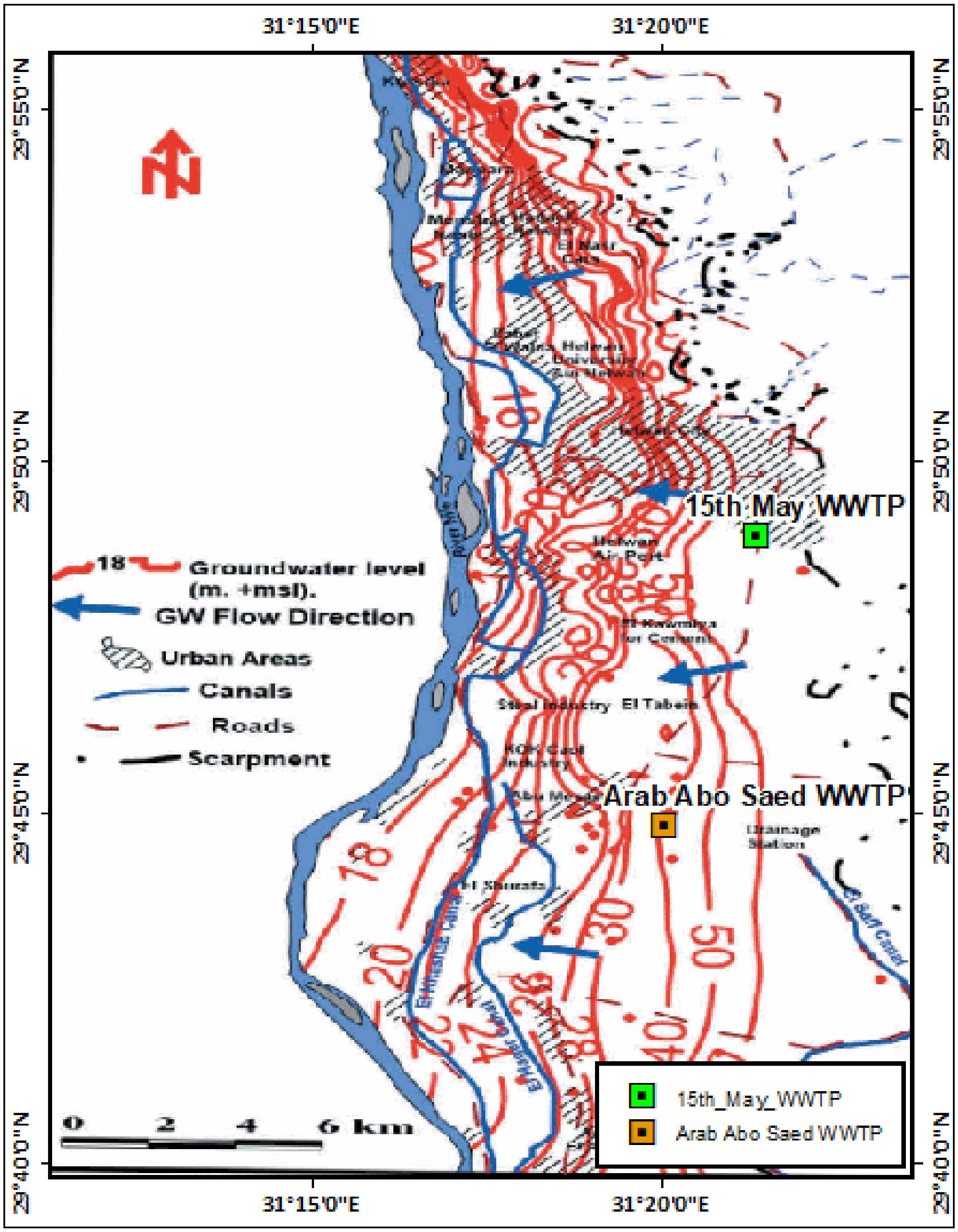


Figure 4-22: Groundwater Levels (m + msl) in the Study Area

Table 4-13: Descriptive statistics for major elements in groundwater of the study area

Parameters	No. of samples	Min.	Max.	Mean	Standard deviation	Irrigation water limits
EC (mmhos/cm)	47	0.65	14.30	5.01	3.62	**3.1**
TDS (mg/l)	47	558	9582	3373	2404	**2000**
pH (Value)	47	6.9	8.6	7.8	0.3	**6.5–8.5**
pHc (Value)	47	6.6	8.9	7.1	0.4	**6.5–8.5**
K^+ (mg/l)	47	2	119	16	19	
Na^+ (mg/l)	47	60	2754	733	619	
Mg^{2+} (mg/l)	47	2	559	92	94	
Ca^{2+} (mg/l)	47	5	837	271	186	
Cl^- (mg/l)	47	65	3206	930	799	**355**
SO^{2-} (mg/l)	47	5	4296	995	966	
HCO^- (mg/l)	47	61	630	306	135	**520**
CO^{2-} (mg/l)	47	0	120	3	18	
NO_3^- (mg/l)	43	0	133	31	36	**135**
NO_2^- (mg/l)	31	0.2	0.2	0.2	0	
SAR (Value)	47	1.42	36.87	9.61	7.24	**10**
Adj SAR (Value)	47	2.98	82.03	21.04	14.75	**10**
Adj RNA (Value)	**47**	**1.86**	**42.68**	**11.94**	**8.20**	**10**

TDS is more than 1000 mg/l in most groundwater samples violating the guideline value for drinking water purposes Figure 4-23. TDS increases eastward reaching more than 3000 mg/l and becomes unsuitable for irrigating many crops. Very high salinity in some locations is due to leaching processes and chemical interaction between water and the carbonate rocks and clay layers that are prevailing in the area. Major cations (calcium, magnesium, sodium, and potassium) increase eastward violating the guideline values for drinking water. Major anions as chloride and sulfate are usually high in groundwater exceeding the drinking water and irrigation water standards (Figure 4.5). The high anions concentrations are caused by dissolution processes and evaporation in water logged sites.

Nitrate content in groundwater is less than 50 mg/l in the western and northern parts of the study area and near the River Nile Figure 4-23. Groundwater in the southeastern part contains nitrate more than 50 mg/l violating the drinking water limits. The increase of nitrate in such areas could be referred to seepage from the released wastewater.

Concentrations of trace elements in water resources are summarized in Figure 4-24 and Figure 4-25. The seepage from the industrial waste disposal sites is most probably the main source of pollution causing the relative increase in the concentration of trace elements. Sometimes, high trace elements as iron and manganese in groundwater could be due to dissolution from the soil. High trace elements affect tolerant crops and severe restrictions must be taken in mind for the planted crops (Awad, 2019).

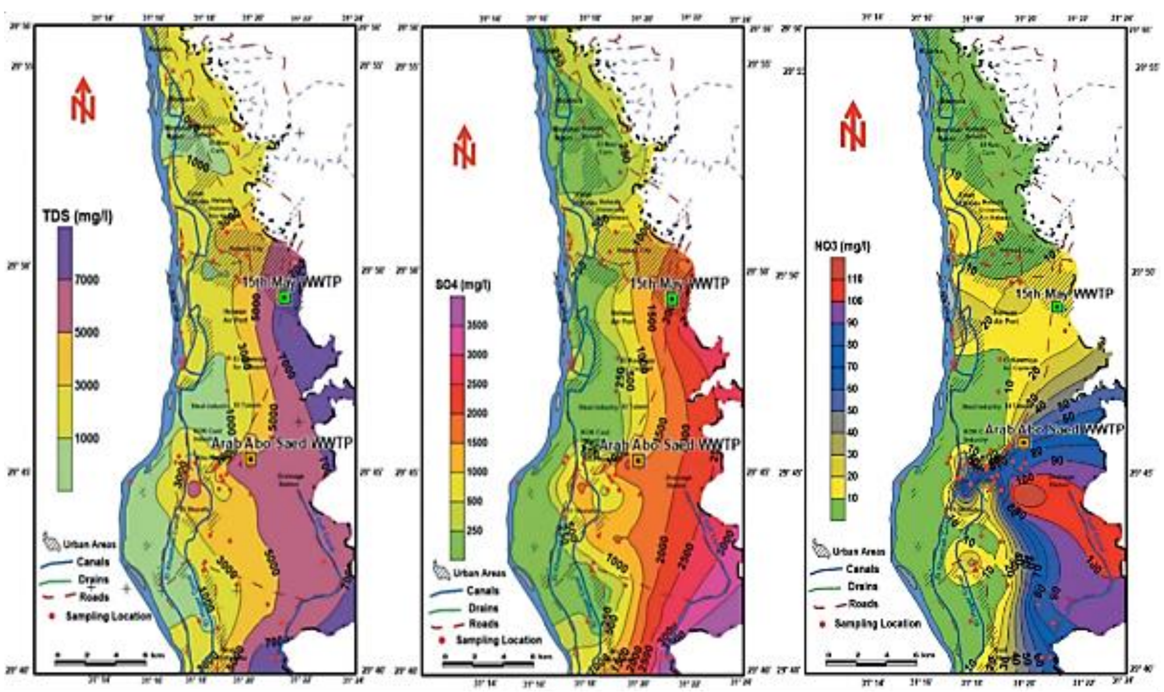


Figure 4-23: TDS, SO4, and NO3 map for groundwater in the study area

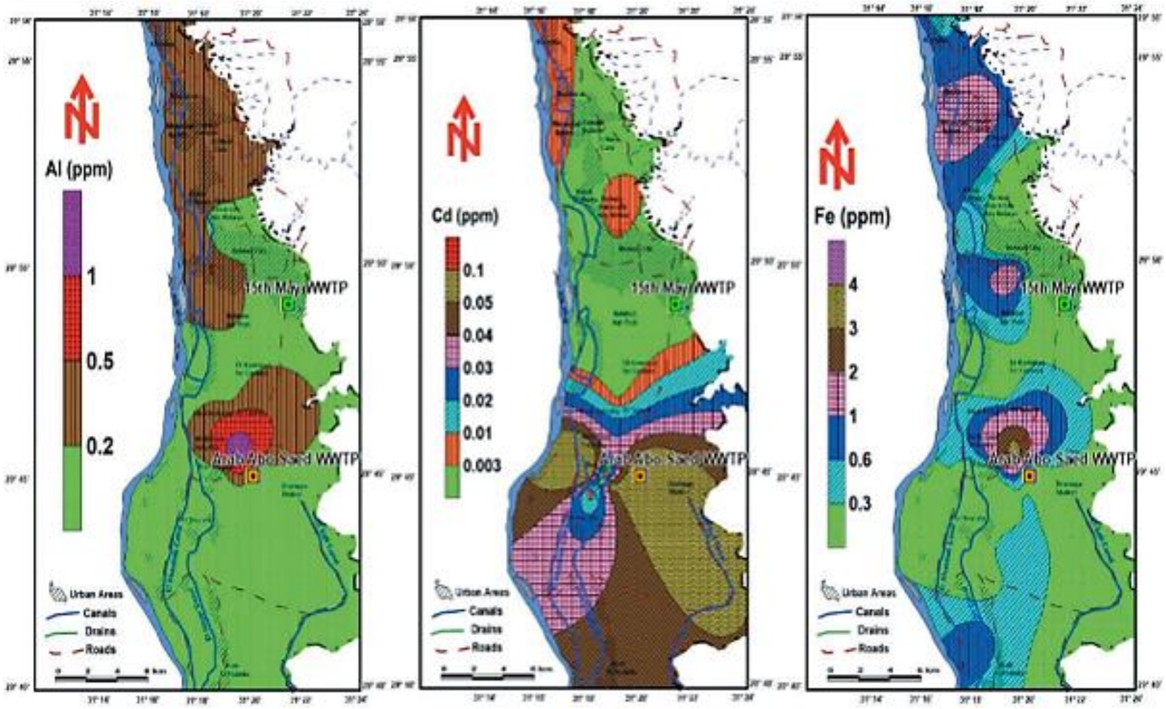


Figure 4-24: Al, Cd, and Fe map for groundwater in the study area

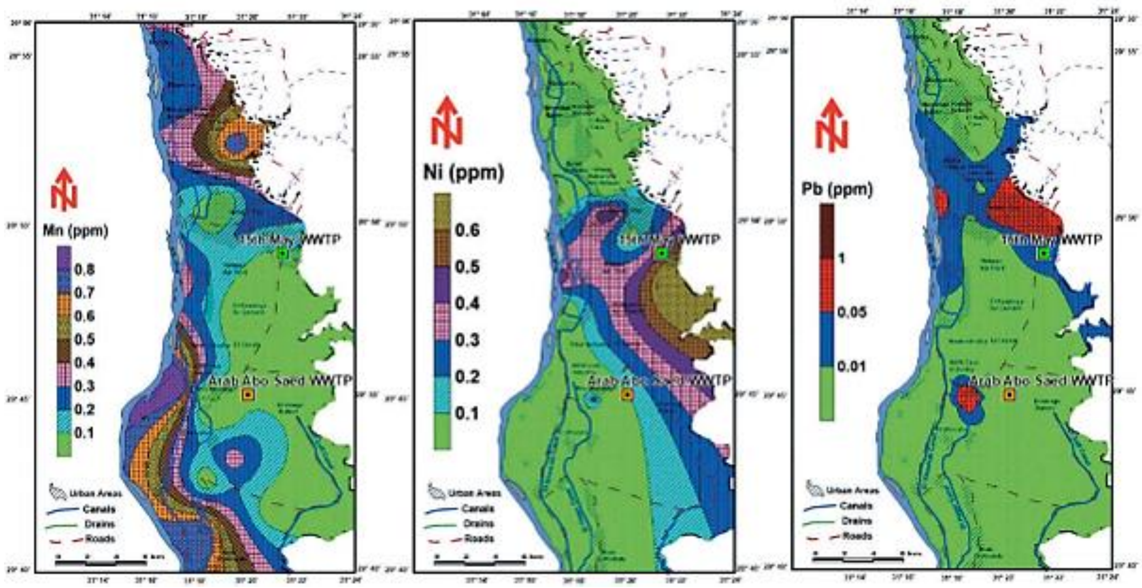


Figure 4-25: Mn, Ni, and Pb map for groundwater in the study area

4.7.4 Treated Wastewater Reuse

Helwan (Arab Abo Sa'ed) WWTP is currently serving a population of about 1.6 million capita. The population will increase to reach 2,368,584 capita by year 2037, and 3,328,645 capita by year 2052. The Helwan WWTP capacity as per the served population of the Maadi, Mokatam and new developments area at the Eastern side of the autostrada is 587,874 m3/day that will reach up to 847,525 m3/day by the year 2037. The capacity proposed for the extension of Arab Abo Sa'ed WWTP of capacity 250,000 m3/day to reach a total capacity of 800,000 m^3/day will be generated by year 2033, see Table 4-14.

Table 4-14: Generated Wastewater Flows to Helwan WWTP[35]

Generated Wastewater Flows to Helwan WWTP (m^3/day)				
Year	2020	2033	2037	2052
Generated wastewater at Helwan WWTP (Existing Case)	661,822	884,672	953,241	1,321,416
Generated wastewater at Helwan WWTP (Alternative 1)	587,874	800,000	847.525	1,167,925

Data acquired from Arab Abo Sa'ed WWTP demonstrated the water quality at the entrance of the WWTP and the treated wastewater quality in the northern and southern section during the month of November 2020. The data showed that the quality of the treated wastewater coming from the WWTP, whether in the northern or southern part, is in line with the limits of the Egyptian Law of 1984 and its Executive Regulations for 2013 for BOD, COD, and TSS.

The influent TSS ranged between127 mg/l to 482 mg/l with corresponding BOD that ranged from 148 mg/l to 366 mg/l and COD that ranged from 241 to 654 mg/l. The higher values look to match the design parameters stated by the process design report of the treatment plant. (TSS of 500mg/l, BOD of 370 mg/l and COD of 800 mg/l).

The effluent characteristics showed that 100 % of samples were in conformity with the required effluent quality as per the Egyptian laws. TSS ranged from 17 mg/l to 46 mg/l, BOD ranged from 19mg/l to 54 mg/l, while the COD ranged from 28 mg/l to 73 mg/l. The WWTP efficiency during the months of May, June & July was in the average of 90% for removal of the three said parameters, see Figure 4-26.

[35] INFRA, Engineering, Helwan Wastewater Collection & Treatment Project Technical Study for Verification of Extension Requirements & Cost updating Technical Report, December 2021

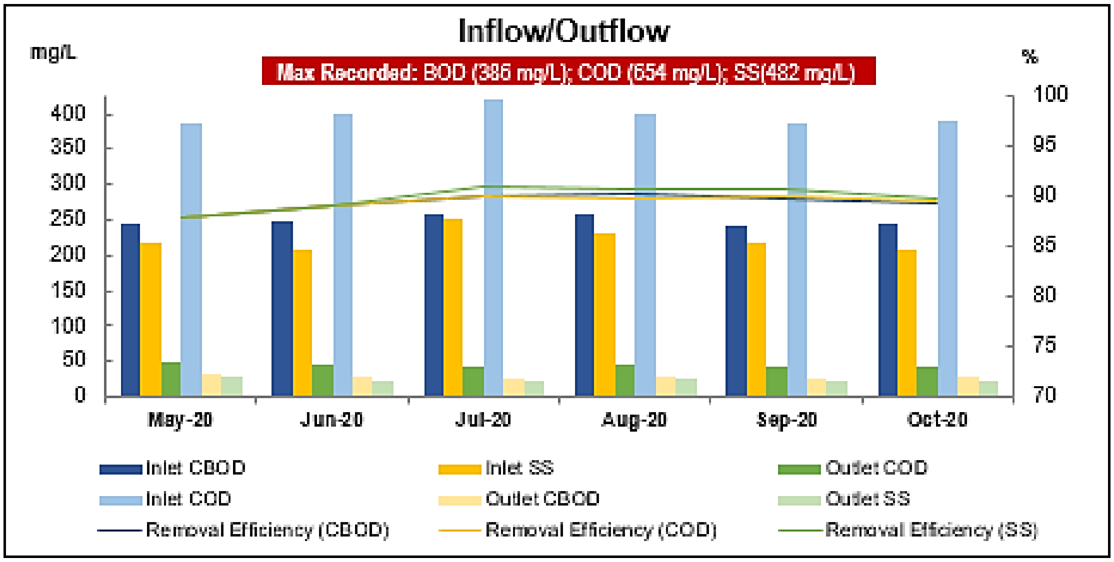


Figure 4-26: Influent & Effluent Characteristics May2020- Oct.2020 Existing[36]

4.8 Climate

In Helwan, the summers are long, hot, humid, arid, and clear and the winters are short, cool, dry, and mostly clear. Over the course of the year, the temperature typically varies from 10°C to 35°C and is rarely below 8°C or above 39°C. Figure 4-27 shows a climate summary for Helwan along the year[37].

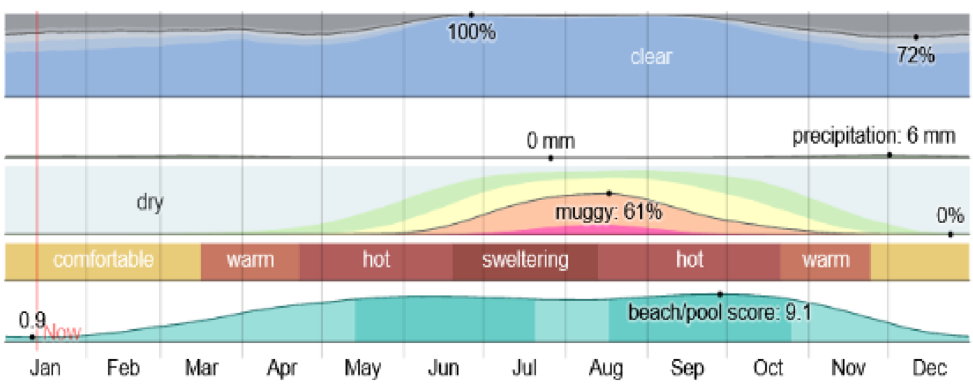


Figure 4-27: Climate summary in Helwan

[36] INFRA, Engineering, Helwan Wastewater Collection & Treatment Project Technical Study for Verification of Extension Requirements & Cost updating Technical Report, December 2021

[37] Cedar Lake Ventures, Inc. "Average weather in Helwan, Egypt" based on a statistical analysis of historical hourly weather reports and model reconstructions from January 1, 1980 to December 31, 2016. https://weatherspark.com/y/96911/Average-Weather-in-%E1%B8%A8alw%C4%81n-Egypt-Year-Round

4.8.1 Temperature

The hot season lasts for 4.7 months, from May 12 to October 2, with an average daily high temperature above 32°C. The hottest day of the year is June 27, with an average high of 35°C and low of 23°C.

The cool season lasts for 3.0 months, from December 3 to March 2, with an average daily high temperature below 22°C. The coldest day of the year is January 20, with an average low of 10°C and high of 19°C. Figure 4-28 below shows the daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

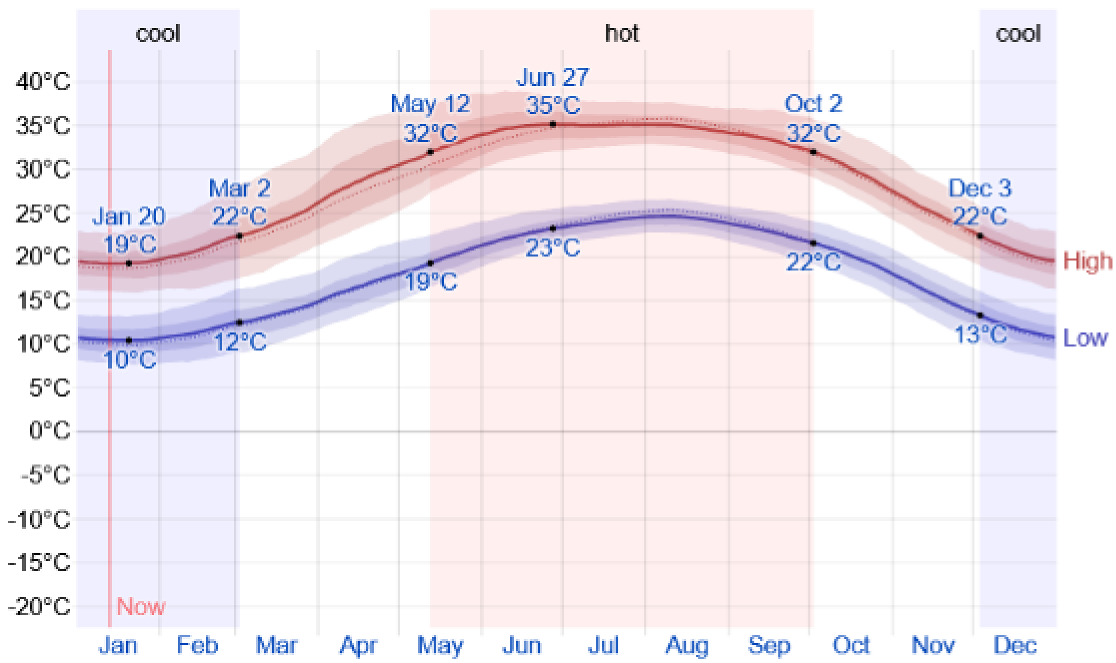


Figure 4-28: Average High and Low Temperature in Helwan.

Figure 4-29 below shows you a compact characterization of the entire year of hourly average temperatures. The horizontal axis is the day of the year, the vertical axis is the hour of the day, and the color is the average temperature for that hour and day.

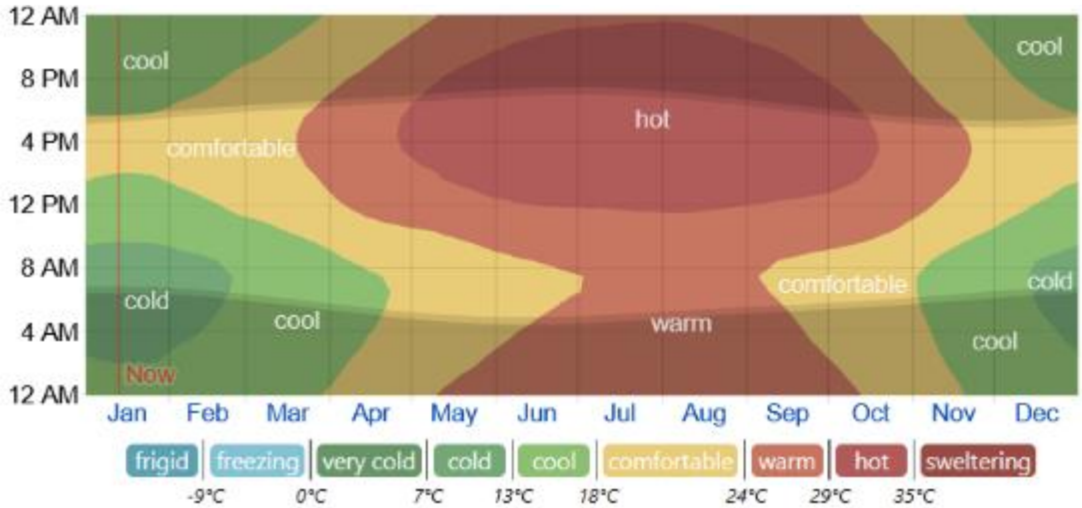


Figure 4-29: Average Hourly Temperature in Helwan

4.8.2 Clouds

In Helwan, the average percentage of the sky covered by clouds experiences significant seasonal variation over the course of the year.

The clearer part of the year in Helwan begins around May 24 and lasts for 4.9 months, ending around October 20. On June 26, the clearest day of the year, the sky is clear, mostly clear, or partly cloudy 100% of the time, and overcast or mostly cloudy 0% of the time.

The cloudier part of the year begins around October 20 and lasts for 7.1 months, ending around May 24. On December 11, the cloudiest day of the year, the sky is overcast or mostly cloudy 28% of the time, and clear, mostly clear, or partly cloudy 72% of the time.

Figure 4-30 below shows the percentage of time spent in each cloud cover band, categorized by the percentage of the sky covered by clouds.

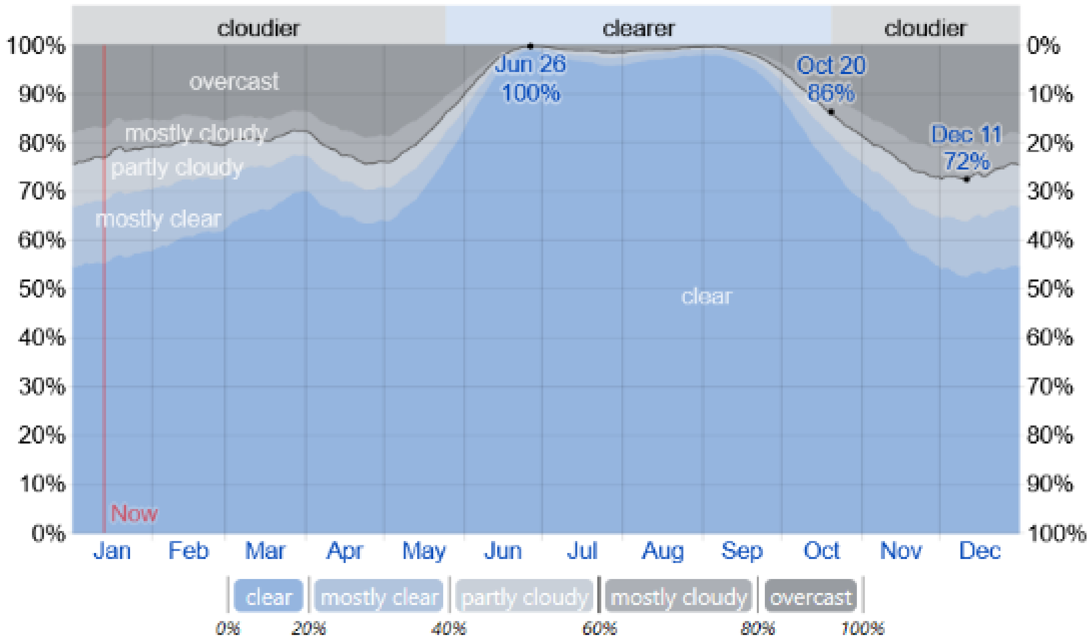


Figure 4-30: Cloud Cover Categories in Helwan

4.8.3 Precipitation

Helwan does not experience significant seasonal variation in the frequency of wet days (i.e., those with greater than 1 millimeter of liquid or liquid-equivalent precipitation). The frequency ranges from -0% to 3%, with an average value of 1%.

Among wet days, the most common form of precipitation throughout the year is rain alone, with a peak probability of 3% on February 10, see Figure 4-31 .

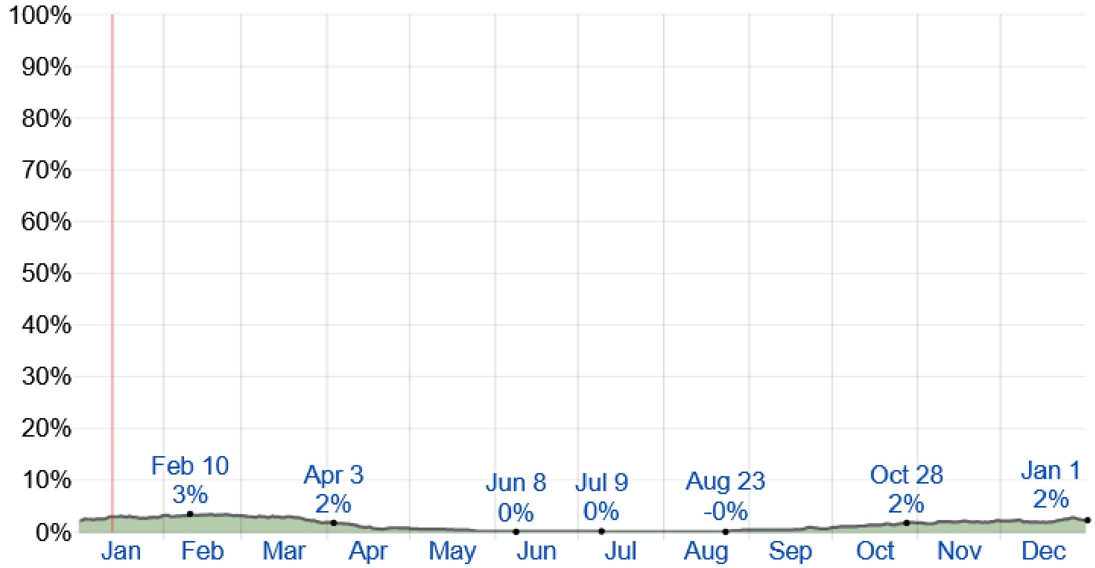


Figure 4-31: Daily Chance of Precipitation in Helwan

4.8.4 Rainfall

The sliding 31-day quantity of rainfall in Helwan does not vary significantly over the course of the year, staying within 3 millimeters of 3 millimeters throughout.

Figure 4-32 below shows the average rainfall (solid line) accumulated over the course of a sliding 31-day period centered on the day in question, with 25th to 75th and 10th to 90th percentile bands.

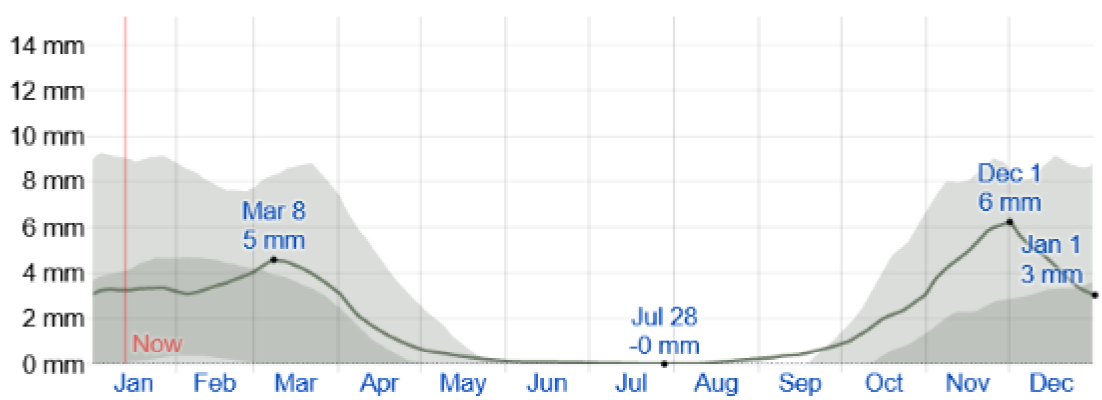


Figure 4-32: Average Monthly Rainfall in Helwan

4.8.5 Sun

The length of the day in Helwan varies significantly over the course of the year. In 2021, the shortest day is December 21, with 10 hours, 14 minutes of daylight; the longest day is June 21, with 14 hours, 4 minutes of daylight.

Figure 4-33 below shows the number of hours during which the Sun is visible (black line). From bottom (most yellow) to top (most gray), the color bands indicate: full daylight, twilight (civil, nautical, and astronomical), and full night.

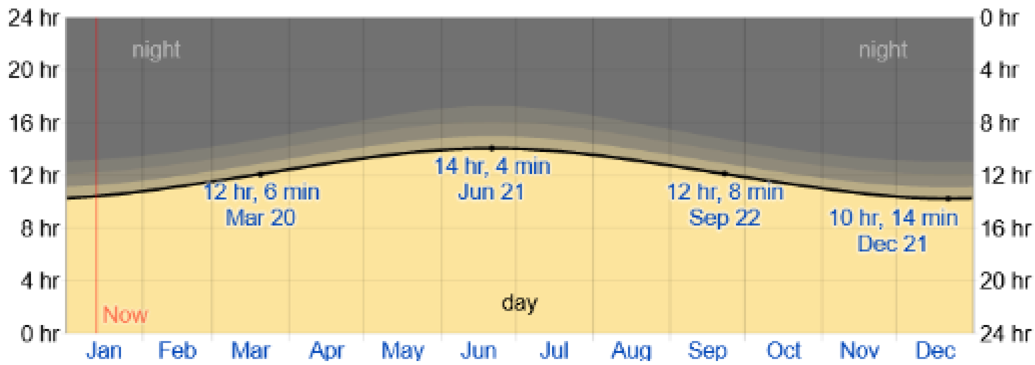


Figure 4-33: Hours of Daylight and Twilight in Helwan

The earliest sunrise is at 4:53 AM on June 11, and the latest sunrise is 1 hour, 58 minutes later at 6:51 AM on January 10. The earliest sunset is at 4:54 PM on December 2, and the latest sunset is 2 hours, 5 minutes later at 6:59 PM on June 30.

Figure 4-34 below shows the solar day over the course of the year 2021. From bottom to top, the black lines are the previous solar midnight, sunrise, solar noon, sunset, and the next solar midnight. The day, twilights (civil, nautical, and astronomical), and night are indicated by the color bands from yellow to gray.

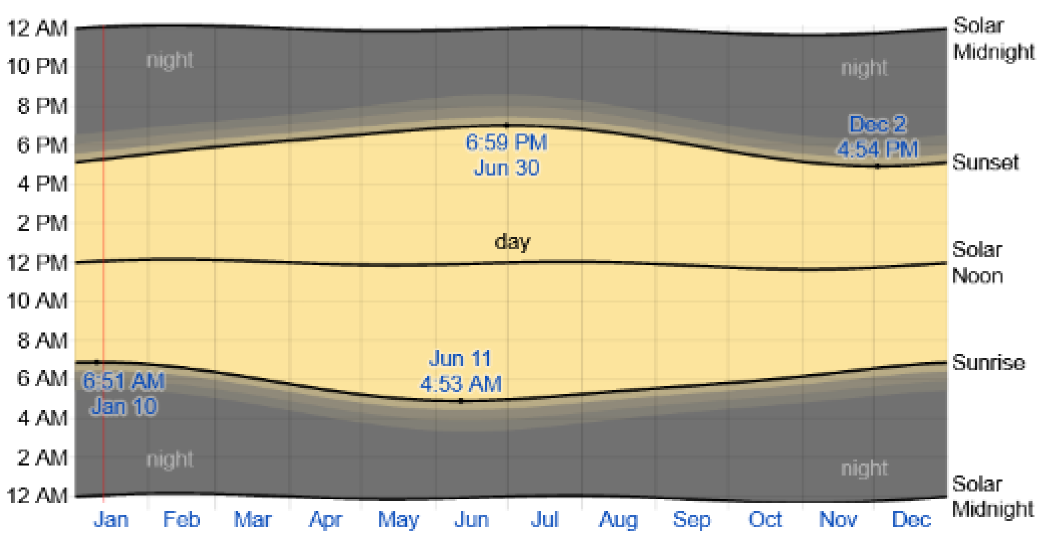


Figure 4-34: Sunrise & Sunset with Twilight in Helwan

4.8.6 Humidity

We base the humidity comfort level on the dew point, as it determines whether perspiration will evaporate from the skin, thereby cooling the body. Lower dew points feel drier and higher dew points feel more humid. Unlike temperature, which typically varies significantly between night and day, dew point tends to change more slowly, so while the temperature may drop at night, a muggy day is typically followed by a muggy night. Helwan experiences extreme seasonal variation in the perceived humidity.

The muggier period of the year lasts for 3.7 months, from June 19 to October 9, during which time the comfort level is muggy, oppressive, or miserable at least 15% of the time. The muggiest day of the year is August 17, with muggy conditions 61% of the time. The least muggy day of the year is December 24, when muggy conditions are essentially unheard of, see Figure 4-35.

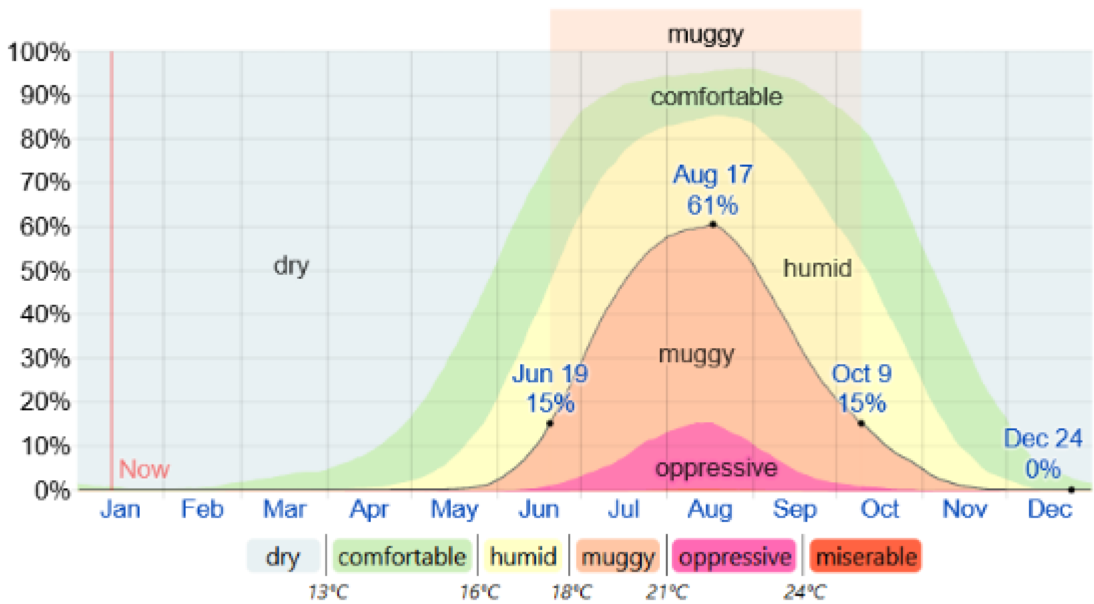


Figure 4-35: The percentage of time spent at various humidity comfort levels, categorized by dew point in Helwan

4.8.7 Wind

This section discusses the wide-area hourly average wind vector (speed and direction) at 10 meters above the ground. The wind experienced at any given location is highly dependent on local topography and other factors, and instantaneous wind speed and direction vary more widely than hourly averages. The average hourly wind speed in Helwan experiences mild seasonal variation over the course of the year.

The windier part of the year lasts for 4.6 months, from March 15 to August 1, with average wind speeds of more than 14.8 kilometers per hour. The windiest day of the year is June 9, with an average hourly wind speed of 16.9 kilometers per hour. The calmer time of year lasts for 7.4 months, from August 1 to March 15. The calmest day of the year is January 5, with an average hourly wind speed of 12.7 kilometers per hour, see Figure 4-36.

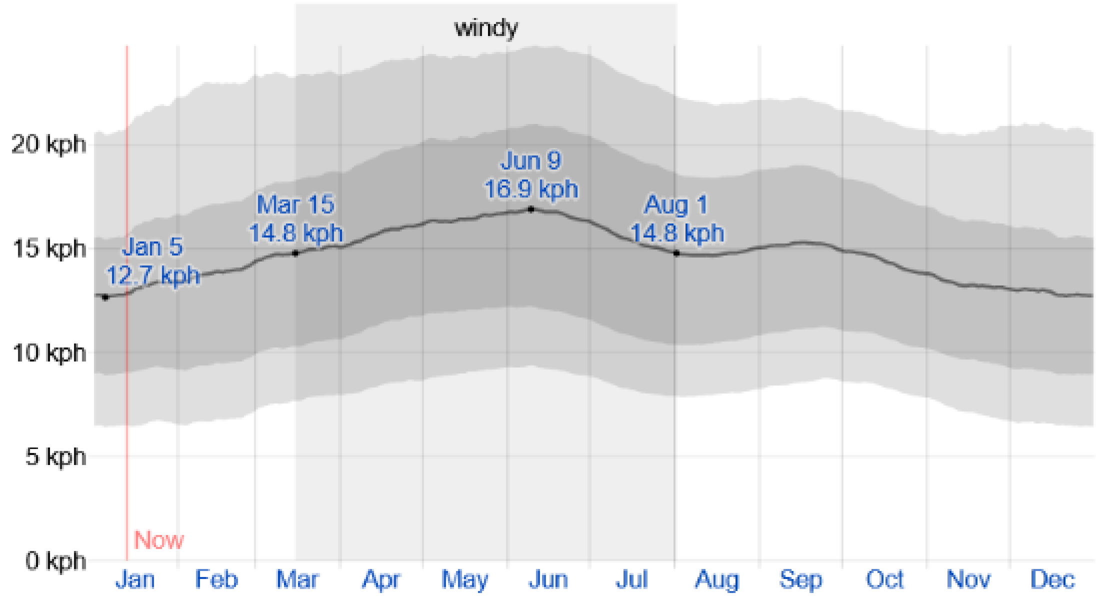


Figure 4-36: The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.

The predominant average hourly wind direction in Helwan varies throughout the year. The wind is most often from the west for 1.2 months, from January 9 to February 15, with a peak percentage of 37% on January 31. The wind is most often from the north for 11 months, from February 15 to January 9, with a peak percentage of 33% on January 1.

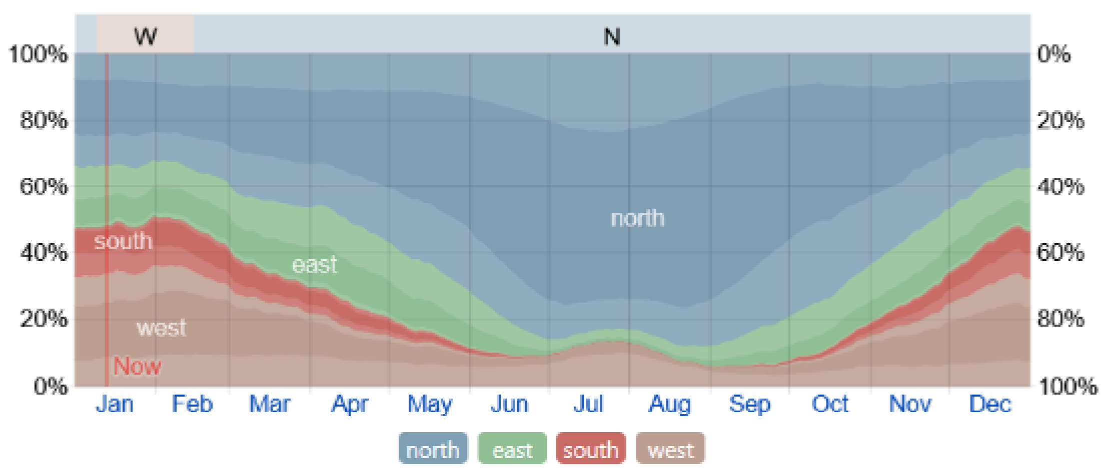


Figure 4-37: The percentage of hours in which the mean wind direction

Figure 4-37 The percentage of hours in which the mean wind direction is from each of the four cardinal wind directions, excluding hours in which the mean wind speed is less than 1.6 kph. The lightly tinted areas at the boundaries are the percentage of hours spent in the implied intermediate directions (northeast, southeast, southwest, and northwest)

4.9 Air Quality

Air pollution in general is a change in the composition of the air that may harm the organisms that breathe it. In studying the air quality in the project area, the study relied on data issued by the Environmental Affairs Agency regarding the environmental characterization of Helwan area, and the following are the elements that may cause a change in the air quality in the study area[38].

4.9.1 Sulphur dioxide

Sulfur dioxide gas is mainly a product of the processes of oxidation of sulfur residues in liquid petroleum fuels during the combustion process, whether in stationary sources such as power generation stations and factories or mobile sources represented in vehicles, especially those that use diesel in their running.

The average annual concentration of sulfur dioxide did not exceed the permissible limits in the environmental law, which is (60 micrograms / m3) in 2007. This is despite the fact that many clay brick factories in the class use mazot as their fuel. The concentration of sulfur dioxide in the air may increase during the autumn. This is due to the different weather factors that lead to the concentration of pollutants and their lack of dispersion in the autumn season.

4.9.2 Nitrogen dioxide

Nitrogen dioxide gas is formed as a product of all fuel combustion processes that take place at high temperatures, and there is no annual limit for the concentration of nitrogen dioxide in the executive regulations of Law No. 4 of 1994 regarding the protection of the environment. Nitrogen has exceeded this annual indicative limit permitted in the place of study during the year 2007. It also turns out that this problem continues with the increase in the number of vehicles during the past years, which led to an increase in fuel burning rates and thus led to an increase in the average annual concentrations of nitrogen dioxide to exceed the limit. Globally permitted guideline

4.9.3 Lead

There are many forms of human exposure to lead contamination, whether by breathing in the air or consuming food contaminated with lead or its derivatives. The most important of them is inhaling it in the form of particles suspended in the air or dust, which leads to the accumulation of absorption of this toxic element in the human blood through the respiratory system. Lead affects the digestive system, immune system, kidneys, liver and blood vessels, and it has been proven that children's bodies absorb lead at higher rates than adults, which exposes them to greater risks.

The results of the monitoring of lead indicated that its concentrations did not exceed the permissible limit in the executive regulations of the Environmental Protection Law. This is due to the strict application of the environmental law and its amendments in the executive regulations, where the regulation was amended to reduce the permissible limit for lead to 0.5 micrograms / m3 in residential

[38] Environmental and Climate Change Research Institute, NWRC. (2009). A preliminary study to assess the environmental impacts of establishing a river port in El Saff.

areas and 1.5 micrograms / m3 in industrial areas instead of 1 microgram / m3 in all industrial areas or residential.

4.9.4 Carbon monoxide

The main source of carbon monoxide is the incomplete burning of various fuels, as in clay brick factories, where fuels, especially diesel, are incompletely burned, as well as emissions from car engines, especially low-efficiency ones.

It is considered one of the most dangerous types of air pollution and the most toxic to humans and animals, where carbon monoxide combines with hemoglobin, forming a carboxy hemoglobin component, thus preventing oxygen from combining with hemoglobin, and in this case the body is deprived of access to oxygen and internal suffocation occurs. The executive regulations of the Environmental Protection Law stipulate that the maximum permissible limit for exposure to carbon monoxide for an hour is 30 mg / m3 and for a period of 8 hours is 10 mg / m3.

Concentrations of carbon monoxide for an 8-hour exposure exceed the permissible limits sometimes in different months of the year, but carbon monoxide concentrations did not exceed an hour exposure at any time during 2005, 2006 and 2007.

4.9.5 Ozone

Ozone is formed in the lower atmosphere from the interaction of pollutants emitted from transportation or devices that contain hydrocarbons (Freon), which is used in the manufacture of refrigerators, air-conditioners and many other industries, and ozone is considered one of the components dangerous to human health. The executive regulations of the Environment Law specify the maximum exposure to surface ozone gas for an hour not exceeding 200 micrograms / m3, while the permissible limit within 8 hours is not more than 120 micrograms/m3 and there are four stations in the republic to monitor ozone concentrations. All of them detected ozone concentrations that are lower than those permitted by law during 2007, 2006 and 2005.

4.9.6 Noise

Noise is the unwanted sounds to be heard, and the sources of noise that are human action are the sounds emanating from machines in factories, means of transport, transportation, electrical devices, amplifiers, alarm devices, and loud music, all of which negatively affect the mental and nervous health of the person and cause him distress and anxiety, which is considered a violation of human comfort and the right to enjoy the calm. The noise levels in the squares and main streets in Helwan city are about 95 dB, which exceed the standards recommended by the World Health Organization, which are 45 dB during the day and 35 dB at night. As for the study area, it is about 2 km from the main road of the city as well as from the residential block, so the noise levels do not exceed the permissible levels globally.

4.10 Ecology

It was observed that many aquatic weeds spread on both sides of the river under study. As for the submerged, floating and semi submerged weeds, they are almost non-existent.

The area of the study is generally characterized by low vegetation and some desert wild plants, while most of the area was planted by many crops. Several plant communities were recognized. The dominant species include: Acacia racldiana, Tamarix aphylla, Retama (Lygos) raetam, Leptadenia pyrotechnics, Launaea spinosa, Hammada elegans, Anabasis articulata, Panicum turgidum, Artemisia judaica, Zilla spinosa and Zygophyllum coccineum. Several species seem to have an eastern affinity and are confined to the eastern margins of the area. These include: Launaea spinosa, Blepharis edulis Convolvulus hystrix, Barleria acanthoides, Iphiona scabra, Taverniera aegyptiaca, etc.

Figure 4-38: Saccharum spontaneum noticed in the study area

Figure 4-39: Imperata cylindrical noticed in the study area

4.11 Potential Natural Hazards

4.11.1 Earthquake

Generally, the distribution of the earthquake epicenters in Egypt is mainly located along the main three trends (systems) as shown in Figure 4-40, These trends are:

- Gulf of Aqaba – Dead Sea (Levant) trend ,
- Red Sea , Gulf of Suez , Cairo – Alexandria trend and
- Fayum – Cairo – Pelusium trend.

In fact, the area under the consideration is located in the intersection between the Gulf of Suez and Cairo-Fayum main trends (Figures 5-16, 5-17 and 5-18). The area is characterized by the occurrence of shallow, micro, small moderated and large earthquakes. The activities are mainly attributed to the Red Sea–Gulf of Suez and Cairo – Fayum systems.

After the Dahshour earthquake (1992), the following features were observed:

Liquefaction

It is very pronounced at Atfeih,Menyet Al-Saff and other areas, the water level increased about one meter over some cultivated lands. The trend of cracks 70 and 90 was also observed on the eastern side of the Nile valley.

Fracturing

Kebeasy, 1990, reported that the NW trend is the major active trend in Egypt. He also mentioned that the activities along this trend increased in recent years. Seismicity records show that the area is vulnerable to seismic activities that may reach 4 – 5 on Richter scale.

Hamdan, 1999 reported the extension of the NW faults which affect the middle Eocene rocks in the area of 15 May City further north. The study area is vulnerable to earthquakes in the magnitude of 3 – 4 on Richter Scale. This should be taken in consideration during the design and the foundation of the station from the engineering point of view.

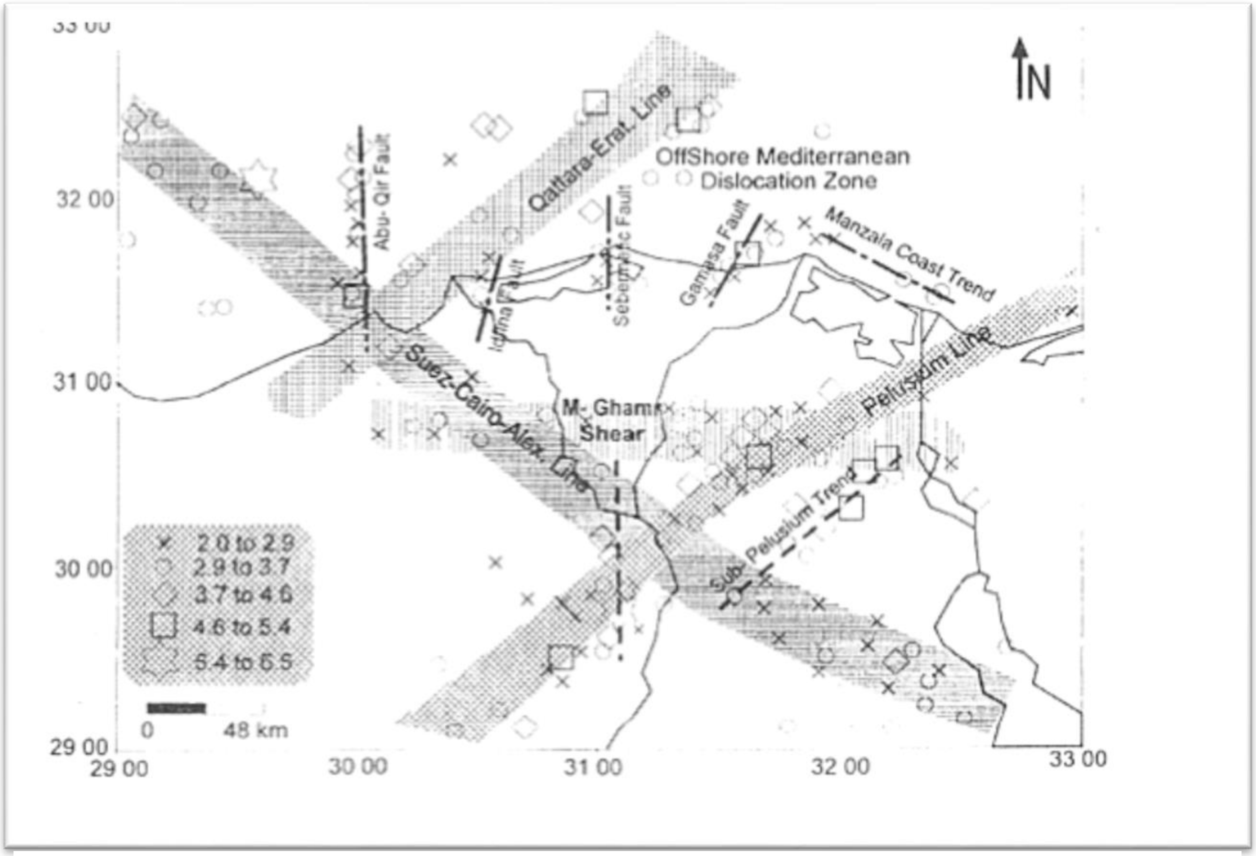


Figure 4-40: Epicenters Distribution of Instrumental Earthquakes' in the Northern Egypt (1900–1997) Modified to Show the Active Seismic Trends (After Al-Ibiary, 2001)

4.11.2 Flash Flood

The Atfeih area subjected to the occurrence of flash floods after occasional rainfall showers. Three spillways are located around the study area, these spillways are:

- Al-Dessimy Spillway
- Atfeih Spillway
- Al-Kureimat Spillway

4.11.3 Seismic hazards

Figure 4-41 shows seismic Hazard, indicating that Egypt is located at the low risk areas (five categories) which represent a good opportunity for development, see also Figure 4-42. Yet it must be taken into consideration that the construction of the stations and the pipeline network must be conducted in compliance with the civil engineering codes. The codes take into consideration calculating the impacts related to seismic hazards on the station and network, in order to avoid any impacts caused by strong earth movements leading to leakage of sewage water and pollution to the groundwater aquifer.

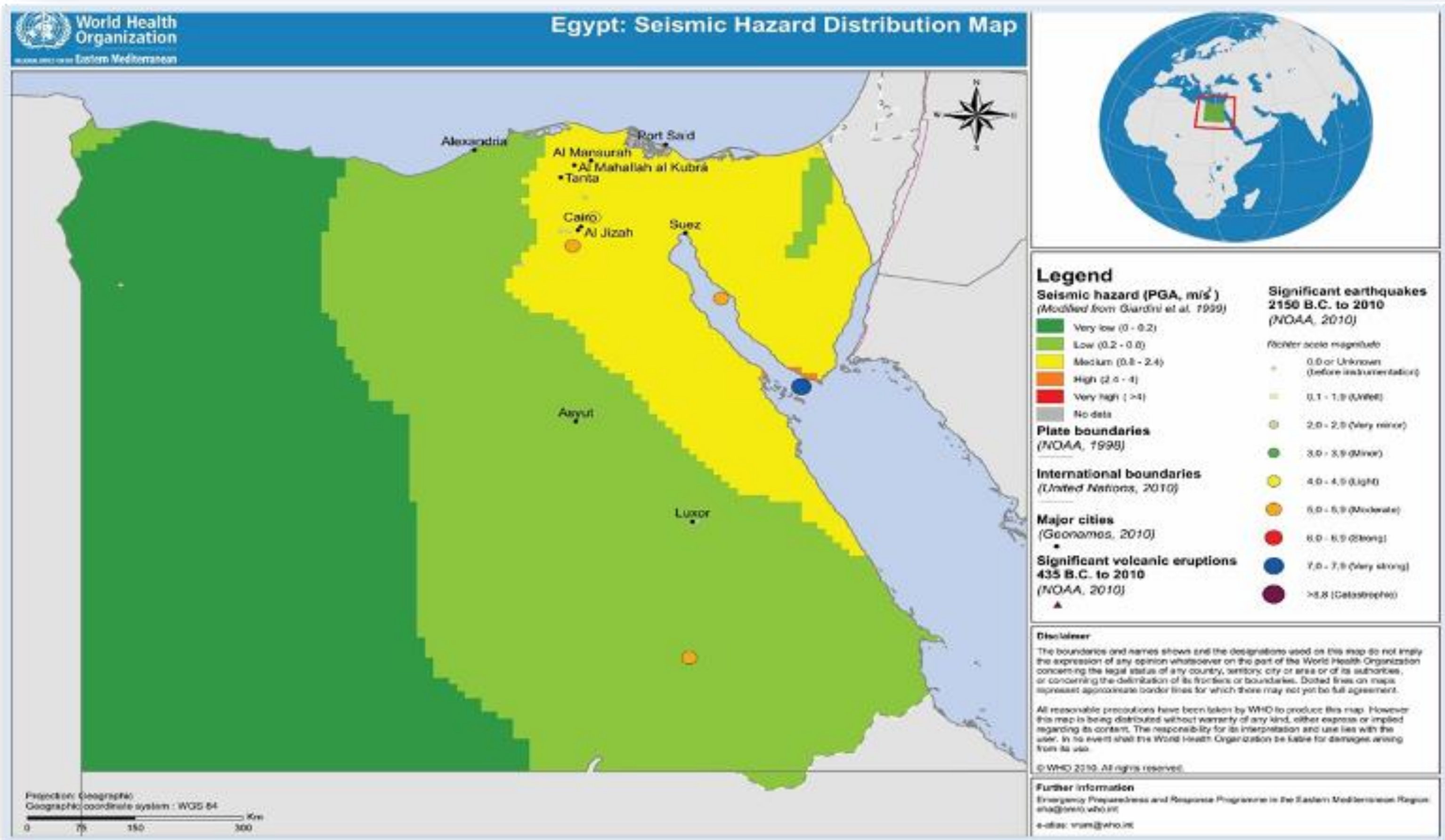


Figure 4-41: classification of Egypt according to seismic hazard[39]

[39] Source: www.who-eatlas.org

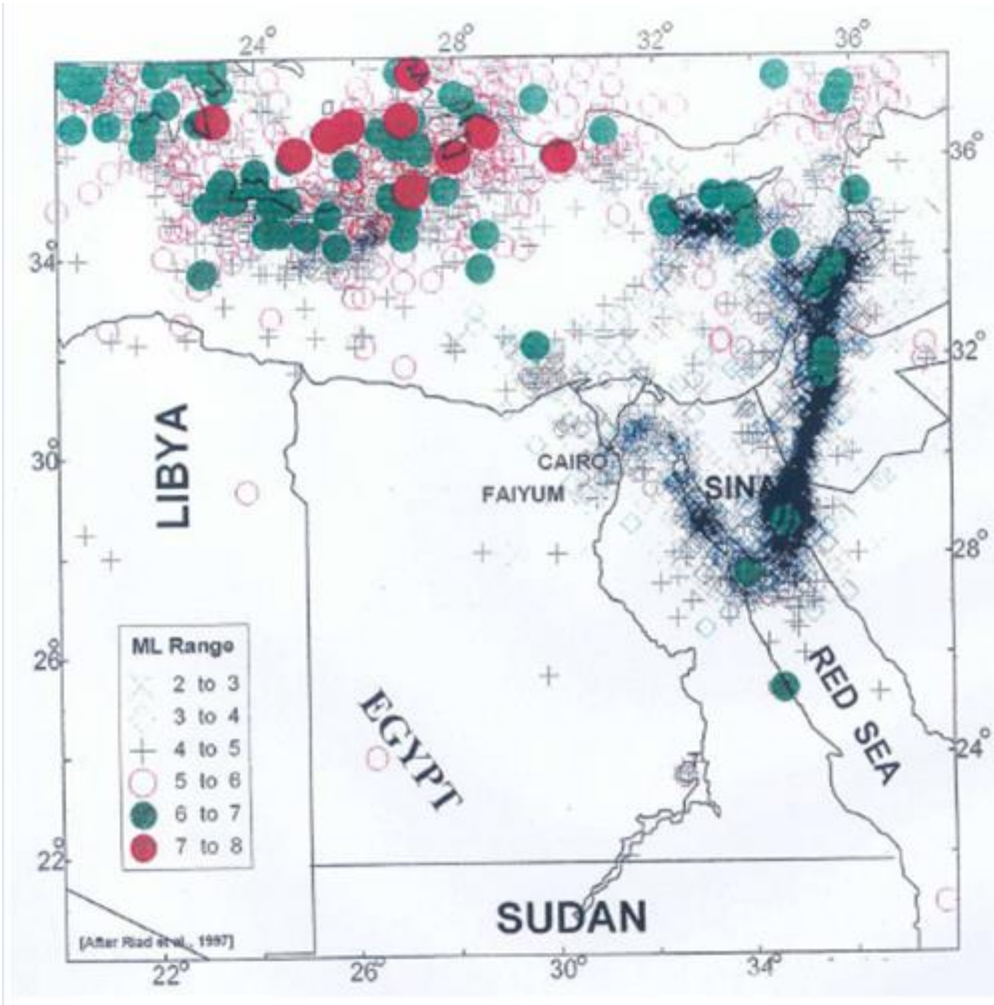


Figure 4-42: Seismicity Map of Egypt and Surrounding Areas during the Period from 1900–1996 (compiled from different authors)

4.12 Man-Induced Hazards

As pollution issues become a problem in several cities all over the world, industrial estates were developed to house a number of industries in one place usually on land peripheral to a city or in its suburbs. Some of these industries pose a sustainable threat to the environment if not well managed.

4.12.1 Smoke

The daily mean concentration of smoke from the industrial areas should not exceed the recommended WHO guide line of 125g/ m.

4.12.2 Suspended Particles

The suspended particulates are due to the dust emitted from the limestone quarries in the eastern part of the study area. However, the concentration should not exceed the WHO guide line of 60 – 90 g / m.

4.12.3 Siltation

Siltation in the Al-Saff canal, agriculture drains, and storm water channels and flood wadis should be monitored routinely to avoid clogging or capacity reduction. Periodic mechanical removal of silt by drag-line type shovels may need to be carried out to the site. To avoid possible slope failure of the canal and the outlet discharge tunnel, stone lining of the banks, in the conventional manner, need to be considered.

4.12.4 High-Tension Power Lines

High tension power lines that extend away from the power station near by the project area should be sited to avoid human settlements and other ancillary human activities. The electromagnetic field encircling these lines is known to have a negative effect on health and communications. Human activities should be kept at a distance from these lines calculated according to conventional standards.

4.12.5 Water Hyacinth

The excessive growth of Water Hyacinth ***(Ward Al-Nile)*** is a problem of national dimension because of the nutritive – nature of the Nile water due to the extensive fertilization of the agricultural land. Mechanical collection of Water Hyacinth and its disposal on land is the common national remedial practice. The open channels should be protected from the invasion of the floating plant.

CHAPTER 5

STAKEHOLDER ENGAGEMENT AND CONSULTATION ACTIVITIES

5 Stakeholder Engagement and Consultation Activities

5.1 Scope

Comprehensive and context-specific stakeholder identification and analysis were conducted during the reporting period (January - February 2021), including identification of individuals and communities actually and potentially impacted by the project, in particular vulnerable individuals or groups, as well as other relevant stakeholders. Description of the precise public engagement and consultation activities undertaken with different groups of impacted individuals, communities and other relevant stakeholders.

The consultation chapter aims at highlighting the key consultation and community engagement activities and their outcomes, in addition to outlining the validity and reliability of the collected data. Throughout the various consultation and engagement activities, the work team experienced and recorded remarkable and overwhelming stakeholder acceptance, even eagerness, by the community and the governmental stakeholders towards the proposed project.

Consultation activities (interviews, focus group discussions, consultations) with various stakeholders and community people in the host communities were held in the project areas:

All activities conducted are in compliance with the following regulations and operational polices:

- EIB and AFD environmental and social requirements. It is noted that AFD has adopted the World Bank's Environmental and Social (E&S) Framework.
- Egyptian regulations related to the public consultation
- Egyptian Law of Environment (Law No. 4 of 1994) and its amendment by Law 9 of year 2009), stipulated that group C projects must conduct two public consultation events. The first event should be held by the consultant as part of the scoping activities to explain the applied ESIA methodology to relevant stakeholders. The second consultation session (people hearing) should be held after completion of the ESIA study and reporting in Arabic language (expected March/April2021).

A further round of public consultation will take place during the design phase of the project according to EEAA and international financing agencies guidelines

5.2 Consultation Objectives

The objective of the SE is to ensure the safe and successful Project delivery by:

- Properly **informing** stakeholders including persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively;
- Actively **listening** to comments, ideas and concerns raised by stakeholders and recording the same for follow up;
- **Avoiding conflict** by addressing impacts and issues raised by stakeholders promptly; particularly with the communities that will not be served by the project

- Ensuring that **fears** and apprehensions about the nature, scale and impact of the operation have been properly considered in the development and management of the Project;
- **Accessing** and making good use of existing local knowledge of the area;
- **Avoiding** any **misunderstandings** about the project and properly manage expectations;
- **Communicating** and implementing a viable community feedback mechanism.

The output of consultations will:

1. Define potential project stakeholders and suggest their possible project roles
2. Identify the most effective outreach channels that support continuous dialogue with the community
3. Get stakeholders feedback on the defined impacts and mitigation measures as part of the drafted ESIA and integrate their feedbacks and comments in the production of the final ESIA

5.3 Consultation Scheme

The Consultation team for this study has adopted a multi-level of consultation activities that enable the marginalized and voiceless, within project area to gain information about the project as well, raise their concerns and worries regarding the project during various implementation phases.

1. The study team visited the project area in order to define the various stakeholders;
2. The study team developed an engagement plan tailored for the rural communities with the study team;
3. Based on the identification of stakeholders, various discussion guides and questionnaires were prepared in order to engage:
4. The study team divided the various engagement of the project to 1) scoping phase, 2) data collection phase and 3) consultation phase;
5. All activities conducted were documented with photos and lists of participants whenever possible in order to warrantee appropriate level of transparency

Consultation session was conducted at WWTP meeting room to enable the participation of the local community members. Transportation was provided in order enable the local community members to arrive to the venue. Other consultation was conducted with farmers at agriculture area served of Al Saf Canal.

Community people in some project areas were of low educational background. Thus, the study team tried to build communication channels through speaking simple Arabic that can be comprehended by the community people. Females from the rural village were reluctant to attend the public meeting due to the norms and traditions. Thus consultations were held with women during the field work.

5.4 Defining Stakeholders

Given the fact that the project areas have been thoroughly defined at this stage, stakeholder identification was based on analysis of geographical, legal, institutional, and operational scope of the project. The following Table 5-1 represents the stakeholders contacted and engaged for the consultation activities, and the list of participants is attached in Annex I.

Table 5-1: Target stakeholders' consultation groups

Group of stakeholders	Stakeholders
Technical group	Consulting Office for Infrastructure Engineering INFRA Engineering Senior Consulting Engineering Hydraulic Research Institute (NWRC- MWRI) Drainage Research Institute (NWRC- MWRI)
Bodies involved in Project implementation and operation	Greater Cairo Wastewater Company Construction Authority for Potable Water & Wastewater Helwan WWTP operators
Local residents	Residents located along roads adjacent to the WWTP and in the surrounding areas
Land owner	Cairo Wastewater Company Ministry of Water Resources and Irrigation MWRI who owns and operates open water bodies around the WWTP such as Al Saf irrigation Canal, agriculture drains and storm channels
Business owner	All factories adjacent and near by the Helwan WWTP Agriculture lands
Administrative Bodies and Authorities	Ministry of Environment (MoE) EEAA Egyptian Environmental Affairs Agency. Ministry of Water Resources and Irrigation
International donors	EIB European Investment Bank AFD L'Agence Française de Développement

5.5 Stakeholders Consultation and major findings

5.5.1 Planning and Design Technical Group

On the 28th of December 2020, the environmental team had a consultation session with the technical team lead by technical team head Dr. Ashmawy. The following images were taken during the consultation session.

Figure 5-1: Meeting with Infra Chairperson

During this session, all aspects of the project were discussed in details which are summarized in the following points:

- Introduction of the project's history: where the general scheme of wastewater treatment in all Cairo was briefed and how the project origins descended as part of such scheme.
- Discussion on the project's alternatives: the history of the alternatives development was reviewed and detailed about each elements and differences in discharge routes, main forces, pump stations, treatment plants and treatment technologies.
- Environmental and social problems: Various environmental and social issues that are rising in the project's area were discussed and given examples; such as manholes overflow due to force main overload and shortage of water allocation and pollution in Al Saff canal.
- Important documents such as general schematic maps, alternatives maps and other relevant documents were discussed.
- Sharing the technical findings concerning the project's finance, technical aspect such as main force route choice, WWT technology choice and others.
- Valuable opinions of the technical team head which can lead to several recommendations which can elevate the efficiency and viability of the project and make it better environmentally.
- Sharing opinions and experience allowed drawing a new perspective for the alternative chosen and make it possible to fit it into a strategic vision. Such perspective allows maximum utilization of current resources and good strategic planning for long term schemes.

Furthermore, this session included vital experience exchange by sharing findings and brain storming for environmental solutions/benefits. The most important points shared at this part of the session included:

- There is urgent need for the proposed project where the proposed project will provide of proper and comprehensive sewerage system of project area south of Cairo.
- 15 May WWTP will be in operation in 2021after rehabilitation at the design capacity 30,000 m3/day, and wastewater effluent will be reused for landscape irrigation within 15 May City.
- No resettlement and land acquisition is required for and pipelines, the new proposed pump stations (2A and 3A) and Helwan WWTP extension

- First Alternative is recommended for short and medium term action while second alternative is a must for short term action and planning.
- Unify the treatment technology for wastewater and sludge is recommended for the following reasons:
    - Better and easer operation and maintenance
    - Unified training and capacity building programs for operation and maintenance crews
    - Better and ease connection for different treatment units
    - Unified spare parts
    - Less human resources and cost required for operation and maintenance

5.5.2 Bodies involved in Project operation

On the 2nd of January 2021, the ESIA consultants's team made a site visit to Arab Abu Sa'ed (Helwan) WWTP. This visit was divided into two main activities. The purpose of the site visit was to have better understanding of the project's area boundaries, the surrounding activities, and the environmental and social conditions and to collect the primary input from the project site. Furthermore, the second main activity of the site visit was to conduct a meeting with Helwan WWTP management and operators.

The ESIA consultant's team held meeting with Eng. Tarek Abdel Azez, Helwan WWTP manger. Eng. Tarek started by brief background and timeline of Helwan WWTP. The following notes the most important points given in that overview:

- Helwan WWTP started in 1992 with treatment capacity of 350,000 m^3/day.
- Further extensions were implemented in the WWTP 2006-2009 to have total treatment capacity of 550,000 m^3/day.
- Different administrations were running the plant during the period of 2009-2018, the current administration took over at the end of 2018 and made remarkable improvements within such short period of time.
- Currently Arab Abu Sa'ed WWTP can treat up to 625,000 m^3/day and during peak times can reach 700,000 m^3/day and can still be treated within the limits without any bypass.
- Currently there are nearly 400 contracted employees in the plant (mostly from the local community) with the possibility of temporary employment when needed.
- Some information was given for 15th May WWTP: it is designed with a capacity of 30000 m^3/day. The produced sludge was handled by the same WWTP and it has a separate line connecting it directly to discharge the treated effluent to Al Saff Canal. Currently due to 15th May on going rehabilitation, all its WW is diverted to Arab Abu Sa'ed WWTP. It should be on operation again in 2021.
- There was a project of mixing Nile water with treated WW in Al Saff canal in order for the local farmers to be able to irrigate their lands, but this mixing project is currently on hold.
- Currently all sludge is thickened via gravity thickeners, then onto drying beds for up to 70 days in winter and finally to stock areas for 3-6 months before selling.
- All sludge is sold for a contractor who is responsible to further sludge treatment if needed.
- Sludge price under 1st administration was 65 LE/ton which is relatively lower than other WWTPs (up to 200 LE per ton) due to the high sludge sand content. But now, sand ration is normal and the administration is planning on setting more equivalent price per ton with the coming tender and contract.

- Generally, for any non-domestic solid waste that needs to be disposed of in the Helwan WWTP the administration has a contract with a public landfill facility in 15th May city.
- Electricity is supplied through the electricity authority, and domestic drinking water is supplied through a pipeline from the nearby Iron and steel industrial facility.
- 30 % of the sludge drying beds will be replaced by mechanical sludge dewatering to treat 30% of the corresponding sludge amount and a possibility of introduction of digester for further treatment.
- The proposed development project will help improve the quality of the wastewater effluent to Al Saff canal to unrestricted irrigation; which will allow a wide variety of crops for the farmers who can find more financially viable alternatives, and more lands can be cultivated then.
- The WWTP administration has already had a session with general security and got the approval for all extensions within the plant's premises and is waiting for the approval of the forcemain paths.
- The introduction of a sludge digester is both beneficial and raises some concerns regarding risk for the plant and surrounding industries and the need of very high capacity building to handle such technology.

A tour of the plant was conducted; the following Figure 5-2 show effluent secondary clarifier and effluent channel (see also Figure 5-3 for administrative building SCADA system). It is worth mentioning that, the surface aerators of the Activated sludge tank had spray barriers installed so as seen from the following Figure 5-4 and that workers could move safely. Also the odor was very minimal through all the tour which is a very good indicator.

Figure 5-2: One of Secondary clarifier Helwan WWTP

Figure 5-4: Activated sludge tank with spray barriers

Figure 5-3: A small demonstration of the SCADA system of Helwan WWTP

Also a tour into the WWTP laboratories was conducted; Figure 5-5 and Figure 5-6 show laboratory facilities and sheets of effluent quality results.

Figure 5-5: Laboratory illustration of the wastewater quality process

Figure 5-6: Laboratory wastewater quality analysis results

The following remarks can be noted:

- The laboratories are equipped with the basic essential technologies for Heavy metals, BOD, TSS pH, Do, free chlorine, salinity other basic parameters (equipment for E. Coli almost there except the counting plates.
- The effluent results of the plants are very good matching with Egyptian allowable standards.
- The WWTP staff is using golden fish as bio indicator of pollution level in effluent water. Figure 5-7 shows the golden fish living in effluent water, these fish are very sensitive to water pollution; and as can be seen no or very little darkened areas appear on their scales as indicator of very good effluent.
- The plant intends to further explore aquaculture projects by applying small scale fish tank of specific species that can survive solely on effluent wastewater and will create fish farm to

cultivate them and sell them for industries that can grind and sell them as animal fodder. This is a research topic that will be applied jointly with Kafr el Shiekh University.

Figure 5-7: Golden fish as bio-indicator in the Helwan WWTP

5.5.3 Bodies involved in Project implementation

Construction Authority for Potable Water & Wastewater (CAPW)

Greater Cairo Wastewater Company (GCWC)

Team leader of this study Dr. M Ashmawy have been in direct consultation with CAPW and GCWC covering all aspects of the project and Introduce & discuss the project's technical studies by Atkins including but not limited to:

- Project components, treatment technologies for wastewater and sludge,
- Project's alternatives: detailed about each elements and differences in discharge routes, main forces, pump stations, treatment plants and treatment technologies.
- Project extension area served and its requirement specially PS 3A and PS 2A and routes for the new forcemain.

Moreover, included the Technical Study for Verification of Extension Requirements & Cost updating by INFRA have been discussed including:

- Validation the predicted population of the served area and generated wastewater flow
- Forcemain length and diameter connecting the new PSs 3A and 2A
- The new intermediate PS for the tertiary treatment at Helwan WWTP extension
- Postpone the dual-forcemain to PS 3 for next phase
- The environmental study should include:
    - Climate Resiliency and Vulnerability Assessment
    - Carbon footprint
    - Sludge management

All parties agreed that scheme alternative (1) offers much enhancements and allows for maximum efficient use of existing resources with lower investment needs than alternative (2). On another perspective, alternative (1) does not nullify alternative (2), it can be considered an efficient stepping stone on the short/medium term, while the area of the new Al-Kurimat WWTP can be more clear in the future (long term) with the population expansion and hence clearer decision making can be done.

5.5.4 International Funding Agencies

EIB and AFD

International Funding Agencies (EIB and AFD) provided conceptual paper including ESIA Specific activities to be followed during the ESIA study for Helwan Wastewater Collection & Treatment Project including :

- Assessment of the Project’s impacts in terms of climate change according to the EIB methodology for assessing Greenhouse Gas (GHG) emissions can be found under:
- https://www.eib.org/en/about/cr/footprint-methodologies.htm
- Preparation of the final ESIA and comprehensive ESMP and confirmation of the project’s compliance with EIB and AFD environmental and social requirements

During the appraisal mission, ESIA will be discussed and feedback will be concluded in the updated report.

5.5.5 Local residents and land & Business owners

Also, from the visit, the ESIA constantan’s team was able to meet with business owner and local community and identify some input about the project and the surrounding relative areas:

- The area surrounding Arab Abu Sa’ed WWTP is all brick factories, mostly illegal squatters. Most of these factories have been out of work due to the new land acquisition fine system. Other activities around the plant are Marble factories and fertilizers industries. Figure 5-8 and Figure 5-9 show some of the area and industries around Arab Abu Sa’ed WWTP and the unpaved road to the WWTP.
- The nearest residential settlement to the WWTP is Arab Abu Sa’ed village around 2.0 km away to West.

Figure 5-8: Brick factories surrounding Helwan WWTP

Figure 5-9: Workshops around along the unpaved access road to Helwan WWTP

5.5.6 Famers

Following the meeting with WWTP operation and management, session with the local farmers conducted as illustrated in the following figures. The participants were:

- Hamid Abu Sa'ed
- Mahmoud Mashhour
- Mohamed Khaled Abu Sa'ed
- Mosallam Kamil
- Mohamed Abdallah
- Abdelhamid Rashid

Figure 5-10: Meeting with the farmers in the project area

During this session very vital issues were discussed summarized in the following points:

- Farmers mostly grow sesame and sometimes wheat in summer, and onions and garlic in winter, with some olive tree and palm trees in the area.
- Agricultural land ownership per farmer is between 2-5 feddans, and up to maximum of 10 feddans for few cases.
- Even though the area is mostly sandy silt with high seepage and infiltration rate and the land doesn’t mostly need fertilizers because the treated wastewater has enough nutrients and farmers rarely need to use artificial fertilizers from the surrounding industries.
- The native farmers of the tribe of Arab Abu Sa’ed are around 700 farmers. Going downstream more incomers from adjacent large communities from other governorates.
- Most farmers follow the ministry of agricultural recommendations to not plant any water retaining crops (vegetables) such as tomato and cucumbers and nothing buried in the ground such as potatoes.
- No irrigation water available in the last 15 kmd Al-Saf Canal so agricultural land in this last reach downstream the canal can only irrigate using groundwater wells. The farmers reported that shallow groundwater is brackish and they need to reach depths up to 30 meters to find the deeper fresh water, which is not financially possible for most of them.

- Farmers as well as employees from the plant showed their concerns of the brick industries in the area as they find a source of air pollution.

Furthermore, some of the joint suggestions that can improve the overall project and also some general remarks on the plant can be summarized in the following points:

- There is a large agricultural land of area 500 feddans close proximity of the WWTP that was used to be irrigated from treated effluent through pipe outlet. The farmers used to irrigate their lands by flooding. This situation caused seepage impacts on the nearby residential houses. This pipe outlet stopped few years ago. Also, the pipe was removed and farmers could no longer cultivate that land. The farmers are proposing to:
  - Reactive this limited irrigation scheme from WWTP effluent with control valve where they are suffering shortage of water. They are willing to introduce drainage system to collect the seepage water from their land and protect the nearby houses from seepage.
  - Also, the collected drainage water can be drained into nearest storm channel.
  - The farmers are willing to pay for the cost for pipeline and valve for irrigation and the drainage for seepage control.

- Al Saff canal agriculture area served about 42,000 feddan which is large scale agriculture area. Large agricultural investment projects are recommended. This will make agricultural in this area more viable economically as modern irrigation methods such as dripping and sprinklers can be used and hence save extensive water loss due to sandy soil. Also, this will make communicating agricultural needs more effective as there will be good clear representative.
- Also, Agriculture association and advisory agriculture unit are recommended to be developed in the Al Saff area served for better management and coordination among famers.
- The Local residents and land & Business owners within project area showed high social acceptability of the project and appreciate the benefits coming out from the project mostly in terms of:

  - Improve Al-Saff water quality;
  - Providing more treated effluents that can meet the demand for downstream reach of Al-Saff Canal;
  - For other served area included in the upgrading the collection system, appreciating provision of proper and comprehensive sewerage system of project area south of Cairo and prevent overflow from manholes of some zones within the served area

5.5.7 Research and Academia Group

Drainage Research Institute is one of eleven institutes of National Water Research Center Its mission is to conduct cutting-edge research in land drainage and surface water quality management on the regional and national levels. Acquire, manage, and execute technically relevant and economically sound basic and applied research programs and technologies to preserve the diversity of the national ecosystems, advance responsible water resource management, and improve human health and welfare.

On the 6th of January 2021, the ESIA consultant's team made a site visit Drainage Research Institute expert team:

- Dr. Mohamed Essa
- Dr. Yesser Mahrous

The purpose of the site visit was to have a better understanding of Al Saff agriculture area in terms of:

- Irrigation and drainage systems serving the project area and their issues;
- Status and issues of agriculture area , crop pattern,
- Impact of the proposed project "extension of Helwan WWTP and effluent up to 800,000 m3/day) " on irrigation and drainage hydraulic capacity
- Recommendations for improvement

The following notes summarize the most important points given in that overview:

Al Saff Irrigation Canal

- The main water supply is Helwan WWTP effluent and other supplement source from Nile is not on operation.
- The Canal is lining with many cracks leading to seepage water into agriculture land specially to right side of the Canal
- Last reach of the canal is dry due to flood irrigation and seepage.
- Study conducted by Hydraulic Research Institute to assess the capacity of Al Saf canal to accommodate the proposed extension Helwan WWTP and effluent up to 800,000 m3/day on the canal hydraulic capacity:
  - Studied the existing condition hydraulic capacity of the canal with the received discharges of 550 m3/day from the WWTP. The results of model scenario showed no flooding problem over the canal banks in both new and old Al-Saf canals.
  - Studied the existing condition hydraulic capacity of the canal after increasing the effluent discharge to be 800 m3/day from the WWTP. The results of this model scenario showed particularly flooding problem over the banks of new Al-Saff canal (from kilometer 20.6 to the canal end). Also, the model results showed flooding problems over the banks of new Al-Saf canals from kilometer 20.6 to the end of the canal.

Open agriculture drains and storm channels

- The current drainage system is not design to accommodate the current drainage water and seepage from irrigation system and agriculture lands.
- May problems due to irrigation losses due to flood irrigation, high drainage water and seepage flow leads to drain system over flow, create many ponds and swamps, see Figure 5-11 and Figure 5-12.
- Many illegal irrigation gates along Al Saff canal can be found.
- Drainage Research Institute conducted study to assess and propose six open main drains can accommodate the drainage water in the area with the current WWTP effluent of 550,000 m^3/day.
- Further study conducted to assess the capacity of the proposed six open drains to accommodate the proposed extension Helwan WWTP and effluent up to 800,000 m3/day on irrigation and

drainage hydraulic capacity. The study showed that the proposed drains can accommodate the drainage due to supply the proposed effluent flow.

- There is an urgent need to improve the drainage system in the project area and minimize water losses.
- Change the irrigation system from flood to farrow or modern irrigation.
- The addition treated wastewater effluent make the effluent up to 800,000 m^3/day is needed to compensate the shortage of water and supply last reach of Al saff Canal water demand.
- Improving the treated wastewater would allow the farmers to have a cash crops and so improve their life and sustain agriculture land.

Figure 5-11: Typical Ponds in the Al-Saff area served receiving the seepage water and losses from irrigation canal

Figure 5-12: Water logging and soil salinization in the project area

5.5.8 EEAA Egyptian Environmental Affairs Agency

In June 1997, the responsibility of Egypt's first full time Minister for Environmental Affairs was assigned as stated in the Presidential Decree no.275/1997. From thereon, the new ministry has focused, in close collaboration with the national and international development partners, on defining environmental policies, setting priorities and implementing initiatives within a context of sustainable development. According to the Law 4/1994 for the Protection of the Environment, the Egyptian Environmental Affairs Agency (EEAA) was restructured with the new mandate to substitute the institution initially established in 1982. At the central level, EEAA represents the executive arm of the Ministry.

On the 11th of January 2021, the ESIA consultant's team made a consultation with:

- Dr. Hethem Salah (Administrator Environmental Compliance Cairo Branch, EEAA)
- Dr. Mohamed Reda (General Manager Water Quality, Greater Cairo Branch, EEAA)

The purpose of the consultation was to get feedback regarding:

- the project from environmental point of view
- Compliance and current status of the Helwan WWTP and its area served;
- Issues and recommendation to be considering in implementation and operation of the proposed project.

The following are the most important points given during the consultation:

- The WWTP receives industrial wastewater such as Iron and steel, cupper, Metal, fertilizer companies which should have their own treatment unit before discharge into the public sewer system. Most of the treatment facilities are old and in many cases their discharge violates the required quality. This situation would have impact on the influent quality and Helwan WWTP treatment efficiency.
- Heavy metals in wastewater and sludge should be analyzed to insure the nontoxicity of the treated wastewater and treated sludge and meeting the required standards.
- The received untreated or violated industrial wastewater should be considered in the Helwan WWTP treatment process and the proposed project.
- Egyptian Pollution Abatement Program (EPAP III) Funding is available for industrial activities in Greater Cairo and Alexandria. Companies applying must be credit worthy. Projects should: a) comply with Egyptian environmental law. b) decrease pollution loads by 50%; c). EEAA is offering this great chance for industrial activities in the project area to reduce their pollution load discharged into the effluent of the Helwan WWTP.
- They would like to be confirmed that during the construction phase (around 3 years), the sanitation facilities will not be interrupted.
- No complains about the treatment and sanitation facilities over the last three years were reports
- Environmental compliance action plan for the WWTP is completed and meets EEAA requirements.

EEAA comments and recommendations are as followings:

- Maintenance crew would need more training and capacity building.
- No need to have more administration staff while the there is a need in increase the technicians for operation and maintenance.
- There is a need to improve Laboratory facilities and train the staff while storage facilities needs to review safety and health measures.
- Insure coordination for operation of pumping station during peak flow according to agreed schedule.
- Insure coordination with Ministry of Water Resources and Irrigation regarding (MWRI) the WWTP treated effluent into Al-Saff Canal.
- Insure coordination between WWTP administration and EEAA to monitor the treated effluent through the National monitoring Program for effluents into water ways.

5.6 Consultation Major Findings

Sharing findings and brain storming for environmental solutions/benefits, the most important points shared at this part of the session included.

5.6.1 The Proposed Sanitation facilities

- There is urgent need for the proposed project where the proposed project will:
    - Provision of proper and comprehensive sewerage system of project area south of Cairo and prevent overflow from manholes of some zones within the served area

- Supply treated wastewater up to 800 m^3/day into Al-Saff Canal and improve the water quality in Al-Saff Canal,
- Efficiently treat and utilize the sludge and so no losing electricity that could cover up to half of the electricity consumption of the WWTP.
- Provision of proper and comprehensive sewerage system of project area south of Cairo.

- First Alternative is recommended for short and medium term action while second alternative is a must for long term action and planning.
- Unify the treatment technology for wastewater and sludge is recommended for the following reasons:
    - Better and easer operation & maintenance and Unified spare parts
    - Unified training and capacity building programs for operation and maintenance crews and Less human resources and cost required for operation and maintenance
    - Better and ease connection for different treatment units
- It is recommended that the administration of Helwan WWTP sets more equivalent price per ton with the coming tender and contract.
- The laboratory need for improvements and update terms of equipment and capacity building.
- The main and only road to Arab Abu Sa'ed WWTP needs to be paved so it is more facilitated to connect to the plant.

5.6.2 Environmental Compliance

- The WWTP receives industrial wastewater such as Iron and steel, cupper, Metal, fertilizer companies. This situation would have impact on the influent quality and Helwan WWTP treatment efficiency.
- Heavy metals in wastewater and sludge should be analyzed to insure the nontoxicity of the treated wastewater and treated sludge and meeting the required standards.
- EEAA is offering this great chance for industrial activities in the project area to reduce their pollution load discharged into the effluent of the Helwan WWTP through Egyptian Pollution Abatement Program (EPAP III) Funding.
- They would like to be confirmed that during the construction phase (around 3 years), the sanitation facilities will not be interrupted.
- No complains about the treatment and sanitation facilities over the last three years were reports
- Environmental compliance action plan for the WWTP is completed and meets EEAA requirements.
- EEAA comments and recommendations are as followings:
    - Maintenance crew would need more training and capacity building and there is a need to increase the technicians' crew for operation and maintenance.
    - There is a need to improve Laboratory facilities and train the staff while storage facilities need to review safety and health measures.
    - Insure coordination between WWTP administration and EEAA to monitor the treated effluent through the National monitoring Program for effluents into water ways

5.6.3 Treated Effluent Irrigation Scheme

- There is a large agricultural land of area 500 feddans close proximity of the WWTP that was used to be irrigated from treated effluent through pipe outlet. The farmers are proposing tor reactive this limited irrigation scheme from WWTP effluent with control valve where they are suffering shortage of water. They are willing to introduce drainage system to collect the seepage water from their land and protect the nearby houses from seepage and pay for all costs.
- There is need to improve Al Saff canal agriculture area served (42,000 feddan) to make agricultural in this area more viable economically as modern irrigation methods such as dripping and sprinklers can be used and hence save extensive water loss due to sandy soil. Also, this will make communicating agricultural needs more effective as there will be good clear representative.
- Also, Agriculture association and advisory agriculture unit are recommended to be developed in the Al Saff area served for better management and coordination among famers.

5.6.4 Al-Saff Canal

- The Canal is lining with many cracks leading to water losses and action I is needed for rehabilitation.
- There are many illegal irrigation gates along Al Saf canal can be found need action for removal and control irrigation intakes along the canal.
- The capacity of Al Saf canal can accommodate the existing Helwan WWTP treated wastewater effluent.
- Hydraulic capacity of the canal cannot accommodate the increasing of the effluent discharge 800,000 m3/day from the WWTP. Where particularly flooding problem over the banks of new Al-Saff canal (from kilometer 20.6 to the canal end) and flooding problems over the banks of new Al-Saf canals from kilometer 20.6 to the end of the canal.

5.6.5 Drainage system and storm channels

- The current drainage systems are not design to accommodate the current drainage water and seepage from irrigation system and agriculture lands.
- Many problems due to irrigation losses due to flood irrigation, high drainage water and seepage flow leads to drain system over flow, create many ponds and swamps.
- There is an urgent need to improve the drainage system in the project area and to minimize water losses.
- The proposed six open main drains can accommodate the drainage water in the area with the current WWTP effluent of 550,000 m^3/day and the planned extension up to 800,000 m3/day
- Change the irrigation system from flood to farrow or modern irrigation.

CHAPTER 6

IMPACT IDENTIFICATION AND ANALYSIS

6 Impact Identification and Analysis

This section of the ESIA sets out the approach and methodology and identifies the potential environmental impacts of the proposed project. The potential environmental impacts have been separated into those occurring during the construction phase and those occurring during the operational and maintenance phase.

The report is ensuring that no major and or serious negative impact shall be associated with the project construction/implementation/operation and maintenance. The overall environmental and social impacts shall be positive from the project operation.

6.1 Impact Evaluation Methodology

Each potential impact resulting directly or indirectly from the project is categorized based on the **Basic Impact Index** and the **Receptor Sensitivity.** Based on these two parameters, the **Impact Significance** is evaluated.

The significance of each potential impact will depend on the project activities and the potential impacts on the environmental receptor. **Basic Impact Index:** The criteria for defining the basic impact index includes assessing the following parameters, see Figure 6-1.

- Magnitude: describes the quantity of the resource (or receptor) potentially affected by the activity.
- Spatial extent: the geographical area over which the impact is experienced.
- Duration: the length of time over which the impact will be experienced. An impact may be present only while an activity is active, or it could persist long after the activity has ceased, in which case the duration may be regarded as the time the receptor needs to recover from the effect.

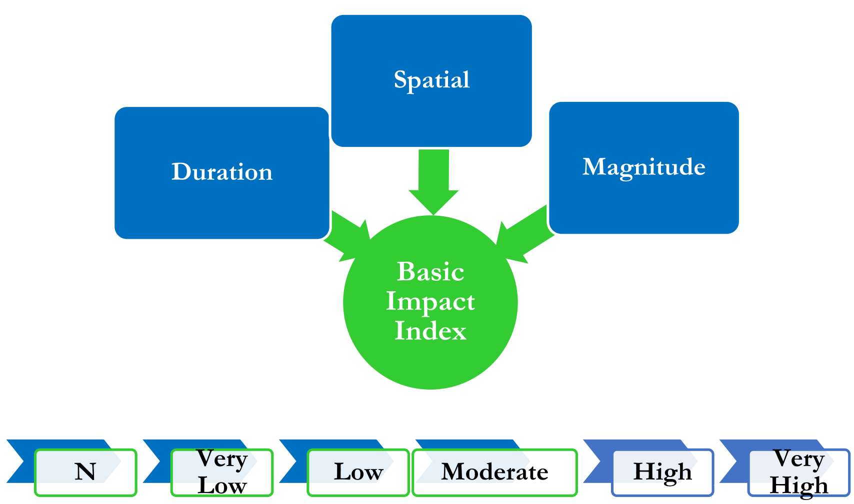


Figure 6-1: Basic Impact Index Assessment

Each potential impact should be evaluated by applying descriptors to each of the above criteria, based on qualitative or, to the extent possible, quantitative evaluation, as follows. **The magnitude of impact is allocated one of the following categories:**

- Very Low (1): A very small proportion of the receptor is affected.
- Low (2): A small proportion of the receptor is affected.
- Moderate (3): A moderate proportion of the receptor is affected.
- High (4): A large proportion of the receptor is affected.
- Very High (5): A very large proportion or all of the receptor is affected.

The spatial extent of impact is allocated one of the following categories:

- N (0): No effect.
- Very Low (1): Local scale impact in the immediate area of the activity.
- Low (2): Local impact in the study area.
- Moderate (3): Regional scale impact.
- High (4): National scale impact.
- Very High (5): Global scale impact.

Duration of impact is described by one of the following categories:

- N (0): No effect.
- Very Low (1): Less than one year.
- Low (2): One to five years.
- Moderate (3): Five to ten years.
- High (4): Greater than ten years.
- Very High (5): Irreversible.

The relative importance of each criterion, as illustrated in Table 6-1 will be evaluated on a scale from zero to five, and expressed as follows: Nil (N), Very Low (VL), Low (L), Moderate (M), High (H), and Very High (VH). The highest figure is assigned to an impact when there is uncertainty about the criteria, so as to reduce the chance of underestimating an impact; thereby minimizing risk. The Basic Impact Index is obtained by the weighted average of these three values, to obtain a whole number between 0 and 5. The magnitude's weight is twice that for spatial extent and duration.

Table 6-1: Basic Impact Index

Basic Impact Index	N	VL		L	M	H	VH
Magnitude	0	1		2	3	4	5
Spatial Extent	0	1		2	3	4	5
Duration	0	1		2	3	4	5

Receptor Categorization: is based on the relationship between the respective project activities and the present baseline environment (the receptor). It is assessed based on the vulnerability of the receptor, including the surrounding population and environment. To illustrate, if the effect of an impact on a receptor is more readily absorbed and easily mitigated, it is less sensitive. On the other hand, as an impact is more challenging to mitigate and cannot be absorbed by the population and/or environment it becomes more sensitive and requires an extensive management plan.

The sensitivity of the receptor is assessed as:

- Low: High capacity to absorb/mitigate impact
- Medium: Limited capacity to absorb/mitigate impact
- High: No capacity to absorb/mitigate impact

Impact Significance: The final impact significance is the result of the combination of the Basic Impact Index and the Receptor Categorization, as shown in Table 6-2: where impact significance may result in one of the following classes: Insignificant (IN), Minor (MI), Moderate (MO) or Major (MA).

Table 6-2: Impact Significance

Receptor Categorization	Basic Impact Index						
	Negative /Adverse						Beneficial
	0	1	2	3	4	5	
L	IN	IN	IN	MI	MO	MA	Positive
M	IN	IN	MI	MO	MA	MA	
H	IN	MI	MO	MA	MA	MA	

Environmental impacts are caused by environmental aspects and can have a direct impact on the environment, contribute indirectly to a larger environmental change, or be cumulative. Those impacts rated as Minor, Moderate or Major are considered to require mitigation measures in order to eliminate the impact or, where this is not possible, to reduce their significance ranking to Minor or Insignificant.

6.2 Potential Impacts during WWTP Construction Phase

The construction phase is envisaged to extend over period of 48 to 54 months. Deep piling is anticipated, with the proposed development requiring deep foundations due to the loose soil in the Helwan WWTP location. A concrete batching plant would be located on-site for the duration of the construction phase, and a temporary area adjacent to the site would be required for material and plant storage.

It is anticipated that the proposed development would employ in the region about 600 workers during the construction phase, none of which would reside on site during this period. Delivery of all construction material, plant and equipment will be via the existing Autostrad and local service roads. While the site is approximately level, excavations and ground leveling will be required. As noted below, the proposed upgrade and extension shall be within the same footprint of the existing Helwan WWTP.

6.2.1 Dust and Air Emissions

Significance of this impact will depend on a number of factors, such as the type of activities taking place, wind speed and location of adjacent properties in relation to the construction site. Meanwhile, the climate of the proposed project area is typical arid environment of Egypt; summer is generally long, hot and dry while winter is short and warm. There are transitional seasons separating the two defined seasons of summer and winter. Air quality at both the construction site and at the nearest receptors could be affected due to the following:

- Exhaust of power generators and vehicles transferring the raw materials and/or those disposing the excavated soil and construction waste.
- Exhaust of construction equipment
- Dust emissions

The following air pollutants are foreseeable for most of the construction activities:

- **Fugitive dust emissions (PM_{10}, $PM_{2.5}$)**
- **NOx and Sox**
- **CO**

Impacts of Exhaust Emissions on Air Quality

Air pollution is likely to be the most significant potential environmental impact during the construction phase. On-site vehicles (lorry, excavators, earth moving machines) will result in the generation of dust and fugitive emissions. Dust emissions are likely to be high due to the prevailing arid climate and the clayey soil within the Helwan WWTP, new PSs and force mains routes. The potential impact results from emissions of certain harmful gases, such as HC, CO, and NOx, due to:

- The movement of site vehicles and mobile plants on unsurfaced ground; and
- Exhaust emissions from mobile equipment and vehicles delivering materials to the site.

Exhaust from heavy machinery (excavators, loaders, trucks), vehicles, equipment, and materials typically associated with the combustion of fossil fuels includes nitrogen oxides (NOx), sulfur dioxide (SO2), carbon monoxide (CO), particulate matter (PM), and volatile organic compounds (VOCs). Relatively high number of equipment and trucks will be needed for the construction works.

Table 6-3 outlines the expected concentration of NO_2, CO, and HC for minimum and maximum expected traffic volumes, as well as allowable limits. The presented values show that such emissions caused during the construction phase are negligible and exert no significant impact on the environment, i.e. air quality.

Table 6-3: Emission level due to traffic associated with the construction works

Emission level ug/m^3	Traffic volume case		Allowable limit ug/m^3
	Minimum	Maximum	
NO_2	1.4	2.8	150
CO	12	24	10,000
HC	2.9	2.9	160*

*USA-EPA standard

Emissions from volatile hazardous materials, such as oils, paints, additives, and chemicals stored on site are will be negligible. However, the expected impacts from emissions will be controlled by using equipment and machinery complying with legal limits, or using equipment and machines causing only very limited emissions. In addition, the provided equipment and machinery used during construction will be certified and maintained as per guidelines, and the increase in emissions stemming from the exhaust of the machinery is unlikely to increase ambient air pollution levels beyond national permissible levels.

Dust

Heavy construction activities are expected to generate dust emissions that may have a substantial temporary impact on local air quality. Dust generation is likely to be particularly significant in a dry environment such as that of project's area.

Helwan WWTP extension

Existing main sources of air pollutants in vicinity of the project site are extensive presence of bricks factories eastern Helwan WWTP, in additions of non-point sources of air emissions such as traffic or existed Helwan WWTP operations.

The Project will represent the major industrial development within Arab Abo Sa'ed area. The proposed activities of upgrade/ extension Helwan WWTP will be carried out within the fence of existed Helwan WWTP.

Figure 6-2 shows the closest sizable population center is Arab Abu Sa'ed village, which is approximately 2km to the west of the project site. However, this dust and emission impact is not likely to extend to the surrounding residential areas of the proposed construction site in the WWTP site. The affected receptors shall only be the workers within the site.

This could result in an adverse impact on the working conditions of workers on the site as well as those working adjacent to the construction site.

Due to the relatively moderate number of vehicles trips (anticipated during construction period) on the surrounding roads connecting the Helwan WWTP site with relative current traffic volume, the generated dust and emission shall only be during their motion and shall disappear within minutes after occurrence. Therefore, the impact will be **"minor", short-term and local**

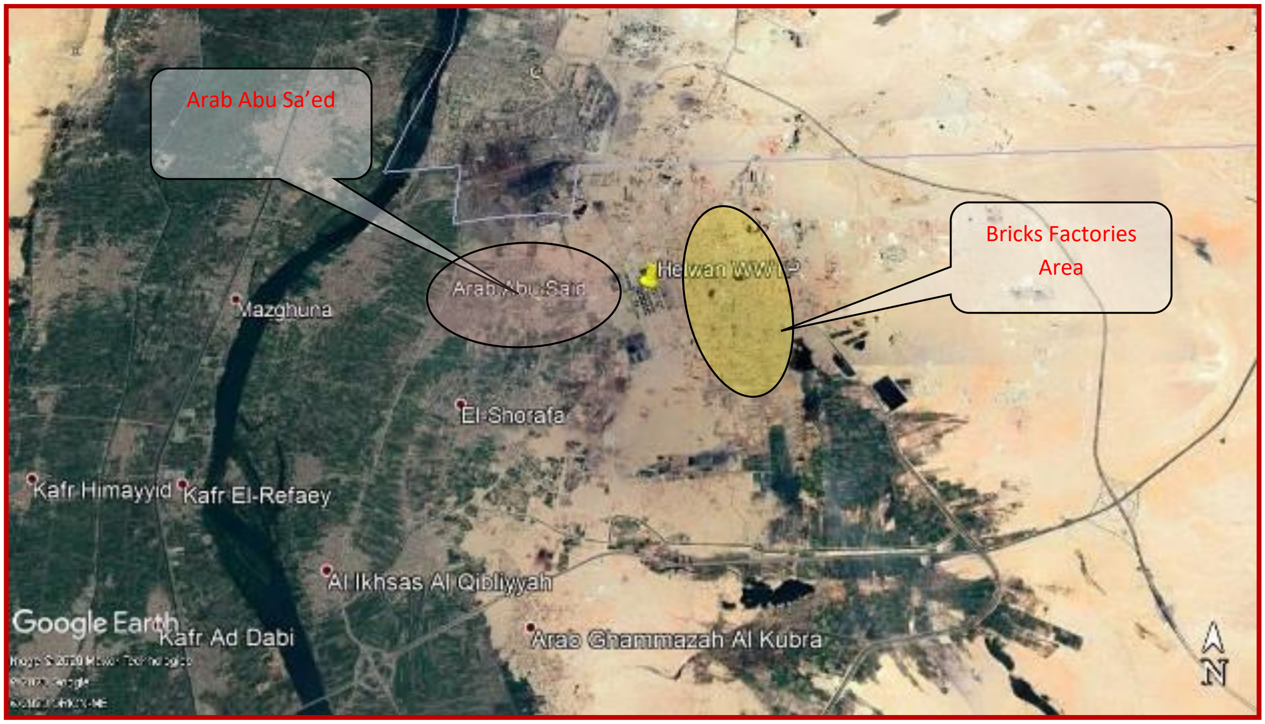


Figure 6-2: Helwan WWTP extension project location, bricks factories and emission sensitive receptors

PSs and Force mains

The proposed project will include construction two pump stations and forcemains in between and to Helwan WTTP in Arab Abu Sa'ed area; construction work will involve soil disturbance and movement, concrete mixing, trenching, compaction and piling.

As described in above, planned construction is to occur over a 48 month period, meanwhile as Figure 6-3 shows the new PSs will be constructed within WWTP facilities, meanwhile both locations are upwind industrial areas. However, force mains routes will pass through residential areas. Consequently, it was concluded that the air quality impacts associated with dust and air emissions generation will be of "Moderate" significance. Table 6-4 is summarizing the expected impact significance of air quality, dust and emissions during construction phase.

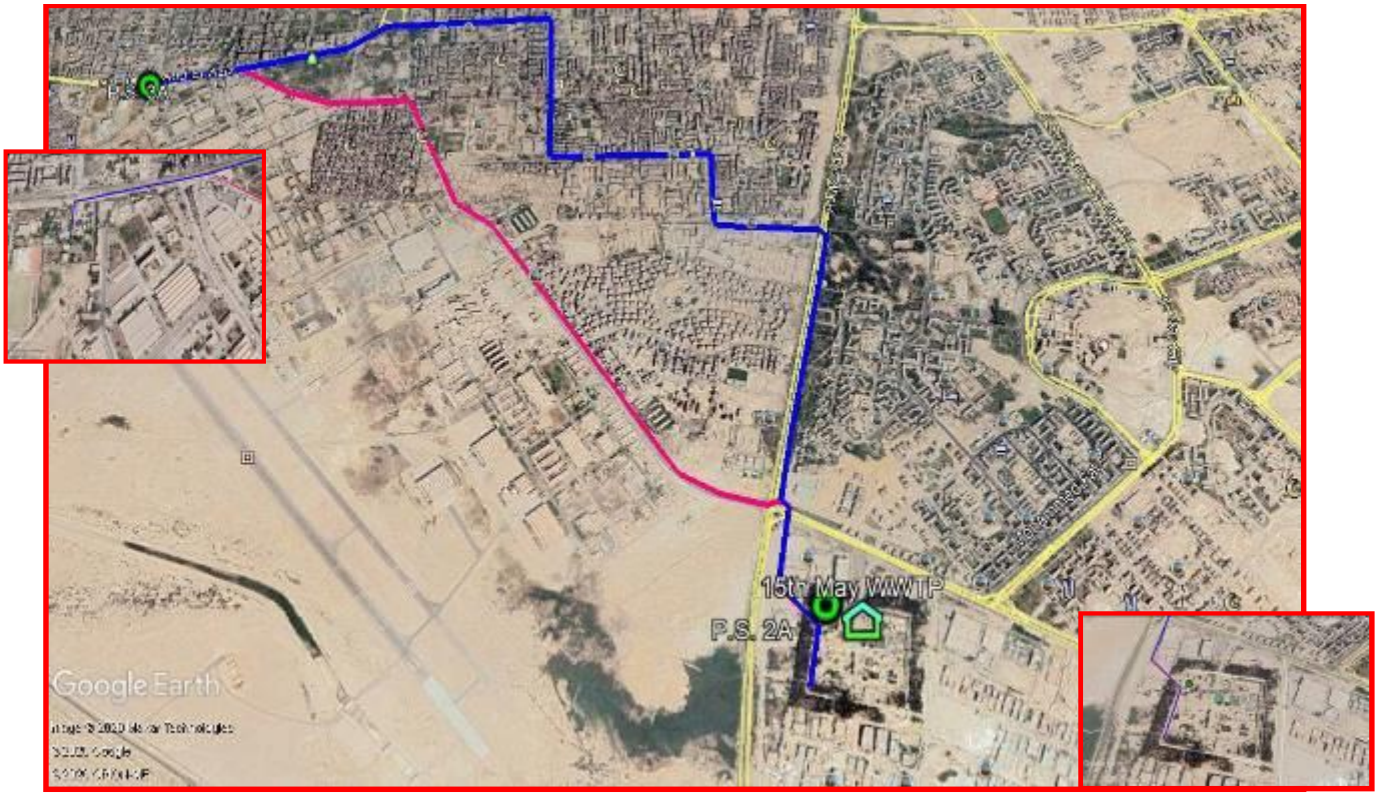


Figure 6-3: shows PSs and force mains project locations, bricks factories and emission sensitive receptors

Table 6-4: Impact of dust on air quality during construction phase

Environmental Receptor		Air Emissions & Dust WWTP extension	Air Emissions & Dust "PSs & Force mains"
BASIC IMPACT INDEX	Magnitude	1	2
	Spatial Extent	1	2
	Duration	2	2
Weighted Average		2	2
Receptor Categorization		Low	Medium
Impact		**Minor**	**Moderate**

Mitigation Measures

Implement a construction site management plan including the following measures:

- Store construction materials in pre-identified storage areas.
- Cover friable materials during storage.
- Cover of all dust generating materials being moved by truck, etc., with a suitable weighted tarpaulin;
- Subject to water availability, surface spraying of road surfaces with water and a soil binding agent;
- Regulation of speed to a suitable speed (20 km/h) for all vehicles entering the village's boundaries.
- Implement preventive maintenance program for vehicles and equipment working on site and promptly repair vehicles with visible exhaust fume.

Monitoring Measures

- Investigate dust complaints from workers and residents of affected villages
- Measure HC, CO and opacity for construction machinery using a gas analyzer
- Visual inspection of vehicles and equipment operating along the gravity sewer and FM routes or entering the site of the PSs

6.2.2 Noise

Various mechanical/electrical equipment will be needed during the construction activities described in the previous section. These include bulldozers, trucks, pavers, and other equipment. The operation of this equipment is the main potential source of noise emissions during the construction and decommissioning phases. The vulnerable groups who are susceptible to the construction noise are the following:

- Onsite Workers; who are the most exposed to the highest noise levels generated from different construction activities due to their proximity to the noise sources.
- Neighboring communities and other sensitive receptors (such as students at schools and other educational institutes, patients at hospitals…etc.).

Noise impact assessment

The site preparation activities such as earth moving, site excavation, transportation of equipment and materials to and from the site through the surrounding road network and the WWTP construction works will contribute to the generation of noise that would impact adjacent facilities and local communities. However, noise exceedance from the construction vehicles, machinery and equipment will be limited to the construction period and will be of short-term. It is likely that some construction activities may overlap and cause increased noise nuisance.

Tools and equipment that will be utilized during the construction phase are not selected yet; however these were identified based on the Consultant's experience and data collected by the Consultant from other similar projects. Table 6-5 includes a list of this construction equipment and their expected noise levels (Society of Automotive Engineers SAE). The equipment was categorized based on the different activities expected during the construction phase of Helwan WWTP project.

Table 6-5: Average noise levels generated by potential machineries used on site[40]

Construction Type	Machine/s	Noise Level d (BA)
Earth Moving	**Compactors**	**78**
	Front loaders/bull dozers	**88**
	Back hoes	**76**
	Tractors	**71**
	Scrapers	**82**
	Caterpillar grader	**84**
	Pavers	**74**
	Dump truck	**74**
	Excavators	**78**
Material Handling	**Concrete mixer**	**76**
	Concrete pumps	**81**
	Cranes	**81**
Stationary	**Pumps**	**82**
	Generators	**82**
	Compressors	**85**
Others	**Vibrators**	**74**
	Vibratory roller	**78**
	Internal electric vibrator	**78**

It is expected that each of the presented activities in Table 6-5 will take place in a different time frame. The Consultant has assumed that the noise emitted from each of the expected activities could be further increased due the noise emitted from power generators, air compressors, etc and has assumed that a 95 dB at source would be representable of such interactions.

Helwan WWTP extension

The proposed activities of upgrade/ extension Helwan WWTP will be carried out within the fence of existed Helwan WWTP. The closest noise sensitive receptor is “Arab Abu Sa’ed” village, which is approximately 1.5km to the west of the project site (see figure 6.2).

[40] Source: Workers compensation Board of British Columbia, 2000 (BS 5228: 1997 Noise and Vibration Control on Construction and Open Sites)

Noise impacts from equipment and facilities delivery are unlikely to be a matter of concern. The main routing of these vehicles will be along the public roads, Al Autostrad road and short (1300m) unpaved access road to Helwan WWTP location.

Construction activities will occur under normal operating conditions, and is expected to have a localized effect with repeated breaches of statutory or prescribed limits mainly causing noise impacts within the neighborhoods. Consequently, minor noise disturbance to the nearest village and sensitive receptors will occur.

New PSs and FMs

New PSs and FMs adjacent to noise sensitive receptors (see Figure 6-3), would be affected by levels of noise ranging between 65 and 75 dB. These are the highest noise level that the nearest receptor to the site may be subjected to. The noise will be of intermittent nature and the intensity will drop down as the center of noise emissions moves away from the receptor. The construction of each site is not expected to exceed a 48 period. Based on that, the noise impacts due to the construction and installation of ***PSs /FMs*** can be considered of **Moderate significance**, see Table 6-6.

Table 6-6: Impact of noise on sensitive receptors during construction phase

Environmental Receptor		Noise WWTP extension	Noise "PSs & Force mains"
BASIC IMPACT INDEX	Magnitude	1	3
	Spatial Extent	1	2
	Duration	1	2
Weighted Average		1	2
Receptor Categorization		Low	Medium
Impact		**Minor**	**Moderate**

Mitigation Measures

The construction contractor will take into consideration all nearby sensitive receptors identified with any other additional receptors identified by the contractor on site such as schools, mosques, medical clinics, churches, etc. and will try to schedule the more noise-intense activities for less intrusive times such as midmorning or afternoon to avoid complaints and potential annoyance to people living or working adjacent to the construction site. It could be recommended to take some mitigation measure to reduce these impacts as follows:

- choosing vehicles, equipment of a good technical specification and status
- good maintenance of these equipment to reduce the resulted noise
- effective scheduling of construction activities to avoid the overlap of noise sources

Monitoring Measures

- Investigate noise complaints from sites workers and residents of affected areas.

6.2.3 Land and Soil

Typical construction activities may result in land and soil contamination due to the following:-

- Uncontrolled disposal of hazardous liquids such as spent oils, paints, or any other chemicals/additives used in concrete making and finishing works.
- Leaching of solid wastes, which are randomly disposed of.

Potential impacts on soil other than contamination include:

- Soil erosion
- Loss of resources if the excavated soil is not segregated and reused as an alternative to transport and use of additional materials from outside the site.

Helwan WWTP extension and PSs

The soils at the Project site are present across a much wider area and therefore the local soil resources are not rare or unique. It should be noted that the assessed potential impact significance is limited to soils within parts of the project area and that because these soil types extend across a much wider area the impact on regional soil resources will be low value.

The geotechnical report (Sept., 2010) of Helwan WWTP location, mentioned the top soil section up 2.5m depth is composed of Medium to fine sand, clay, cohesive sand, fine gradient aggregate size, vegetable residues, organic residues and calcareous materials.

Construction works of the Helwan WWTP can have an impact on soil and geology through soil compaction, soil sealing, and the excavation of soft sediments and virgin soil. During the construction period the soil will be excavated and stored within the construction site boundary. The soil on the proposed site is clayey soil and has low sensitivity to compaction.

Potential impacts to soils during the construction phase could be spillage of fuel or lubricant leading to contamination of soil or inappropriate storage of hazardous materials.

The soil impacts during the construction of extension Helwan WWTP and new PSs should be considered of **Minor significance** and will be controlled by applying the mitigation measures related to waste management and by maximizing the reuse of the excavated soil.

Gravity Sewers and FMs

Four force mains will be installed as part of the proposed project with 1500mm diameter and 30km approx. The estimated top soil layers will be excavated 250,000m3 approx. As mentioned previously, the soils present at the Project site are present across a much wider area and therefore the local soil resources are not rare or unique, meanwhile the economic value of soils across FMs areas is low.

The main impacts on soil quality associated with gravity sewers / FMs construction activities will be associated with the following impact sources:

- Considerable volume of excess soils wastes along with FMs routes.
- Accidental leaks.
- Soil compaction.
- Excavation of the trench and associated pipe-laying activities.
- Potential wind erosion.
- Impacts associated with waste generation/management.
- Impacts associated with discharge of water generated from dewatering activities.

The excavated trenches for 1500mm diameter and relatively considering the large spatial context of the gravity sewers and FMs network, the land and soil impacts during the construction of the gravity sewers and FMs should be considered of **Moderate significance**. The following Table 6-7 shows the impact on soil and land during construction phase.

Table 6-7: Impact on land and soil during construction phase

Environmental Receptor		Land & Soil “Sewers & FMs	Land & Soil “PSs & WWTP”
BASIC IMPACT INDEX	Magnitude	3	2
	Spatial Extent	2	1
	Duration	2	1
Weighted Average		2	2
Receptor Categorization		Medium	Medium
Impact		**Moderate**	**Minor**

Mitigation Measures

- The potential impact on soil as a result of soil compaction, excavation, loosening, filling and sealing is considered to be low, short term and local. The potential impact will be the same in the temporary work areas that will be required during the construction phase.
- All soils removed and stored during the construction phase should be handled in accordance with best practice. In backfilling the trench, the stockpiled subsoil material will be placed back into the trench.
- Rocks and soil containing debris removed from the subsoil areas, topsoil or from any excavations will be hauled off to approve disposal site.
- Following the completion of the Gravity Sewers / FMs, any right-of-way will be restored to its original pre-construction elevation and contour.
- Spill prevention plan will be applied, however in case of soil pollution may occur from accidental leakage of chemicals, fuel or oil products from construction equipment or moving vehicles, will be removed and replaced with clean soil.

Monitoring Measures

- Investigate spill signs in working areas.
- Review site restoration practices.

6.2.4 Water Resources

The planned routing for the gravity sewers and FMs will not involve crossings canals or drains. Meanwhile, Groundwater might be encountered but the probability is low because the depth to groundwater ranges between 20 and 50m in project's area.

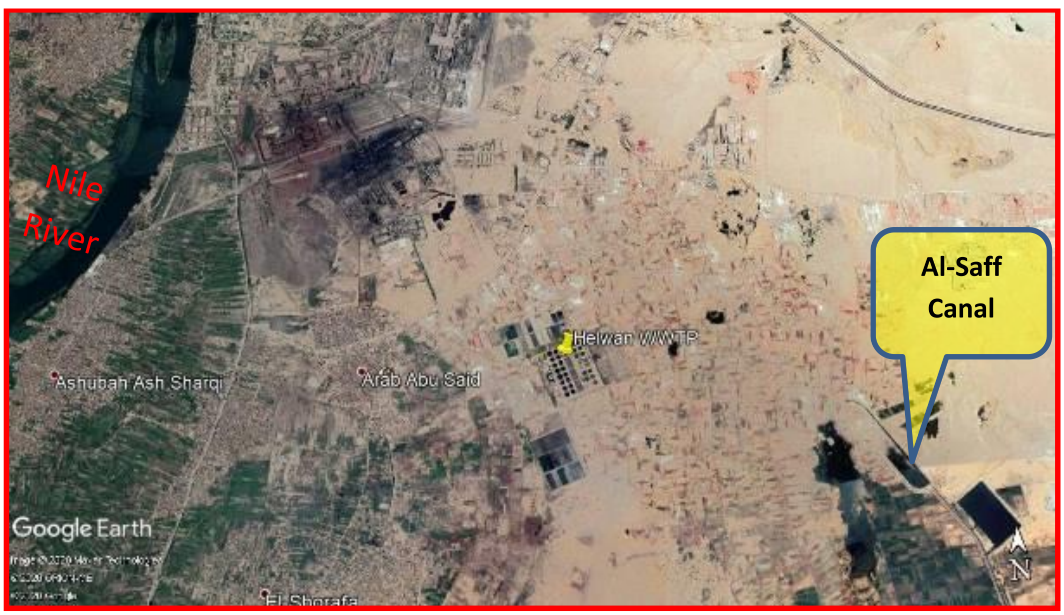


Figure 6-4: Helwan WWTP and Al Saff canal

The distance between the Nile River and the WWTP location is 4.5 km and the distance between the Al-Saff Canal and the WWTP site is 2.5 km (see Figure 6-4). No impacts are foreseen during the construction of the PSs and WTTP.

The Water Quality impacts during the construction of the proposed project should be considered of **Minor significance**. Table 6-8 is summarizing the expected impact significance of water resources during construction phase.

Table 6-8: Impact on surface water and groundwater during construction phase

Environmental Receptor		Water Resources "Sewers & FMs	Water Resources "PS & WWTP"
BASIC IMPACT INDEX	Magnitude	2	2
	Spatial Extent	1	1
	Duration	1	1
Weighted Average		2	2
Receptor Categorization		Medium	Medium
Impact		**Minor**	**Minor**

6.2.5 Waste Generation and Disposal

Impacts due to hazardous (H) and non-hazardous (NH) waste generation and handling of hazardous chemicals

Impact overview

This section presents an evaluation of the environmental impacts due to H and NH waste generation during the construction phase. The following are the types of wastes expected to be generated on site during the construction of the PSs, Helwan WWTP extension and during excavation and installation activities for the gravity sewers and FMs.

Impact Significance of NH waste generation

Non Hazardous wastes

- Food residuals
- Paper, plastics, and glass
- Concrete, bricks
- Steel, metals
- Wood
- Excavated soil
- Water collected during dewatering activities (potentially contaminated with sewage)
- Old cesspit content
- Sewage and waste resulting from onsite workers'

- Empty Sacks

The NH wastes generated on site during the construction phase normally have a high recycling potential. If not recycled they would be sent to landfills or randomly dumped and burned, which would be a loss of natural resources. Random dumping and accumulation of wastes on or around the site would cause a negative visual impact to workers as well as users of the surrounding areas. It could also block the roads, increase the rate of accidents. Accumulated wastes may be burned, a practice commonly found in Egypt, which could emit toxic emissions especially if plastic substances were among the waste streams.

Accumulation and/or uncontrolled disposal of organic wastes (food residuals) would also result in potential impacts on the health and hygiene of both general public and on-site workers by attracting vermin to the site such as birds, rodents or insects, which can act as disease vectors. This will result in spread of disease, and disruption of the natural ecosystem.

Odor may also be generated following long periods of accumulation due to the decomposition of some organic wastes, which will be an annoyance to both general public and on-site workers. Leaching to soil may occur in areas where accumulated waste is in direct contact with the soil. This would lead to a direct impact on the groundwater quality.

Liquid wastes may be encountered during the evacuation of existing cesspits; also construction site sewage will need to be evacuated. This waste will be of non-hazardous nature but will have to be properly disposed of in order to prevent potential contamination to soil, groundwater and surface water.

The evaluation of impacts due to non-hazardous waste generation during the construction phase is illustrated in Table 6-9 below. Some impacts are considered of **Moderate significance,** mainly due to the proximity of receptors. The impact of NH waste generation is expected to be fully controlled by implementing the mitigation and monitoring measures listed in the following section.

Table 6-9: Impact of NH wastes during construction phase

Environmental Receptor		NH Wastes
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	2
	Duration	1
Weighted Average		2
Receptor Categorization		**high**
Impact		**Moderate**

Hazardous wastes

- Waste electrical and electronic equipment (WEEE)
- Empty chemical containers
- Expired chemicals and spent oils

Hazardous wastes may also be generated during the construction phase as listed above. The storage and disposal of these waste streams have to be carefully performed as to abide by the existing legal framework (Chapter 2). In addition to that, these hazardous wastes if not handled, stored and disposed of according to engineering best practice would have major and irreversible effect as follows:

- Mishandling and uncontrolled disposal of hazardous liquid and solid wastes would have major health impacts for on-site workers, inhabitants in the project's area of influence, people who get in contact with waste during transportation and disposal, and flora and fauna exposed to such wastes.
- Uncontrolled disposal of hazardous wastes, in particular in liquid form, would cause soil contamination through direct contact or leaching.
- There is a possibility that uncontrolled disposal of hazardous wastes may affect the groundwater quality, through extended leaching.

Air quality could also be affected since uncontrolled dumping of hazardous and non-hazardous materials would result in most of the cases to open burning and potential release of toxic emissions.

The impacts listed above are evaluated as presented in Table 6-10 below. Most of the impacts should be considered of **Moderate significance** and will be fully controlled by implementing the mitigation and monitoring measures listed in the following section.

Table 6-10: Impact of Hazardous wastes during construction phase

Environmental Receptor		Hazardous Wastes
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	2
	Duration	1
Weighted Average		2
Receptor Categorization		**high**
Impact		**Moderate**

Mitigation and monitoring measures

A waste management plan complying with international best practice and relevant Egyptian regulations and covering all types of construction waste (hazardous and non-hazardous) shall be developed and implemented by the construction contractors and made applicable to all sub-contractors. This plan shall define exact procedures and locations for waste management and disposal. The waste management plans should also refer to health and safety procedures, and emergency procedures for containing and managing accidental spillages.

Mitigation measures for non-hazardous wastes

- Implement a segregation system based on compatibility of different waste streams during each phase of project implementation
- Specify an area/containers for non-hazardous wastes which accommodate for the generated segregated streams
- Dispose of non-recycled wastes in the nearest landfill, including waste generated from clearing two PSs locations.
- Register the amounts of disposed of wastes and keep waste disposal and transportation receipts/manifests, to be ready for review.
- Portable water cabinets for the workforce will be provided on sites to provide hygienic work environment for the work force. Portable water cabinets are supplied with an external tank for sewage storage.
- Construction contractor shall contract the competent authority for safe disposing of generated sewage

For liquid wastes (dewatered liquid during excavation);

- Estimate of dewatered liquid volume during the digging works
- Collect and analyze samples of the dewatered liquid
- Arrange for disposal by tankers in the nearest existing WWTP in consultation with and after getting approval.

Monitoring measures for non-hazardous wastes

- Regular inspection of the waste storage area (for PS's and WWTPs' sites)
- Regular inspection of the site(s) in general to identify random disposal of waste materials, specifically during the installation of gravity sewers and FMs.
- Regular inspection of the waste disposal manifests.
- Visual inspection to water cabinet connections and sewage storage tank to ensure that there is no leakage

Mitigation measures for hazardous wastes

a) General measures

- All types of hazardous waste can only be transported by licensed hazardous waste service providers and disposed of in licensed landfill. Both, the service providers and disposal sites have to be identified at the beginning of construction works. At the time of producing this study, the nearest (only) hazardous waste disposal site is the Nasreya Centre in Alexandria.
- The different types of hazardous wastes should not be mixed.
- Spent mineral oils shall be collected, stored in sealed containers and recycled using a licensed company which also has to be identified by the contractor

b) Adopting an Identification system for hazardous wastes generated on site

c) Storage and Management of the waste accumulation area

- It is recommended that the maximum period for storing hazardous waste is 270 days from the start date of accumulation of waste.
- The storage area must have a water supply
- A hazardous waste label that has a "Hazardous Waste" mark on it must be placed on the container while still at the generation point.

d) Emergency Response

For the purpose of first response, when a hazardous substance release is first discovered or witnessed, the individual of concern who had to be previously trained would initiate an emergency response sequence by notifying the proper authorities of the release. The individual will take no further action beyond self-evacuation and notification. The aim of the response at this level is limited to protect nearby persons, property, or the environment from the effects of the release. No trials are performed at this stage to actually stop the release. This level of response includes;-

- actions to contain the release from a safe distance
- prevent its spreading
- evacuation

Monitoring measures for hazardous wastes generated

- Regular inspection of the hazardous waste storage area
- The spent oil containers are inspected monthly for leaks or any other form of damage and are kept in good condition.
- Regular inspection of the site to identify randomly dumped hazardous waste materials.
- Inspection of HW disposal receipts and manifests.

Impacts related to creation of on-site workers and staff camps

The majority of the workforce will be sourced from local communities and will live locally. No on-site camps will be therefore required except individual accommodation for the guards at the different project's sites. Some management offices will be located at the PS sites in addition to other interim sewage and potable facilities which will be constructed.

Potential impacts include soil, groundwater and health impacts due to unsuitable waste and sewage management, which should be considered of **MINOR significance**, see Table 6-11, due to the expected low amounts.

Table 6-11: Impact of camp wastes during construction phase

Environmental Receptor		Camp Waste
BASIC IMPACT INDEX	Magnitude	3
	Spatial Extent	1
	Duration	1
Weighted Average		2
Receptor Categorization		Medium
Impact		**Minor**

6.2.6 Flora, Fauna, Habitats

No flora or fauna has been identified during site visits to the proposed WWTP and PSs sites. While not seen during the site visit, the fauna that may be present or near to the site may include wild dogs, rats, cats, desert foxes and birds.

Although some faunal species of mammals, birds, reptiles and insects exist at the project's area, faunal impacts are not likely to be significant given the small scale of the development relative to the extent of similar intact habitats in the area.

None of the species that may be present on or around the site are protected or endangered. As a result, it is considered that the potential impact of the project during the construction phase on flora and fauna will be none, short-term and local. So the impact of the project's construction on the floral and faunal species should be considered **Minor insignificance**. Table 6-12 is summarizing the expected impact significance on flora and fauna during construction phase.

Table 6-12: Impact on Flora, Fauna, and Habitats during construction phase

Environmental Receptor		Flora, Fauna, Habitats
BASIC IMPACT INDEX	Magnitude	1
	Spatial Extent	1
	Duration	1
Weighted Average		1
Receptor Categorization		Low
Impact		**Insignificant**

Mitigation and monitoring measures

No specific mitigation and monitoring measures are needed; they are included under other impacts.

6.2.7 Visual Impact

Visual Impact Significance

During the construction of gravity sewers and FMs

Only temporary visual impacts will be caused during the construction of the gravity sewers and force mains, resulting mainly form the over ground storage of excavated soil and raw materials (i.e. pipes, pipe connections, cement sacks, concrete mixers, construction wastes, etc). However, due to the short period of exposure and reversibility nature of this impact, it should be considered of **MINOR significance**.

During the construction of the central WWTP and PSs

During the construction of the central WWTP and PSs, the project would gradually change the aesthetics and landscape of the areas where the PSs and WWTP will be constructed. However, the expected heights of the PSs are comparable to surrounding buildings and will be acceptable. The Visual impacts due to the construction of the WWTP and PSs should be considered of **MINOR significance**, see Table 6-13.

No mitigation measures are required expect constructing an interim fence around the site in order to improve the aesthetics as well as reducing other environmental impacts until the construction of the designed concrete fence.

Table 6-13: Visual Impact during construction phase

Environmental Receptor		Visual
BASIC IMPACT INDEX	Magnitude	3
	Spatial Extent	1
	Duration	1
Weighted Average		2
Receptor Categorization		Medium
Impact		**Minor**

6.2.8 Potential Social and Health Impacts

Health and Safety Impact Assessment

Construction sites are considered the most potentially hazardous and accident-prone parts of any working environment. Excessive exposure to these construction site hazards exposes workers to injury and possible death. To prevent this, contractors should be aware of all possible dangers that can be encountered during normal business operations. According to the safety and health standards every employee shall have sound knowledge of their susceptibility to harm or injury in the workplace.

Occupational health and safety impact significance

Listed below are the main six construction site hazards identified by the Occupational Safety and Health Administration (OSHA), all of which will be encountered during the construction of the different components of the ISSIP II project.

1. **Excavation and Trenching** – OSHA has recognized excavation and trenching as the most hazardous construction site operation.
2. **Falls** – Falling from scaffolding over six feet or a fixed ladder over twenty feet is the most dangerous and common construction site hazard. The usual cause of this incident is slipping, tripping and using unstable ladders. There are many reasons for fall hazards and to eliminate such risks, employers must have a fall protection program as part of any overall workplace safety and health program.
3. **Stairways and Ladder** – According to OSHA's construction safety and health standards, stairways and ladders are important sources of injuries and fatalities among construction workers.
4. **Scaffolding** –The most potential risk of scaffolding is due to moving scaffold components; scaffold failure related to damage to its components; loss of the load; being struck by suspended materials; electrical shock; and improper set-up. Construction workers who assemble and

dismantle scaffolding and work platforms at construction sites face the risk of serious injuries due to falls.

5. **Use of Heavy Construction Equipment** –The main causes of such accidents include: ground workers struck when a vehicle is backing up or changing direction; equipment rollovers that injure the operator; mechanics run over when brakes are not properly set; and ground workers crushed by falling equipment from backhoes, buckets, and other moving construction vehicles.
6. **Electrical Hazards** - Electricity is one of the greatest hazards to workers on site. Power line workers, electricians and electrical engineers work continuously work with electricity can face exposure to this hazard on a daily basis.

Due to the high probability of occurrence and the high risk involved, the occupational safety and health impacts during the construction of the WWTP should be considered of **MAJOR significance** and it should be considered of **Moderate significance** during the construction of PSs, gravity sewers and FMs due to the relatively lower risks involved, see Table 6-14. The impacts will be controlled to a large extent by applying the mitigation measures listed below.

Table 6-14: Impact of air emissions on air quality during construction phase

Environmental Receptor		Health & Safety "WWTP"	Land & Soil "PSs, gravity sewers & FMs"
BASIC IMPACT INDEX	Magnitude	3	2
	Spatial Extent	3	1
	Duration	3	3
Weighted Average		4	3
Receptor Categorization		High	Medium
Impact		**Major**	**Moderate**

Mitigation measures

The Contractor shall adopt an Occupational Health and safety plan during the construction phase. According to OSHA standards the main mitigations measures to prevent common construction hazards are:

- Workers must follow safety standards and use protective equipment to minimize hazards while trenching and excavating
- Workers should be trained to identify and evaluate fall hazards and be fully aware of how to control exposure to such risks as well as know how to use fall protection equipment properly.
- Workers must comply with OSHA's general rule for the safe use of ladders and stairways.

- The scaffolding hazard shall be addressed as stated by OSHA standards. They give specific requirements for the maximum load, when to use scaffolding, bracing systems and the use of guardrails.
- To prevent Heavy Construction Equipment risk, workers should follow all construction safety guidelines necessary to eliminate the exposure to such injuries and accidents
- The best way to prevent the Electrical hazard is for the workers to be at a safe working distance away from the power lines. Other precautionary measures include guarding and insulating of the vehicle from which they might work. This would help prevent electrical hazards from injuring them while working.

The Occupational Health and safety plan shall also include the Egyptian Labor law No. 12 for 2003 and the international construction standards requirements, including, but not limited to , the following measures:

- Identification of hazard sources to workers
- Eliminating the sources of hazards
- Workers must be trained to recognize potential hazards, use proper work practices and procedures, recognize adverse health effects, understand the physical signs and reactions related to exposures, and are familiar with appropriate emergency evacuation procedures. They must also be trained to how to use the Personal Protective Equipment (PPE).
- Inspection and testing of all equipment and machines
- Appointing an Accident Prevention Officer at the site, to take protective measures to prevent accidents
- Designation of restricted areas, such as construction sites
- Preparation of an emergency response plan
- Provision of necessary rescue equipment
- Elaboration and management of a safety guarantee plan
- Provision of appropriate and sufficient first aid equipment

Monitoring measures

- Regular reporting of any accidents, as well as records and reports on health, safety and welfare of workers
- Continuous monitoring of all hazardous events.
- Regular inspection of workers against pathogenic agents and provision of immunization when needed.

6.2.9 Traffic Control

It is anticipated that the increase in road traffic associated with development of the proposed project including extension Helwan WWTP, new PSs and new force mains will peak during the construction phase.

During the construction phase, an increase in traffic can be expect as a result of the influx of workers, the transportation of workers around the sites, the delivery of materials and equipment. The early works set-up will require the delivery of earthmoving equipment to the sites. And also, there will be traffic control need during the excavation to construct the forcemains underneath the roads premises.

The majority of construction materials may be transported to the site by roads, either from their port of origin. Locally sourced materials, such as clean sand and fill, will be utilized wherever possible to reduce the requirement to import bulk materials from other locations, therefore reducing highway movements bringing material from far fields.

During construction phase of Helwan wastewater expansion project will generate road traffic through the movement of workers, raw materials for construction, construction equipment, WWTP equipment, pumps, pipes and wastes. Specifically, these are expected to include:

- Trucks delivering raw materials for the construction, including cement, structural steel, clean sand… etc;
- Trucks delivering consumables such as cleaning chemicals, paint, fuel and maintenance equipment (e.g. vehicle spare parts);
- Buses for transporting the construction workers to the worksites;
- Construction machinery such as graders, bulldozers, backhoes and cranes (delivery/collection from site);
- Trucks and heavy load carriers transporting WWTP equipment and pipes to sites;
- Trucks transporting other waste materials (such as empty drums, dismantled crates, used oils and lubricants etc) to local waste treatment/disposal/recycling facilities.

Helwan WWTP extension and PSs

Extension project's activities at Helwan WWTP and new PSs will be within the fence of existing facilities, in addition and as Figure 6-, Figure 6-5 and Figure 6-6shows Helwan WWTP / PSs locations are adjacent to network of main roads, all narrows roads or residential areas will be avoided.

The main sources of traffic are represented by materials delivery and workers pick-up / drop-off from/to project's working areas. The impact to the local traffic network associated with this flow is expected to be marginal, given that the proposed locations of activities can be accessed through many existing roads as shown in Figure 6-, Figure 6-5 and Figure 6-6 Consequently, traffic impact should be considered of Minor significance during the construction of Helwan WWTP extension and PSs.

Figure 6-5: Helwan WWTP and surroundings roads

Figure 6-5: 3A new pumping station and the surrounding area

Figure 6-6: 2A new pumping station and the surrounding area

Gravity Sewers and FMs

The proposed project will involve installation of 4 force mains as follows:-

1. From 3A PS to 2A PS, 1500mm diameter and 4.6km (phase 1).
2. From 3A PS to 2A PS, 1500mm diameter and 6.0km (phase 2)
3. Two force mains from 2A PS to Helwan WWTP, 1500mm and 9.0km

Installation of force mains between 3A PS and 2A PS will involve access to extensive residential areas as shown in Figure 6-7. The construction of sewer gravity and FMs will generate **major impacts** on roads traffic through the movement of workers, raw materials for construction, construction machinery such as graders, bulldozers, backhoes and cranes, pipes, and wastes, see Table 6-15.

Figure 6-7: Force main proposed routes (phase 1 & Phase 2)

Table 6-15: traffic Impact during construction phase

Environmental Receptor		Traffic "Gravity sewers & FMs"	Traffic "WWTP & PSs"
BASIC IMPACT INDEX	Magnitude	3	2
	Spatial Extent	3	1
	Duration	3	3
Weighted Average		4	3
Receptor Categorization		High	Medium
Impact		**Major**	**Minor**

Mitigation Measures

In accordance with the IFC General EHS Guidelines 2007, vehicles will not access the public highway wherever possible. However, whenever this is not possible, vehicles will be routed off the local highways (e.g. transportation of wastes) and use existing access roads wherever available to avoid impacts on the local community.

The main contractor/s will be required to submit a traffic management plan to Hewlan WWTP extension project management, detailing their proposals for the appropriate use of the local transport network. This plan should detail, but not be limited to, the following:

- Responsibility and procedures for co-ordination and liaison with the local authority of traffic regarding transporting during construction;
- Outcomes of traffic risk assessments undertaken;
- Access routes for construction plant and materials;
- Transport routes for the workforce (on arrival to/departure) to the work areas);
- On-site traffic management;
- Training and awareness; and measures to protect the local community where appropriate.
- Traffic flow and site access will be managed such that tail-backs onto public roads will be avoided;
- Delivery of heavy loads will be timed to avoid peak traffic flows;
- Drivers will be fully trained in road safety and a transport management plan has been prepared for the construction phase;
- All national and industrial city speed limits will be observed;
- Where vehicles accessing site operate within the site on unpaved roads that are watered.

The above measures are anticipated to minimize congestion and inconvenience to other petroleum area users and people living in the vicinity.

Monitoring Measures

- The contractor will undertake regular audits of the management plan to confirm ongoing effectiveness.
- Investigate traffic complaints from residents of affected areas.

6.2.10 Employment

Construction of the Project is expected to last for approximately 48 Months. During construction of Helwan WWTP extension and associated infrastructure, it is expected that the local and national economies will be beneficially impacted, primarily through increased employment opportunities and diversification of skill base within the existing workforce.

As well as enhanced employment opportunities, the project will create employ 600 persons approximately, with different disciplines (please revert to section 3) as direct job opportunity, in addition to many indirect job opportunities such as provision of goods, services, food, building materials, earthmoving equipment, etc.

Potential Positive socioeconomic Impacts during construction phase direct positive impacts. Regarding job creation, the project is expected to result in the creation 600 direct and 1500 job opportunities. Consequently, the construction of Helwan WWTP extension will generate positive impacts for employment opportunities.

6.2.11 Land Acquisition

The extension of the Arab Abo Sa'ed WWTP 250,000 m3/day advanced treatment shall be in the same premises of the existing Arab Abo Sa'ed WWTP. The site is supplied with all existing utilities which are also expected to minimize the environmental impacts during the construction phase. Also, the upgrade and extension of the Helwan WWTP shall be in the same location of the WWTP in Arab Abu Sa'ed. Hence, no land acquisition is required for the extension.

As for the two new pump stations 3A and 2A:

- 3A: will be constructed in the existing land near the existing station No. (3) in Helwan, within the premises of the site of the old Helwan plant.
- 2A: will be constructed within the premises of 15th May WWTP which is currently under rehabilitation.
- The force mains will be buried under roads, as by the Egyptian codes.

Hence, this impact is unforeseen as, Helwan WWTP extension project will be within the fence of existing Helwan WWTP. Regarding new pumping stations 3A and 2A; the proposed project will be within premises of existing WWTPs and other and excavation/ trenching of FMs and sewers will under public roads and no land acquisition is needed for any element of the total project.

Meanwhile, the majority of the workforce will be sourced from local communities and will live locally. No on-site camps will be required, except individual accommodation for the guards at the different project's sites. Some management offices will be located at the PS sites. Consequently, impact on land acquisition is **insignificance** from the proposed project.

6.2.12 Culture Heritage

There are no legally protected cultural heritage areas at the project area. Consequently, impact on culture heritage is **insignificance** from the proposed project.

6.2.13 Community Health and Safety

Potential impacts

- **Excavation and Trenching** – this is recognized as the most hazardous operation during the construction phase for the surrounding community, because most of the excavation will be performed in narrow streets which increase the probability of members of community falling into the trenches. The slurry/mud waste generated from the excavation would slip the passengers, the solid wastes generated would trip them. All these events increase the probability of falling and increase the danger of excavations operations. The risks of excavation and trenching operation increase when they occur;
- Besides the railway line and or
- On both sides of water ways.
- Excavation and trenching could also affect the structural integrity of the village's houses, since many are old and weak.

- **Electrical shock**- Electricity is one of the greatest hazards to people passing by the construction site. Power cords will be used which may cause electrical shock if not well maintained and/or they were left hang out freely.

Mitigation measures

- To prevent Excavation and Trenching accidents and injuries, both the contractors and workers must follow safety standards and use protective equipment to minimize hazards while trenching and excavating. The sides of the trenches should be strengthened by wood or aluminum reinforcement sheets installed on both sides of the excavated trench, in critical areas (adjacent to existing houses and near canals and drains).
- Using fences and warning signs during the construction phase
- Using protective barriers and safe walkways
- Appointing of an officer on site, to take protective measures to prevent accidents and/or to respond to accidents.
- Provision of appropriate and sufficient of first aid equipment on site.
- The construction contractor should bear the cost and responsibility to coordinate with the local authorities to prevent damage to underground utilities and restoration of the affected structure.

6.3 Potential Impacts during WWTP Operation Phase

6.3.1 Project's Sustainability

Water supply and sanitation projects have several impacts, including effects on health, education, gender and social inclusion, and on income and consumption. In addition, the water shortage problem in Egypt and shortage of irrigation water are serious issues. The current per capita share of water is below the water poverty limit of 1,000 m3/capita/year (An Egyptian person's water share is 650 m3/capita/year as per the National Water Resources Plan 2017 and the Sustainable Development Strategy – Egypt's Vision 2030).

Improving the existing wastewater facilities in South of Cairo through the diversion of wastewater flows from the flooded main collectors (culverts) and pumping stations will enhance the standard of living at Helwan area and overcome the negative health and diseases effect generated by the flood of raw sewage at the walkways and streets of Helwan catchment zone due to insufficient capacity of both the collection and treatment facilities. Contributing to increased coverage of improved sanitation and clean environment for the nearly 2.25 million population living in this area, by the completion of the collection system and treatment facilities with the additional treatment capacity of 250,000 m3/day as a first phase is urgent priority and a first objective of this project.

One of the main objectives of the project also is to improve the quality of treated wastewater discharged into the Al Saff canal. Where, Irrigation water presents approximately 78% of water demand in Egypt; therefore, establishment of new water resources is strongly required by treating the wastewater inflow all over Egypt in general and specially inflow to Helwan WWTP. Currently, the effluent from Helwan WWTP is mixed with untreated over capacity wastewater and consequently does not meet the standards of the irrigation water quality.

This proposed treatment process is the same process as followed in El-Gabal El-Asfar WWTP (the largest WWTP in Egypt) which proved to be the most efficient sludge treatment process for large Wastewater Treatment Plants in Egypt. It worth here mentioning that, the current upgrading process of Abo Rawash WWTP (the second largest WWTP in Egypt) shall follow the same treatment methodology. Lessons learned from sludge treatment of these two largest WWTP in Egypt shall be utilized in the proposed sludge treatment methodology for Helwan (Arab Abo Sa'ed) WWTP. The bio-gas generated from the anaerobic digestion process shall be utilized to generated electricity which can cover up to half of the WWTP electricity consumption.

The stabilized treated dried sludge shall have high quality and shall be converted to compost and sold to farmers for agricultural usage purposes for reasonable price following all environmental and health regulation and restrictions in handling and transporting process. With reference to the quantity of dried sludge to be supplied a volume of approximately 150-200 m^3/day.

The previously described sludge treatment methodology adopted for large WWTPs in Egypt helps to reduce the greenhouse gases developed during sludge treatment process which shall definitely help to minimize the effect on the climate change.

6.3.2 Air Emissions, Dust and Odour

The only source of air emissions within the PSs and WWTPs sites will be the stand-by diesel generators. The impacts of such emissions are considered to be of **Minor Significance** as the generators will be only turned on during power cut-offs. The compliance of generators emissions with Law 4/1994 standards will be sufficient to safeguard against unacceptable air emissions impacts to the surrounding areas. Meanwhile, the nearest residential area (i.e. Arab Abu Sa'ed Village) is upwind from proposed WWTP by 1.5km approximately.

The impact of air pollution (dust and fugitive emissions) is anticipated to be minor during the operation and maintenance phase of the Helwan WWTP extension, as a relatively small number of vehicles will be required during this phase relative to the current traffic volume on the service road from the proposed site. Table 6-16**Error! Reference source not found.** is summarizing the expected impact significance of air quality, dust and emissions during operation phase.

Table 6-16: Impact of dust on air quality during operation phase

Environmental Receptor		Air Emissions & Dust WWTP extension	Air Emissions & Dust "PSs & Force mains"
BASIC IMPACT INDEX	Magnitude	2	2
	Spatial Extent	1	1
	Duration	1	1
Weighted Average		2	2
Receptor Categorization		Medium	Medium
Impact		**Minor**	**Minor**

Odour in WWTP can be noticed only at inlet works and grit chambers. Other treatment facilities (primary and secondary) usually do not emit any odour. Odour arising from inlet works operational activities will be extracted by extraction fans and filtered in soil filter beds. Odors are the products of decomposition of organic matter. The main constituent of these odors is hydrogen sulphide (H_2S) due to its relatively high concentration in wastewater.

Within the WWTPs, odors are expected to be generated near the inlet open channels and screens; oxidation ponds, and sludge storage areas.

Table 6-17 indicates the concentration of different chemicals found in wastewater and sludge and their detection threshold by people.

Table 6-17: Thresholds for odour detection and recognition associated with wastewater[41]

Odorous compound	Detection threshold (ppm volume)	Recognition threshold (ppm volume)
Ammonia	17	37
Chlorine	0.08	0.314
Dimethyl Sulphide	0.001	0.001
Diphenyl Sulphide	0.0001	0.0021
Ethyl Mercaptan	0.0003	0.001

[41] Sniffer. 2008. Human Health and the Environmental Impacts of Using Sewage Sludge on Forestry and for Restoration of Derelict Land.
Tchobanoglous, G. and Franklin L. B. 1991.Wastewater Engineering, Treatment, Disposal and Reuse, Third Edition, McGraw-Hill, Inc.
The WHO guidelines for detection of H2S is 0.2-2 µg/m3 (about 0.0002 to 0.002 ppm)), for recognition is 0.6-6 µg/m3 (about 0.0006-0.006 ppm) while the guideline value to protect against substantial annoyance is 7 µg/m3 (about 0.007 ppm)

Hydrogen Suphide	<0.00021	0.00047
Indole	0.0001	-
Methyl Amine	4.7	-
Methyl Mercaptan	0.0005	0.001
Skatole	0.001	0.019

It has been established that such odors are a cause of direct irritation and can be a health threat through toxicological routes. Irritation could evolve in to psychological stress after prolonged exposure which could lead to loss of appetite, reduced water consumption, impaired respiration, nausea and vomiting. Socioeconomic impacts, which will be discussed in more detail, associated with places of offensive odors have the ability to lower the living standards of the communities, affecting people's dignity and value of life. However, we should not neglect the fact that there is a biological difference from one person to another which allows each person to react to such odors differently. This is why impacts associated with odors are sometimes subjective. Not to mention the level of tolerance that some people develop over time. This is of particular interest to workers at the pump stations and WWTPs which will naturally acquire high odor tolerance.

In the vicinity of the existing WWTPs, there are no nearby sensitive receptors. Closest residential clusters are located 1500m western (Up Wind) of the Helwan WWTP. It is not therefore expected that the nearest villagers from Helwan WWTP (considering the current situation) will be affected by odor generated, which will result from the increase in the capacity of the plant due to the implementation of the proposed extension project. The impact on such receptors, see Table 6-18, should be considered of **Moderate significance.**

Table 6-18: Impact of odour on air quality during operation phase

Environmental Receptor		Air quality "Odour"
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	2
	Duration	2
Weighted Average		2
Receptor Categorization		Medium
Impact		**Moderate**

6.3.3 Climate Change

GHG and carbon footprint

Due to the increasing tangible and foreseen consequences of climate change; GHG and carbon footprint of any project is a vital decision making tool. Water and wastewater handling is one of the major municipal energy consumer and GHG emitters. Direct and indirect emissions are predicted to have commenced operation in 2024 and the carbon foot print will be modeled till 2037. The three sludge treatment scenarios are:

- **Scenario 1** : Anaerobic Digestion for only 250,000 m^3/day , mechanical dewatering for sludge produced from the extension of 250,000 m^3/day + one third of the mixed sludge produced from the existing WWTP (550,000 m^3/day)
- **Scenario 2**: Anaerobic Digestion for 800,000 m^3/day , mechanical dewatering for sludge produced from the extension of 250,000 m^3/day + one third of the mixed sludge produced from the existing thickeners of the current WWTP (550,000 m^3/day)
- **Scenario 3**: Anaerobic Digestion for 800,000 m^3/day, mechanical dewatering for sludge produced from the extension of 250,000 m^3/day+ all mixed sludge produced from the existing thickeners of the current WWTP (550,000 m^3/day)

Direct emissions

Table 6-19 summarizes the different direct emissions results from Arab Abu Sa'ed WWTP. Note that the three scenarios suggested will not affect the nitrous oxide emissions, only the methane ones. The only difference in direct emissions between scenario 2 and 3 will appear in the amount of sludge in drying beds and storage piles. The sum results include only IPCC guidelines scopes and not the storage emissions. The recovered methane in the three scenarios is going to be used to generate thermal and electric energy, hence, according to the IPCC guidelines, it will be integrated in the energy section (here the indirect emissions).

Table 6-19: Summary of Direct emissions results

Emissions ton CO_2 equivalent	1990-2009	2010-2023	2024-2037		
			Scenario 1	Scenario 2	Scenario3
N_2O - WWTP					
Cumulative period	5,958	6,554	9,533	9,533	9,533
Average yearly	298	468	681	681	681
N_2O - Effluent					
Cumulative period	68,706	75,577	48,858	48,858	48,858
Average yearly	3,435	5,398	3,490	3,490	3,490
N_2O - soil Application					
Cumulative period	14,623	16,085	22,474	22,474	22,474
Average yearly	731	1,149	1,605	1,605	1,605
CH_4 - WWTP					
Cumulative period	19,485	33,420	13,928	13,928	13,928

Average yearly	974	2,387	995	995	995
CH_4 - Effluent					
Cumulative period	6,367	7,004	8,150	8,150	8,150
Average yearly	318	500	582	582	582
CH_4 - Digester					
Cumulative period	-	-	15,020	28,727	28,727
Average yearly	-	-	1,073	2,052	2,052
yearly average of					
All N_2O emissions	4,464	7,015	5,776	5,776	5,776
All CH_4 emissions	1,293	2,887	2,650	3,629	3,629
N_2O+ CH_4 (without SDB)					
Total (Yearly average)	5,026	8,754	6,821	7,800	7,800
Total cumulative	100,517	122,555	95,488	109,195	109,195
N_2O Storage + drying beds					
Cumulative period	50,038	57,939	38,626	38,626	-
Average yearly	2,634	4,138	2,759	2,759	-
CH_4 Storage + drying beds					
Cumulative period	167	193	129	129	-
Average yearly	9	14	9	9	-
SBD sum (N_2O+ CH_4)					
Sum cumulative	50,205	58,132	38,755	38,755	-
Sum Yearly average	2,642	4,152	2,768	2,768	-
N_2O+ CH_4 (with SDB)					
Total (Yearly average)	7,668	12,906	9,589	10,568	7,800
Total cumulative	150,722	180,687	134,243	147,950	109,195

Indirect emissions

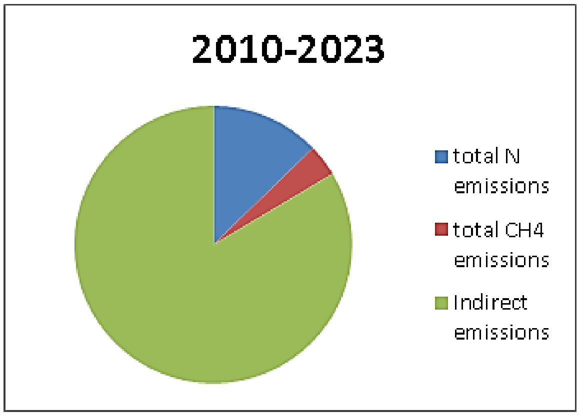
In this section emissions equivalent due to energy use, which is generated by the consumption of fossil fuel mainly, will be displayed in Table 6-20. Note that the total and net energy consumption of the WWTP is displayed separately from the energy consumption of the irrigation pumping station, for better comparisons of alternatives and clearer understanding of the effect of setting on the carbon footprint. An assumption of 16 working hours a day and 365 working days was made in converting kW to kWh, and the percent savings of the energy in scenario 1 compared to only the new extension energy consumption was 60%, which matches the updated cost study report.

Table 6-20: Summary of indirect emissions results

Emissions ton CO_2 equivalent	1990-2009	2010-2023	2024-2037		
			Scenario 1	Scenario 2	Scenario3
Energy consumption WWTP					
Cumulative period	834,158	917,574	1,646,673	1,646,673	1,672,630
Average yearly	41,708	65,541	117,620	117,620	119,474
Energy consumption Irrigation P.S					
Cumulative period	1,160,617	1,276,678	1,856,987	1,856,987	1,856,987
Average yearly	58,031	91,191	132,642	132,642	132,642
Thermal Energy consumption digester					
Cumulative period	-	-	142,440	361,311	361,311
Average yearly	-	-	10,174	25,808	25,808
Thermal Energy Production digester					
Cumulative period	-	-	437,779	837,288	837,288
Average yearly	-	-	31,270	59,806	59,806
Net thermal energy	-	-	"+ ve"	"+ ve"	"+ ve"
Recovered Methane (m^3/year)	-	-	13,939,566	26,660,548	26,660,548
Electric Energy Production digester					
Cumulative period	-	-	437,779	837,288	837,288
Average yearly	-	-	31,270	59,806	59,806
Net Energy (without Irrig. P.S)					
Cumulative period	834,158	917,574	1,208,894	809,386	835,342
Yearly Net average	41,708	65,541	86,350	57,813	59,667
% Yearly Energy Savings (WWTP without Irrig. P.S)	-	-	27	50.8	50.1
Net Energy (With irrigation PS.)					
Cumulative period	1,994,775	2,194,252	3,503,660	3,503,660	3,529,616
Yearly Net average	99,739	156,732	218,992	190,455	192,309

Impact Assessment

Charts in Figure 6- indicate that indirect emissions are the dominant emissions source in both current situation and future plans. This fact emphasizes that savings in energy consumption, i.e. energy recovery using anaerobic digestion will have great impact on the emissions as total load.



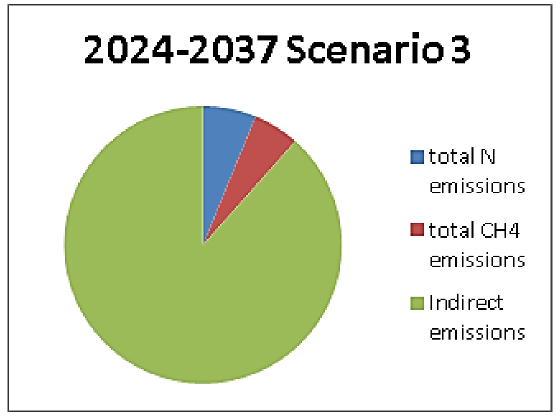


Figure 6-9: Ratio of direct and indirect emissions for the present case and future scenario 3

The following Figure 6-1 illustrates the average yearly CO2 equivalent emissions in tons. The effluent emissions factors were adjusted for better fit, for both the nitrous oxide and the methane, were the lowest factors of the suggested range of the IPCC guidelines were applied. We can note that emissions due to nitrous oxide are the most dominant in all the WWTP stages. Also, effluent emissions from both nitrous oxide and methane both declined sharply with the new extensions even though there was a drastic increase in flow rate and hence the loads. This is due to the decrease in pollutant in the effluent due to the tertiary treatment.

Another very important finding is that the drying beds and storage piles can represent a significant emissions source, especially nitrous oxides. Scenario 3 of future extensions, which suggests all the sludge to be mechanically dewatered then anaerobically digested, has significantly lower direct emissions due to the removal of drying beds. Furthermore, the emissions from the digester were relatively high for escape emissions when calculated with the initial emissions factor, hence, a smaller emission factor of 0.5 g CH_4/kg waste treated was applied, which is very relevant to the slip emission factor given by Daelman, 2014[42] work of 0.8% kg CH_4 /kg $COD_{digester}$.

[42] DAELMAN, M. R. J., 2014. Emissions of methane and nitrous oxide from full-scale municipal wastewater treatment plants, s.l.: Delft University of Technology.

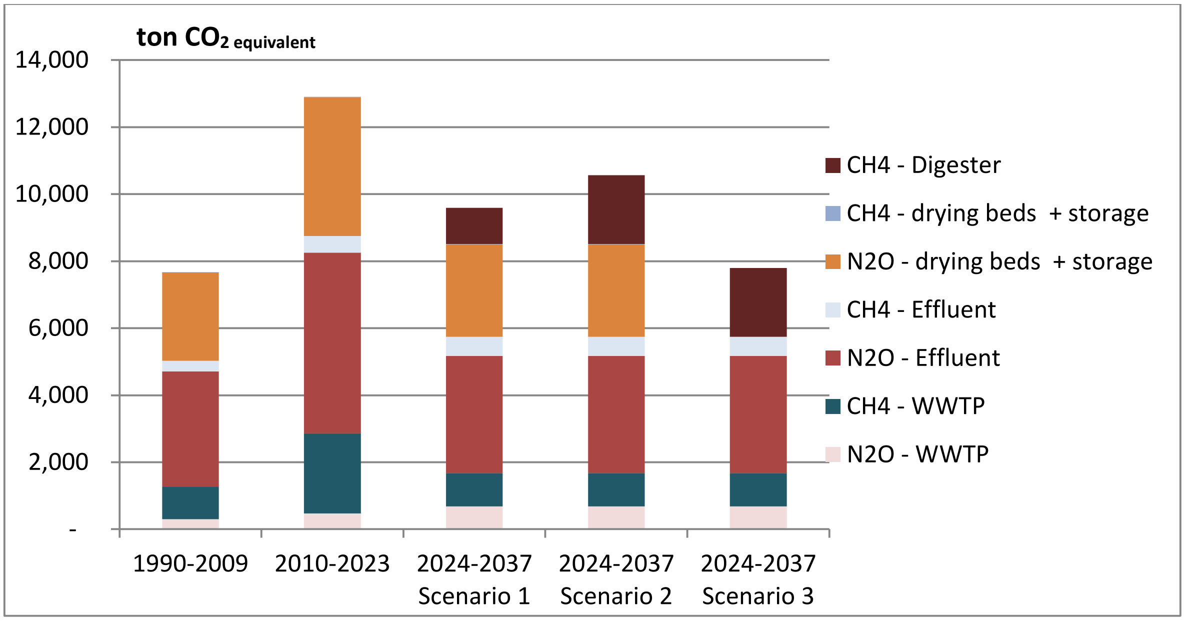


Figure 6-10: Average yearly CO2 equivalent of direct emissions

For the indirect emissions, the following Figure 6- shows that the irrigation pumping stations is a major energy consumer. If we set this consumer aside, it is very apparent that energy recovery (will be subtracted in later figure) has caused tremendous cut on energy consumption from grid (16%, 51% and 51% energy savings compared to WWTP consumption without irrigation pump station in scenario 1, 2 and 3 respectively).

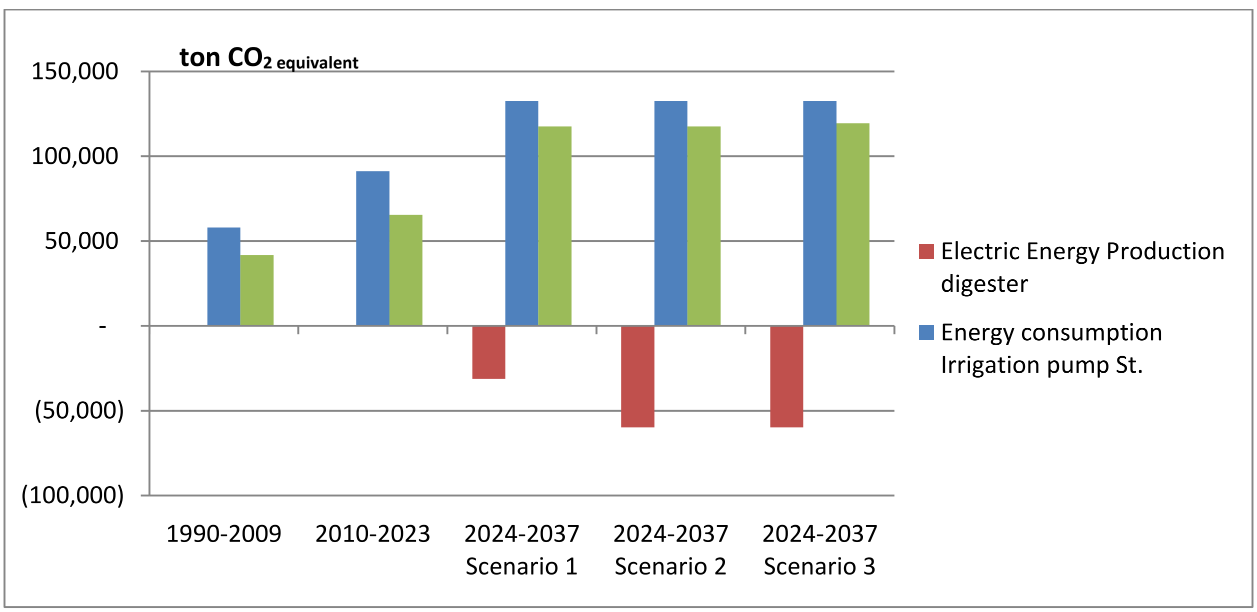


Figure 6-11: Energy emissions of Arab Abu Sa'ed WWTP

The thermal energy consumed and produced by the digester shown in Figure **Error! No text of specified style in document.**-, where the thermal energy consumed is always much less than the thermal energy produced by the digester, this might be due to several reasons: that the temperature difference most of the year in Egypt is on average not very large, and the fact that heat efficiency is much high than electrical efficiency in the CHP.

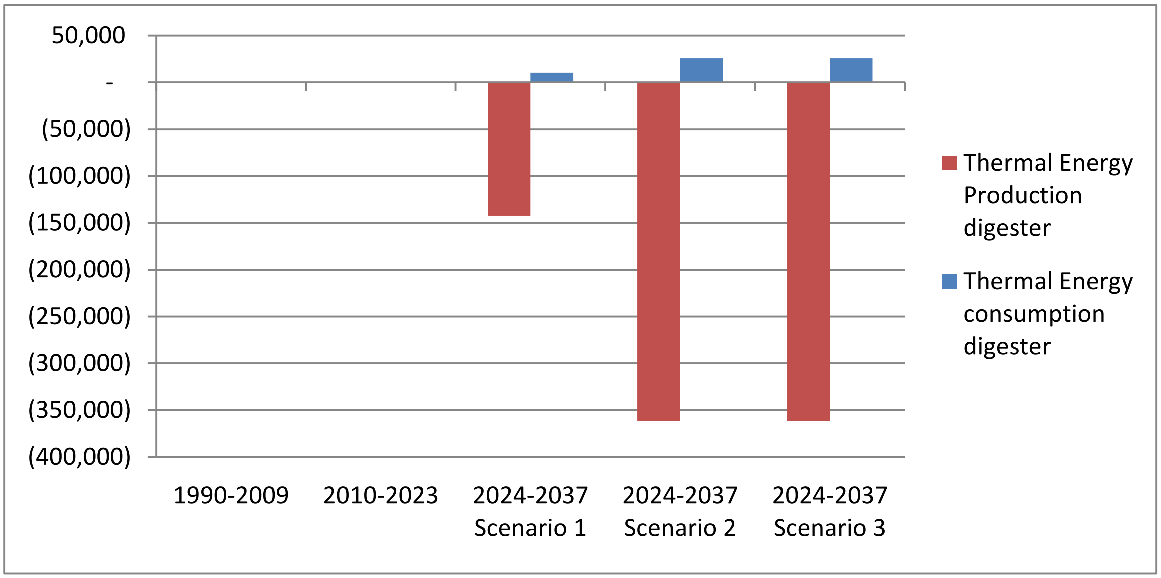


Figure Error! No text of specified style in document.**-12: Thermal energy consumption and production in the digester**

The following Figure 6**Error! No text of specified style in document.**- illustrates the indirect emissions due to energy consumption in the WWTP only without the irrigation pump station and without the thermal energy consumption and production by the digester. It is very clear that emissions were lowered significantly (halved in scenario 2 and 3) with energy recovery using anaerobic sludge digestion.

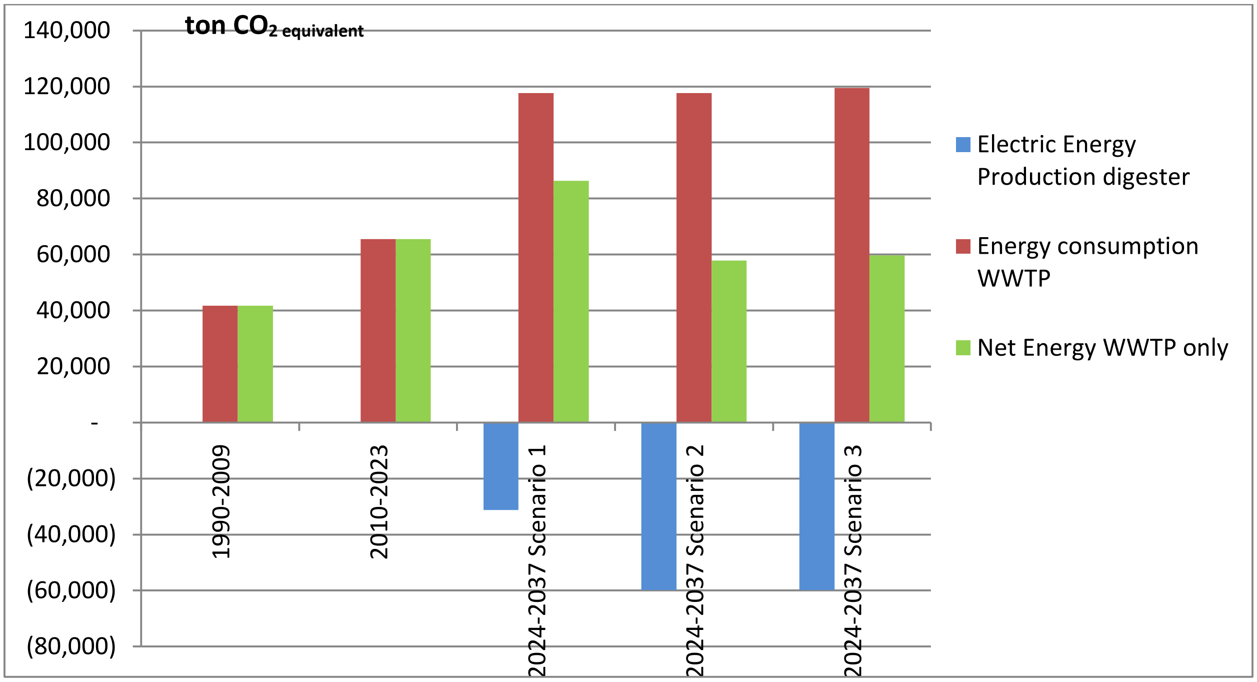


Figure 6 Error! No text of specified style in document.**-13: Indirect emissions due to electric energy consumption and production in the WWTP only and net electric energy**

For the total general comparison as shown in Figure 6-9, the major emission source is the energy use, that's why there has been a drastic decline in the indirect emissions when introducing the digester, especially the full plant capacity energy recovery. Nitrous oxides are the second major emissions gas followed by the methane. Even though the flow has increased in the last three scenarios, the emissions decreased that's due to two major causes:

1. The introduction of energy recovery by sludge digestion.
2. Introduction of tertiary treatment which decreased the effluent emissions greatly.
3. The removal of the extensive sludge drying beds impacted a remarkable decrease in nitrous oxide emissions.

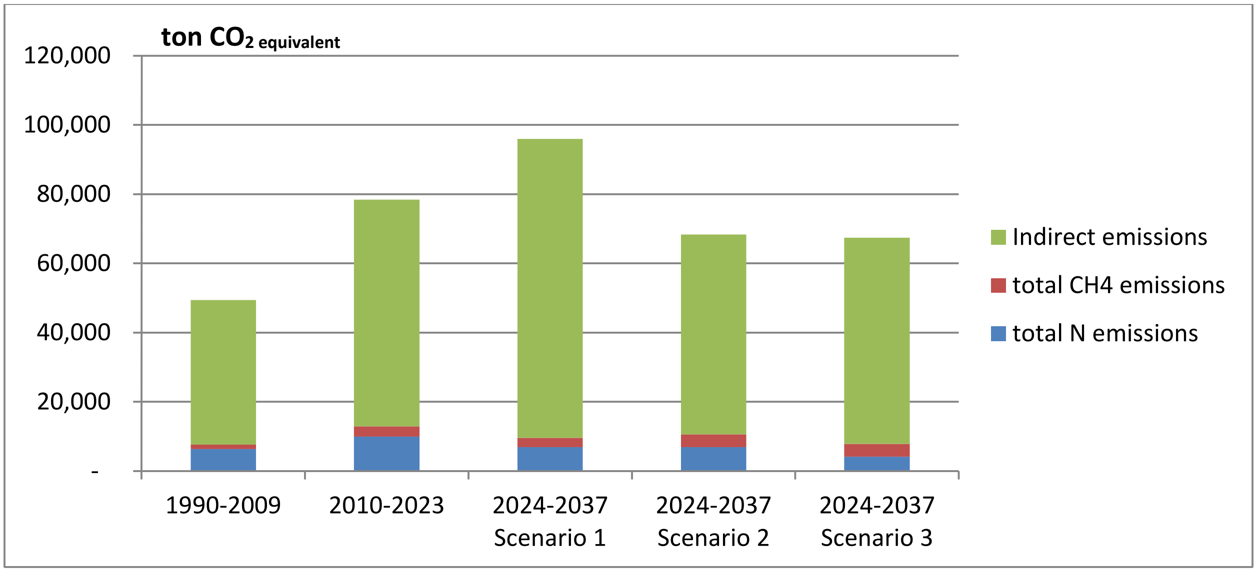


Figure 6-9: Total average yearly direct and indirect emissions Arab Abu Sa'ed WWTP

Finally, as shown in Figure 6- below, the total plant emissions per served population (carbon dioxide equivalent per capita) is drastically decreasing due to the introduction of the future expansions, with the digester and the tertiary treatment.

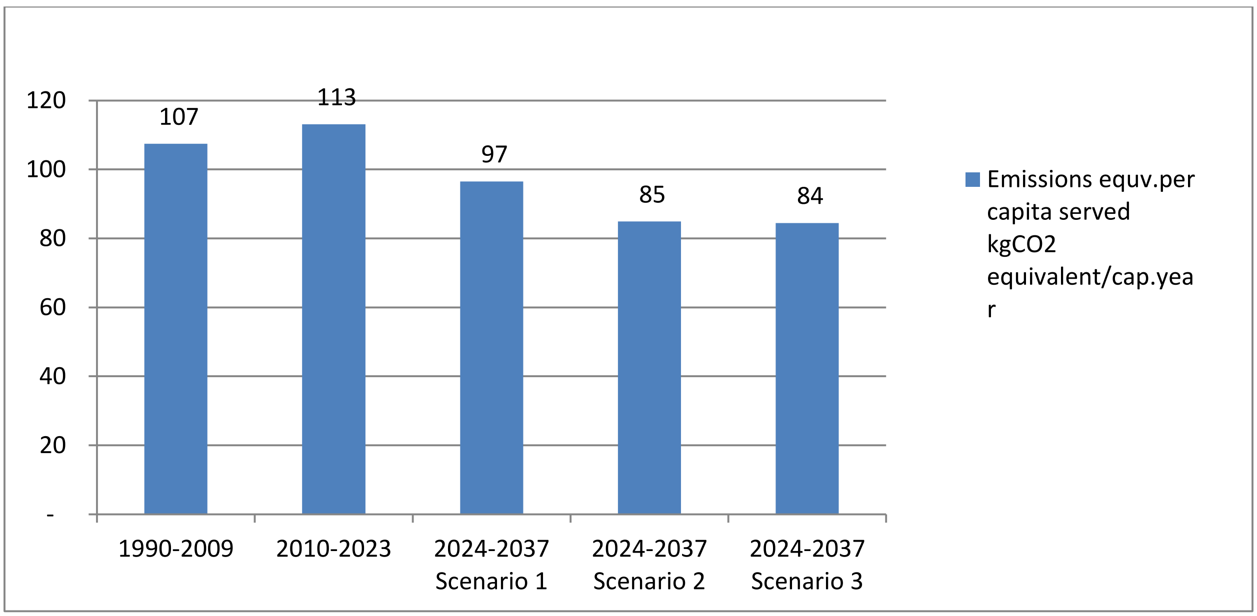


Figure 6-15: Emissions per capita served of Arab Abu Sa'ed WWTP present and future plans

The following Table 6-22 summarizes the impact of the project on climate change GHG and carbon footprint.

Table 6-21: Impact of the project on Climate Change GHG and Carbon footprint

Environmental Receptor		Climate Change GHG and Carbon footprint "PS & WWTP"
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	1
	Duration	1
Weighted Average		2
Receptor Categorization		Major
Impact		Positive

Recommendation

- Using anaerobic sludge digestion is a very effective tool in both emission reduction and sludge quality treatment. Egypt is already in the strategic direction of applying such technology to major wastewater treatment plants, and has already been successful operating digestion for decades in Al Gabal Al Asfar WWTP and other major WWTP such as Alexandria WWTP.
- The replacement of sludge drying beds is recommended, not only due to its technical difficulties in operation and maintenance and its low final sludge quality. It is also proved that it has major impact on nitrous oxide direct emissions. The replacement of the drying beds along with the introduction of the digesters can be easily implemented gradually, where one third of the capacity can be dewatered mechanically and demolishing its drying beds while a digester for each next one third of the capacity of the plant and so on. This will help in gradually accomplishing capacity building and allows being able to observe the results and predict further outcomes for future decisions.
- Tertiary treatment is highly needed to raise the quality of the effluent treated wastewater and is considered a very good decision not only emission wise but also for the economical and agricultural future of the area.

(For more details please revert to annex II - Climate change assessment / Carbon Footprint report)

6.3.4 Climate resiliency and vulnerability

The project has a very strong potential when it comes to climate resiliency and vulnerability as, all the proposed project outputs and components may be considered as a reduction to the vulnerability to climate change as the project will:

- Increase the wastewater conveyance network capacity, which will help contain more intense rainfall and storms/floods.

- Supply unrestricted irrigation water quality with additional 800,000 m^3/day, which would have otherwise been extracted from the Nile. This will help compact droughts and shortage of water resources and agricultural water stress.
- Will improve wastewater treatment quality to compact the climate change impacts.
- Compact the damage and halt in service due to power cutoffs by depending less on the national grid by utilizing energy recovery in sludge digestion.
- Decreasing the carbon footprint per capita served by utilizing energy recovery and tertiary treatment.
- Increasing the WWTP capacity along with upgrading to tertiary treatment will allow for more containment to the peak average daily water consumption increase as temperatures increase.

While the measures needed to increase the project's resiliency to climate change impacts and decrease its vulnerability towards them, are simple measures such as more frequent maintenance for the possible exposed elements of the project to floods, extremely cold weather, and the frequent check on mechanical items due to higher temperatures and higher possible wear in the equipment. The following Table 6-22 summarizes the impact of the project on climate change resiliency and vulnerability.

Table 6-22: Impact of the project on Climate Change resiliency and vulnerability

Environmental Receptor		Climate Change resiliency and vulnerability "PS & WWTP"
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	1
	Duration	1
Weighted Average		2
Receptor Categorization		Major
Impact		Positive

(For more details please revert to annex III - Climate change resiliency and vulnerability assessment)

6.3.5 Noise

Helwan WWTP extension

The noise impact from continuous operation of the blowers in some places in the WWTP shall not exceed the premises of the WWTP and shall not extend outside the WWTP premises and shall not affect the surrounding residential areas. The impact on external receivers during the operation and maintenance phase are considered to be low, local and short term due to the location of the proposed

WWTP away from sensitive receptors. Noise impact from moving vehicles to and from the WWTP on the surrounding residential area shall be low, local and short term.

For Helwan WWTP (New WWTP), The noise emitted during the operation of the WWTP may reach 75 dB , close to the operating pumps. From the site visit, it was clear that no residential units or other receptors adjacent to Helwan WWTP.

Noise impact on workers within the WWTP location from the operation of the WWTP shall be significant and severe in some places where blowers are operated continuously. This impact shall need to be mitigated. Therefore the workers on site and with necessary personal protective equipment (PPE) including earmuff, the impact could be fully controlled. The potential generated noise will the impact should be therefore considered of **Minor significance**.

PSs and FMs

Regarding FMs no foreseen noise impacts during normal operation. However, with regards to both the expected noise generated during operation and the proximity of sensitive receptors, the most critical component of Helwan WWTP project with regards to noise impacts during the operation phase will be the operation of the PSs.

The proposed PSs development, comprise a number of potential noise sources. It is must that the overall noise level at one meter from PSs battery limits does not exceed **75dB**.

The existing noise sources that may contribute to the high background noise levels are compressors and pumps of existed stations. Consequently, it should be considered of **Moderate significance** during the operation of PSs, see Table 6-23.

Table 6-23: Impact of noise on sensitive receptors during operation phase

Environmental Receptor		Noise "PS & FMs"	Noise "WWTP extension "
BASIC IMPACT INDEX	Magnitude	3	2
	Spatial Extent	2	1
	Duration	2	1
Weighted Average		2	2
Receptor Categorization		Medium	Medium
Impact		**Moderate**	**Minor**

Mitigation measures

On site noise emissions control during operation shall be achieved by implementing an occupational health and safety plan, which considers national and international requirements. This to ensure a safe work environment and to ensure that on-site noise levels stay within the allowable limits. The plan shall include the following measures:

- Cultivate and maintain a tree belt around the site where feasible
- Implement a complaints system to investigate any noise complaints from neighboring communities.
- Ear muffs/protective hearing equipment shall be made available to all workers in noise critical areas
- Training on how and when to use protective hearing equipment shall be conducted as part of the workers' induction sessions.
- Place visually clear instructions in areas where noise emissions are significant.
- Regular maintenance of all equipment

Monitoring measures

- Measuring the ambient noise level in noise critical areas, using a portable noise meter and at the nearest sensitive receptors.
- Investigate noise complaints from workers and neighboring communities in the affected location.

6.3.6 Land and Soil

Helwan WWTP extension and PSs

Potential impacts on land and soil during the operation of the WWTP and PSs will also arise from potential leaks. However, these should be considered of **Minor Significance** because of the following:

- All the units of the WWTP and PSs are constructed over a sealed concrete base layer which prevents direct contact with the underneath soil and allow for repair time.
- Tanks and ponds are all sealed.
- The leaks will be mostly visible as compared with potential leaks in the gravity sewers and force mains which will be hidden underground.

Potential impacts on land and soil during the operation phase may arise from any leak developing in the system. The impact should be considered of **Moderate significance** with respect to gravity sewers and Force mains (the impact is more critical with respect to FMs due to the higher pressure and the higher rate of contaminant migration to the surrounding soil and groundwater. The contact with the surrounding soil in all cases will be direct. The probability of the impact occurrence will depend on the quality assurance during the construction works and the impact's duration will depend on the response time to the leak until the repair works start. Other potential impacts on soil and groundwater are due to waste generation, sludge management and also due to Effluent use in irrigation of the timber forest. Table 6-24 is summarizing the expected impact significance on land and soil during WWTP operation phase.

Table 6-24: The impact on land and soil during operation phase

Environmental Receptor		Land & Soil “Sewers & FMs	Land & Soil “PS & WWTP”
BASIC IMPACT INDEX	Magnitude	2	2
	Spatial Extent	1	1
	Duration	1	1
Weighted Average		2	2
Receptor Categorization		Medium	Medium
Impact		Moderate	Minor

Mitigation measures

- Implement a leak detection plan

Monitoring measures

- Regular inspection of all components of PSs and WWTPs for any potential leaks
- Regular inspection of water quantity in the timber forest

6.3.7 Water Resources and Water Quality

The project of upgrading the Helwan WWTP to advanced treatment shall significantly enhance the effluent quality, consequently stop the untreated wastewater disposal into Al-Saff Canal and significantly reduce the current pollution levels in the first reach of Al-Saff canal and improve the water quality in it, meanwhile will reduce the abstraction of fresh water from the Nile River.

Helwan WWTP extension and PSs

The key impact on the surface water during the operation of the WWTPs and PSs will result from the reuse of the treated effluent in irrigation, disposal of the treated effluent in Al Safe canal. Other than these, no impacts on the surface water quality would be expected during the operation of the WWTP and PSs.

On the long run enhancement of groundwater shall occur due to enhancement of the surface water quality and reduction of pollution loads as indicated. Significantly reduce the current pollution levels in the first reach of Al-Saff canal and improve the water quality in Al-Saff Canal, see Table 6-25.

Table 6-25: Pollutants reduction loads in effluent before and after the extension of Helwan WWTP

Parameters	Before extension	After extension	Pollutants load reduction %
BOD (ton/day)	129.5	48.0	62.9%
COD (ton/day)	207.5	64.0	69.2%
TSS (ton/day)	148.0	40.0	73.0%

Supplying advanced treated water quality to the farmers in the first reach of the canal with more good quality water in the canal shall enhance the reuse for irrigation purposes. Therefore, the operation of the project has **positive impact** on the water quality in the project area (drain water, lake water and marine water).

Table 6-26 Impact of the project on Climate Change resiliency and vulnerability

Environmental Receptor		Water Resources "PS & WWTP"
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	1
	Duration	1
Weighted Average		2
Receptor Categorization		Major
Impact		Positive

(For more details please revert Helwan WWTP-Influent flow 2019/2020, Wastewater Quality laboratory data (July –October 2020)– Annex IV(a))

Gravity sewers and FMs

Impacts on water quality might arise from potential leaks. This will directly affect the surface water quality. The impact should be temporary until repair action are implemented and will have low probability of occurrence. The impact should be considered of **Minor significance**.

6.3.8 Al Saff Canal - Effluent Reuse Opportunities

One of the main project's purposes is using the effluent treated water discharges into Al Saff canal which is then used for agricultural purposes. The treated effluent will contain low pollution levels that would allow for safe effluent discharge into surface water bodies compared with Egyptian standards. The current design will consider the main parameters as BOD, COD, suspended solids, total Nitrogen and total phosphorus values to be all within the allowable limit.

Discharging quantity of Helwan WWPT in Al Saff canal will increase from 550,000m3/day to 800,000m3/day with better quality of treated water, see Figure 6-.

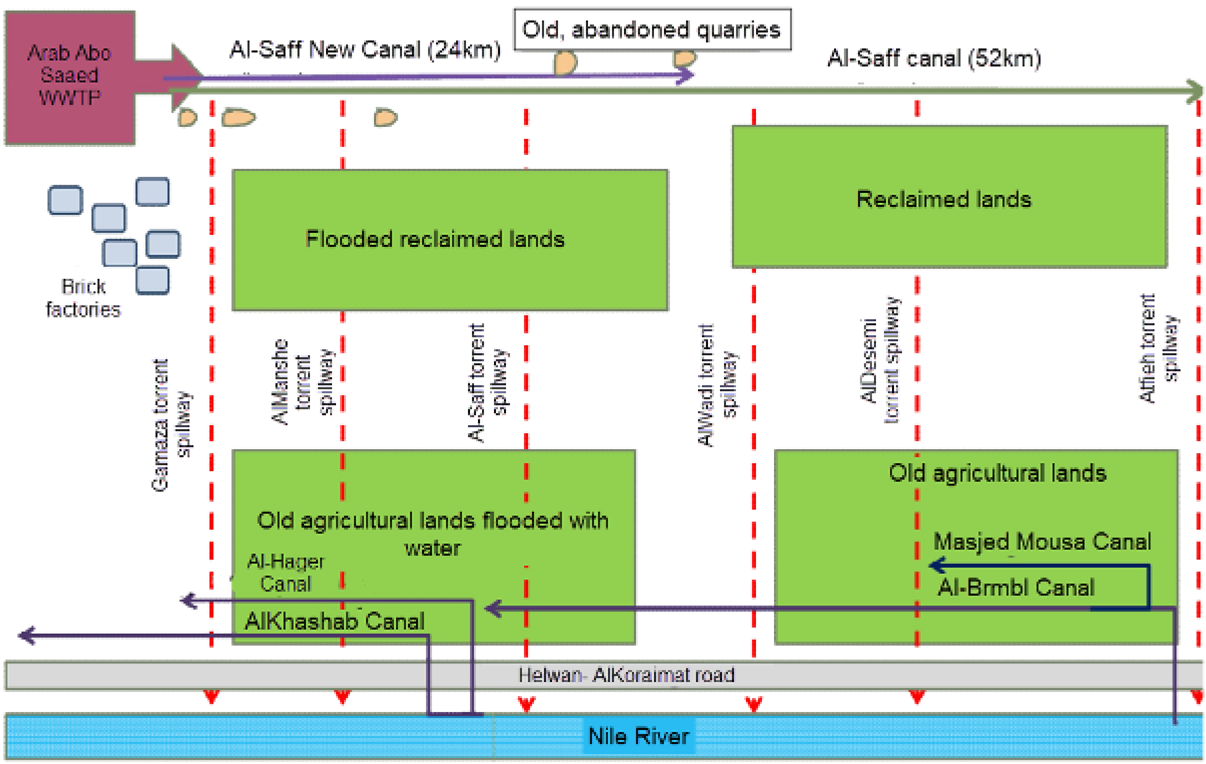


Figure 6-16: Schematic diagram of Al-Saff area and irrigation methods

Discharging the advanced treated wastewater into the open canal Al-Saf shall increase the limited water resources within the area with good quality which can be used for different purposes locally within the surrounding areas of the WWTP, hence no need for excessive treatment of nutrients. Therefore, other nutrients removal intensive technologies such as Denitrification-Nitrification are neither an energy nor operational optimum.

Meanwhile, it is worth to mention using of adequately treated wastewater effluent will reduce demands a considerable volume of fresh surface water from the River Nile, as the current process is mixing Nile River fresh water to improve effluent quality and fulfilling shortage in water in discharge in Al Saf canal, which means the saving of the River Nile water by a total of 500,000 m3/ day taken daily from the River Nile that will be used later in the Delta to substitute the deficiency of water at the end on Delta. It can be concluded the proposed project has **positive impact** regarding water resources in project's area, Table 6-26 summarizing the expected impact significance on water resources during WWTP operation phase.

Table 6-26: shows the impact on water resources during operation phase

Environmental Receptor		Water Resources "Sewers & FMs	Water Resources "PS & WWTP"
BASIC IMPACT INDEX	Magnitude	3	2
	Spatial Extent	2	1
	Duration	2	1
Weighted Average		2	2
Receptor Categorization		Medium	Major
Impact		Minor	Positive

6.3.9 Al Saff Canal - Hydraulic Capacity

The proposed project aims to increase the existing capacity of Helwan WWTP from 550,000 m3/day to be 800,000 m3/day. Hydraulic capacity of al Saff canal should be increased to accommodate the new WWTP effluent of 800,000 m3/day. As seen in the following Figure 6- that the predicted water level will be overflow the canal bank in case of introduced the new flow 800,000 m3/day

Moreover, the treated wastewater is being discharged into the El-Saff canal which has some problems related to the increase of the groundwater table in the surrounding agricultural lands, leading to bank failure and flooding problems in different places. summarizes impact on Hydraulic Capacity of El Safe canal that should be considered of **Moderate significance** as follows.

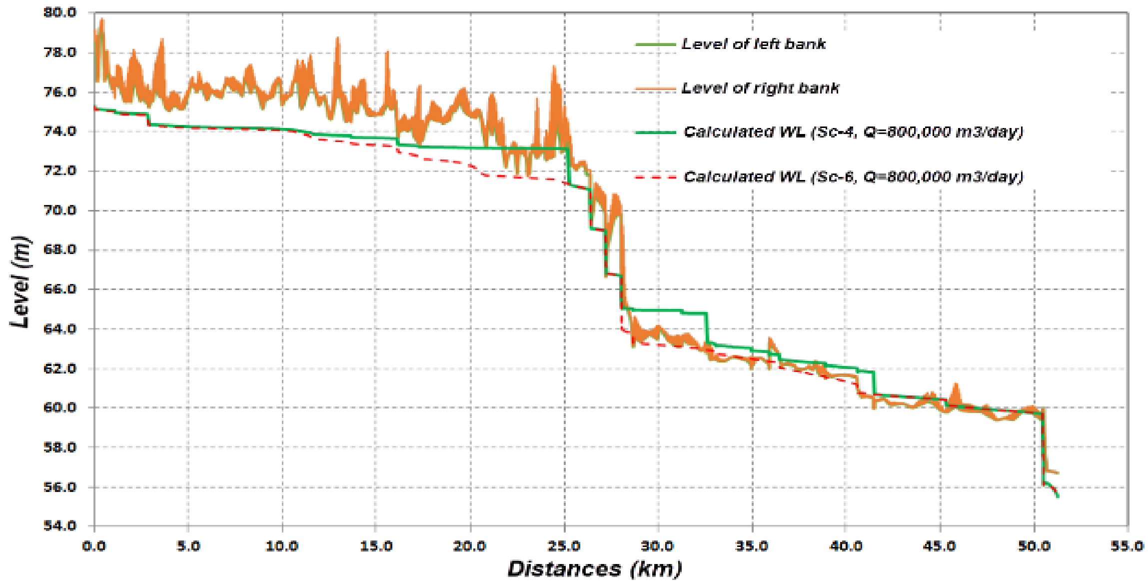


Figure 6-17: The water level results to Al-Saff old canal in model

Table 6-27: shows the impact on El Saff canal Hydraulic Capacity during operation phase

Environmental Receptor		"El Saff canal Hydraulic Capacity"
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	2
	Duration	2
Weighted Average		2
Receptor Categorization		Medium
Impact		Moderate

Mitigation measures

Repair and maintenance of canal banks and the concrete sector of the canal in some places and modify the diameters of some of the siphons pipes, as shown in Table 6-28.

Table 6-28: Places of Canal banks collapses

Region	Start of collapse (km)	End of collapse (km)	Canal bankside
One	1.45	2.5	Right and Left
Two	3	3.1	Right
Three	3.14	3.26	Right
Four	3.18	3.5	Left
Five	5.56	8.58	Right and Left
Six	12	12.72	Right and Left
Seven	14.76	17.44	Right and Left
Eight	21.3	23.3	Right and Left

(For more details please revert to study of Hydraulic Capacity of Al-Saff Canal – Annex V)

6.3.10 Impact on drainage network in the Al-Saff area

An estimated 4,200 feddans are being reclaimed in the East Markaz Al Saff area, where the water of Al-Saff Canal was used in irrigation and cultivation of lands of the region and with the continuation of irrigation of these lands a problem appeared in the flooding of large areas of land adjacent to the canal and the ponds therein in addition to the rise in ground water levels in the old agricultural lands adjacent to the river Nile in addition to the rise in ground water levels within the residential areas in the region due to water infiltration within the soil and the direction of water to the old low-lying lands has become a natural drainage for the eastern highlands, adjacent to the canal, where ground water levels have risen, which helped in flooding the soil and the emergence of drainage problems.

The area relies on its reclamation on the water of the El-Saff canal, which is fed by the output of the WWTP west of Abu MuSa'ed with a capacity of 550,000 m3/day, and it is intended to increase its capacity to 800,000 m3/day by adding a new phase with a capacity of 250,000 m3/day and as is intended to study the impact of this increase on each of:

- Drainage network in the Al-Saff area.
- The stability of the canal and its banks.
- Environmental impact.
- The quality of the water passing through the canal.

Wastefulness and failure to rationalize the use of irrigation water in agriculture lead to large quantities of it leaking into the groundwater, causing a rise in the groundwater level and a concentration of salts at different depths, which leads to a deterioration of soil productivity, and then it becomes necessary to establish subsurface drainage networks, see Figure 6-18. The productivity and area of agricultural lands, facilitating service using agricultural machinery, saving in irrigation and drainage regulations, and the cost of maintenance per feddan, removing excess salts by periodic washing of the soil, and the health effects of eliminating endemic diseases in the environment.

Table 6- summarize impact on drainage network of El Safe should be considered of **Moderate significance** as follows.

Figure 6-18: waterlogging and salinization of lands in the study area

Table 6-30 Tthe impact on water resources during operation phase

Environmental Receptor		Water Resources “El Safe canal Hydraulic Capacity”
BASIC IMPACT INDEX	Magnitude	3
	Spatial Extent	3
	Duration	4
Weighted Average		3
Receptor Categorization		Medium
Impact		Moderate

Mitigation measures

To accommodate the additional discharge of the WWTP in Arab Abu Sa’ed provided that the necessary measures are taken in accordance with the scenarios: -

- The necessity of the maintenance and reshaping of the current cross-sections of the torrent spillways to be identical to the design situation. This is to accommodate the discharge of the open drains.
- Implement the proposed subsurface drainage network (Studied by Drainage Research Institute and to be implemented by Egyptian Public Authority for Drainage Projects) comprises 6 drains as shown in the following figure.
- The Al-Saff canal's efficiency must be improved by preventing the illegal irrigation from the canal and preventing the placement of conveyor irrigation pumps on the banks of the canal, as well as through lined irrigation sides parallel to the canal on the right and the left.
- Emphasis should be placed on monitoring and making field and laboratory measurements of the quality of the final discharge of the wastewater treatment plant in Arab Abu Sa’ed to ensure its compliance with local laws' standards.
- Banning the surface irrigation system by flooding as it leads to a tremendous waste of irrigation water quantities more than the quantities that are actually utilized, causing a rise in the groundwater level and soil salinization.
- The drip irrigation system must be generalized, especially in the new reclamation lands, as it saves irrigation quantities with a homogeneous distribution. It is also best suited for irrigation with treated water.

(For more details please revert to El Saff drainage network study – Annex VI)

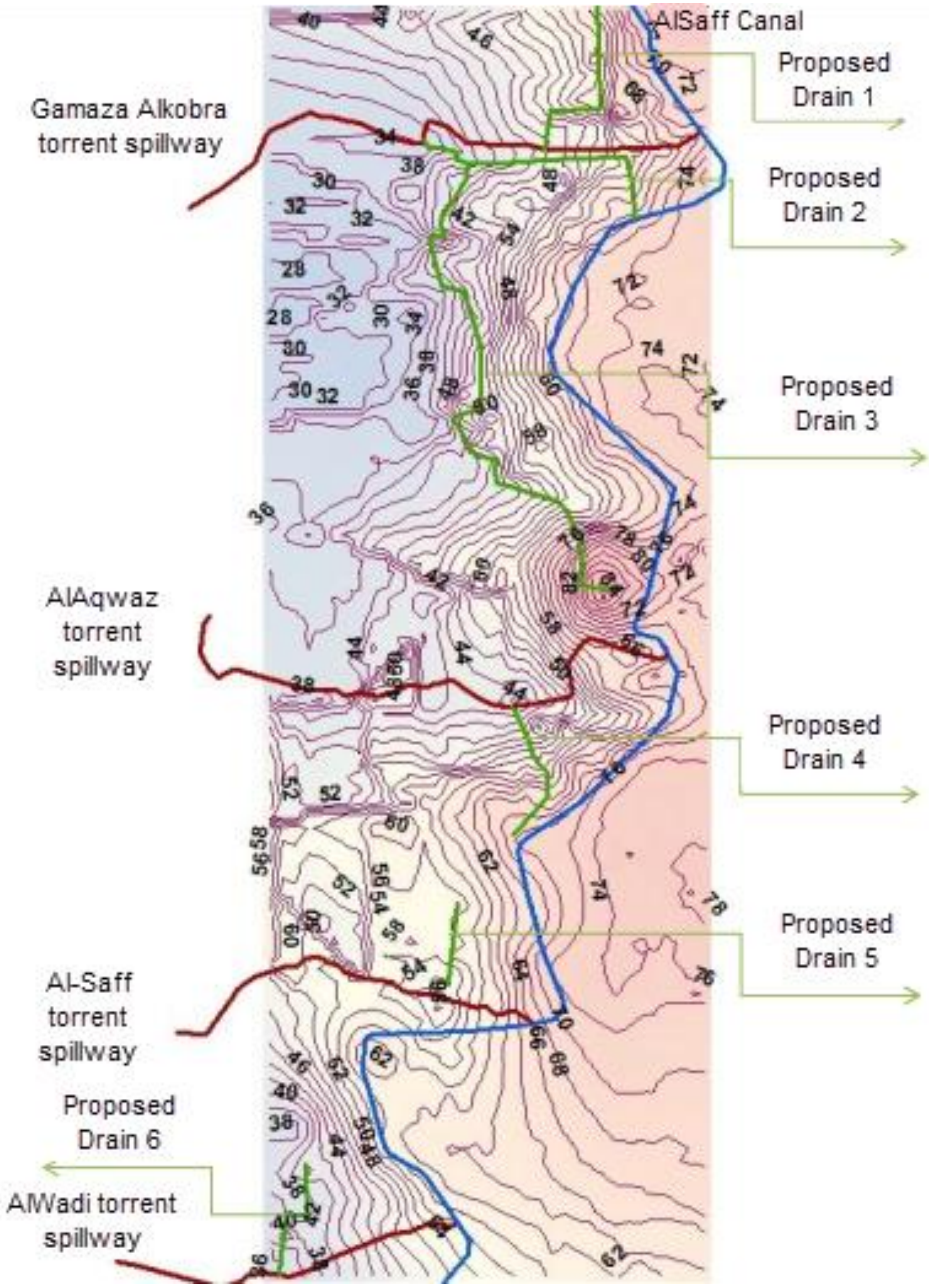


Figure 6-19: Al-Saff canal and the locations of the proposed drains to serve Al-Saff area

6.3.11 Sludge Quality

Helwan is also considered an industrial one as it hosts many industries such as: Iron & Steel, Cement, basic metals, engineering and electronics, as well as mining. Moreover, the project area hosts three industrial zones; one of them is located in Tebbin and has big industrial companies. The other two zones are located at Maady and Helwan. In addition to that, the area hosts many new projects such as the under construction new Tebbin power plant of capacity 2x350 MWe.

The number of industrial facilities within the existing service area is about 65 facilities. Their total discharge reaches 671,811 m3/month with an average of 22,394 m3/day. In addition to that, the service area of the 15th of May City will be linked to the treatment plant directly. This area counts for another 58 industrial facilities. Their total discharge sums up to 47,293 m3/month with an average of 1,596 m3/day.

The total daily discharge from the industrial zone therefore is around 23,970 m3/day. Heavy metals in wastewater and sludge should be analyzed to insure the nontoxicity of the treated wastewater and treated sludge and meeting the required standards.

As bioaccumulation and metal can transfer to the food chain are greatly affected by the kind and strength of the bonds of the toxic metals in sludge, it has become evident that the environmental impact of a particular metal species may be more important than the total metal content[43].

Sediment contaminations can influence the overall quality of aquatic and terrestrial environment. Sludge provides habitats to benthic organisms, and crops which some of them are the food sources to humans. Therefore, ensuring a good sediment quality is crucial to maintain a healthy aquatic ecosystem, which ensuring good protection of human health and aquatic life.

In the sludge assessment, metal speciation is recommended to separate the bioavailability forms (Exchangeable and Carbonate) of heavy metals to evaluate the environmental risk of metals in sludge/sediment. The heavy metals bioavailability form and portion depends on many factors[44] [45]included but not limited to:

- Sludge type
- Sludge salinity
- Sludge alkalinity
- Oxidation
- Yield history and sludge layer position (top or bottom)

[43] https://www.researchgate.net/publication/273460249" Robert Boyd, Transfer of Heavy Metals Through Terrestrial Food, Environmental Monitoring and Assessment Journal, · April 2015

44 Singh, S.P.; Tack, F.M.G.; Verloo, M. "Extractability and bioavailability of heavy metals in dredged sediment derived surface soils", Laboratory of Analytical Chemistry and Applied Ecochemistry, Coupure-Links 653, B-9000 Gent, Belgium, Chemical Speciation and Bioavailability Journal 8:105-110, 1996

45 Riba, E. García-Luque, J. Blasco & T. A. DelValls "Bioavailability of heavy metals bound to estuarine sediments as a function of pH and salinity values", Chemical Speciation & Bioavailability, 15:4, 101-114, DOI, 2003: 10.3184/095422903782775163. To link to this article: https://doi.org/10.3184/095422903782775163

Recent sludge samples were collected from Helwan WWTP and analyzed at Ministry of health Central laboratory in November 2020. The tested metals were: Cd, Pb, Fe, Zn, Al, Cd, Pb, Ar, Hg, Mo, Ni, Cu and Mn.

The results (Attached in Annex IV (b)) showed that all heavy metals and E. coli values comply with Egyptian regulation and code of year 2015.

This could be due to the following reasons:

- The WWTP receives industrial wastewater such as Iron and steel, cupper, Metal, fertilizer companies which have their own treatment unit before discharge into the public sewer system.
- The current industrial flow are relatively low to domestic waste flow (industrial 24,000 m3/day to 550 m3/day so industrial wastewater representing around 4% of total wastewater flow)
- Moreover, Egyptian Pollution Abatement Program (EPAP III) Funding is available for industrial activities in Greater Cairo and Alexandria. Companies applying must be credit worthy. Projects should: a) comply with Egyptian environmental law. b) decrease pollution loads by 50%; c). EEAA is offering this great chance for industrial activities in the project area to reduce their pollution load discharged into the effluent of the Helwan WWTP.

6.3.12 Wastes

Impacts due to handling and disposal of non-hazardous wastes

Non-hazardous wastes are expected to be generated during the operation of the PSs and WWTP. These will result from the cleaning and scrubbing of inlet filters (contaminated solid particles), as well as from the daily activities of workers. The latter will comprise of a mix of food residual, plastic and paper packages.

The first potential impact would be the contamination of soil, groundwater and/or surface water due to the uncontrolled disposal of contaminated solid wastes. Another potential impact would be the loss of natural resources (for recyclables) if recycling has not been implemented.

Other impacts would include negative visual impacts if waste is accumulated in front or around the PSs and the WWTPs. Burning of the accumulated wastes would impact the air quality around the PSs and the WWTPs sites, and could emit toxic emissions especially if plastic substances were among the waste streams.

Accumulation and/or uncontrolled disposal of organic wastes (food residuals) would also result in potential impacts on the health and hygiene of both general public and on-site workers by attracting vermin to the site such as birds, rodents or insects which can act as disease vectors. This will result in spread of disease, and disruption of the natural ecosystem.

Odor may also be generated following long periods of accumulation due to the decomposition of some organic wastes, which will be an annoyance to both general public and on-site workers.

The evaluation of impacts due to non-hazardous waste generation during the operation phase is illustrated in the Table below. Most of the impacts should be considered of Moderate significance, which is mainly due to the proximity of receptors (with respect to the PSs).

Table 6-29: The impact of non hazardous wastes during operation phase

Environmental Receptor		NH Wastes
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	2
	Duration	1
Weighted Average		2
Receptor Categorization		high
Impact		Moderate

Mitigation measures for non-hazardous wastes

A waste management plan complying with international best practice and relevant Egyptian regulations and covering all types of potential non-hazardous wastes shall be developed and implemented by the project's operator. This plan shall define exact procedures and locations for waste management and disposal.

- Implement a segregation system based on compatibility of different waste streams
- Specify an area / container for non-hazardous wastes which accommodate for the generated segregated streams.
- Dispose of non-recycled wastes in the nearest landfill.
- Register the amounts of disposed of wastes and keep waste disposal and transportation receipts/manifests, to be ready for review.
- Daily removal of PS screens waste to domestic solid waste disposal sites
- Stabilizing separated grit with lime, dry it in separate drying beds and dispose dry grit in domestic solid waste disposal sites

Monitoring measures for non-hazardous wastes

- Regular inspection of the waste storage area (for PS's and WWTP's sites)
- Regular inspection of the waste disposal manifests.

Impact evaluation due to handling of hazardous wastes

Hazardous wastes may also be generated during the operation phase such as spent oils and empty chemical containers. The storage and disposal of these waste streams have to be carefully performed as to abide by the national legal framework (Chapter 2). In addition to that, these hazardous wastes if not handled, stored and disposed of according to engineering best practice would have major and irreversible effect as follows:

- Mishandling and uncontrolled disposal of hazardous liquid and solid wastes have major health impacts for on-site workers, inhabitants in the project's area of influence, people who get in contact with waste during transportation and disposal, and flora and fauna exposed to such wastes.
- Uncontrolled disposal of hazardous wastes, in particular in liquid form, would cause soil contamination through direct contact or leaching.
- There is a high possibility that uncontrolled disposal of hazardous wastes may affect the groundwater quality, through extended leaching.
- Air quality could also be highly affected since uncontrolled dumping of hazardous and non-hazardous materials would result in most of the cases in open burning and potential release of toxic emissions.

The impacts listed above are evaluated as presented in Table 6-30 below. Most of the impacts should be considered of Moderate significance and will be fully controlled by implementing the mitigation and monitoring measures listed in the following section.

Table 6-30: The impact of hazardous wastes during operation phase

Environmental Receptor		Hazardous Wastes
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	2
	Duration	1
Weighted Average		2
Receptor Categorization		high
Impact		Moderate

Mitigation measures for the handling and disposal of hazardous wastes

Empty chlorine cylinders, should be collected at a certain location inside the chlorine building before being returned to the supplier. The vendor who will supply the WWTP with chlorine cylinders should take waste cylinders back on the same truck. This process should be documented in manifests that should be signed by the vendor.

Diesel ASTs should be surrounded with impermeable bund with a capacity equal to the AST capacity. Any leaked diesel from ASTs should be pumped to diesel trucks until the leakage in AST has been repaired. No USTs should be used in the project.

A waste management plan complying with international best practice and relevant Egyptian regulations and covering all types of potential hazardous wastes shall be developed and implemented by the project's operator. This plan shall define exact procedures and locations for waste management and disposal. The waste management plans should also refer to health and safety procedures, and emergency procedures for containing and managing accidental spillages.

a) General measures

- All types of hazardous waste can only be transported by licensed hazardous waste service providers and disposed of in licensed landfill. Both, the service providers and disposal sites have to be identified at the beginning of the operation phase. At the time of producing this study, the nearest and only hazardous waste disposal site is the Nasreya Centre in Alexandria.
- The different types of hazardous wastes should not be mixed.
- Spent mineral oils shall be collected, stored in sealed containers and recycled using a licensed company which also has to be identified at the beginning of the operation phase.

b) Adopting an Identification system for hazardous wastes generated on site

The operator shall be able to identify the different potential hazardous wastes. Identification shall be performed according to the Egyptian hazardous waste classification system by the operator's in-house staff (PMU-EM and RSUs or with the aid of an independent waste management consultant).

c) Storage and Management of the waste accumulation area

The waste storage area for hazardous wastes could be integrated with the general waste storage area but shall be fenced, secured with limited admission and shaded from rain and sun heat/light.

- It is recommended that the maximum period for storing hazardous waste is 270 days from the start date of accumulation of waste.
- The storage area must have a water supply
- A hazardous waste label that has a "Hazardous Waste" mark on it must be placed on the container while still at the generation point.

Monitoring measures

- Diesel leaks from ASTs will be detected through visual observation. Any leakage should be documented in regular reports, along with measures taken by the operator to contain the leakage.
- Records of empty containers returned to vendors, or contaminated soil transported to hazardous waste facilities should be kept in the WWTP, along with signatures of hazardous waste facility operator acknowledging receipt of the containers.
- Registering the amount of hazardous waste sent for disposal and archiving the collection and disposal receipts. This shall be done in the form of a waste register as required by the Egyptian law.
- Regular inspection of the waste storage area
- Regular inspection of the site to identify random disposal of waste materials

- The containers should be inspected monthly for leaks or any other form of damage and are kept in good condition.
- Regular inspection of the site to identify randomly dumped hazardous waste materials.

Sludge

If sludge is sufficiently dried and treated/stabilized, prior to being reused (i.e. applied to land), there is unforeseen environmental and health impacts upon condition that sample analysis proves that sludge does not possess hazardous characteristics.

The main environmental and health risks arise from incomplete/absence of sludge stabilization. In such case, there is an increased risk that the sludge might contain high pathogen content. Potential health hazards to human and animal health could arise from the application of sludge to agricultural crops because dumping raw sludge on agricultural lands could lead to the production of contaminated crops, especially if applied directly to plants. The consumption of these crops, their handling by vendors, and any contact with soil by farmers may also have biological and health impacts. These are also considered some of the main form of human exposure to agricultural sludge contaminants.

Mitigation Measures

Sludge handling options depending on the actual quality of sludge. If sampling of dried sludge proof fulfilling the quality standards for heavy metals as indicated in according to the Executive Regulations of Law 93/1962 followed and updated by the Ministerial Decrees 288/2000 and 329/2001 through issue of an Egyptian Code for Reuse of Treated Sewage water in irrigation and Use of Sludge in agriculture , and the US EPA threshold concentrations of heavy metals of sludge (table 3.2 – section 3) to be applied on agricultural land (whichever is lower), meanwhile sludge must not be applied to soil in which fruit and vegetable crops are being grown, or less than ten months before fruit and vegetable crops are to be harvested.

Another option, dried sludge could be sent to cement factories as RDF according to an contractual agreement between HCWW and the Cement Company. If sludge cannot be reused, the right landfill category must be determined. Based on the chemical analysis of the sludge, it should be sent to the respective landfill.

The technology of the extension of the WWTP is almost identical to the already existing functional technology with one difference in upgrading the aeration system to a more efficient one.

Conventional activated sludge (CAS) system is a very flexible system that can be easily connected to different pre or later treatment systems. For the existing CAS system, the effluent of it can be easily connected to mechanical drying sludge system instead of the gravity thickeners; a very big advantage which will help to update the sludge treatment system in the entire plant (existing and extension).

CAS is optimum in this project as there is no need for extra investment for extensive nutrients removal on the contrary; extensive nutrients removal will be not favorable in this case. CAS is also optimum operational wise.

The treated sludge will be stored until sold as fertilizers for agricultural purposes, or one third of generated sludge will be used as source of energy via anaerobic digestion gives higher quality treated sludge and recovers energy which decreases the operational costs. Sludge waste impact should be considered as **positive significance**, if re-used in energy recovery or as fertilizers subject to take precautionary measures to confirm its specification before using in commercial purposes, Table 6-31 summarizing the expected impact significance from sludge waste during WWTP operation phase.

Table 6-31: The impact of sludge waste during operation phase

Environmental Receptor		Sludge waste "Helwan WWTP"
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	1
	Duration	1
Weighted Average		2
Receptor Categorization		Medium
Impact		Positive

6.3.13 Visual impacts

During the operation of gravity sewers and FMs

No foreseen impacts;

During the operation of the New WWTP and PSs

The project will change the aesthetics and landscape of the areas where the PSs and WWTP will be located. However, the impact will be relatively acceptable when considering the height of adjacent buildings. The visual impacts see Table 6-32, due to the operation of the WWTP and PSs should be considered of **MINOR significance.** No mitigation measures are foreseen; except developing a suitable landscape (tree belt) around the site.

Table 6-32: The visual impact during operation phase

Environmental Receptor		Visual Impact
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	2
	Duration	2
Weighted Average		2
Receptor Categorization		Medium
Impact		Minor

6.3.14 Potential Social and Health Impacts

Health and Safety Impact Assessment

As mentioned in the project description chapter some of the hazardous substances required for operation processes include chorine, diesel for standby generators, lubricating oils and laboratory chemicals.

WWTP Extension

Chlorine gas has a distinctive, strong smell, and light-yellow color. Chlorine is considered toxic at certain levels and upon inhalation or swallowing could be poisonous. Due to its nature, chlorine gas settles in low elevation when it is released making it more of a hazard to the health of workers and residents living near the WWTP. In order to comply with the Executive Regulations of Law 4/1994 the concentration of chlorine in the working environment should not exceed 1.5 mg/m3 for long term (8-hours) exposure, and should not exceed 2.9 mg/m3 for short term exposure. Designing chlorine buildings for WWTP should follow the precautions for safe storage and handling outlined by the Egyptian Engineering Code for Design and Execution of Wastewater Treatment Plants, Decree 169/1997.

Any increase in the specified amount of chlorine for treatment would affect the quality of the final effluent negatively. Moreover, the chlorination by-products which are produced as a result of chemical reactions of water with chlorine pose risk to human health upon ingestion.

Precautions are taken and warning signs to prevent people from drinking treated wastewater are currently in place for other WWTPs in Egypt. In addition, people are generally reluctant to drink the treated effluent since they know its source. The project design and planning indicated that steel chlorine cylinders needed for the treatment and disinfection processes are to be returned to the vendor for replenishing; reducing risks associated with the disposal of empty chlorine cylinders.

Diesel and lubricating oils will be used and usually have some hazardous and toxic properties. However, the workers handling them are expected to have high awareness regarding their risks. The higher risk in this regard will be that associated with the necessary disposal of empty containers. Impacts on soil (and groundwater) quality could result from fuel storage tank leakage. Secondary containment shall be therefore incorporated in the design as to ensure a minimum of 110% external volume.

Laboratory chemicals comprise of many hazardous substances and liquids. The health risks due to the handling of hazardous substances should be considered of **MAJOR significance** However, implementing safety induction classes, and operational health and safety procedures in addition to implementing the normal laboratory operating procedures including the preparation of COSSH forms and wearing PPE ensure that the impact's significance is reduced.

Sanitation and potable water supply are considered to be the most important determinates of public health. Poor sanitation provision increases health risks substantially and can lead to a multitude of health problems. The proposed WWTP upgrade would result in a positive social impact by improving the general public health conditions in the region than if it were not present. This is in line with the Millennium Development Goal Target 10 which aims to substantially increase the number of population who has a sustainable access to safe sanitation.

In general, WWTP upgrade and operation enhances the general health of inhabitants due to the proper handling of the wastewater as well as sludge and reduction of human exposure to poor treated wastewater and sludge. Upgrading the WWTP from secondary to advanced treatment shall enhance the quality of the effluent as well as the sludge which resulting in less negative impact on human health in surrounding areas.

Regarding the WWTP workers and operators, during the operation and maintenance phase, chemical use should where possible be minimized through the use of monitoring equipment to optimize chemical dosing and reduce the risk of possible accidental chemical spills. For the common types of chemicals and their amounts expected to be used during the operation and maintenance phase, the potential impact can be expected to be low, short term and local.

Table 6-33: The impact on Health and Safety Impact Assessment during operation phase

Environmental Receptor		WWTP extension
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	2
	Duration	1
Weighted Average		2
Receptor Categorization		high
Impact		Major

Emergency Response

For the purpose of first response, when a hazardous substance release is first discovered or witnessed, the individual of concern who had to be previously trained would initiate an emergency response sequence by notifying the proper authorities of the release. The individual will take no further action beyond self-evacuation and notification. The aim of the response at this level is limited to protect nearby persons, property, or the environment from the effects of the release. No trials are performed at this stage to actually stop the release. This level of response includes;

- actions to contain the release from a safe distance
- prevent its spreading
- evacuation

Monitoring Measures

- Chlorine leak detectors with continuous sensors should be provided for chlorine detection. Any leakage incident should be documented by Helwan WWTP operator in the monthly reports along with taken measures and the adequacy of the emergency ventilation system.

6.3.15 Traffic Control

No foreseen impacts during operation, movement of vehicles accessing proposed project's location will be limited to those associated with:

- Workers accessing the site;
- Waste collection; and
- Deliveries of consumables and spare parts.

The traffic impacts due to the operation of the WWTP and PSs should be considered of MINOR significance. No mitigation measures are foreseen, see Table 6-34.

Table 6-34: Traffic impact during operation phase

Environmental Receptor		Traffic Control
BASIC IMPACT INDEX	Magnitude	1
	Spatial Extent	1
	Duration	1
Weighted Average		2
Receptor Categorization		Medium
Impact		Minor

6.3.16 Employment

This represents a significant opportunity for the local population in Al Saff (Giza Governorate). The Project can positively contribute to reduce the current high level of unemployment in the area, particularly among high school graduates by creating 150 direct job opportunity approx.

Usually, percentage of indirect jobs created 150% from direct employment opportunities. This can be expected to have a significant positive impact on the levels of employment in businesses, and the range of employment opportunities available in supporting sectors.

Long-term direct, indirect and induced employment opportunities are also likely to be created on a sectorial level through supply chain development associated with the Project, resulting in a medium magnitude of **positive impact**, see Table 6-35.

Table 6-35: The impact of sludge waste during operation phase

Environmental Receptor		Sludge waste "Helwan WWTP"
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	1
	Duration	1
Weighted Average		2
Receptor Categorization		Medium
Impact		Positive

6.3.17 Women Participation

While women are the pivotal factor in farming development in the existing rural societies in Egypt, they also represent a crucial factor of agriculture in the newly reclaimed lands such as El-saff area in the eastern part of great Cairo. Women represent a large percentage of the residents on the newly reclaimed land. They are landholders, wives of landholders, emigrants from the Nile Valley, or laborers who do most of the farm work in the newly reclaimed land. Women on the reclaimed land have not received adequate attention. They receive very limited agricultural extension services.

Women on the New Lands such as El-Saff areas have many skills in dealing with different crops. Women represent a large percentage of the labor forces in the newly reclaimed lands. Women agricultural workers are usually residents of the new residential communities on the new lands.

Women have always played a critical role in Egyptian agriculture. They continue to be perceived in terms of their reproductive and domestic roles and their multiple roles as members of the household, family, and community are not fully appreciated or supported. In Egypt, studies have revealed that women perform 60% of the farm work. While women are the pivotal factor in farm development in the existing rural societies in Egypt, they also represent a crucial factor of agriculture in the newly reclaimed lands. Women represent a large percentage of the residents on the newly reclaimed land. They are landholders, wives of landholders, emigrants from the Nile Valley, or laborers who do most of the farm work in that region. Women contribution in agriculture include plowing, leveling, hoeing, irrigation, cultivation, fertilizing, animal, production and harvesting. Typical contribution percentage stated in the following Table varies from 20% for lowing up to 67% for animal, production and harvesting.

Table 6-368: Typical women participation in agricultural operations in new reclaimed area in Egypt[46]

Agricultural operations	Percentage of women participation
Plowing	20.5%
Leveling	18.1%
Hoeing	32.7%
Irrigation	25.8%
Cultivation	63.8%
Fertilizing	62.8%
Animal Production and Harvesting	67%

Sex Ratio (males per 100 females):105 (2016)

The project support water supply to sustain agriculture area served of 42,000 Feddan within Al-Saff Canl at full reclamation and operation. Around 5 feddan are allocated to each families. So, around 8,200 families will get benefits from the project with average 5 members per family (Sex Ratio (males per 100 females):105, World Data Atlas, Egypt 2016). So, around 16,400 females can get benefits of this project.

6.3.18 Land Acquisition

Unforeseen impact as there is no land acquisition required for the proposed project; the areas allocated for the WWTP original site as well as for the extension and upgrade have no other potential.

Moreover, no resettlement and land acquisition is required for and pipelines, the new proposed pump stations (2A and 3A).

[46] Korany Ismail. Abdel-Gawad, “The Role of Women in Egyptian Agriculture” , Research Gate, May 2017

6.3.19 Community Health and Safety

Sustain the wastewater treated effluent disposal method of reuse into Al-Saff Canal for irrigation will reduce significantly the health risk for the community downstream Al-Saff Canal (last reach) using the groundwater for domestic and irrigation use. Moreover, using the treated wastewater will reduce the overall energy required where for abstraction of disposal into any other system; open drains, storm water channels or aquifer recharge will almost need double the energy.

Agricultural irrigation is the most viable option and alone could utilize the entire volume of generated treated wastewater. Health implications associated with direct contact and the actual use of irrigation water would still exist. Risk assessment model for wastewater reuse scheme is presented in the following Figure. Strict monitoring would be required to minimize risk. However, the exposure group is limited compare to the exposure group using the groundwater for different uses.

Advantages

- This option will contribute in direct way to the project area water resources (Al-Saf Canal).
- Sustain the agriculture land in the Al Saff Canal project area and reduce the gap between supply and demand. So, sustain the socioeconomic activities in the project area.
- No pollution impact on the water resources of the project area.
- There are no potential health risks due to reuse of the treated effluent in irrigating restricted crops.
- Nutrients value that lead to reduction in fertilizer application and so reduction in cost of crop production.
- Fewer risks associated with violating safety precautions
- No compliance problems to environmental or other related laws.

It can be concluded that the reuse alternative has no significant impact on surface and groundwater and will improve the surface and groundwater quality and so, health risk will be reduce to the community using this water for irrigation in Al Saff Canal Command area. Moreover, the reuse of treated wastewater will reduce the pressure and demand from fresh surface water by sustain providing 800,000 m3/day treated wastewater (Egypt facing challenge to fill the gaps between supply and demand) and sustain the agriculture development in Al Saff canal (around 42,000 feddan). So, the reuse treated wastewater project will have a **positive impact** on current and future development plans and the community and considered the viable option, see Table 6-37.

Table 6-37: The impact on community Health and Safety during operation phase

Environmental Receptor		Community Health and Safety
BASIC IMPACT INDEX	Magnitude	2
	Spatial Extent	1
	Duration	1
Weighted Average		2
Receptor Categorization		Medium
Impact		Positive

6.3.20 Risk of Digester Operation

During operation, explosion dispersion risk may arise from digesters assessment study mentioned the risk zone may fall within 500m radius around digesters location. Figure 6-20 shows the proposed location of digesters in Helwan WWTP and its surrounding, which revealed there is no permanent residential fall within 500m radius. Southern and western digesters location are still within Helwan WWTP fence, however admin buildings are outside risk zone (i.e. 500m radius). About five brick factories Eastern and Northern digesters location will fall within risk zone, all safety and emergency measures should be taken to prevent risk against personnel working in brick factories.

A full Explosive Atmospheres (ATEX) study will be required during the design phase and include it in the ESMP both under construction and operation.

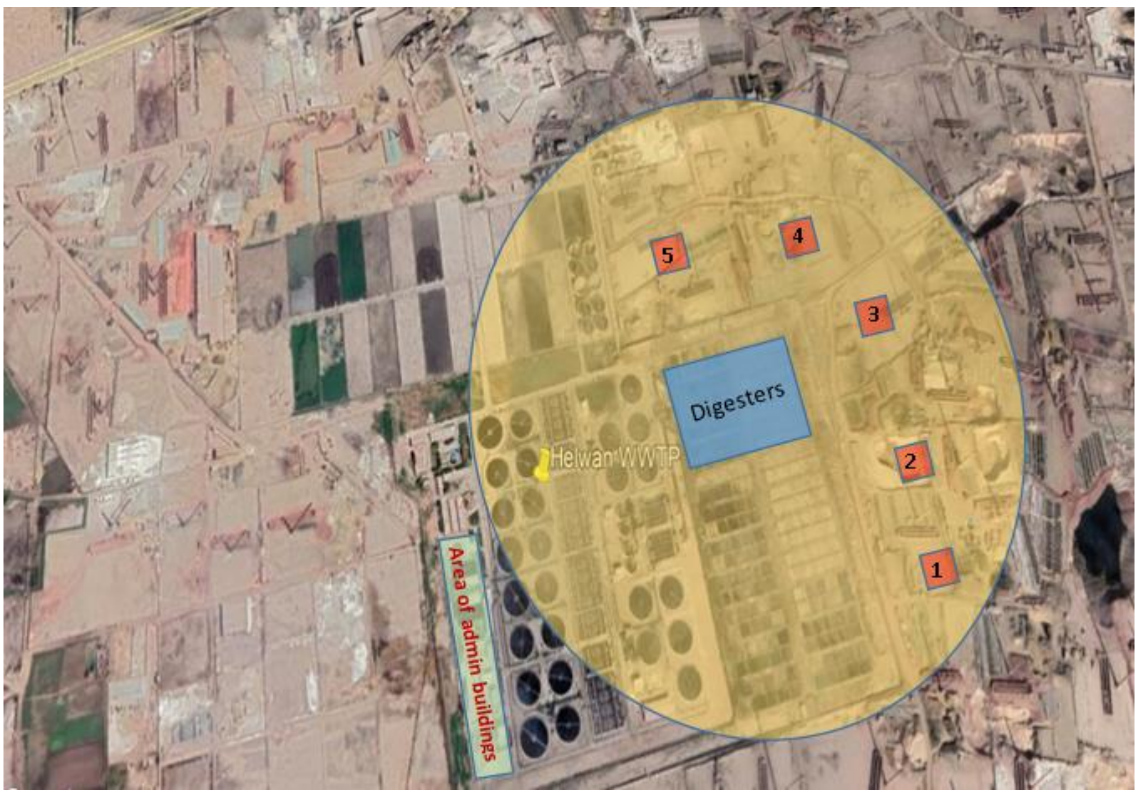


Figure 6-20: Digestors proposed location and its 500m radius surrounding

6.4 Summary of Impacts

In general, the environmental and social impacts from the WWTP upgrade are considered as positive. However, minor negative impacts shall occur during construction works which shall be local and temporary limited and can be easily mitigated through effective and low cost mitigation measures and good construction site management. The following Table 6., Table , Table 6.41 and Table Summaries the findings and outcomes of the environmental and social impact assessment.

Table 6.39: Summary of Impacts assessment during Construction Phase

Activities causing the impact	Overall Impact Significance										
	Dust and Air Emission	Noise	Land and Soil	Water Resources	Waste Generation and Disposal	Flora and Fauna	Visual Impacts	Health and Safety Impact Assessment	Traffic Impact	Community Health and Safety	Socioeconomic
Construction of Helwan WWTP extension	Minor	Minor	Minor	Minor	Moderate	**Insignificant**	Minor	Moderate	Minor	Minor	Positive
Construction of PSs including all sub components	Moderate	Moderate	Minor	Minor	Moderate	**Insignificant**	Minor	Moderate	Minor	Minor	Positive
Construction of FMs	Moderate	Moderate	Moderate	Minor	Moderate	**Insignificant**	Minor	Moderate	Major	Moderate	Positive

Table 6.40: Summary of Impacts assessment during Construction Phase (considering mitigation measures)

Activities causing the impact	Overall Impact Significance									
	Dust and Air Emission	Noise	Land and Soil	Water Resources	Waste Generation and Disposal	Flora and Fauna	Visual Impacts	Health and Safety Impact Assessment	Traffic Impact	Community Health and Safety	Socioeconomic
Construction of Helwan WWTP extension	**Insignificant**	**Insignificant**	**Insignificant**	**Insignificant**	Minor	**Insignificant**	**Insignificant**	Minor	**Insignificant**	**Insignificant**	Positive
Construction of PSs including all sub components	Minor	Minor	**Insignificant**	**Insignificant**	Minor	**Insignificant**	**Insignificant**	Minor	**Insignificant**	**Insignificant**	Positive
Construction of FMs	Minor	Minor	Minor	**Insignificant**	Minor	**Insignificant**	**Insignificant**	Minor	Moderate	Minor	Positive

Table 6.41: Summary of Impacts assessment during Operation Phase

Activities causing the impact	Overall Impact Significance									
	Air Emissions, Dust and Odour	Carbon footprint & Climate Change	Noise Impact	Land and Soil	Water Resources	Wastes	Visual impacts	Health and Safety Impact Assessment	Traffic Impact	Community Health and Safety	Socioeconomic
Operation of Helwan WWTP extension	Minor	Positive	Minor	Minor	Positive	Moderate	Minor	Major	Minor	Positive	Positive
Operation of PSs including all sub components	Minor	Insignificant	Moderate	Minor	Positive	Moderate	Minor	Moderate	Minor	Positive	Positive
Operation of FMs	Minor	N/A	Insignificant	Moderate	Minor	Insignificant	Moderate	Minor	Minor	N/A	Positive

Table 6.42: Summary of Impacts assessment during Operation Phase (considering mitigation measures)

Activities causing the impact	Overall Impact Significance										
	Air Emissions, Dust and Odour	Carbon footprint & Climate Change	Noise Impact	Land and Soil	Water Resources	Wastes	Visual impacts	Health and Safety Impact Assessment	Traffic Impact	Community Health and Safety	Socioeconomic
Operation of Helwan WWTP extension	Minor	Positive	Minor	Insignificant	Positive	Minor	Minor	Moderate	Insignificant	Positive	Positive
Operation of PSs including all sub components	Minor	Insignificant	Minor	Insignificant	Positive	Minor	Minor	Minor	Insignificant	Positive	Positive
Operation of FMs	Insignificant	N/A	Insignificant	Insignificant	Insignificant	Insignificant	Minor	Minor	Insignificant	N/A	Positive

CHAPTER 7

ANALYSIS OF PROJECT ALTERNATIVES

7 Analysis of Project Alternatives

This chapter analyses different alternatives that were considered during the design and conception of this project; in order to evaluate those alternatives from an environmental perspective. Such analyses will lead to decision/confirmation of which alternatives are the optimum for the project which are environmental and financial perspectives.

The proposed project is expected to result in significant environmental improvement in the project areas. Even though there are some impacts associated with project construction and operation as previously indicated, the overall environmental impacts are expected to be significant positive. The project will directly contribute to achieving the objectives significant improvement to sanitation facilities and water resources management in the project area (Al-Saff Canal). The project institutional structure will have a Monitoring and Evaluation unit (M&E) to verify the expected improvements of surface water quality.

7.1 Analysis of Project Alternatives

The No-Action Alternative is not to proceed in the proposed project. Comparisons with the proposed project are discussed in the following section and the implications of No-project alterative:

- Absence of proper and comprehensive sewerage system of project area south of Cairo and continue overflow from manholes of some zones within the served area.
- Absence of proper and treatment facilities for wastewater generated from south of Cairo area.
- Increase the greenhouse gases emissions from the wastewater and sludge treatment increase the impact on climate change
- Continuing non-efficiently treating and utilizing the sludge and so losing electricity that could cover up to half of the electricity consumption of the WWTP.
- Continuing non-utilize stabilized treated sludge in agricultural and farming purposes.
- Continuing the partially untreated wastewater disposal into Al-Saff Canal,
- Increase of pollution levels in Al-Saff canal and deteriorating the water quality in Al-Saff Canal,
- Present poor water quality to the farmers in the first reach of the Al-Saff canal agriculture area served,
- The current partially untreated wastewater disposal percolate to groundwater and dispose into surface water (Al-Saf Canal) which could cause pollution to groundwater and surface water. This situation would lead to significant impact water resources (ground and surface water quality) and so health risk farmers, crop consumers.

The situation of the existing sanitation scheme makes the improvement of the sanitation facilities a necessity for achieving better hygienic for residents and environmental conditions of the present use including houses, buildings condition and agriculture land in the project area.

7.2 Project scheme alternatives

There are two main alternatives for the general scheme of this project as followings:

- Alternative (1) scheme is mainly to construct a new expansion to the existing Arab Abo Sa'ed WWTP.
- While alternative (2) scheme is to construct the required expansion in a new site at the Al Kurimat- Al Zafarana Desert Road.

The following section views both alternatives and weighs them against each other to be able to conclude the optimum alternative.

7.2.1 Alternative (1)

This alternative is aimed to relief the overloading discharges transported through the existing network of collectors, pump stations all way the way to the existing Arab Abo Sa'ed WWTP. This relief will take place by diverting the wastewater flows from some Areas as follows:

- Areas East and West of Autostorad main road which include (Al Maadi Al Gedida, 70 Feddan (Al Hadabah Al Wosta), Sobhi Hessien, Maadi Al Sarayat Al Sharqia, and Zahraa Al Maadi) will be diverted to Ahmed Zaki collector in Cairo project with force-main of diameter 1200 mm by CAPW. This modification will lead to decrease discharges on the collector of contract No. (4) and decrease discharges on the existing screw pump station No.4 (Maasarah) which suffers from a persistent overflow.
- Constructing a new pumping station No. (3A) in Helwan City to divert the wastewater flows from reaching pumping station No. (3), through a flow diversion from the existing gravity collector in Omar Ebn Abdel Aziz street to P.S. No. (3A) by constructing new collector, and new force-mains to divert discharges from P.S. No. (3A) to a new pumping station No. (2A) in the same location of the currently under-rehabilitation WWTP in 15th May.
- The wastewater flows of the new pumping station No. (2A) will be delivered directly to Arab Abo Sa'ed WWTP instead of discharging to the pumping station No. (3) at Helwan. This delivery will be through a new force main to discharge directly to Arab Abo Sa'ed WWTP.

These works will allow Greater Cairo Wastewater Company (GCWC) to implement the required sewer network cleaning to restore the collector original design capacity to sustain the future flows.

7.2.2 Alternative (2)

The alternative includes the construction of the needed added capacity in a new site at the Al Kurimat- Al Zafarana Desert Road. Like alternative (1), this alternative aims to relief the overloading discharges on the existing collectors, pump stations, and WWTP by diverting some Areas, but with an alternative location of the treatment plant at the Al Kurimat – Al Zafrana Desert Road, and the works will be as follows:

- Areas East and West of AUTOSTORAD main road which include (Al Maadi Al Gedida, 70 Feddan (Al Hadabah Al Wosta), Sobhi Hessien, Maadi Al Sarayat Al Sharqia, and Zahraa Al Maadi) will be diverted to Ahmed Zaki collector in Cairo project with force main of diameter 1200 mm by CAPW. This modification will lead to decrease discharges on the collector of contract No. (4) and decrease discharges on the existing screw pump station No. (4) (Maasarah) which suffers from a persistent overflow.

- Constructing a new pumping station No. (3A) in Helwan City to divert the wastewater flows from reaching pumping station No. (3), through a flow diversion from the existing gravity collector in Omar Ebn Abdel Aziz street to P.S. No. (3A) by constructing new collector, and new force-mains to divert discharges from P.S. No. (3A) to a new pumping station No. (2A) in the same location of the currently under-rehabilitation WWTP in 15th May.
- The wastewater flows of the new pumping station No. (2A) will be delivered via a new force mains which will discharge in a new booster (1A) at the Al Kurimat Desert Road, and then at Al-Kurimat new WWTP. This modification will lead to decrease discharges on the collector of diameter 3000 mm (circular) from screw P.S. No. (3) to screw P.S. No. (2), and decrease discharges on the existing screw pump station No. (2) (Al Tebbin).
- This diversion works will lead to decrease the wastewater flows and discharges in the collector of diameter 3000 mm (circular) from the screw pumping station No. (3) to the screw pumping station No. (2), and decrease discharges on the existing screw pumping station No. (2) at Al Tebbin.
- These works will allow Cairo Wastewater Company to implement the required sewer cleaning to restore the collector original design capacity to sustain the future flows.

7.2.3 Alternatives assessment and conclusion

The following Figure 7-1 shows the current state and the planned scheme of alternative (1) and (2) as indicated:

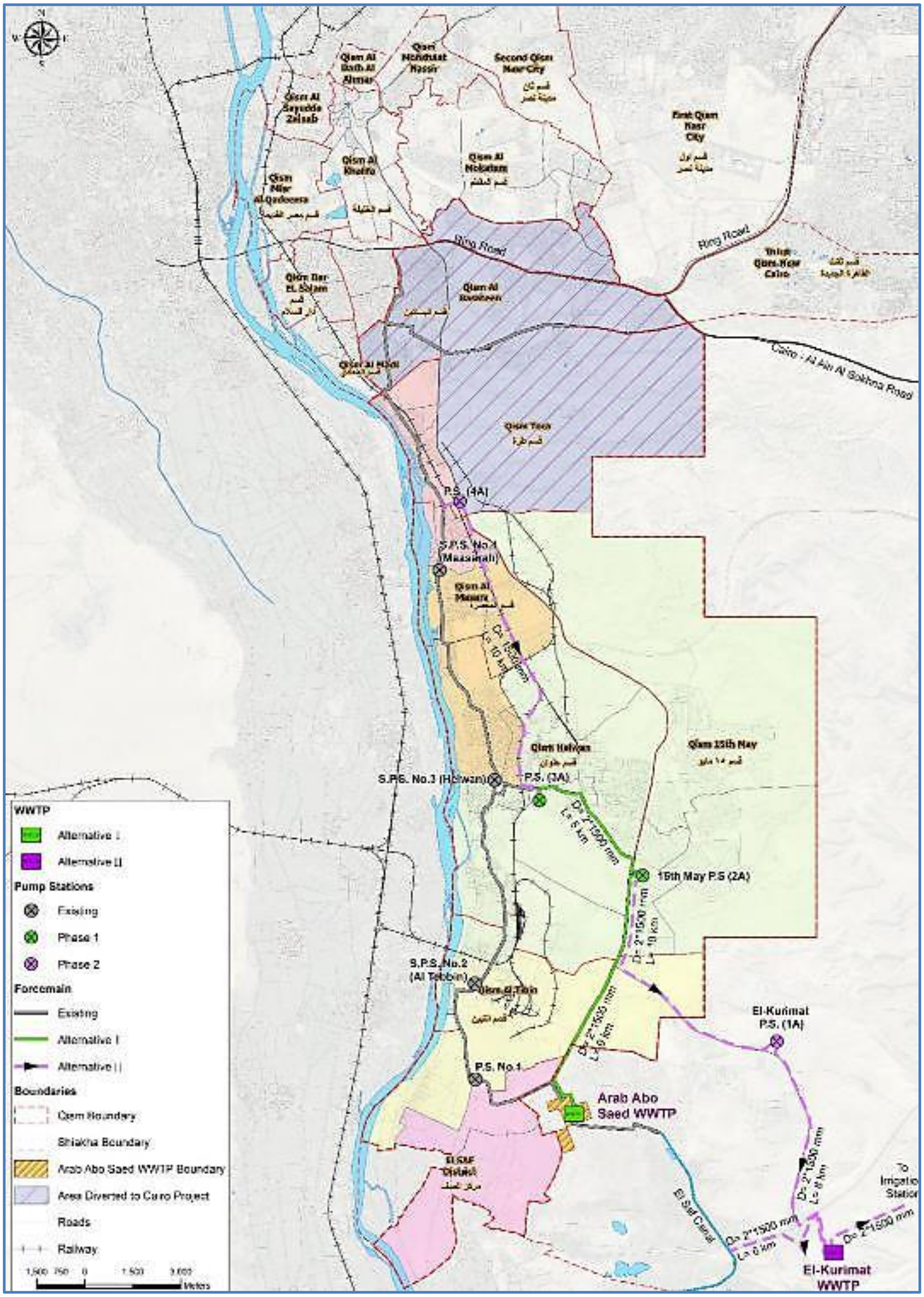


Figure 7-1: Illustration of alternatives 1 and 2

Previous studies by Atkins 2020 concluded that scheme alternative (1) offers much enhancements and allows for maximum efficient use of existing resources with lower investment needs than alternative (2), and with well-established plan which serves many environmental and economic aspects such as effluent water quality of unrestricted irrigation into Al Saff canal which is in a dire need for these resources. Hence, it is an optimum short/medium term solution for the WWT issue in the area. On another perspective, alternative (1) does not nullify alternative (2), it can be considered an efficient stepping stone on the short/medium term, while the area of the new Al-Kurimat WWTP can be more clear in the future (long term) with the population expansion and hence clearer decision making can be done.

7.3 Wastewater Treatment Technologies

7.3.1 Potential Wastewater Treatment Systems

There are many different types of sewage treatment systems based on the previous main treatment concepts. The followings sewage treatment systems are the most common and widely used treatment systems in the region. Some of these systems are advanced and others are traditional. The following section will describe shortly the advantage and disadvantage of each treatment system.

Activated Sludge Systems

Advantages of Activated Sludge Process

- Easy for operation and maintenance
- Low electro-mechanical installations cost (compared to some of other technologies)
- Good quality effluent which can meet the standards in many developing countries.
- Well established system with reasonable experience in system operation and maintenance in the Middle East region.

Disadvantages of Activated Sludge Process

- Relatively large land is required.
- Require large amount of civil and construction works.
- Sludge treatment and disposal are required on large scale.
- This process is sensitive to certain industrial wastes
- The quality of produced effluent is affected by the characteristics of influent sewage.
- Effluent product contains a large number of bacteria, pathogens and viruses, which requires the addition of a high amount of disinfectant (chlorine) to remove these microorganisms to accepted limits.

Membrane Bio Reactor (MBR)

The advantages of Membrane Bioreactor (MBR) technology:

- The effluent is of very high quality, very low in BOD (less than 5 mg/l), very low in turbidity and suspended solids.

- The "simple filtering action" of the membranes creates a physical disinfection barrier, which significantly reduces the disinfection requirements.
- The produced effluent is free from pathogens and some virus.
- Easy of operation, it depends on only a few number of skilled operators,
- The treatment process also allows for a smaller "footprint".
- Can be designed with long sludge age, hence low sludge production. Sludge yield of 35-45% less than conventional activated sludge.

The disadvantages of Membrane Bioreactor (MBR) technology:

- The membrane modules will need to be replaced partially or all between (5) and (10) years according to the operation conditions. Where, the membranes become "dry out" due to the flexible polymers leaching out, the closing/plugging of the pores, and the membranes becoming somewhat hard or brittle.
- Although membrane modules price have decreased over the past several years, these modules can still be classified as expensive.
- Relatively high investment cost is required,
- Difficult operation and maintenance. Usually it needs skilled operators,
- The operation and maintenance cost are significantly high,
- Membrane fouling problems require frequent cleaning procedures by chemicals, with intermittent operation of the system,
- There may be cleaning solutions that require special handling, treatment, and disposal activities depending on the manufacturer. These cleaning solutions may be classified as hazardous waste depending on local and state regulations,
- Experience with the system operation is very low in the region.

Sequencing Batch Reactor (SBR)

Advantages of SBR Treatment Process:

- All treatment steps are contained in one tank,
- A great deal of flexibility in operating conditions allows for optimizing different treatment objectives. This flexibility has allowed successful treatment of a wide range of sewage types, from very strong to very dilute. In particular, aeration during the REACT stage can be cycled on and off to provide a suitable environment for complete ammonia conversion to harmless N_2 gas. Operation can also be manipulated to achieve biological phosphorus removal.

Disadvantages of SBR Treatment Process:

- Expense of providing aeration,
- More than one treatment unit is required to accommodate cleaning schedules,
- Requirement for monitoring and operating expertise to manage the reactor in such a way that will achieve desired treatment results.

Earthen Basin Treatment Systems (aerated lagoons)

Advantages:

- Longer lifetime than concrete basins, especially if they are exposed to corrosive ground water or septic sewage, that can be seriously damaged after just a few years. HDPE linings have been proven to be extremely resilient and have sustained durability for more than 30 years (for example in garbage landfills, lagoons and ponds)
- Significantly lower capital investment costs
- Increased security as the flexible earthen basin construction with HDPE lining is less vulnerable than concrete structures to the settling and compaction of underlying soil, or cracking damage from earthquakes
- Significantly reduced construction time, typically only 30% of concrete basin construction
- Superior structural characteristics than large concrete basins.
- Modular - process volume can easily be enlarged at a later date.

Disadvantage

- Occupy very large area
- Can produce bad odour in the area
- Can produce fly nuisance

7.3.2 Treatment systems assessment and proposing appropriate system

The following Table 7-1 and Table 7-2 will describe comparison between these different treatment types regarding operating and maintenance requirements, biological performance and effluent quality, economic aspects as well as the environmental impacts. This will facilitate of selecting the most compatible and appropriate treatment systems with respect to the project conditions and effluent reused requirements.

Table 7-1: comparison between different treatment systems[47]

	Activated Sludge	MBR	SBR	Earthen basin systems
Performance				
The ability to achieve the required quality (Effluent water quality)	G	Ex	G	G
Workability and performance history	G	G	G	G
The ability to accommodate with changes in hydraulic and organic loads	Ex	Ex	G	Ex
Amount of sludge production and the required treatment processes	G	Ex	G	G
Quality of Effluent				

[47] L: Low; M: Moderate; H: High; G: Good, EX: Excellent

Notes: most of the previous data are based on consultant previous experience in similar projects in the Region

	Activated Sludge	MBR	SBR	Earthen basin systems
Total suspended solids (mg/Lit)	10-30	< 1	10-30	10-30
Turbidity (NTU)	2-2.5	< 0.5	2-2.5	2-2.5
BOD_5 (mg/Lit)	10-20	< 2	10-20	10-20
Total number of E. Coli **before** chlorine disinfection (No./100mL)	20,000	0	20,000	20,000
Total number of Coli forms **before** chlorine disinfection (No./100mL)	30,000	0	30,000	30,000
Total number of E. Coli **Afte**r chlorine disinfection (No./100mL)	< 100	0	< 100	< 100
Total number of Coli forms **before** chlorine disinfection (No./100mL)	< 100	0	< 100	< 100
Ammonia (mg/Lit)	0.5	< 0.3	0.5	0.5
Phosphorus (mg/Lit)	0.5	< 0.3	0.5	0.5
Design Criteria			Oct-20	
MLSS	2000-3000	10,000	2000-5000	2000-3000
Hydraulic retention time (Hr)	18-36	6-8	12-15	18-36
Max. allowable change in Hydraulic load without change in water quality	110 %	200%	100 %	110 %
Operation and Maintenance				
Skilled operator requirement	M	H	H	M
Power Consumption (KW/m^3)	2.4	1.7	3	2.4
Chemical consumption (g/m^3)				
Chlorine	10	8	10	10
Soda	0	0.1	0	0
Citric acid	0	0.1	0	0
Spare parts consumption	M	H	M	L
Experience with the system in the region	H	L	M	L
Land Use				
required footprint (m^2/m^3)	M	L	L	H
Costs				
Capital costs of Electromechanical works	M	H	M	L
Capital costs of Civil works	H	M	H	M

Table 7-2: Suggested ranking for each of the treatment systems:

	Activated Sludge	MBR	SBR	Earthen basin systems
Performance				
The ability to achieve the required quality (Effluent water quality)	10	10	10	10
Workability and performance history	7	8	7	7
The ability to accommodate with changes in hydraulic and organic loads	9	10	7	9
Amount of sludge production and the required treatment processes	7	8	6	7
Environmental Impacts				
Effects of resulting emissions	8	8	8	4
Effects of pathogens and toxics substances in the produced water (with disinfectant)	9	10	9	9
Experience of Operation Staff				
requirement of skilled operators	9	7	7	10
Land Requirement				
required footprint	7	9	8	4
Cost				
Capital costs of Electromechanical works	8	7	9	6
Capital costs of Civil works	7	9	8	9
Annual operation and maintenance cost	9	6	7	10
Previous Experience in Operating				
Availability of required experience	9	3	3	5
Total Evaluation (120)	**99**	**95**	**89**	**90**
Percentage (%)	**82.5%**	**79%**	**74%**	**75%**

From above comparison, the activated sludge process is the most relevant system to Arab Abu Sa'ed WWTP as the suitability of using this process in such region is over 82%, whereas, the suitability of other systems are in the range of 74% to 79%. Therefore, activated sludge process in general and extended aeration in particular is selected to be used in this project. Also the existing wastewater treatment technology in Arab Abu Sa'ed WWTP is conventional activated sludge CAS method with surface aerators. While the technology of the added capacity will be also conventional activated sludge but with diffused aeration. These two choices are very viable for the following reasons:

- The effluent treated water discharges into Al Saff canal which is then used for agricultural purposes; hence no need for excessive treatment of nutrients. Therefore, other nutrients removal intensive technologies such as Denitrification-Nitrification are neither an energy nor operational optimum.

- The technology of the extension of the WWTP is almost identical to the already existing functional technology with one difference in upgrading the aeration system to a more efficient one. Varying the technology in the same plant is uncalled for, especially that the current technology is working well. Unifying the technology used over all the plant will reflect many benefits in operation, training and capacity building, spare parts, trouble shooting, etc.; hence such choice of technology is optimum.
- Conventional activated sludge system is a very flexible system that can be easily connected to different pre or later treatment systems. For the existing CAS system, the effluent of it can be easily connected to mechanical drying sludge system instead of the gravity thickeners. A very big advantage which will help to update the sludge treatment system in the entire plant (existing and extension).
- CAS technology allowed for easy addition of tertiary treatment of the wastewater.

It can be concluded that despite the fact that there are various treatment technologies with higher nutrients removal or less space needed or other general favorable advance; the choice of CAS is optimum in this project as there is no need for extra investment for extensive nutrients removal on the contrary, extensive nutrients removal will be not favorable in this case. CAS is also optimum operational wise.

7.4 Disinfection Alternatives

The current and proposed extension of Helwan project design includes disinfection of the final effluent through chlorination. The M&E unit of the plant is evaluating the effectiveness of such disinfection procedures by monitoring coliform bacteria and residual chlorine for the treated effluent. The chlorination of the final effluent would produce carcinogenic THMs and TAA5s.

Other available means of disinfection include:

- Using ozone disinfection, which in addition to being associated with high operating costs beyond the affordability of the local communities, the process produces bromate which has similar adverse health effects as THMs and TAA5s
- Ultra Violate (UV) disinfection, which should be associated with fine filtration processes in order to effectively kill bacteria. However, such system is believed to be much more expensive than the chlorination system.

The advantages of using chlorination are:

- Elimination or reduction of pathogens in the final effluent, which in turn will reduce the numbers of pathogens in receiving water body (Al-Saf Canal). This will have direct environmental and health benefits in protecting people from possible infections during their contact with the Canal’s water. A high percentage of villagers are expected to benefit from this especially women and children who might use watercourses for cleaning and bathing.
- Reduction of the organic load of the final effluent, as the application of chlorine provides chemical oxidation to the effluent and reduces oxygen demand

- On the other hand the main disadvantage is the production of THMs and TAA5s which can potentially have indirect effects on drinking water supplies and on freshwater marine life which is not our case.
- The UV disinfection will be the best alternative in case proven to be feasible. Otherwise, it is believed that the advantages of chlorination outweigh the disadvantages due to its direct benefits for many people using the Al-Saf Canal. Furthermore, de-chlorinating the wastewater after sufficient chlorine contact time will significantly reduce the risks of chlorine by-products. The application of sulphur dioxide or sodium thiosulphate as de-chlorination agents will slightly reduce dissolved oxygen and raise the oxygen demand (in terms of BOD and COD) and therefore the plant designer should consider more effective biological treatment to balance this effect.

7.5 Sludge treatment alternatives

7.5.1 Potential Sludge Treatment Systems

Sludge drying beds

Advantages of sludge drying beds:

- Drying beds are the simplest treatment method.
- No artificial energy requirements, only evaporation and gravity drainage.
- Low maintenance needs.
- Medium – high investment cost (price of land + concrete work).

Disadvantages of sludge drying beds:

- Needs very large surface area.
- Needs extensive time spans especially in winter.
- The quality of the treated sludge is not within the best range of other treatment technologies.

Sludge anaerobic digester

Advantages of sludge anaerobic digester:

- High energy recovery.
- Better sludge stability and quality.
- Needs less surface area than drying beds.
- Needs less time to treat than drying beds.

Disadvantages of sludge anaerobic digester:

- Complex operation.
- Risk factor of explosion especially in high temperature countries.
- Relatively high investment cost.

Sludge incineration

Advantages of sludge incineration:

- Various levels of energy recovery.
- The sludge is used and reduced into much smaller volumes.

Disadvantages of sludge incineration:

- Pollution to the environment.
- High operation cost for filters.
- High – medium operation complexity.

7.5.2 Sludge Treatment Systems Assessment

The current sludge treatment technology used in Arab Abu Sa'ed WWTP is gravity thickeners followed by drying beds and finally to stacking area where the treated sludge stored there until it is sold. On the other hand, with the new extension that will be added, the project will also update the sludge treatment system by replacing all the gravity thickeners and using mechanical dewatering instead. Also, the proposed plan of the project is to replace one third of the drying beds and anaerobically digest the equivalent sludge instead using a digester of 250,000 m^3/day capacity.

The demolition of a part of the drying beds saves much space for the more advanced mechanical drying for the whole plant. Anaerobic digestion gives higher quality treated sludge and recovers energy which decreases the operational costs. Also this technology is already running successfully in Egypt in the Mega WWTP Gabal Al Asfar. Hence, these technologies are excellent choice.

On the other hand, the fact that only one third of the sludge will be anaerobically digested does not make this technology very viable in this case. Hence, another suggestion is made in the cost estimate report to extend the digestion to all the sludge of the plant, then, much more energy can be recovered and it can provide large percent of the whole plant's energy and cut down operational costs vastly.

7.6 Treated Effluent Disposal and Reuse

7.6.1 Groundwater Recharge

Chlorine dosing to disinfect treated wastewater is carried out to eradicate bacteria and viruses. However, heavy doses of chlorine to domestic wastewater that may contain concentrations of organic matter can result in the formation of trihalomethanes (THMs), which in concentration can be carcinogenic. THMs can accumulate in aquifers, and this problem can be exacerbated by repeated injection, storage and recovery cycles, and thereby affects the groundwater quality. It is therefore necessary to remove all residual chlorine prior to the injection of treated wastewater.

The potable water supply to the project area is distributed via a piped network. The majority of residences in the agricultural strip are sometimes supplied from shallow wells, the water being used for a variety of purposes including animal feeding, and washing. Within the agricultural strip pollutant exposure pathways are associated mainly with oral consumption or other physical contact. The health of consumers could be compromised by using water abstracted from abstraction wells close to injection wells. The risk assessment model for aquifer recharge is presented in the following Figure7-.

Advantages:

- Fewer risks associated with violating safety precautions.

Disadvantages:

- This option could not contribute in direct way to the project area water resources.
- There is a potential health risks due to groundwater in case using groundwater in agriculture and domestic use.
- There is a need for construction cost (need for pumping, deep wells and pipelines)
- There is a need for practice and management to avoid any health risk for groundwater users
- This option consumes a lot of energy.

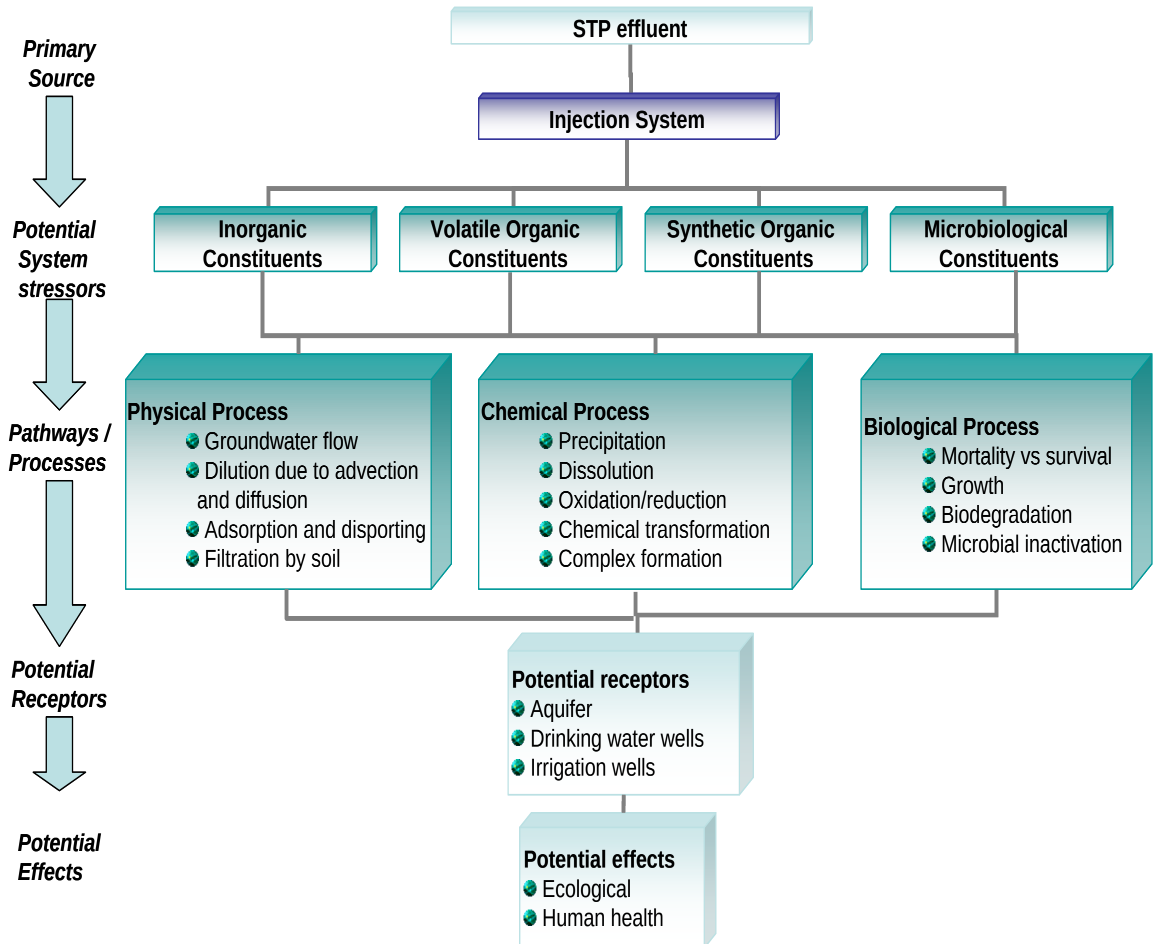


Figure7-2: Risk assessment model for aquifer in project area

7.6.2 Discharge into Agriculture Drain and/or storm channels

One of the effluent disposal alternatives is discharging the final effluent of Arab Abu Sa'ed Wastewater Treatment Plant into agriculture drain and/or storm channels. The expected treated effluent quality of Arab Abu Sa'ed WWTP is assessed.

It is expected that the treated effluent will contain low pollution levels that would allow for safe effluent discharge into surface water bodies compared with Egyptian standards. The current design thus considers that main parameters as BOD, COD, Suspended solids, Total Nitrogen and Total Phosphorus values to be all within the allowable limit. Therefore, according to current considerations in the new extension design, the treated effluent from the wastewater treatment plant would be ready for either discharge into nearest open agriculture drain and/or storm channels.

Advantages:

- Lower cost of construction (no need long irrigation pipelines or open channel)

- Greater ease of operation, with no need for human input except for the undertaking of simple repairs
- Fewer risks associated with violating safety precautions
- No compliance problems to environmental or other related laws.
- There are little or no potential health risks

Disadvantages:

- Need for hydraulic remodeling for the receiving water bodies to accommodate the treated effluents
- The treated effluents contain nutrients that can lead to aquatic weed growth in the receiving water body. This situation will impact the hydraulic performance of the drain and increase the maintenance cost to the drain.
- No direct benefits of treated wastewater as a resource of nonconventional water resources and gaps between supply and demands in Al-Saff canal area served will be increased.

7.6.3 Reuse of treated effluents

Sustain the wastewater treated effluent disposal method of reuse into Al-Saff Canal for irrigation will reduce significantly the health risk for the community downstream Al-Saff Canal (last reach) using the groundwater for domestic and irrigation use. Moreover, using the treated wastewater will reduce the overall energy required where for abstraction of disposal into any other system; open drains, storm water channels or aquifer recharge will almost need double the energy.

Further, it should be stressed that a considerable volume of fresh surface water from the Rover Nile is main source in the project area for irrigation purposes. Use of adequately treated wastewater effluent for this purpose would also reduce demands placed on the surface water.

Agricultural irrigation is the most viable option and alone could utilize the entire volume of generated treated wastewater. Health implications associated with direct contact and the actual use of irrigation water would still exist. Risk assessment model for wastewater reuse scheme is presented in the following Figure 7-. Strict monitoring would be required to minimize risk. However, the exposure group is limited compare to the exposure group using the groundwater for different uses.

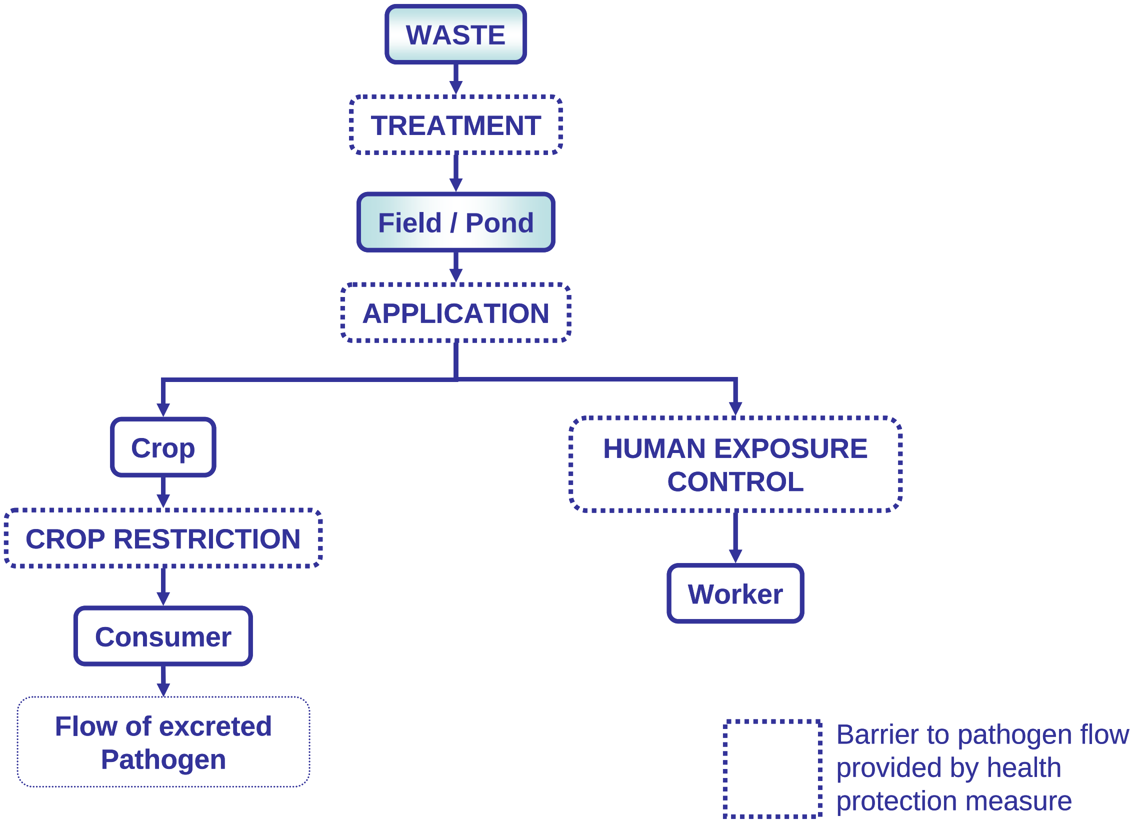


Figure 7-3: Risk assessment model for treated effluent of Arab Abu Sa'ed WWTP project

Advantages

- This option will contribute in direct way to the project area water resources (Al-Saff Canal).
- Sustain the agriculture land in the Al Saff Canal project area and reduce the gap between supply and demand. So, sustain the socioeconomic activities in the project area.
- No pollution impact on the water resources of the project area.
- There are no potential health risks due to reuse of the treated effluent in irrigating restricted crops.
- Nutrients value that lead to reduction in fertilizer application and so reduction in cost of crop production.
- Fewer risks associated with violating safety precautions
- No compliance problems to environmental or other related laws.

Disadvantages

- There is a need for construction cost (need for limited remodeling Al-Saff Canal.
- There is a need for practice and management to avoid any health risk for farmers.

7.6.4 Preferred Option

It can be concluded that the reuse alternative has no significant impact on surface and groundwater and will improve the surface and groundwater quality and so, health risk will be reduce to the community using this water for irrigation in Al Saff Canal Command area. Moreover, the reuse of treated wastewater will reduce the pressure and demand from fresh surface water by sustain providing 800,000 m3/day treated wastewater (Egypt facing challenge to fill the gaps between supply and demand) and sustain the agriculture development in Al Saff canal (around 42,000 feddan). So, the reuse treated wastewater project will have a positive impact on current and future development plans and the community and considered the viable option.

7.7 Sludge Use Practices and Prospects

The sludge generated from Helwan WWTPs is being utilized in conditioning agricultural lands, after treatment process as previously discussed in Chapter 6. Sending to cement and Brick factories as Refuse Derived Fuel (RDF) is a second option, and the third option is to dispose of it in landfills. Various environmental risks associated with these options will be discussed in coming section.

The utilization of sludge as RDF and use on agricultural land, are the preferred option providing there are safe concentration levels of heavy metals, safe biological properties, and safe land application rates followed according to the specifications of Law 93/1962 and the guidelines of USEPA. The reason for this preference over landfill disposal is that volume of waste received in disposal sites will be reduced and an equivalent quantity of fuel/chemical fertilizers, associated with an environmental cost for their production, will be saved.

On the other hand, the sustainability of using sludge as a land conditioner will not be favorite option if the costs for sludge quality monitoring are not covered by revenues from sale of the sludge. In other words if revenue from the sale of sludge does not cover the extra WWTP operating costs resulting from stabilization processes and monitoring activities recommended in the ESMP, it will be better to go for other options.

Although land disposal of sludge will be practiced by a waste contractor as mentioned in the ESMP, the process could be easily monitored to check its compliance with the waste disposal contract. However, the landfill disposal of sludge has the following risks/negative environmental impacts:

- Loss of resources
- Waste directives in many parts of the world prohibit the disposal of organic wastes (or place an upper limit of around 5% of total organic carbon in the waste for it to be accepted for disposal). The potential of applying similar laws in Egypt during the life cycle of the project exit and this puts a risk on the sustainability of the landfill disposal option.
- Although the waste contractor could be monitored, random/illegal dumping of the sludge on agricultural lands or water streams still remains possible.

However, the conclusion which could be made is that under the current conditions, the following options are listed in order of preference:

- Stabilization and soil fertilizer
- Refuse Derived Fuel for cement and brick factories as (RDF)
- Controlled landfill disposal.
- Co-composting with solid waste

The current practice with produced and treated sludge by Helwan WWTP is to sell for a contractor who is responsible to further sludge treatment if needed.

Sludge price under 1st administration was 65 LE/ton which is relatively lower than other WWTPs (up to 200 LE per ton) due to the high sludge sand content. But now, sand ration is normal and the administration is planning on setting more equivalent price per ton with the coming tender and contract.

So, with improving the treated sludge quality with the proposed scheme makes the alternative of selling the treated sludge to be used agricultural land as a source for fertilizer and land conditioner is the recommended alternative. Moreover, with more equivalent price per ton in the coming tender, could contribute in cost recovery for WWTP operation and maintenance.

CHAPTER 8

Environmental and Social Management Plan

8 Environmental and Social Management Plan

The Environmental and Social Management Plan (ESMP) presented in this chapter reflects the implementation procedures and mechanisms as well as the roles and responsibilities for the implementation of the mitigation measures and monitoring activities for the expected impacts as outlined in section 6.

The Environmental and Social Management Plan (ESMP) identifies mitigation measures to reduce / remedy / eliminate any potential adverse / negative environmental and socio-economic impacts that might occur during the construction (here rehabilitation and upgrading) and subsequent operation of Helwan WWTP upgrade and extension. Furthermore, where possible; positive impacts may also be maximized by other actions. The Environmental and Social Management Plan (ESMP) identifies measures to address any potential adverse environmental and socio-economic impacts that might occur during the construction of the Helwan WWTP extension and the subsequent operation phase.

Responding to the environmental and socio-economic impacts detailed mitigation measures have to be identified and evaluated in order to avoid, reduce or remedy the impacts from the WWTP implementation during the construction and operation phases.

Implementation of the ESMP should be adapted to the local community in order to maximize the positive impacts and minimize negative impacts, especially among the most vulnerable groups such as nearby village population and women. These groups should be consulted during the construction to ensure their views are taken into account and appropriate actions are taken to mitigate the negative impacts. Consultation with the local community and the relevant stakeholders are among the requirements for the success of the ESMP which is also a role that should be enhanced.

Environmental and Social Management and Monitoring matrices have been prepared for the actions to be taken during the full Project cycle.

8.1 Environmental and Social Mitigation during WWTP Construction

The mainly short-term negative environmental impacts, which inevitably occur during the demolition and construction works will be minimized by proper planning and application of preventive measures, and will be mitigated by restorative actions after the works are completed as listed in table (8.1).

In practice, proper planning means that environmental and social requirements become an integrative part of the construction contractor's obligations and have to be approved by the supervision engineer and competent authority/ies prior to any construction works. In the following reference is made to mitigation measures in accordance with the Egyptian legislative provisions:-

Air Quality

- Wetting the construction area in case of high dust generation.
- Construction equipment and machinery as well as material transporting vehicles will be required to meet Egyptian emission standards. Regular emission checks and maintenance of vehicles and equipment will be required.
- Provide workers with safety tools (e.g. masks) while working in very dusty conditions in the site.

Noise

- Where possible provide construction equipment (e.g. generators etc…) with silencer.
- Provide workers with safety tools (e.g. ear muffs) while working in very high noise levels within the site.

Flora, Fauna, and Natural Habitat

The impacts of the WWTP on the flora, fauna and natural habitat during the construction phase will be insignificant due to the absence of any identified ecological values. No mitigation is considered necessary.

Soil and Land

- Temporary storage of sanitary and cleaning wastes in containers. Disposal of such wastes will occur at sites approved by the management Unit of the Protectorate or the appropriate local authorities.
- Tanks for fuel storage shall be leak-proof and installed on impermeable surfaces. Fuel storage tanks shall be checked daily and in case of leakage will be replaced or repaired. Fuel storage facilities should be protected from damage such as from reversing trucks.
- A procedure for storage and handling of non-hazardous wastes and raw materials shall be provided in the contractors' waste management plan.
- No disposal of any kind of waste on the soil surface. No storage of any kind of waste directly on soil surface (waste containers must be used).

Surface Water and Groundwater

- Construction activities must be within a safe distance from open water surface. A fence and signs must be placed within the construction site to keep the construction activities at a distant from the surface water bodies.
- Prohibition of disposal of any kind of waste to open water bodies. Waste management within the site is required to store waste into containers and not to dispose them into surface water bodies and not to dispose them onto soil surface to prevent groundwater contamination.

Material Assets and Infrastructures Facilities

The following mitigation is proposed to reduce the impact on material assets and infrastructures facilities within the site and in its surroundings during the construction phase:

- Any damage to the local roads, any spill of material on the roads from the moving of the material transport trucks or construction equipment shall be remedied on the contractor's expenses.
- The construction activities should be contained within the existed Helwan WWTP premises and not to extend to the surrounding areas.

- All infrastructures facilities within Helwan WWTP shall be rehabilitated properly.
- No excavation outside the existing WWTP premises.
- Contractor has to submit the construction management plan showing all his activities, equipment list, etc. for review and approval before construction activities commencing.

Traffic

The following mitigation is proposed to reduce the impact on traffic and roads in the surrounding areas of the WWTP within the site and in its surroundings during the construction phase:

- Coordination with the local traffic department when moving heavy construction equipment to the construction site or from the site.
- Construction activities should be scheduled carefully by contractors in order to minimize the impacts, resulting in successful mitigation.

Occupational Health and Safety

The contractor shall prepare and implement specific health and safety measures include but are not restricted to:

- Use of personal protection equipment by employees, workers, engineers and all personals within the construction site.
- Adequate health and safety training of all employees, including training on specific procedures as appropriate to various individual staff groups.
- Provision of rescue equipment and designated medical first-aid facilities.
- Firefighting equipment should be provided into the construction site and should be checked and inspected regularly.
- Medical emergency evacuation plans for different types of incidents and injuries that might occur.
- Provision of adequate sanitary facilities at the construction site.
- Procedures for working with heavy equipment, in confined spaces, for the handling and use of dangerous substances and wastes including asbestos waste material, for excavations and for heavy lifting.
- Provision of adequate waste and material storage facilities.

In addition, the following measures should be considered to minimize hygiene and health problems at construction site:

- Implementation of adequate solid waste management practices.
- Provision of adequate sanitary facilities at the construction site.
- Avoidance of standing water on the construction site through the proper maintenance of the site and through the removal of water from ditches.

Table 8-1: Environmental Management Plan during the construction phase

<table>
<tr><th>Potential Impact</th><th>Main activities causing the impact</th><th>Proposed Mitigation Measures</th><th>Project Phase</th><th>Institutional Responsibility for Implementation</th><th>Responsibility of Direct Supervision</th><th>Cost L.E.</th></tr>
<tr><td>Air Quality Impacts</td><td>Construction of WWTP, PSs, FMs and gravity sewers</td><td>Implement a <u>construction site management plan</u> including the following measures:
• Store construction materials in pre-identified storage areas.
• Cover friable materials during storage.
• Wet the network of unpaved roads on site. The use of water should be restricted to extremely active areas.
• Regulation of speed to a suitable speed (20 km/h) for all vehicles entering the village's boundaries.
• Implement preventive maintenance program for vehicles and equipment working on site and promptly repair vehicles with visible exhaust fume.</td><td>Construction</td><td>Construction Contractor</td><td>CAPW / GCWC</td><td>0.0</td></tr>
<tr><td rowspan="2">Ambient noise impacts</td><td>Construction of WWTP, PSs, FMs and gravity sewers</td><td>On site construction, noise shall be mitigated to ensure a safe work environment by implementing an occupational health and safety plan, which considers national and international requirements. The plan shall include the following measures:
• Ear muffs/protective hearing equipment shall be made available to all workers in noise critical areas
• Training on how and when to use protective hearing equipment shall be conducted as part of the workers' induction sessions.
• Place visually clear instructions in areas where noise emissions are significant.</td><td>Construction</td><td>Construction Contractor</td><td>CAPW / GCWC</td><td>30000</td></tr>
<tr><td></td><td>Off-site construction noise shall be mitigated as follows:
• Optimize the use of noisy construction equipment and turn off any equipment if not in use.
• Regular maintenance of all equipment and vehicles
• Stop all construction activities during the night
• Communicate the construction schedule with neighboring communities and sensitive receptors
• Implement a complaints system</td><td>Construction</td><td>Construction Contractor</td><td>CAPW / GCWC</td><td>0.0</td></tr>
<tr><td>Soil and land quality Impacts</td><td>Construction of WWTP, PSs, FMs and gravity sewers</td><td>Design and construct an impermeable protective base layer underlying areas with potential hazardous liquids storage or use</td><td>Pre-construction & Construction</td><td>Construction Contractor</td><td>CAPW / GCWC</td><td>100000</td></tr>
<tr><td></td><td></td><td>Implement a site <u>construction management plan</u> including segregation and reuse options of excavated soil.</td><td>Construction</td><td>Construction Contractor</td><td>CAPW / GCWC</td><td>0.0</td></tr>
</table>

Potential Impact	Main activities causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of Direct Supervision	Cost L.E.
Occupational health and safety impacts	Construction of WWTP, PSs, FMs and gravity sewers	The Contractor shall adopt an Occupational Health and safety plan during the construction phase. According to OSHA standards the main mitigations measures to prevent common construction hazards are: • Workers must follow safety standards and use protective equipment to minimize hazards while trenching and excavating • Workers should be trained to identify and evaluate fall hazards and be fully aware of how to control exposure to such risks as well as know how to use fall protection equipment properly. • Workers must comply with OSHA's general rule for the safe use of ladders and stairways • The scaffolding hazard shall be addressed as stated by OSHA standards. They give specific requirements for the maximum load, when to use scaffolding, bracing systems and the use of guardrails. • To prevent Heavy Construction Equipment risk, workers should follow all construction safety guidelines necessary to eliminate the exposure to such injuries and accidents • The best way to prevent the Electrical hazard is for the workers to be at a safe working distance away from the power lines. Other precautionary measures include guarding and insulating of the vehicle from which they might work. This would help prevent electrical hazards from injuring them while working. The Occupational Health and safety plan shall also include the Egyptian Labor law No. 12 for 2003 and the international construction standards requirements, including, but not limited to, the following measures: • Identification of hazard sources to workers • Eliminating the sources of hazards • Workers must be trained to recognize potential hazards, use proper work practices and procedures, recognize adverse health effects, understand the physical signs and reactions related to exposures, and are familiar with appropriate emergency evacuation procedures. They must also be trained to how to use the Personal Protective Equipment (PPE). • Inspection and testing of all equipment and machines • Appointing an Accident Prevention Officer at the site, to take protective measures to prevent accidents • Designation of restricted areas, such as construction sites • Preparation of an emergency response plan • Provision of necessary rescue equipment • Elaboration and management of a safety guarantee plan • Provision of appropriate and sufficient first aid equipment	Construction	Construction Contractor	CAPW / GCWC	30,000

Potential Impact	Main activities causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of Direct Supervision	Cost L.E.
Community Safety Impacts	Construction of PSs, FMs and gravity sewers	• To prevent Excavation and Trenching accidents and injuries, both the contractors and workers must follow safety standards and use protective equipment to minimize hazards while trenching and excavating. The sides of the trenches should be strengthened by wood or aluminum reinforcement sheets installed on both sides of the excavated trench, in critical areas (adjacent to existing houses and near canals and drains). • Using fences and warning signs during the construction phase • Using protective barriers and safe walkways • Appointing of an officer on site, to take protective measures to prevent accidents and/or to respond to accidents. • Provision of appropriate and sufficient of first aid equipment on site • Implement a complaints system	Construction	Construction Contractor	CAPW / GCWC	20,000
Risks of uncontrolled disposal of non-hazardous solid wastes generated during construction	Construction of WWTP, PSs, FMs and gravity sewers	A waste management plan complying with international best practice and relevant Egyptian regulations and covering all types of construction waste shall be developed and implemented by the construction contractors. This plan shall define exact procedures and locations for waste management and disposal. The waste management plan shall include the following measures:- • Implement a segregation system based on compatibility of different waste streams during each phase of project implementation. • Specify an area/container for non-hazardous wastes which accommodate for the generated segregated streams • Dispose of non-recycled wastes in the nearest landfill (the location of which needs to be confirmed at the beginning of the construction phase). • Register the amounts of disposed of wastes and keep waste disposal and transportation receipts/manifests. • Portable water cabinets for the WWTP workforce will be provided on site to provide hygienic work environment for the work force. Portable water cabinets are supplied with an external tank for sewage storage. • WWTP construction contractor shall contract the competent authority for safe disposing of generated sewage.	Construction	Construction Contractor	CAPW / GCWC	100,000
Risks of improper disposal of liquid wastes generated during construction	Construction of WWTP, PSs, FMs and gravity sewers	Prior estimation of dewatered liquid volume during the digging works • Collect and analyze samples of the dewatered liquid. • Arrange for disposal by tankers in nearest sewers, PSs, existing WWTP or pre-determined drain locations, depending on the sample analysis results in consultation with and after getting approval of the CSC and RSU/PMU • Evacuation of closed household cesspits and construction site sewage to existing WWTP, or pre-determined drain locations in consultation with and after getting approval of the CSC and RSU/PIU	Construction	Construction Contractor	CAPW / GCWC	50,000
Risks of improper handling and/or disposal of hazardous	Construction of WWTP, PSs, FMs and gravity sewers	A hazardous waste management plan complying with international best practice and relevant Egyptian regulations and covering all types of construction waste shall be developed and implemented by the construction contractors. This plan shall define exact procedures and locations for waste management and disposal. The waste	Construction	Construction Contractor	CAPW / GCWC	200,000

Potential Impact	Main activities causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of Direct Supervision	Cost L.E.
solid wastes generated during construction		management plans should also refer to health and safety procedures, and emergency procedures for containing and managing accidental spillages **General measures** • All types of hazardous waste can only be transported by licensed hazardous waste service providers and disposed of in licensed landfill. Both, the service providers and disposal sites have to be identified at the beginning of construction works. At the time of producing this study, the nearest (only) hazardous waste disposal site is the Nasreya Centre in Alexandria. • The different types of hazardous wastes should not be mixed. • Spent mineral oils shall be collected, stored in sealed containers and recycled using a licensed company which also has to be identified by the contractor **Adopting an Identification system for hazardous wastes generated on site** • The Contractor shall be able to identify the different potentially hazardous wastes. Identification shall be performed according to the Egyptian hazardous waste classification system by the contractor's in-house staff or with the aid of an independent waste management consultant appointed by the contractor. **Storage and Management of the waste accumulation area** The waste storage area for hazardous wastes could be integrated with the general waste storage area but shall be fenced, secured with limited admission and shaded from rain and sun heat/light.: • It is recommended that the maximum period for storing hazardous waste is 270 days from the start date of accumulation of waste. • The storage area must have a water supply • A hazardous waste label that has a "Hazardous Waste" mark on it must be placed on the container while still at the generation point. **Emergency Response** For the purpose of first response, when a hazardous substance release is first discovered or witnessed, the individual of concern who had to be previously trained would initiate an emergency response sequence by notifying the proper authorities of the release. The individual will take no further action beyond self-evacuation and notification. The aim of the response at this level is limited to protect nearby persons, property, or the environment from the effects of the release. No trials are performed at this stage to actually stop the release. This level of response includes; • actions to contain the release from a safe distance • prevent its spreading • evacuation				
Disturbance of traffic and access difficulty	Construction of WWTP, PSs, FMs and gravity sewers	• All mitigation measures for safeguarding long delays of vehicles and traffic will be undertaken by Local Traffic Department. The role of the project management will be focused on involving the authorities in the project planning process, to identify the type of crossing works, and to take permission for the duration and method of execution for specific crossings.	Planning and pre-construction	Construction Contractor in coordination with traffic police authority	CAPW / GCWC	0.0

Potential Impact	Main activities causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of Direct Supervision	Cost L.E.
		• During the excavation of roads in villages, there should be a wood or metal bridge for pedestrians access over each opened trench. Pedestrian paths beside or across trenches should be as flat as possible, and clearly marked with warning signs that are visible at night. In all cases the maximum length of an open trench in certain road should not exceed 500 meters[48]. • Alternate access routes should be identified and communicated with the residents before starting /during construction.	Construction	Construction Contractor in coordination with traffic police authority	CAPW / GCWC	0.0
		• Assign one worker to be present for helping people with difficulty in access or respond to falling accidents	Construction	Construction Contractor	CAPW / GCWC	0.0

8.2 Environmental and Social Monitoring during Project Construction

The monitoring scheme will cover monitoring of the construction program to ensure the implementation of the mitigation measures; monitoring of the construction performance of the Helwan WWTP upgrade / extension project, and monitoring of the impacts from the proposed project on the surrounding environment to assess the suitability and efficiency of the mitigation measures. Monitoring activities shall be recorded in the Environmental Register during construction which shall record daily all activities related to environmental issues and potential pollution.

Table 8-2: Environmental Monitoring Matrix during the construction phase

Potential Impact	Monitoring Indicator	Monitoring Location	Monitoring Methods	Monitoring Frequency	Monitoring Responsibility	Cost L.E.
Air emissions	HC, CO% and opacity for construction machinery	Construction site	Onsite gas analyzer measurement for exhaust	Once before construction + once quarterly for each machine during construction+ once monthly for PSs located close to residential areas	CAPW / GCWC	100,000
	Opacity and black fume	Construction site	Visual inspection	Once before construction + once quarterly for each machine during construction+ once monthly for PSs located close to residential areas	CAPW / GCWC	20,000
	Dust complaints	nstruction site	Record and document complaints	Recording to be once complaint is received. Documentation shall be in monthly reports	CAPW / GCWC	5000
Noise emissions	Noise intensity, exposure durations and noise impacts	nstruction site	Onsite noise meter measurements from representative locations (Map1)	Once quarterly during construction+ once monthly for PSs located close to residential areas	CAPW / GCWC	60,000
	Complaints from residents	nstruction site	Record and document complaints received from residents	Recording to be once complaint is received. Documentation shall be in monthly reports	CAPW / GCWC	10,000
Soil Impacts	Amount of soil disposed of and the amount of soil brought in	Construction site	Record	Whenever soil is disposed of or brought in	CAPW / GCWC	0.0
Risks of improper handling of waste generated during construction	Accumulation of waste water cabinet connections and sewage storage tank	Construction sites	Regular inspection Observation, documentation	Daily field observation and documentation in monthly reports	CAPW / GCWC	0.0

Potential Impact	Monitoring Indicator	Monitoring Location	Monitoring Methods	Monitoring Frequency	Monitoring Responsibility	Cost L.E.
	Amount of delivered hazardous waste to licensed facility	Construction sites	Manifests and waste disposal receipt review	Monthly	Environmental consultant supervising clearance of contaminated sites	0.0
Risk of improper management of culturally valuable sites	Date, time, locations and status of chance finds	Construction site	Documentation of chance-find procedures	In case an object has been found	CAPW / GCWC	0.0
Disturbance of traffic and access difficulty	Accidents, complaints and remarks from residents Contractors' access facilitation adequacy	Construction site	Record and document complaints received from residents	Recording to be once complaint is eceived. Documentation shall be in monthly eports	CAPW / GCWC	0.0
Occupational Health & Safety	Regular reporting of any accidents, as well as records and reports on health, safety and welfare of workers Regular inspection of workers against pathogenic agents and provision of immunization when needed	Construction site	Record and document accidents – Medical inspection	Monthly	CAPW / GCWC	0.0

8.3 Environmental and Social Mitigation during Project Operation

Air Quality

The following mitigation can be proposed to reduce the impact of dust and emission on air quality in the operation phase:

- Operation of fans and ventilation equipment to prevent any odour from the inlet works and other treatment works. Odour shall be mitigated by extraction fans and filtered in soil filter beds.
- Construction equipment and machinery as well as material transporting vehicles will be required to meet Egyptian emission standards. Regular emission checks and maintenance of vehicles and equipment will be required.
- Provide workers with safety PPEs (e.g. masks) while working in confined areas with considerable amount of odours.

Noise

- Where possible provide equipment with high level of noise (e.g. generators, blowers, fans, pumping rooms, etc.) with silencer. Also provide their buildings with sound insulation wherever applicable and possible.
- Provide workers with PPEs (e.g. ear muffs) while working in excessive noise levels within the WWTP site.

Flora, Fauna, and Natural Habitats

- No mitigation is required.

Soil and Land

- Good site practice is recommended for tanks for fuel storage; these should be leak-proof and installed on impermeable surfaces with secondary containment. Fuel storage tanks shall be checked daily and, in case of leakage, be replaced until repaired. These should be protected from damage as well – from reversing trucks.
- Procedures for storage and handling of non-hazardous waste and raw materials shall be described in the contractors' waste management plan.

Surface Water and Groundwater

The operation of the Helwan WWTP extension project shall have a positive impact on the surface water quality and on the long run-on groundwater quality due to enhancement of the effluent quality to be disposed to surface water. The following mitigation can be proposed to maximize the benefit of the reuse of the treated effluent in the operation phase:

- Planning and construction of the reuse scheme facilities to be used in agricultural applications reuse from Al-Saff Canal (e.g. pumping transmission pipelines) to maximize the benefit of the treated effluent and not to waste water resources and disposing them into the desert.
- In case of mal-functioning of the WWTP as well as the off-specification of the treated effluent, mitigation measures shall be taken into consideration in the design of the WWTP to handle these circumstances. This shall be discussed in further details in the Emergency Response Plan section.

Material Assets and Infrastructures Facilities

- The upgrade and extension shall have positive impact on the infrastructure facilities and material assets within the WWTP site in the operation phase. All material assets and infrastructures facilities shall be rehabilitated or re-constructed.
- No mitigation shall be required for the infrastructures facilities and material assets in the surrounding areas.
- In case that damage occurs due to any material asset or infrastructure facility due to traffic activities from or to the WWTP site, this shall be remedy on the cost of the WWTP operator.

Sludge Management

- Area used to store the dried sludge should be restricted to humans and worker with warning signs.
- The sludge should be transported to N9 site in closed container with warning signs on the vehicles about their content.
- Sludge quality should be tested regularly specially that is used in fertilizer manufacturing process.

Conventional activated sludge (CAS) system is a very flexible system that can be easily connected to different pre or later treatment systems. For the existing CAS system, the effluent of it can be easily connected to mechanical drying sludge system instead of the gravity thickeners; a very big advantage which will help to update the sludge treatment system in the entire plant (existing and extension).

CAS is optimum in this project as there is no need for extra investment for extensive nutrients removal on the contrary; extensive nutrients removal will be not favorable in this case. CAS is also optimum operational wise. The treated sludge will be stored until sold as fertilizers for agricultural purposes, or one third of generated sludge will be used as source of energy via anaerobic digestion gives higher quality treated sludge and recovers energy which decreases the operational costs. If re-used in energy recovery or as fertilizers subject to take precautionary measures to confirm its specification before using in commercial purposes. The current practice in handling the sludge all produced and treated sludge is sold for a contractor who is responsible to further sludge treatment if needed. Sludge price under 1st administration was 65 LE/ton which is relatively lower than other WWTPs (up to 200 LE per ton) due to the high sludge sand content. But now, sand ration is normal and the administration is planning on setting more equivalent price per ton with the coming tender and contract.

Health and Safety (In potentially explosive environment)

Regarding the workplace environment, the directive 2014/34/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on "The harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres" was addressed to maintain a safe workplace. Directive 2014/34/EU, or commonly named ATEX, is intended to support effective safety measures concerning explosion hazards. Those measures are conducted during purchasing/procurement of equipment, installation, operation and maintenance of the plant facilities. The risk analysis for the plant facilities would be primarily classified as a non-mining zone, given by symbol (II), secondly by the surrounded hazard in atmosphere; (G) symbol for explosive atmospheres caused by gases, vapors or mists and (D) symbol for explosive atmospheres caused by dust. The classification is further categorized into 3 zones depending on the likelihood of occurrence. Equipment and instruments would be marked with an explosion protection mark, symbolized by "Ex", followed by the category of the protection depending on the surrounded hazards.

- The treatment plant zoning would be mainly addressed to the areas in contact with the sludge and its by-products (methane), as sludge pumping station, anaerobic digester and energy production facility.
- The equipment would be installed in accordance to the manufacturer's instructions to maintain a safe assembling and operation; regarding any electrical or non-electrical parts.
- Integrated protection system from any leakage, sparking of any ignition sources and personal hazards to maintain a stable safety standard in a potentially explosive atmosphere.

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Table 8-3: Environmental Management Matrix during the operation phase

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
Air Quality and Odor Impacts	Operation of the WWTP and PSs	Maintain efficient performance of treatment efficiency in Helwan WWTP	Operation	GCWC	Helwan WWTP	- Review of monthly reports and field supervision	0.0
		Establish close communication with the neighboring areas, establish a complaints handling system and assign a staff member in Helwan WWTP to receive odor complaints. This could be done through posters and the distribution of brochures that illustrate the right to complain, and the contacts information of the responsible staff.	Operation	GCWC	Helwan WWTP	- Field audit to ensure that a communication system and complaints handling system are established	0.0
		Supplied standby generators to PSs and WWTP should be checked with suppliers for their emission standards	Operation	GCWC	Helwan WWTP	- Review certificate for emission standards from the supplier and measure emissions for verification	15,000
Noise Impacts	Operation of the WWTPs and PSs	Off site: • Cultivate and maintain a tree belt around the site where feasible • Implement a complaints system to investigate any noise complaints from neighboring communities.	Operation	GCWC	Helwan WWTP	- Field audit	0.0

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
		On site noise emissions control during operation shall be achieved by implementing an <u>occupational health and safety plan</u>, which considers national and international requirements. This to ensure a safe work environment and to ensure that on-site noise levels stay within the allowable limits. The plan shall include the following measures: • Ear muffs/protective hearing equipment shall be made available to all workers in noise critical areas • Training on how and when to use protective hearing equipment shall be conducted as part of the workers' induction sessions. • Place visually clear instructions in areas where noise emissions are significant. • Regular maintenance of all equipment and vehicles.	Operation	GCWC	Helwan WWTP	-Field audit -Review H&S records	30,000

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
Risks of improper handling of sludge	Operation of the WWTPs	Sludge handling and treatment • Following the drying process, the stabilization of sludge using quicklime should be implemented on site if sampling of the dried sludge indicated compliance with national requirements in all parameters except the pathogenic content. • The sludge and lime should be thoroughly mixed. A pH not less than 12 and a temperature not less 55°C should be maintained for at least 2 hours after mixing. • A manual for sludge treatment shall be developed and should be annually revised based on the actual sludge quality, actual quantity, news laws and regulations. • Workers handling sludge, or working near sludge tanks in the WWTP should wear suitable gloves and boots. • Hygiene instructions should be disseminated to workers, before they start working. These instructions should be clearly illustrated in posters placed in the offices and rest rooms of workers.	Operation	GCWC	Helwan WWTP	Field supervision and check that the procedures for sludge treatment are documented and are being followed.	0.0
		Sludge application on land (if proven feasible): • It is very important to ensure that sludge is of adequate quality for reuse. The quality of the sludge has to fulfill the quality standards for heavy metals as indicated in according to the Executive Regulations of Law 93/1962 , and the US EPA threshold concentrations of heavy metals of sludge to be applied on agricultural land (whichever is lower). • Sludge must not be applied to soil in which fruit and vegetable crops are being grown, or less than ten months before fruit and vegetable crops are to be harvested.	Operation	GCWC	Helwan WWTP	Field supervision and check that the procedures and regulations for sludge management are documented and are being followed.	0.0

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
		Sludge Use as RDF (if proven feasible): • Dried sludge could be sent to cement factories as RDF according to an contractual agreement between HCWW and the Cement Company. In that case the need for lime treatment should be reconsidered if it will affect the calorific value/properties of the sludge. • If the sludge was found hazardous (based on the sludge sampling results), it shall be handled by workers wearing PPE and transported by a licensed contractor to a cement factory licensed to incinerate hazardous wastes.	Operation	GCWC	Helwan WWTP	Field inspection and check that RDF contract is being implemented	0.0
		Sludge disposal in landfill: • If sludge cannot be reused, the right landfill category must be determined. Based on the chemical analysis of the sludge, it should be sent to the respective landfill (HW landfill or non HW landfill).	Operation			Field inspection, and documents review	0.0
Risks associated with disposal and/or reuse of final treated effluent	Operation of Helwan WWTP	• Implement preventive maintenance Programme to all structures and electromechanical equipment in PSs and WWTP. • The supplier of each equipment should provide a preventive maintenance schedule for supplied equipment. Implementing this schedule should be part of the WWTP and PS operational manual.	Operation	GCWC	Helwan WWTP	Field inspection, and documents review	0.0

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
Risks of improper handling and/or disposal of non-hazardous solid wastes generated during operation	Operation of the WWTP and PSs	A waste management plan complying with international best practice and relevant Egyptian regulations and covering all types of potential non-hazardous wastes shall be developed and implemented by the project's operator. This plan shall define exact procedures and locations for waste management and disposal. **The following measures shall be implemented:** • Implement a segregation system based on compatibility of different waste streams • Specify an area/container for non-hazardous wastes which accommodate for the generated segregated streams • Dispose of non-recycled wastes at the nearest landfill. • Register the amounts of disposed of wastes and keep waste disposal and transportation receipts/manifests, to be ready for review by EEAA.	Operation	GCWC	Helwan WWTP	Field supervision and review that the PSs/WWTP' waste management plan is documented and being implemented	0.0

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
Risks of improper handling and/or disposal of hazardous solid wastes generated during the operation phase	Operation of the WWTP and PSs.	A waste management plan complying with international best practice and relevant Egyptian regulations and covering all types of potentially hazardous wastes shall be developed and implemented by the project's operator. This plan shall define exact procedures and locations for waste management and disposal. The waste management plans should also refer to health and safety procedures, and emergency procedures for containing and managing accidental spillages. HCWW/PMU should adopt the measures listed below and ensure that all waste relevant information (types, amounts, disposal methods, etc..) are included in the environmental register of the plant. In addition to that, a separate hazardous waste register (according to the Egyptian Laws) has to be prepared , containing all information relevant to the generation , handling and disposal of hazardous wastes. **General measures** • All types of hazardous waste can only be transported by licensed hazardous waste service providers and disposed of in licensed landfill. Both, the service providers and disposal sites have to be identified at the beginning of the operation phase. At the time of producing this study, the nearest and only hazardous waste disposal site is the Nasreya Centre in Alexandria. • The different types of hazardous wastes should not be mixed. • Spent mineral oils shall be collected, stored in sealed containers and recycled using a licensed company which also has to be identified at the beginning of the operation phase.	Operation	GCWC	Helwan WWTP	Field inspection and check that hazardous wastes operating procedures are being documented and implemented	250,000

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
		Adopting an Identification system for hazardous wastes generated on site The operator shall be able to identify the different potentially hazardous wastes. Identification shall be performed according to the Egyptian hazardous waste classification system by the operator's in-house staff.					
		a) Storage and Management of the waste accumulation area The waste storage area for hazardous wastes could be integrated with the general waste storage area but shall be fenced, secured with limited admission and shaded from rain and sun heat/light.: • It is recommended that the maximum period for storing hazardous waste is 270 days from the start date of accumulation of waste. • The storage area must have a water supply • A hazardous waste label that has a "Hazardous Waste" mark on it must be placed on the container while still at the generation point.		GCWC	Helwan WWTP		0.0.
Risks of handling hazardous substances	Operation of the Helwan WWTP and PSs.	• Empty chlorine cylinders, should be collected at a certain location inside the chlorine building before being returned to the supplier. The vendor who will supply the WWTP with chlorine cylinders should take waste cylinders back on the same truck. This process should be documented in manifests that should be signed by the vendor.	Operation	GCWC	Helwan WWTP	- Documents review and occasional site inspections	0.0

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
		• Diesel ASTs should be surrounded with impermeable bund with a capacity of 110% of AST capacity. Any leaked diesel from ASTs should be pumped to diesel trucks until the leakage in AST has been repaired. No USTs should be used in the project, this has been further discussed in the screening criteria.	Operation	GCWC	Helwan WWTP	- Documents review and occasional site inspection	0.0
Occupational health and safety impacts	Operation of the Helwan WWTP and PSs.	The project's operator shall implement an occupational health and safety plan, which	Operation	GCWC	Helwan WWTP	Documents review and occasional site supervision	75,000

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
		shall include, but not be limited to, the following measures:- • **Immunization** Ensure routine vaccinations for workers for influenza, tetanus, and Hepatitis “A” (according to Consultations with the institute’s physicians). • **Safe Practices and Personal Protective Equipment (PPE)** - It is recommended to avoid liquid contact with exposed skin, by using a full-body impervious suits in addition with using rubber boots, gloves, hard hats and eye protection. - Using the Respirator instrument is based on an evaluation of respiratory hazards in the workplace and other relevant workplace and user factors. - During cleaning operations performed outside a tank or and pipelines, where the atmosphere is not immediately dangerous to life or health, the worker(s) shall wear supplied-air or air-purifying respirator with organic vapor HEPA (High-Efficiency Particulate Arresting cartridge). - When working in confined spaces, the team (inside and outside) must have extra					

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
		flashlights and two-way radios readied for communication. - A first-aid kit must be readily available; an eyewash and flushing station, neutralizing solutions, cleaning equipment, and emergency medical services. - **Training** Workers must be trained to recognize potential hazards, use proper work practices and procedures, recognize adverse health effects, understand the physical signs and reactions related to exposures, and are familiar with appropriate emergency evacuation procedures. They must also be trained to select and use the appropriate Personal Protective Equipment (PPE). **Control Measures Prior to entering and/or maintenance** • Assess and review sewage systems, components and piping. • Perform jobsite safety and health analyses and be aware of all associated risks and hazards. Inform all workers involved of the risks and hazards determined by the jobsite safety and health analyses. • Post warning signs and labels. • Secure all toilets, urinals, drains, pumps, and sewage treatment systems. • Isolate, close, secure, divert, de-energize, lockout and apply tags-plus applications to all valves, piping and associated mechanical equipment. • Check for residual pressure or vacuum effects in tanks and piping. • While remaining outside the tank, continue to test the atmosphere inside the tank remotely for safe conditions.					

Potential Impact	Main activity causing the impact	Proposed Mitigation Measures	Project Phase	Institutional Responsibility for Implementation	Responsibility of direct supervision	Means of supervision	Cost (annual) L.E.
		Post-Work Cleanup • Remove contaminated clothing and bag for proper disposal or decontamination. • Shower or wash face, arms, hands and legs with soap, using a substantial amount of water. • Disinfect equipment (e.g., using iodine compounds, bromine, chlorine, ozone, or their equivalent) and wash contaminated spaces, decks and bulkheads with detergent, sanitizer, or bleach. • Dispose of or re-wash rubber boots, gloves, eye goggles, face shields and respirators with a disinfectant solution. • Wash contaminated clothing separately. • Do not enter other spaces while still wearing contaminated clothing.					
Community health and Safety	Operation of the WWTP, PSs, FMs and Gravity sewers	• Using warning signs during maintenance periods and/or close the roads • Regular inspection for all the components of the sewage system especially the manholes covers and take instantaneous measurements for correction. • Preventive maintenance program • Adjust the maintenance schedules away from the rush hour	Operation	GCWC	Helwan WWTP	Occasional site supervision	0.0

8.4 Environmental and Social Monitoring during WWTP Operation

Permanent monitoring of the plant operation itself is required to ensure compliance with the EEAA laws. A well-functioning monitoring scheme will include (but not be limited to) the following:

- On-line monitoring will ensure that the quality of treated wastewater water remains in specification which will be suitable for irrigation and agricultural purposes.
- Carrying out of regular inspections of the entire WWTP facility,
- Regular maintenance of pumping facilities and reservoirs.
- Performing regular chemical and biological analysis of the inflow wastewater treated wastewater as well as the output sludge according to national and international standards.
- Selection of responsible and qualified personnel for operation and maintenance and providing training to them.
- Documentation of the results of the inspections in an inspection report.

Monitoring of the impacts from the facility on its surrounding environment (noise, air, water, soil, fauna and flora ecology, landscape, human health, traffic) to assess the suitability and efficiency of the mitigation measures - for example the quality of the soil at the effluent disposal site should be periodically monitored to ensure that the deterioration of the soil quality at this location is controlled. Visual monitoring could also be utilized to confirm the acceptability of the landscaping.

Table 8-4: Environmental Monitoring Matrix during the operation phase

Potential Impact	Monitoring Indicator	Monitoring Location	Monitoring Methods	Monitoring Frequency	Monitoring Responsibility	Cost (annual_ L.E.
Unacceptable odors	Neighbors' complaints	PSs and WWTP	• Record odor complaints received from neighboring areas. The record should include name of the person who has made the complaint, time of complaint, GPS location of the affected area, time and duration of unacceptable odor. Complaints records should be reported in monthly reports.	Daily	Helwan WWTP / GCWC	0.0
Air emissions	CO, SO_2, total hydrocarbons and NOx	Generators at WWTPs and PSs	• Onsite gas analyzer measurement for exhaust	Annually	Helwan WWTP / GCWC	45,000
ıbient Noise	Noise intensity, exposure durations and noise impacts Noise complaints	PSs and WWTP	• Measuring the ambient noise level in noise critical areas, using a portable noise meter. • Measuring the ambient noise level using a portable noise meter at the nearest sensitive receptors (Map). • Investigate noise complaints from workers and neighboring communities in the affected locations	Annually	Helwan WWTP / GCWC	15,000
Soil and groundwater	Any leaks	PSs , WWTP and pipeline network	1. Regular inspection of all components of PSs and WWTPs for any potential leaks	Monthly	Helwan WWTP / GCWC	0.0
Risks of improper handling of sludge	pH of fresh sludge	WWTPs drying beds	• Undertake continuous monitoring of pH of immature sludge drying beds. Logs of pH values should be used for controlling the lime dosing.	Continuous for two days after laying fresh sludge in drying beds (2 days average to be documented)	Helwan WWTP / GCWC	
	Zn, Cu, Ni, Cd, Pb, Hg, Cr, Mo, Se, As, faecal coliforms, salmonella and escharis eggs	WWTP drying beds	• Taking representative sample and analyze it according to requirements of Law 93/1962	Once each 3 months, or whenever sludge is being sold	Helwan WWTP / GCWC	20,000
	Water borne diseased for WWTP workers	Identified medical center	• Periodical medical examination for the workers and lab analysis	Quarterly	Helwan WWTP / GCWC	150,000
Risks associated with disposal of	Discharge rate of influents	WWTP	• Continuous monitoring of PS and WWTP incoming and outgoing discharges. Daily averages should be calculated and documented	Continuous, average flow to be recorded daily	Helwan WWTP / GCWC	0.0

Potential Impact	Monitoring Indicator	Monitoring Location	Monitoring Methods	Monitoring Frequency	Monitoring Responsibility	Cost (annual_ L.E.
final effluent Helwan WWTP	pH, COD, BOD, TSS, TDS, TKN, Oil & Grease, DO	WWTP	• Sampling and analysis in WWTP lab	- Every 3 days	Helwan WWTP / GCWC	0.0
	Performance efficiency of WWTPs	WWTP	Detailed environmental audit of the WWTP to review performance efficiency	- Annually	Environmental consultant	30,000
Risks associated with disposal of final effluent	Discharge rate of influents	PS and WWTP	• Continuous monitoring of PS and WWTP incoming and outgoing discharges. Daily averages should be calculated and documented	- Continuous, average flow to be recorded daily	Helwan WWTP / GCWC	0.0
	COD, TSS, TKN and P	WWTPs influent and effluent	Sampling and analysis in WWTP lab	- Daily	Helwan WWTP / GCWC	0.0
	Full Law 48/1982 parameters	WWTP effluent	Sampling and analysis in WWTP lab	- Monthly	Helwan WWTP / GCWC	0.0
	BOD, TSS, Total coliforms and insitu analysis of temperature, pH, conductivity and DO	Receiving drain (Al Saff)	Sampling and analysis in WWTP lab	- Monthly	Helwan WWTP / GCWC	0.0
	Performance efficiency of WWTP	WWTP	Detailed environmental audit of the WWTP to review performance efficiency	- Annually	Environmental consultant	30,000
Risks of improper management of solid hazardous and non hazardous wastes	Data and information in waste and environmental registers	PSs and WWTP	Auditing waste and environmental registers	Quarterly	Helwan WWTP / GCWC	0.0

Potential Impact	Monitoring Indicator	Monitoring Location	Monitoring Methods	Monitoring Frequency	Monitoring Responsibility	Cost (annual_ L.E.
Risks of handling hazardous substances	Integrity of ASTs	WWTP	Visual observation	- Daily - Leak incidents to be documented in monthly reports	Helwan WWTP / GCWC	0.0
Risks of handling hazardous substances	Chlorine concentration in air	Chlorine building in WWTP	Chlorine detectors	- Continuous leak detection - Leak incidents to be documented in monthly reports	Helwan WWTP / GCWC	0.0
	Integrity of ASTs	WWTP	Visual observation	- Daily - Leak incidents to be documented in monthly reports	Helwan WWTP / GCWC	0.0
	Amount of delivered containers to vendors	WWTP	Checking signatures in waste manifests	- Monthly check of waste documents	Helwan WWTP / GCWC	0.0

Table 8-5: Social Management plan

Potential Impacts	Proposed Mitigation Measures	Performance Indicators	Institutional responsibilities	Direct Responsibilities	Cost (L.E)
During Construction Phase					Cost by the contractor
Impacts on infrastructure	• Conducting surveillance activities to detect available pipelines or networks (water or electricity) • Coordination with the Local Governmental Units and the water and network companies to repair any damages. The contractor should pay for this cost.	Reducing rates of complaints related to infrastructure	Contractor, LGUs	Contractor	0.0
Impacts on mobility	• Provide alternative routes for pedestrians • Signage and Marking to avoid disruptions • Traffic diversion plan • Alternative pedestrian crossings • Excavation equipment are not moved during the day in the streets	Adequate signs at the streets Reduced number of grievances related to mobility	Helwan WWTP, Contractor, Traffic department	Contractor	0.0
Influx of workers on the community	• Comply with work places legal requirements and stringent safety regulations should be observed to avoid work accidents. • Employ workers from the local community	Number of workers from the local community Health records for workers	Helwan WWTP, Contractor,,	Contractor	0.0
Restoration رد الشي لأصله	• A time plan should be developed for street rehabilitation • Inform the local community with any potential delay of street rehabilitation • Paving the streets immediately after the construction. That should be done by specialized companies or the contractors but not by the Local Governmental Units • Monitor the process of street rehabilitation and realistic fines should be applied on the entities responsible of street rehabilitation • The construction contract shall bear the responsibility and the cost of coordinating with local authorities to prevent damage to underground utilities and restoration of affected structures.	Street rehabilitation plans Awareness raising activities related to project implementation plan Street conditions (re-pavement of streets)	Helwan WWTP, Contractor,,	Contractor	0.0
Impacts on the physical integrity of houses	• Boreholes should be used to identify the type of soil and the potential of impacts on the current structures • In case the soil is fragile, wood support may be provided to the houses and land • Measuring ground water levels before construction	Reducing rates of complaints related to structures	Helwan WWTP, Contractor,,	Contractor	0.0
Loss of income of groups working in evacuation of septic tanks.	• Number of unskilled workers employed in the construction from evacuation workers	Employment records	Helwan WWTP, Contractor,,	Contractor	0.0
During Operation Phase					
No mitigation measures during the operation phase					

8.5 Grievance and handling complaints and concerns

Special committees will be established at the central and governorate level of the company to handle grievances or concerns of local residents. Establishing a grievance mechanism is perceived as a key proactive measure to ensure that the concerns of local communities are sufficiently handled in an efficient manner and that feedback loops are closed.

8.5.1 Proposed Grievance Mechanism

Grievances and redress represent one of the important processes that should be tackled carefully during the project implementation. Grievance system should ensure that complaints are properly handled without delay that may negatively affect the project. This part explains the following:-

- Institutional responsibility for handling grievances
- Grievance mechanism sensitive to group vulnerability (women, poor, illiterate and disabled)
- Grievances channels
- Response to grievances
- Role of local NGO's
- Disclosure of grievances
- Monitoring of grievances

In general, all grievances and communications must be registered and the actions taken/responses should be tracked and recorded. Proper administration and internal records of stakeholder complaints and communications are essential for transparency and quality.

A best practice standard is to acknowledge all complaints within 10 days. Due to the complexity of some of the complaints, not all of them can be resolved immediately. In this case medium or long-term corrective actions are required, which needs a formal procedure recommended to be implemented within 30 days:-

- The aggrieved person (community member or workers[49]) has to be informed of the proposed corrective measure.
- In case no corrective action is required, the petitioner should also be informed accordingly.
- Implementation of the corrective measure and its follow up has to be communicated to the complainant and recorded in the grievance register.

A. Institutional responsibility for handling grievances

i. Raise awareness among the local community about grievance mechanism.
ii. Collect complaints received by different communication modes
iii. Document received grievances
iv. Direct grievances to the concerned bodies
v. Follow up on proposed procedures
vi. Document, report and disclosure of grievances
vii. Monitor grievance handling activities

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- Community awareness must be raised towards the grievance mechanism using the following: brochures that will be produced and distributed to different stakeholders.
- Activities should be documented carefully; electronic documentation of the received grievances is recommended as well as all relevant documents related to each complaint.
- A monthly report must be prepared about submitted grievances, how they were handled, level of satisfaction and the report must be published over the website.

B. Grievances' tiers:

Complaints could be submitted by multiple intake points including submission by hand, mail or by email. Following are the procedures that must be applied to highlight grievance mechanisms:

<u>Tier 1:</u>

1. Conduct more awareness raising activities about the grievance mechanism, such as more community meetings or posters.
2. Raise awareness among community members of the grievance mechanism, and the person they have to address grievances to. He will be responsible for documenting activities related to received grievances and will follow up on taken measures.
3. Documentation of the received grievances.
4. Direct the grievance to relevant internal department at the water company or other stakeholders
5. Informing the local community of the outputs of the grievances.

<u>Tier 2:</u>

In case no resolution was reached, the petitioner should resort to the second level as follows:

1. A grievance mediation committee will be formed. It should be responsible for discussing problems that were not solved and propose solutions and make decision.
2. The mediation committee should convene periodically and petitioners should attend these meetings.

C. Grievances channels

Given the diversity of socio-economic characteristics, appropriate grievance mechanisms must be identified to communicate with them, and the following are the main channels of communication to submit complaints:

1. The hotline '125'
2. Website, official Facebook page and other social media

D. Response to grievances

Responses to grievances will be conducted through the following channels:

1. Response should be conducted using the same channel for submitting the grievance. Written grievances must be replied in written format. Grievances submitted via the website should be replied by email.
2. The second channel should be religious institutions in the area (Mosque or Church)
3. Grievances should be responded to within the identified time limit, to give the community the sense of responsibility towards their concerns and taking effective measures to solve arising issues.

E. Monitoring grievances

All grievance activities should be monitored in order to verify the process. The following indicators should guide the monitoring process:

1. **Grievance register**: Received grievances per month (Channel the grievance was submitted, gender, age, basic economic status of the complainants should be mentioned)
2. Type of grievance received (according to the topic of the complaint)
3. Number of grievances solved
4. Dissemination of activities taken
5. Level of satisfaction with solutions
6. Documentation efficiency
7. Efficiency of response to grievance provided (efficiency in time and action taken).

F. Disclosure of grievances

All grievances and communications will be registered and the actions taken/responses given will be disseminated through the LGU, NGOs and Helwan WWTP. Frequently asked questions can be added to the website which would include responses to recurrent grievances and methods for handling them. This report must be published through the website of Helwan WWTP, the NGO’s and the LGU.

8.6 Emergency Response Plan

An emergency plan during the operation phase shall be developed by a specialized agency and in accordance with the rules and standards for safety and security and under the supervision of competent authorities. Meanwhile, during the construction phase, the contractor will be responsible for the preparation of the emergency plan for the construction sites. Emergency scenarios shall be developed and run regularly a competent team of employees will be identified to work with the project's emergency team and shall receive adequate training. The emergency plan will include the following measures:

- Identifying stakeholders.
- Fire-fighting plan.
- Emergency response plan for spills and leaks of hazardous substances and oils.
- First Aid and Injury Plan.
- Evacuation plan in case of emergency

8.7 Implementation Plan

The detailed Implementation Plan should describe and address all the required and necessary steps to be performed to implement each of the suggested mitigation measures, i.e. address when and how to be performed, and who will be responsible for their implementation and at what cost. This will ensure sound implementation of the mitigation.

For example, to mitigate the negative impact of the construction of the WWTP on the land use and landscape, it is suggested that the WWTP should be constructed using authentic materials and in regionally typical colours and in conjunction with the adjacent facility. The implementation scheme should advise that the contractor would be responsible for this.

Another example, to mitigate the impact of the disposal of the effluent into the Canal, the quality of the disposed effluent should comply with the Egyptian standards for disposal (law 48/1982). The IP should advise that the operator of the WWTP will periodically check the quality of the effluent (by water quality sampling and testing) and by checking the performance and efficiency of all the components of the WWTP.

8.8 Development of Environmental registers

The Contractor and Project Operator will be responsible for the issuance of the Environmental Register (ER) and Hazardous Waste Register in accordance with Appendix 3 of Law No. 4 of 1994, amended by Law No. 9 of 2009 and Law No. 105 of 2015 using the Guidelines for environmental registers issued by the Department of Environmental Inspection at EEAA.

REFERENCES

References

- Arab Republic of Egypt-The Cabinet Information & Decision Support Center: Egypt's Description by Information 2009, Helwan area
- Baha el Din, S. M., & Saleh, M. A. (1983). Report of the ornithological results of the Egyptian Red Sea pollution expedition. Ornithological Society of Egypt, Cairo.
- CAPMAS: Statistical Year Book, Dec. 2009
- Cedar Lake Ventures, Inc. "Average weather in Helwan, Egypt" based on a statistical analysis of historical hourly weather reports and model reconstructions from January 1, 1980 to December 31, 2016.
- chobanoglous, G. and Franklin L. B. 1991.Wastewater Engineering, Treatment, Disposal and Reuse, Third Edition, McGraw-Hill, Inc.
- COWI-ATKINS- "Rehabilitation & Extension of Various WTPs-WWTPs Prefeasibility Study" Aug 2020 -Helwan Wastewater Expansion Project.
- Danis B, Wantier P, Dutrieux S, Flammang R, Dubois P, Warnau M (2004) Contaminant levels in sediment and asteroids (Asterias rubens L., Echinodermata) from the Belgian coast and Scheldt estuary: polychlorinated biphenyls and heavy metals. Science of the Total Environment 333, 149-165.
- Drainage Research Institute, Technical final report of the design the open drainage system study for Al-Saf area, October 2019 submitted to Egyptian Public Authority for Drainage Projects, EPADP- MWRI
- EEAA guidelines related to the Public Consultation; Guidelines of Principles and Procedures for "Environmental Impact Assessment" 2nd Edition January 2009
- Environmental and Climate Change Research Institute, NWRC. (2009). A preliminary study to assess the environmental impacts of establishing a river port in El Saff.
- Executive Regulation(ER) No 338 for Year 1995 and the amended regulation No 1741 for Year 2005, amended with ministerial decree No 1095/2011, ministerial decree No 710/2012, and ministerial decree No 964/2015
- Geochemistry and Health 19, 63-66.Larsen, B. and Jensen, A. (1989): Evaluation of The Sensitivity Of Sediment Monitoring Stationary In Pollution Monitoring. Mar pollut Bull 20:556-60.
- Guangliang Zhang and others, Heavy metal fractions and ecological risk assessment in sediments from urban, rural and reclamation-affected rivers of the Pearl River Estuary, China, ELSEVIER Journal, Volume 184 Pages 278-288, October 2017.
- Guidelines of Principles and Procedures for "Environmental Impact Assessment" 2nd Edition EEAA, January 2009 and its amended Lists in October 2010.
- Hand-out, INFRA Engineering, January 2021
- Helwan: Information and Decision Support Center, November 2010
- Houba, V.J.G., Lexmond, Th.M., Novozamsky, I. & V a n d e r Lee, J.J. (1996) State of the art and future developments in soil analysis for bioavailability assessment. – Sci. Total Environ. 178, 21.
- http://www.eeaa.gov.eg/en-us/topics/nature/protectorates/protectoratesdescription.aspx

- https://weatherspark.com/y/96911/Average-Weather-in-%E1%B8%A8alw%C4%81n-Egypt-Year-Round
- ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/twas20
- Japan International Cooperation Agency, The strategic urban development master plan study for a sustainable development of the greater Cairo region in the Arab Republic of Egypt, Final Report (Volume 2), 2012
- Law 4 for Year 1994 for the environmental protection , amended by Law 9/2009 and law 105 for the year 2015
- Law 94/2003 on the National Council for Human Rights (NCHR)
- Law No 102 for Year 1983 for natural habitats.
- Law No 12 for Year 2003 for the protection, occupational health and safety for the workers, which is amending Law 137 for Year 1981 and its executive decrees.
- Law No 38 for Year 1968 for the public cleanliness, which is amended by Law No 31 for Year 1976.
- Law No 48 for Year 1982 for the protection of the Nile River, agricultural drains, ponds and aquifer from pollution, and the ER amended with Decree No 92 for Year 2013.
- Law No 93 for Year 1962 for discharge on the public sewer network and protection and treatment of wastewater wastes and safe discard methods of the treatment by products, amended with Decree No 44 for Year 2000.
- Maha Ahmed and others, “Mobility and risk assessment of heavy metals by sequential extraction in coastal sediment south Mediterranean Sea, Egypt”, Marine Systems & Ocean Technology ISSN 1679-396X Volume 14 Number 1, April 2019
- INFRA, Engineering, Helwan Wastewater Collection & Treatment Project Technical Study for Verification of Extension Requirements & Cost updating Technical Report, December 2021
- Perin, G., Craboledda, L., Lucchese, M., Cirillo, R., Dotta, L., Zanette, M. L. and Orio, A. A., (1985) “Heavy metal speciation in the sediments of Northern Adriatic Sea. A New approach for environmental toxicity determination, in Lckkas, T.D. (cd). Heavy metals in the environment” vol. 2, CEP Consultants, Edinburgh.
- Presidential Decree No. 135 of year 2004 related to the esablishment of WWHC
- Riba, E. García-Luque, J. Blasco & T. A. DelValls “Bioavailability of heavy metals bound to estuarine sediments as a function of pH and salinity values”, Chemical Speciation & Bioavailability, 15:4, 101-114, DOI, 2003: 10.3184/095422903782775163. To link to this article: https://doi.org/10.3184/095422903782775163
- RIGW (1997) Hydrogeological maps of Egypt, scale 1:100,000.National Water Research Center, Ministry of Public Works and Water Resources, Egypt
- RIGW, 1997. Hydrogeological Map of Egypt, Scale 1: 500000, Helwan Map Sheet.
- RIGW/IWACO, 1998, ‘Environmental management of groundwater resources (EMGR): Identification, priority setting and selection of area for monitoring groundwater quality’, Technical ReportTN/70.00067/WQM/97/20, Research Institute for Groundwater (RIGW), Egypt.
- Saber S. (1989): Ecological studies on reptiles from Eastern desert. Ph. D. Thesis, Faculty of Science, Al-Azhar University, Cairo.

- Samir R. Awad, Groundwater hydrogeology and quality in Helwan area and its vicinities in Egypt, Water Science 2019, VOL. 33, NO. 1, 10–21
- Sanja Sakan and others" Geochemical Fractionation and Risk Assessment of Potentially Toxic Elements in Sediments from Kupa River, Croatia", MDPI, the United Nations Global Compact, Water Journal, Switzerland July 2020
- Singh, S.P.; Tack, F.M.G.; Verloo, M. "Extractability and bioavailability of heavy metals in dredged sediment derived surface soils", Laboratory of Analytical Chemistry and Applied Ecochemistry, Coupure-Links 653, B-9000 Gent, Belgium, Chemical Speciation and Bioavailability Journal 8:105-110, 1996
- Sniffer. 2008. Human Health and the Environmental Impacts of Using Sewage Sludge on Forestry and for Restoration of Derelict Land.
- Stark L (1998) Heavy metal pollution and macrobenthic assemblages in soft sediments in two Sydney estuaries, Australia. Marine and Freshwater Research 49, 533-40.
- The Constitution (1971, amended in year 1980)
- The Constitution (2014, articles 33 and 35)
- The WHO guidelines for detection of H2S is 0.2-2 µg/m3 (about 0.0002 to 0.002 ppm)), for recognition is 0.6-6 µg/m3 (about 0.0006-0.006 ppm) while the guideline value to protect against substantial annoyance is 7 µg/m3 (about 0.007 ppm)
- Thorweihe U (1990) Nubian Aquifer System. In: Said R (ed) Thegeology of Egypt, 2nd edn. Balkema, Rotterdam
- USEPA, "Framework for Metals Risk Assessment", Office of the Science Advisor Risk Assessment Forum U.S. Environmental Protection Agency Washington, DC 20460, March, 2007
- www.who-eatlas.org
- Y.R. Gedamy, A.M. El-Aassar and A.M. Abdel-Gawad, "Pollutants Detection in Water Resources at El Saff Area and Their Impact on Human", International Journal of Environment 1(1): 1-14, 2018, ISSN: 2077-4508

Annexes

Annex I – Stakeholders Consultation List of Participants

Annex II - Climate change assessment / Carbon Footprint report

Annex III - Climate change resiliency and vulnerability assessment

Annex IV - (a) Helwan WWTP-Influent flow 2019/2020, Wastewater Quality laboratory data (July –October 2020)

Annex IV - (b) Sludge samples lab. results for heavy metals and E. coli of Helwan WWTP Nov. 2020

Annex V - Hydraulic Capacity of Al-Saff Canal

Annex VI - El Saff drainage network study

Annex I

Stakeholder Consultation

January 2021

List of participants and illustrated photos

L’Agence Française de Développement (AFD)

Construction Authority for Potable Water & Wastewater **CAPW**

Environmental and Social Impact Assessment Report

Stakeholder Consultation

January 2021

List of participants and illustrated photos

Prof. Dr. Moustafa Ashmawy

List of participants

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5		Maintenance Engineer	Eng. Mohamed Samy	01023926272
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7		General Manager Water Quality, Cairo Branch	Dr. Mohamed Reda	
8	Ministry of Water Resources and Irrigation	Saff Irrigation district	Eng Mahmoud Yassen Aid	01123180886
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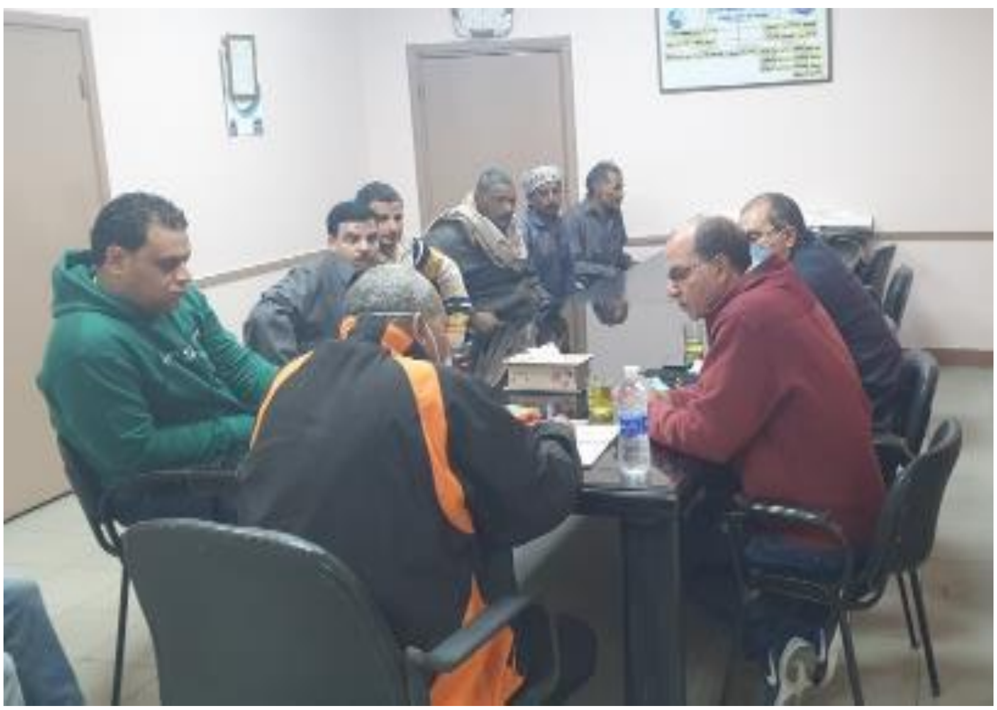
13	Consulting Office for Infrastructure Engineering INFRA Engineering	Director	Dr. Moustafa Ashmawy	01222101320
14	Senior Consulting Engineering	Director	Dr. M Shabaan Negm	01222421457
15	Arab Abu Sa'ed surrounding area	Farmer/ elderly leadership	Hamid Abu Sa'ed	01006105326
16		Largest agricultural land owner in the area	Mohamed Khaled Abu Sa'ed	
17		Farmer	Mosallam Kamil	
18		Farmer	Mohamed Khaled	01003003380
19		Farmer	Abdelhamid Rashid	
20		Farmer	Mahmoud Mashhour	
21		Farmer	Rady Salama	
22		Farmer	Ahmed Rady Salama	
23		Business owner	Khaled Gamal	01004959353
24		Saff City council	Ahmed Ezz El dein	01012031203

Illustration of the consultation



Meeting with the farmers in the project area

and WWTP Helwan managers

Meeting with the Arab Abu Sa'ed (Helwan) WWTP mnagment team

Arab Abu Sa'ed (Helwan) WWTP laboratory Team

Meeting with Infra Chairperson

Annex II

Climate Change Assessment

Carbon Footprint Report

Executive summary

Due to the increasing tangible and foreseen consequences of climate change; GHG and carbon footprint of any project is a vital decision making tool. Water and wastewater handling is one of the major municipal energy consumer and GHG emitters. Helwan wastewater treatment scheme is at its limits already. Immediate actions needed to be taken to save some urgent situations until a full scale scheme upgrade is decided and implemented.

Helwan wastewater treatment scheme upgrade contained two alternatives. Alternative 1: to support the overloaded pump stations with parallel ones and to convey the extra current and future flow to Arab Abu Sa'ed WWTP, to which an upgrade in capacity shall be done. Alternative 2 is basically the same only the extra flow will be conveyed to a new WWTP in Al Kuraimat desert road. Alternative 1 seems a logical first step of alternative 2, through which the needed action can be taken more immediately and all existing resources such as Arab Abu Sa'ed WWTP can be used to its maximum capacity and efficiency.

This report is part I of the climate change aspect assessment of alternative 1, in which the carbon footprint of Arab Abu Sa'ed WWTP will be calculated. Arab Abu Sa'ed WWTP was modeled for the three different sludge treatment suggested scenarios by Infra Engineering. Viewing the results of direct emissions and energy consumptions of the three scenarios helps in the decision making process by adding pros and cons to each scenario. Also, adding tertiary treatment system to the full capacity of the plant, according to the model, has its very positive impacts on emissions reductions.

The model results were compared against other international and recent outcomes of other models and direct measurements of other wastewater treatment plants to verify whether the results fit within the normal range. The results of the model were discussed in details and how per example the use of anaerobic digester has saved more than half the energy consumption from the grid of the WWTP (excluding irrigation pumping station), and their indications and some recommendations were drawn from those conclusions:

1. The introduction of the anaerobic sludge digestion is a very effective tool in both emission reduction and sludge quality treatment.
2. The replacement of sludge drying beds is recommended, as it proved that it has major impact on nitrous oxide direct emissions.
3. The replacement of the drying beds along with the introduction of the digesters can be easily implemented gradually, which will help in gradually accomplishing capacity building and allows being able to observe the results and predict further outcomes for future decisions.
4. Tertiary treatment is highly needed to raise the quality of the effluent treated wastewater and is considered a very good decision not only emission wise but also for the economical and agricultural future of the area.

The second part of this report is the Climate Resiliency and Vulnerability Assessment. The project has a very strong potential when it comes to climate resiliency and vulnerability as, all the proposed project outputs and components may be considered as a reduction to the vulnerability to climate change as the project will:

a. Increase the wastewater conveyance network capacity, which will help contain more intense rainfall and storms/floods.
b. Supply unrestricted irrigation water quality with additional 800,000 m^3/day, which would have otherwise been extracted from the Nile. This will help compact droughts and shortage of water resources and agricultural water stress.
c. Will improve wastewater treatment quality to compact the climate change impacts.
d. Compact the damage and halt in service due to power cutoffs by depending less on the national grid by utilizing energy recovery in sludge digestion.
e. Decreasing the carbon footprint per capita served by utilizing energy recovery and tertiary treatment.
f. Increasing the WWTP capacity along with upgrading to tertiary treatment will allow for more containment to the peak average daily water consumption increase as temperatures increase.

1. Project description

1.1 Project background and rationale

Cairo has a number of large scale wastewater treatment schemes (wastewater collection and conveyance systems and large scale wastewater treatment plants). On the Northeast there is the Gabal Al Asfar WWTP and on the Northwest there is Abu Rawwash. The Southern part of Cairo depends on a separate collection and treatment system starting from the south of Maadi district; Wastewater is collected and delivered through culverts and in-series screw pump stations further south to Helwan WWTP which is the project discussed in this report. The existing Helwan (Arab Abo Sa'ed) WWTP is currently serving a population of about 1.6 million capita within different areas starting from the Ring road at Maadi to Helwan and El-Tebeen in the south of Cairo. Initially designed with a capacity of 550,000 m^3/day, it is now overloaded as the current average wastewater generation is about 587,874 m3/day, and reaches 700,000 m^3/ day in summer – resulting in over flow of manholes in some areas of the catchment and the intermittent discharge of untreated wastewater flows into the Al Saff irrigation Canal. Moreover, the estimated wastewater generation is expected to increase up to 1,167,925 m^3/day by 2052, so that the addition of new treatment capacities and network extensions as a first stage is urgently required.

The original project was divided into several contracts and funded by the European International Development Agencies together with the local component of the project budget. The master plan and the project designs were completed in 1978 based on constructing two stages; the first up to 1992 and the second stage up to the year 2000. The first stage of Helwan wastewater treatment plant has a design capacity of 350,000 m^3/day to serve approximately one million inhabitants. The plant capacity was increased to 550,000 m^3/day by the Arab-Contractors company to serve approximately 1.5 million inhabitants. The plant expansion was completed and set into operation in 2010.

Egypt is well below water poverty lines of 1,000 m^3/capita/year (650 m^3/capita/year as per the National Water Resources Plan 2017 and the Sustainable Development Strategy – Egypt's Vision 2030). Irrigation water presents approximately 78% of water demand in Egypt; therefore, it shortage represents urgent issues in economy, food security, employment and other sectors. Being able to obtain new water resources is strongly required by treating the wastewater inflow all over Egypt in general and specially inflow to Helwan WWTP. Recently, the effluent from Helwan WWTP is mixed with untreated overflow capacity wastewater and consequently does not meet the standards of the irrigation water quality, even though this is beginning to show much improvement currently.

The main objectives of the project are:

1. Promote efficient and sustainable wastewater treatment in South of Cairo Governorate: the Project will allow accommodating the area's demographic growth, ensuring that the

targeted population of approximately 2,000,000 (by year 2037) benefits from a safely managed wastewater service.

2. Reduce wastewater related pollution in Al Saff Irrigation Canal and promote the use of unconventional water resources: The Project will allow the Helwan WWTP to achieve the regulatory thresholds in terms of water discharged into the Canal and unrestricted irrigation, and allow for the safe reuse of at least 500,000 m^3/day of treated wastewater for agricultural purposes.
3. Promote a climate change-friendly growth: apart from its benefits in terms of adaptation to the growing climate change-driven water stress, the Project will allow Helwan WWTP to be autonomous for a significant percentage of its electricity needs.

The catchment zone of Helwan project extends from the Cairo ring road on the north direction down to the rural area of Arab Abu-Sa'ed in the south direction, and from Kattamia on the East side to the Nile Cornish on the West side . In addition to that, the current wastewater and treatment system of Helwan receives wastewater from the areas of Mokattam middle knoll, Almeerage and Sakr Koreach, Wadi Degla, Al Autostrad, Zahraa Al Maady and parts of New Cairo, Tura(s), Al Maasara(s), Al Teben and Helwan areas up to Arab Abu-Sa'ed and the new regional ring road to the south of Cairo as shown in

Figure 11. The general project of Helwan is designed and implemented to serve the southern part of Greater Cairo, which starts from Al-Maadi and extends southward for a distance of 30 km, to serve residential areas. Industrial areas, including iron and steel factories, coke factories, forgings, cement factories, the Nasr Company for Cars, many military factories in the region, in addition to the residential areas and industrial areas covered by the wastewater project. It also serves Helwan University and many military and security sites, including Helwan Airport, Tora Prisons, security forces in Tora, Police Trustees Institute in Tora, Helwan Air Force Secondary School, entertainment and commercial areas[1].

The current project includes three screw pump stations (Station No. 4 in Al Maasarah - Station No. 3 in Helwan - Station No. 2 in Al-Tebbin), main pump station No. 1., four force mains, each with a diameter of 1500 mm (2 first stages, 2 second stages) from pump station No. 1 to the entrance of the treatment plant. Also, two water treatment plants, the small scale 15th Mayo WWTP and the large scale Arab Abu Sa'ed WWTP (Helwan WWTP). Inside Arab Abu Sa'ed WWTP there is an irrigation pumping station, which receives the treated water from the plant and pumps it to the entrance of El-Saf canal at distance 3.5 km from the plant. The following

Table 6 summarizes the project technical components:

[1] Source: Feasibility study report for Helwan, 2015; Pre-feasibility study for Helwan, 2020.

Table 6: Key Data of the Existing Wastewater Project in Helwan (Ref. Atkins study)

Item	Sanitation project in Helwan
Design capacity of the treatment plant (m^3/day)	First stage: 350,000 m^3/day starting from year 1990 Second stage: 200,000 m^3/day starting from year 2000
Starting operation date	End of 1989/Start of 1990
Units in the Treatment plant	Wastewater units in Arab Abu Sa'ed WWTP: ▪ Conventional activated sludge (primary sedimentation tank, aeration tank, final sedimentation tank, and chlorination tank). ▪ Sludge units: Gravity thickener and drying beds.
Service area	The southern part of Greater Cairo (North of Maadi to the South of Al-Tebbin). 15th of May District- all residential areas surrounding the Autostrad - the industrial zone of Helwan, Al-Tebbin, and the 15th of May. Military areas (Helwan Airport, Tora Prisons, Security Forces, Police Trustees Institute). Commercial and recreational areas, clubs, etc.
Population	One million Capita (First stage)./ 1.5 million Capita (Second stage).
Project components	Major collectors start from Al-Maadi, passing by Al-Tarwat and Kafr Al-Alwi, to Arab Abu Sa'ed. ▪ Three screw pump stations (Station No. 4 in Al Maasarah - Station No. 3 in Helwan - Station No. 2 in Al-Tebbin) ▪ Main pump station No. 1. ▪ Four force mains, each with a diameter of 1500 mm (2 first stages, 2 second stages) from pump station No. 1 to the entrance of the treatment plant. ▪ Treatment plant using aeration system. ▪ The irrigation pumping station inside the treatment plant, which receives the treated water from the plant and pumps it to the entrance of El-Saf canal at distance 3.5 km from the plant.

Arab Abu Sa'ed WWTP total plant area is estimated at about 259.65 feddans, with a design capacity of 550,000 m3/day, so that it receives water from the main pump station No. (1) through (4) force mains with a diameter of 1500 mm in addition to the force main coming from the service of three villages in Qism El-Saf. Construction Authority for Potable Water and Wastewater (CAPW) has also prepared tender documents and awarded to a Contractor to increase the irrigation pumping capacity with additional 250,000 m3/day, so that the final capacity of the irrigation pumping station will be 900,000 m3/day.

Figure 11 shows the general layout of Helwan (Arab Abo Saed WWTP). The area of the existing plant is divided into three plots, as the following:

- The first plot with an area of 129.3 feddans contains the main units of the plant (entrance, screens and grit removal chambers), primary sedimentation basins, aeration basins, final sedimentation basins, chlorination mixing basins, the main irrigation pumping station that pumps treated water to the El-Saf canal through (4) force mains with a diameter of 1500 mm. There are drying basins for sludge that can be used with the built-in area for future plant expansion.
- The second plot, with an area of 59.5 feddans, contains sludge thickener basins, drying basins, and sludge stacking areas.
- The third plot, with an area of 70.85 feddans, contains drying beds and sludge stacking areas.

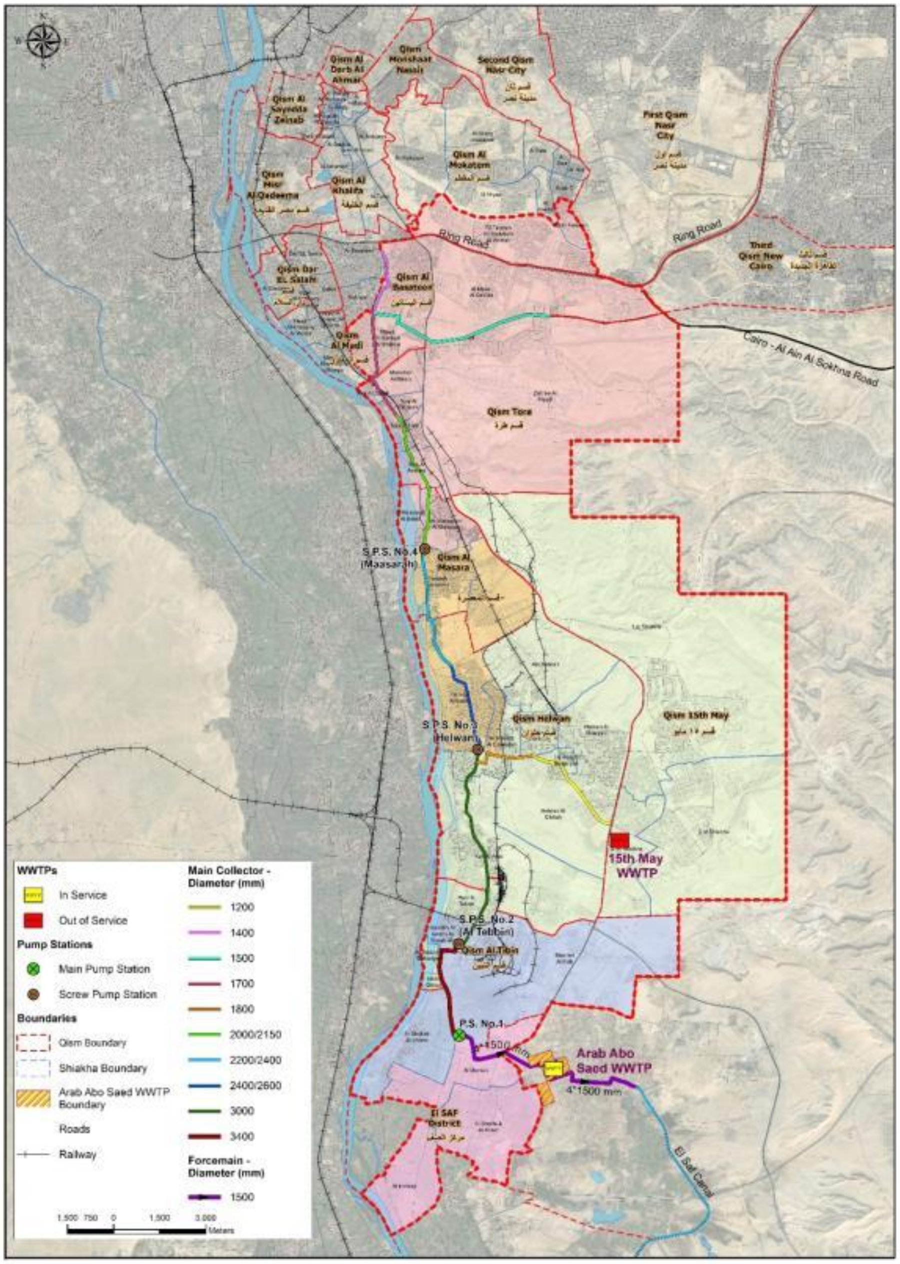


Figure 11: Existing situation of Helwan project (Source: Feasibility study report for Helwan, 2015; Pre-feasibility study for Helwan, 2020)

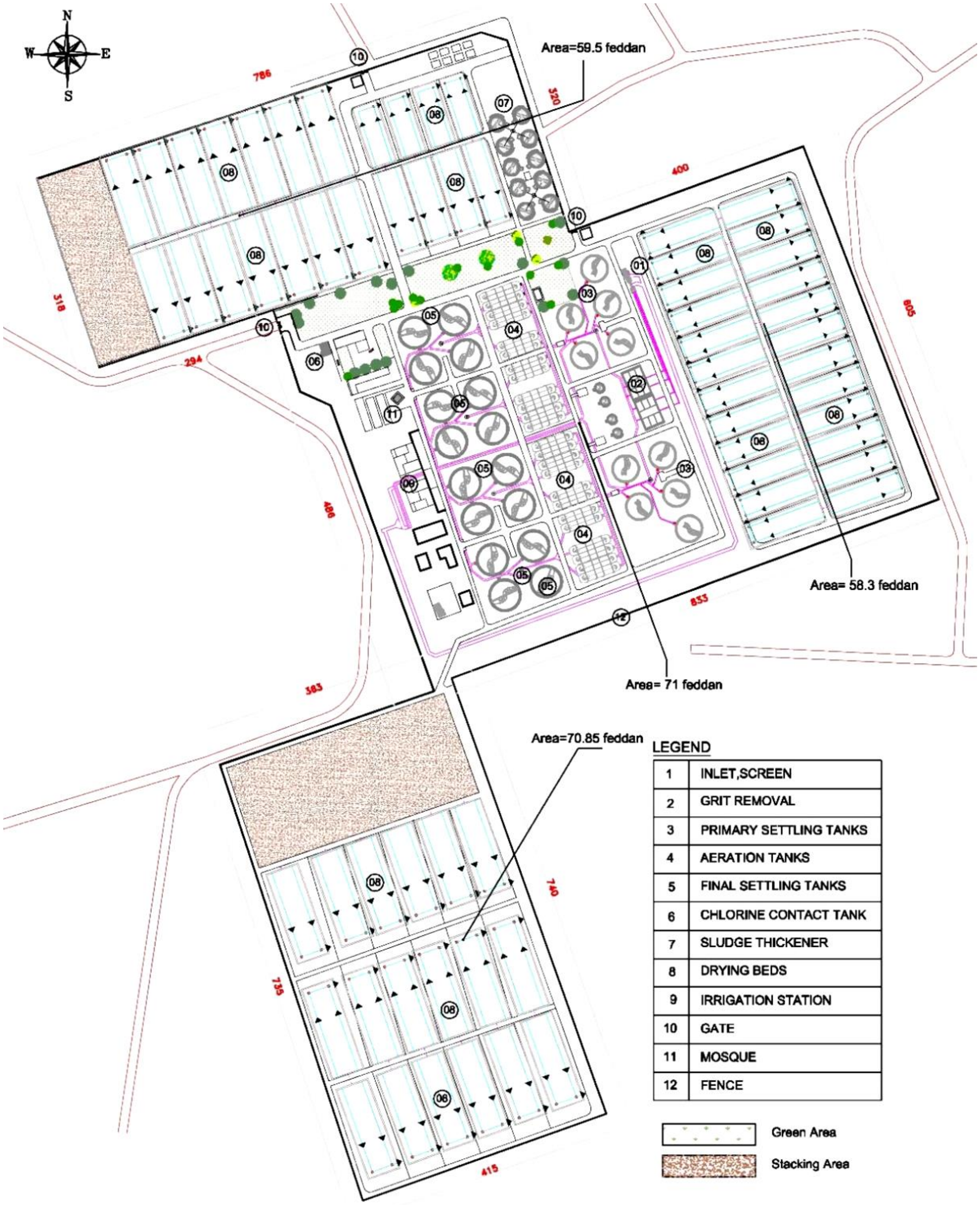


Figure 12: Current General Layout of Helwan (Arab Abu Sa'ed WWTP) (Source: Feasibility study report for Helwan, 2015; Pre-feasibility study for Helwan, 2020)

1.2 Project components summary

The project as agreed with CAPW and Greater Cairo Wastewater Company was studied as two alternatives. Figure 13 presents the map of the two alternatives. The first alternative includes the expansion of existing WWTP in Arab Abo Saed Site with a design capacity 250,000 m^3/ day, while the second alternative is to construct a new treatment plant at the El-Kurimat Desert Road site with a capacity of 250,000 m^3/ day.

It should be noted that, the selected Helwan wastewater project shall be the first alternative which is construction of 250,000 m3/day advanced treatment in Arab Abo Saed existing site. The current ESIA shall focus only on the new construction works of the 250,000 m^3/day advanced treatment in Arab Abo Saed location and the operation of the whole Arab Abo Saed Plant (the existing 550,000 m^3/day after upgrade to advanced treatment and the new 250,000 m3/day advanced treatment)

Alternative (1): Treatment Plant at Arab Abo Saed existing site::

- Construction of Collector of diameter 1800 mm with 100 m length to take water from the existing collector in Omar Ebn Abdel Aziz street to a new pump station No. (3A) in Helwan.
- Construction of civil works for new Pumping Station No. (3A) of capacity (400,000 m3/day), including Electro-mechnical works of the first phase (capacity 200,000 m3/d) including five (3+2) pumps, pump capacity 1,000 L/sec and 60.0 m head.
- Construction of two Forcemain of diameter 1500 mm and length of 5 km from the new P.S. No. (3A) to 15th May P.S (2A).
- Construction of new 15th of May Pumping Station (2A) civil works of capacity 550,000 m3/d including electromechanical works of capacity (250,000 m3/day) with five (3+2) pumps for phase (1), pump capacity 1,500 L/sec and 25 m head.
- Construction of two forcemains each of diameter 1500 mm and length of 9.00 km from the new 15th May P.S. (2A) to Arab Abo Saed existing WWTP.
- An expansion for the existing WWTP of capacity 250,000 m3/day (provided with mechanical dewatering of sludge) in the same Area of the existing Arab Abo Saed WWTP. It also includes an advanced treatment unit (DynaSand) for the whole plant capacity (800,000 m3/ day).
- Anaerobic digesters for Arab Abo Saed WWTP with a total capacity 250,000 m3/day.
- Rehabilitation and Expansion of the first part of El Saff Irrigation Canal of 25 km length starting from km 0 to km 25)

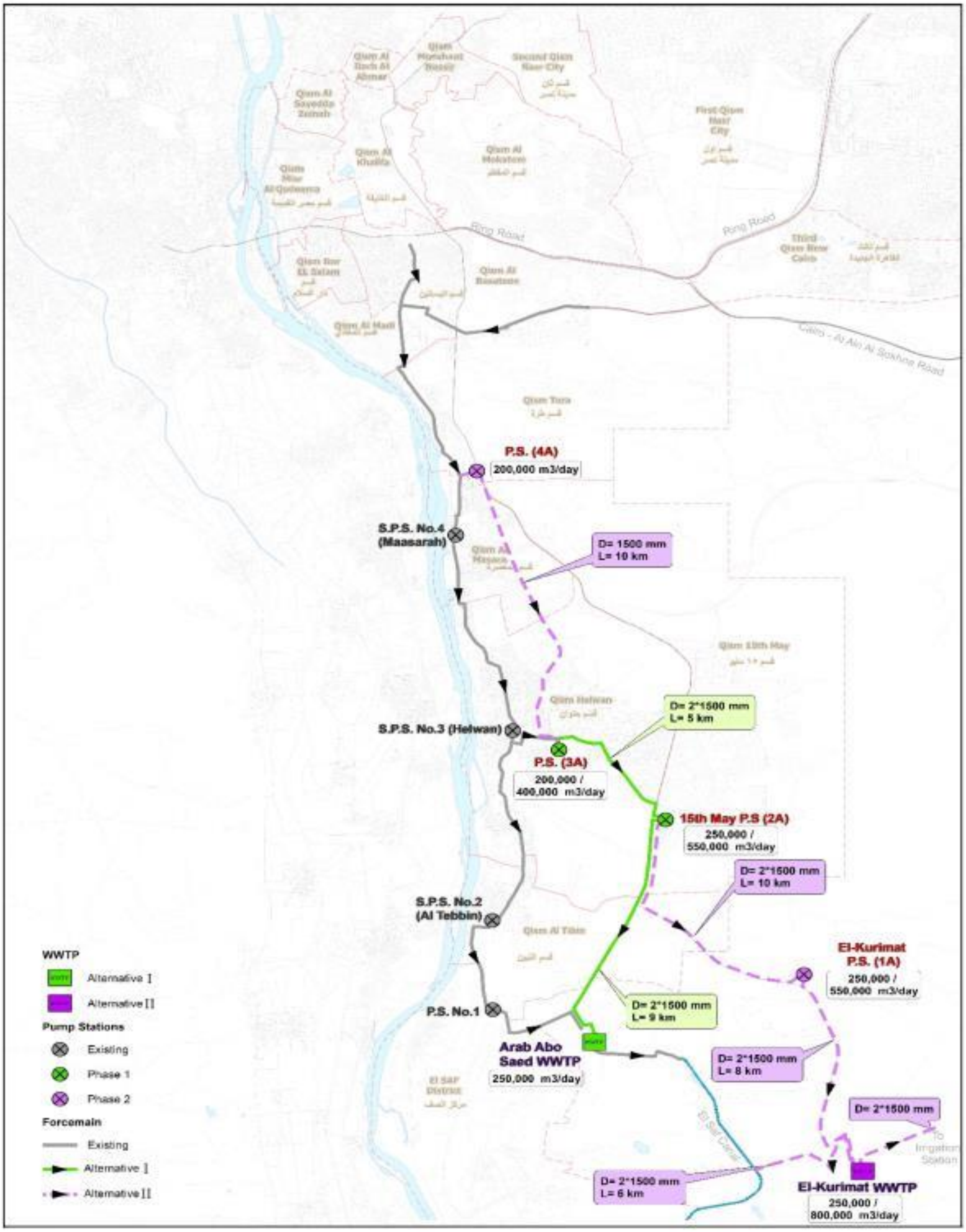


Figure 13: Proposed Helwan project as two Alternatives with design capacities of facilities (Source: Pre-feasibility study for Helwan, 2020

2. Carbon footprint boundaries and elements

Wastewater is responsible for 10% of the anthropogenic methane emissions (IPPC, 2014), and other greenhouse gases (GHG) emission. This chapter is concerned with energy and carbon footprint of the baseline project and a number of alternatives in the extension project. According to the Greenhouse Gas Protocol there are three scopes of emissions:

- Scope 1: all emissions coming directly from the wastewater treatment processes.
- Scope 2: all indirect emissions resulting from purchase or consumption of electricity, heating and cooling.
- Scope 3: all indirect emissions that are related to the facility but not directly controlled by it, example: emissions from land application of treated sludge after selling it.

Carbon footprint analysis of a WWTP is concerned with the GHG direct, indirect and other emissions of a plant throughout its life cycle, in order to be aware of emission intensive parts of the treatment and to cast light on potential emission and energy savings. In this work, the focus will be on the direct and indirect emissions only, as they are the most relevant to decision making and technology alternatives comparisons.

In this section, the boundaries that will be taken into the carbon footprint calculations will be defined; i.e. which gases are climate change related, and the different emitting elements within/related to the WWT process will discussed.

2.1 Direct emissions

Direct Greenhouse Gases (GHG's) from wastewater treatment plants are gases that escape directly from wastewater into the environment as a result or during physical, chemical or biological process that are related to wastewater treatment and sludge treatment. There are three major GHG's that can come directly from wastewater in the treatment process, they are: methane CH_4, nitrous oxide N_2O, and carbon dioxide CO_2. Carbon dioxide emissions from wastewater were not considered by the IPCC guidelines in the count of carbon footprint as they are generally of biogenic origin; hence their effect is not considered harmful with respect to climate change. However, in the most recent refinement of the IPCC guidelines 2019, they start to recommend to taking a fraction of the CO2 fraction into account as studies show that some wastewater treatment plants contain carbon from fossil origins such as ethanol added to enhance Denitrification, and other trace cosmetics products in wastewater. Yet, these fractions vary quite drastically from one research to the other and exist mostly due to advanced interventions such as pharmaceutical industrial wastewater. Hence, it is most likely that even if this fraction exists in the Egyptian conditions it can be considered negligible and of negligible effect compared to the other emissions.

Nitrous Oxide escapes during both Denitrification and nitrification processes, but in this WWTP there is only Nitrification process happening in both the current plant and future expansions. Nitrification process is an aerobic process where ammonium is oxidized to nitrite, which is then oxidized to nitrate. Nitrous oxide can be emitted due to incomplete reactions due to various factors[1]. Not only that but some nitrous oxide is expected to escape during anaerobic digestion of sludge and also from bio solids when applied as fertilizers for agricultural[2] as the case in Egypt. Nevertheless, emissions from the application of sludge to land are considered within the scope of indirect emissions.

Methane gas forms in WWTP's when anaerobic conditions happens which are almost always concentrated in the sludge digestion system[3]. Methane production is linked with the amount of biochemical oxygen demand BOD or chemical oxygen demand COD in the sludge (the degradable organic material)[4]. Also, as temperature increases so does the rate of methane production; hence it is very relevant to locations with warm climate like Egypt.

Methane can be generated in the primary sedimentation tank when anaerobic conditions happen but that's unlikely in well managed WWTP which is the case in Arab Abu Sa'ed WWTP, where site visits confirmed the non-existence of even foul odors. More prominent source of emission is the drying units of sludge such as belt thickener of the surplus sludge and the primary sludge, and the centrifuge for dewatering the digested sludge or the drying beds. Moreover, the digester itself generating methane can have some methane losses along with the incomplete combustion of gas in the gas engine[5]. Finally further methane emissions could be formed after the effluent flows back into the water body of Al Saff canal or further decomposition of digested sludge, when it is applied for agricultural, but these latter are considered indirect emissions of wastewater treatment plants.

2.2 Indirect emissions

Indirect emissions are related to energy use for the transport and pumping of wastewater, the biological treatment aerators and mixers, heaters for the digester and other electricity needs of the WWTP facility[6]. Also the emissions that result from further disintegration of the remaining pollution in effluent wastewater or indigenous respiration in digested sludge, and the transport of bio solids to their final

[1] Foley, J. & Lant, P., 2007. *Fugitive Greenhouse Gas Emissions from Wastewater systems.* s.l.:Water Services Association of Australia.

[2] De Haas, D., Foley, J. & Barr, K., 2008. *Greenhouse Gas Inventories from WWTPs - the trade-off with nutrient removal.* s.l., The Water Environment Federation-Sustainability 2008 Green Practices for the Water Environment.

[3] Xu, X., 2013. *The Carbon Footprint Analysis of Wastewater Treatment Plants and Nitrous Oxide Emissions from Full-Scale Biological Nitrogen Removal Processes in Spain.* s.l.:Department of Civil and Environmental Engineering-Massachusetts Insitute of Technology.

[4] Doorn, M. R. J. et al., 2006. Chapter 6: Wastewater Treatment and Discharge. In: *Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories.* s.l.:IPCC.

[5] Daelman, M. R. et al., 2012. Methane emission during municipal wastewater treatment. *water r e s e arch,* Volume 46, pp. 3657-3670.

[6] Listowski, A. et al., 2011. Greenhouse Gas (GHG) Emissions from Urban Wastewater System: Future Assessment Framework and Methodology. *Water Sustainability,* 1(1), pp. 113-125.

purpose/dumping place but this transport is out of the scope of Arab Abu Sa'ed WWTP as it is done by external contractors who buy the sludge.

2.3 Boundaries summary

The arriving raw wastewater and the gases that might have formed as a result of the water transport system; according to the IPCC closed sewers are considered an insignificant source of methane. Furthermore, the first step in a WWTP is the pretreatment (screens, sand and grit removal, etc.), which is responsible for removing relatively large bodies from wastewater, are also not considered as significant emissions source. Also, the GHG emissions equivalent caused by the material and the construction of a WWTP are considered very small and negligible if we stretch their effect to the entire life time of the plant[1].

The old IPCC guideline (2006) approach about Nitrous oxide direct emission is very collective and does not assign emissions to specific steps of the treatment process line. Furthermore, there was no mention of emissions from secondary sedimentation tanks in the paper of De Haas2; which takes IPCC guidelines as reference. And also, no significant emissions from both clarifiers were observed in the research of Czepiel3. Hence, for this boundaries of this project it will be justifiably assumed that nitrous oxide emissions from secondary clarifiers negligible. For the sludge treatment line, methane and nitrous oxide are expected to be emitted from the drying and the treatment steps.

Figure 14 shows a schematic diagram of the plant including future extensions, and summarizes the direct emissions expected from each step.

[1] Chai, C. et al., 2015. Carbon Footprint Analyses of Mainstream Wastewater Treatment Technologies under Different Sludge Treatment Scenarios in China. *Water,* Volume 7, pp. 918-938.
[2] de Haas, D. W., Pepperell, C. & Foley, J., 2014. Perspectives on greenhouse gas emission estimates based on Australian wastewater treatment plant operating data. Water Science & Technology, Volume 69, pp. 451-463.
[3] Czepiel, P., Crill, P. & Harriss, R., 1995. Nitrous oxide emissions from municipal wastewater treatment. *Environmental Science and Technology,* 29(9), pp. 2352-2356.

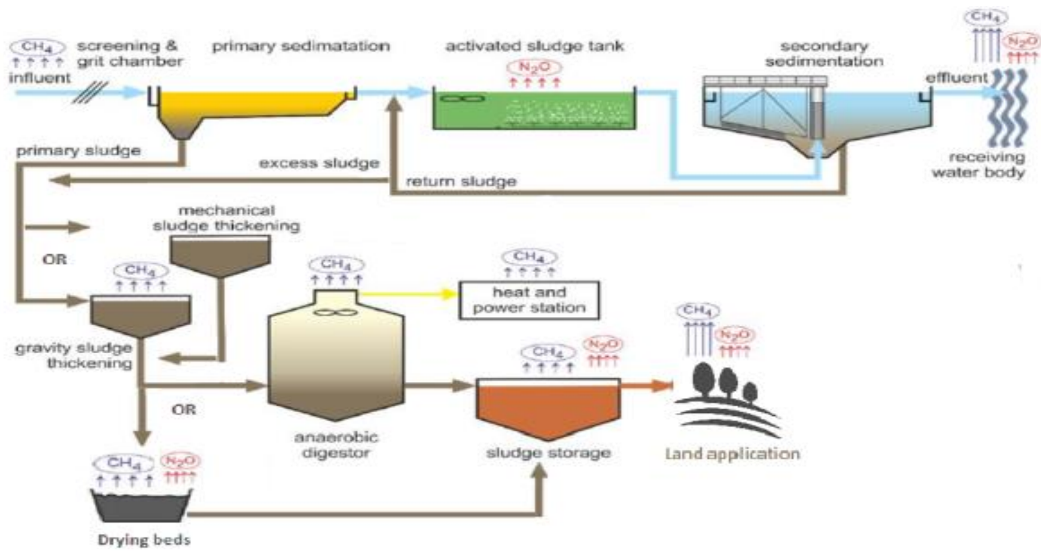


Figure 14: Schematic diagram of the plant with future extensions and summary of the direct emissions expected from each step.

Finally, the indirect emissions of the energy use in the plant, and the last destination of the treated sludge (application in agricultural) and the effluent treated WW to Al Saff canal where further emissions are expected from both.

Figure 15 shows an example of the distribution of energy consumption in WWTP, retrieved from Water Environment Energy Conservation Task Force[1], yet energy data specific to Arab Abu Sa'ed WWTP will be used in this footprint whenever available.

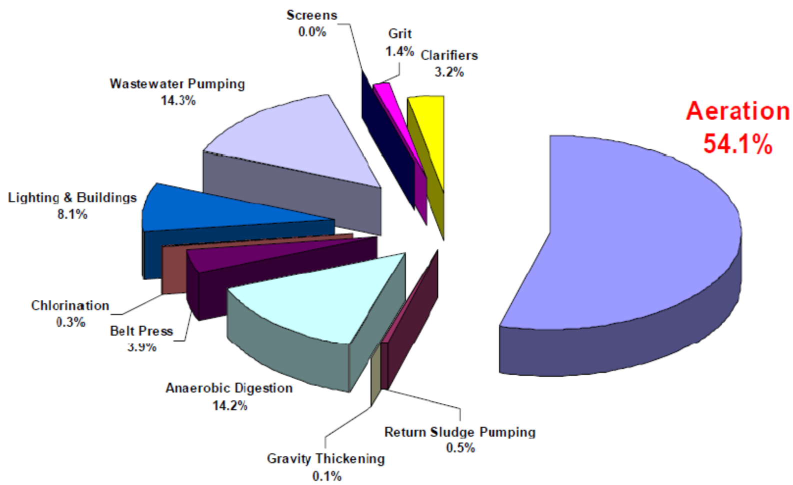


Figure 15: An Example of the distribution of energy consumption in WWTP

3. Methodology

The general methodology of this carbon footprint will take the EIB methodology which depends on IPCC guidelines in calculating the emissions for wastewater handling. The recent EIB methodology mentions IPCC guidelines 2006, but the new refinement of these guidelines published in 2019 renders many methods and factors no more "Good practice" and somewhat holistic and evasive, especially with the new findings obtained by continuous thread of data. Hence, in this work, IPCC refinement 2019 will be the main guideline for the carbon foot print calculations. Parallel to the IPCC guidelines 2019 refinement, literature will be used as aid or to fill any gaps in the required footprint, especially that the carbon footprint is preferred to be done by components. Also, any missing data will be reasonably assumed or estimated. Emission factors suggested can be adjusted within the given range in the IPCC guidelines to better fit the givens of this project. This section will lay out the guidelines and calculation methods used for each step of the wastewater and sludge handling.

[1] Chitikela, S. R. & Ritter, W. F., 2014. *Greenhouse Gas Emissions from Wastewater treatment A Comprehensive Review.*

a. Nitrous Oxide emissions

The latest update of the IPCC guidelines 2019, offers a holistic approach when calculating nitrous oxide emissions. It divides the nitrous oxides emissions into two parts:

1. The Nitrous oxide emissions in sewer networks and from nitrification where N_2O is generated as a by-product. These two sources of emissions where considered minor in the previous IPCC guidelines 2006, but now they are taken into consideration in the refined emission factors. Since various factors such as the temperature and dissolved oxygen concentration of the wastewater, and the specific operational conditions, affect N_2O emissions from wastewater treatment systems, this work will select the factors based on as much similar conditions as possible to the underlying data by reviewing the references given in the IPCC and selecting factors of the most fitting case.
2. Emissions from wastewater treatment effluent discharged into aquatic environments. Such emissions dependent on nutrient level and oxygen status of the aquatic environment receiving the wastewater discharge, in our case, Al Saff canal represents nutrient-impacted water ways.

For Nitrous oxide direct emissions from the both transport system and biological treatment process, the IPCC gives the equation in the following Figure 105:

EQUATION 6.9 (UPDATED)
N_2O EMISSIONS FROM DOMESTIC WASTEWATER TREATMENT PLANTS

$$N_2O\ Plants_{DOM} = \left[\sum_{i,j} \left(U_i \bullet T_{ij} \bullet EF_j \right)\right] \bullet TN_{DOM} \bullet \frac{44}{28}$$

Figure 105: IPCC equation for Nitrous Oxide emissions from domestic WWTP

Where:
N_2O Plants $_{DOM}$ = N_2O emissions from domestic wastewater treatment plants in inventory year, kgN_2O /yr
TN_{DOM} = total nitrogen in domestic wastewater in inventory year, kg N/yr.
U_i = fraction of population in income group i in inventory year.
T_{ij} = degree of utilization of treatment/discharge pathway or system j, for each income group fraction i in inventory year.
i = income group: rural, urban high income and urban low income

j = each treatment/discharge pathway or system
EF_j = emission factor for treatment/discharge pathway or system j, kg N_2O -N/kg N
The factor 44/28 is for the conversion of kg N_2O -N into kg N_2O.

Since we are calculating the Nitrous oxide emissions for one treatment plant and not many treatment plants across a country; we know 100% of the influent flow and nitrogen load is treated inside of this plant by 100% of the served population; hence the factors U_i and T_{ij} are both 100%. And for TN_{DOM} we will take the average reading of the Total Kelda Nitrogen influent concentration and multiply it by the flow rate to can get the total Nitrogen load. The assumption that TKN is representative of TN for the influent flow is reasonable as the occurrence of nitrate or nitrite nitrogen in influent flow to the WWTP is very unlikely. Finally for the emission factor for treatment system the most fitting case in the IPCC tables of factors will be Centralized, aerobic treatment plant and the N_2O emission is variable and can be significant and the recommended EF value is 0.016. Nitrous oxide emissions, for sludge anaerobic treatment, are considered minor by the IPCC and their EF is zero.

The second part of nitrous oxide emissions according to the new IPCC guidelines is the direct emissions due to discharging treated wastewater effluent into a receiving water body (Al Saff canal in our case), the IPCC gives the equation in the following Figure 106:

EQUATION 6.7 (UPDATED)
N_2O EMISSIONS FROM DOMESTIC WASTEWATER EFFLUENT

$$N_2O_{EFFLUENT,DOM} = N_{EFFLUENT,DOM} \bullet EF_{EFFLUENT} \bullet \frac{44}{28}$$

Figure 106: IPCC equation for Nitrous Oxide emissions from Domestic WW effluent

Where:

$N_2O_{EFFLUENT,DOM}$ = N_2O emissions from domestic wastewater effluent in inventory year, kg N_2O /yr
$N_{EFFLUENT,DOM}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr.
$EF_{EFFLUENT}$ = emission factor for N_2O emissions from wastewater discharged to aquatic systems, kg N_2O-N/kg N
The factor 44/28 is the conversion of kg N_2O -N into kg N_2O.

For the $EF_{EFFLUEN}$ the IPCC give two general aquatic discharge environments:

- Freshwater, estuarine, and marine discharge.
- Nutrient-impacted and/or hypoxic freshwater, estuarine, rivers, or locations where stagnant conditions occur, and marine environments.

In the current project, the effluent is discharged in Al Saff canal which generally has no other major contributing discharge besides this effluent, hence the second choice of slow flowing river which can be even stagnant at its end reach or no water at all. The recommended $EF_{EFFLUEN}$ is 0.019.

Since there is no or limited readings on the Nitrogen effluent from the WWTP, the IPCC effluent nitrogen calculation method will be adopted here. The equation is given to get $N_{EFFLUENT,DOM}$ as shown in Figure 107:

EQUATION 6.8 (UPDATED)
TOTAL NITROGEN IN DOMESTIC WASTEWATER EFFLUENT

$$N_{EFFLUENT,DOM} = \sum_{j} \left[(TN_{DOM} \bullet T_j) \bullet \left(1 - N_{REM,j}\right) \right]$$

Figure 107: IPCC equation for total nitrogen in doemstic wastewater effluent

Where:
$N_{EFFLUENT,DOM}$ = total nitrogen in the wastewater effluent discharged to aquatic environments in inventory year, kg N/yr.
TN_{DOM} = total nitrogen in domestic wastewater in inventory year, kg N/yr.
T_j = degree of utilization of treatment system j in inventory year.
j = each wastewater treatment type used in inventory year.
N_{REM} = fraction of total wastewater nitrogen removed during wastewater treatment per treatment type. Where Pathways for N removal include transfer to sludge and nitrification–denitrification with concomitant N loss to the atmosphere.

Again, T_j here will be 100% for this aerobic wastewater treatment plant, adding the digester does not add to Nitrous oxide emissions as mentioned earlier. The T_{NDOM} factor is also like mentioned above. For N_{REM}, we have two cases best fit this project from IPCC guidelines:

- From year 1990 till 2024: we have secondary biological treatment and the recommended factor is 0.40.
- From year 2025 till 2037: we have tertiary advanced biological (filters) treatment and the recommended factor is 0.80.

The final step in nitrogen is the sludge final destination. An increase in the available Nitrogen boosts nitrification and denitrification rates in the soil which then increase the production nitrous oxide. According to the IPCC guidelines, such increase can be due to (among others) the addition of synthetic N fertilizers or organic N applied as fertilizer (e.g., animal manure, compost, sewage sludge). In Arab Abu Sa'ed, so far the sludge was sold wholly to an external contractor which applies further treatment to it and sells it privately. There is a current intention to take advantage of the future increase in sludge quality of Arab Abu Sa'ed's WWTP, hence a better chance of raising its prices and even selling it directly. It is safe to assume that eventually this sludge is most likely going to be applied on agricultural land, so, whether the emissions from the application of sludge on agricultural land will be considered indirect emissions scope 2 or scope 3, the IPCC guidelines gives the equation to calculate nitrous oxide from managed soils shown in Figure 108:

EQUATION 11.1
DIRECT N_2O EMISSIONS FROM MANAGED SOILS (TIER 1)

$$N_2O_{Direct}\text{–}N = N_2O\text{–}N_{N\,inputs} + N_2O\text{–}N_{OS} + N_2O\text{–}N_{PRP}$$

Where:

$$N_2O\text{–}N_{N\,inputs} = \begin{bmatrix} \left[\left(F_{SN} + F_{ON} + F_{CR} + F_{SOM}\right) \bullet EF_1\right] + \\ \left[\left(F_{SN} + F_{ON} + F_{CR} + F_{SOM}\right)_{FR} \bullet EF_{1FR}\right] \end{bmatrix}$$

$$N_2O\text{–}N_{OS} = \begin{bmatrix} \left(F_{OS,CG,Temp} \bullet EF_{2CG,Temp}\right) + \left(F_{OS,CG,Trop} \bullet EF_{2CG,Trop}\right) + \\ \left(F_{OS,F,Temp,NR} \bullet EF_{2F,Temp,NR}\right) + \left(F_{OS,F,Temp,NP} \bullet EF_{2F,Temp,NP}\right) + \\ \left(F_{OS,F,Trop} \bullet EF_{2F,Trop}\right) \end{bmatrix}$$

$$N_2O\text{–}N_{PRP} = \left[\left(F_{PRP,CPP} \bullet EF_{3PRP,CPP}\right) + \left(F_{PRP,SO} \bullet EF_{3PRP,SO}\right)\right]$$

Figure 108: IPCC equations for direct nitrous oxide emissions from managed soils

Where:
N_2O_{Direct}-N = annual direct N_2O–N emissions produced from managed soils, kg N_2O–N /yr
N_2O-$N_{N\ inputs}$ = annual direct N_2O–N emissions from N inputs to managed soils, kg N_2O–N/yr
N_2O-N_{OS}= annual direct N_2O–N emissions from managed organic soils, kg N_2O–N/yr
N_2O-N_{PRP}= annual direct N_2O–N emissions from urine and dung inputs to grazed soils, kg N_2O–N/yr

F_{SN} = annual amount of synthetic fertilizer N applied to soils, kg N/yr
F_{ON} = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils kg N/yr
F_{CR} = annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N/yr
F_{SOM}= annual amount of N in mineral soils that is mineralized, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N/yr
F_{OS} = annual area of managed/drained organic soils, ha (the subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively)
F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr-1 (Note: the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and other animals, respectively)
EF_1 = emission factor for N_2O emissions from N inputs, kg N_2O–N/(kg N input)
EF_{1FR} = is the emission factor for N_2O emissions from N inputs to flooded rice, kg N_2O–N/(kg N input)
EF_2 = emission factor for N_2O emissions from drained/managed organic soils, kg N_2O–N/ha yr
EF_{3PRP} = emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg N_2O–N/(kg N input) (the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)

The only term relevant to the carbon footprint of Arab Abu Sa'ed WWTP is $N_2O\text{-}N_{N\ inputs}$, which is the direct N_2O–N emissions from N inputs to the agricultural land, which is the most probable final destination of the sludge produced by the plant. Also, since the nature of the soil in this area is sandy it is very unlikely to have flooded rice fields, also confirmed from the interview with the local farmers, the crops of summer and winter does not include flooded field rice. Hence the equation will be simplified as shown in Figure 109:

$$N_2O_{Direct}\text{–}N = N_2O\text{–}N_{N\,inputs}$$

Where:

$$N_2O\text{–}N_{N\,inputs} = F_{ON} \bullet EF_1$$

$$N_2O = N_2O\text{–}N \bullet 44/28$$

Figure 109: Simplified IPCC managed soils equations fitting Arab Abu Sa'ed WWTP case

Where:
N_2O_{Direct}-N = annual direct N_2O–N emissions produced from managed soils, kg N_2O–N /yr
$N_2O\text{-}N_{N\ inputs}$ = annual direct N_2O–N emissions from N inputs to managed soils, kg N_2O–N/yr
F_{ON} = annual amount of sewage sludge applied to soils kg N/yr
EF_1 = emission factor for N_2O emissions from N inputs, kg N_2O–N/(kg N input)

EF_1 for N additions from application of sewage sludge in dry climates is given by the IPCC new guidelines as 0.005 [kg N_2O–N/(kg N)].and the input is the amount of Nitrogen in the sludge applied. Typically, treated sludge contains about 1 to 6 percent nitrogen on a dry weight basis (Metcalf and Eddy, 1991;

Dean and Smith, 1973). In this work we will assume 2% N on dry weight basis of the sludge. For the modeling of the future expansion with tertiary treatment, we will assume that the decrease in effluent Nitrogen will be in the sludge removed. Assuming the current quality of effluent is less than 50 mg/l as per Egyptian standards, and given that the tertiary treatment N effluent is 10 mg/l, then an increase of 20% in nitrogen in the sludge removed in the tertiary treatment phase.

There are also indirect nitrous oxide emissions due to sludge application on land which occur through surface runoff that floods the land with sludge applied or water moving in soil and flowing elsewhere. Assuming in the future, if sludge from Arab Abu Sa'ed's WWTP is applied on the land around Al Saff canal the lands are generally sandy and even the last reach of Al Saff canal mostly has no water left. So it is very unlikely that any leaching will go elsewhere than back to Al Saff canal, shallow or deep wells to irrigate lands around Al Saff canal or the cross-sectional drains that exist and will be dug between the agricultural land on the canal's side to capture agricultural drainage water. Or else, there is no further definitive data on the final destination of the sludge (waterways nearby, runoff, ground water flow). So indirect nitrous oxide emissions from managed soils will be only a double calculation or speculations in this case, hence will not be further considered.

Even though it is not among the IPCC recommended emissions calculations, we suggest taking the emissions from the vast areas of drying beds into account. The sludge is stored for many months on a vast area of total 798,000 m^2 (190 feddan). Taking these direct emissions on the premises of the WWTP is more relevant in decision making than, for instance, the sludge application to soil, especially that there are three suggested scenarios of replacing those drying beds by anaerobic sludge digestion. Especially that mechanically dewatered sludge does not need to stay for extensive periods as in drying beds, and the digested sludge quality is much higher than that of drying beds, which means much less emissions are expected to be released. That's, beside the fact that, for the storage of dewatered sludge, a housed stock area can be adopted to minimize fugitive emissions unlike the extensive areas needed for sludge drying beds. Hence, we will assume that the amount of mechanically dewatered sludge will have negligible emissions compared to the drying beds emissions.

In this work, we will be taking the measurements work from Australia of Majumder, et al., 2014 as reference, where they measured emissions from young stockpiles of sludge. From our understanding, the sludge is dried for varying number of months (depends on season) and then stored in stockpiles. Hence, this reference is relevant. The yearly direct emissions for young pile of sludge (<1 year) are: 0.2 kg CO_2-eq/Mg (ton) bio solids year for methane emissions and 60 kg CO_2-eq/ton bio solids year for nitrous oxide[1]. The emissions from those stock piles will be calculated for the baseline and removed by intervals of as more sludge is anaerobically digested according to the three scenarios suggested by Infra engineering assessment. The emission reduction in the different scenarios of replacing more drying beds will be compared to the extra indirect emissions of the mechanical dewatering system replacement in order to be able to make informed comparisons with respect to climate change.

[1] Majumder, R., Livesley, . S. J., Gregory, D. & Arndt, S. K., 2014. Biosolid stockpiles are a significant point source for greenhouse gas emissions. *Journal of Environmental Management,* Volume 143, pp. 34-43.

b. Methane emissions

Anaerobic conditions can form within the treatment system and also the closed conveyance network, which is extensive in this project, increasing the potential for methane generation from an otherwise aerobic system. According to the latest refinement of the IPCC guidelines 2019, methane gas can be generated from wastewater treatment systems through several means. Firstly, wastewater collection and conveyance systems that are closed (either gravity driven or pressurized), can emit dissolved methane upon reaching the aerobic parts of the treatment system. Furthermore, some wastewater treatment process use anaerobic conditions, such as anaerobic sludge digestion as in our case, such processes emit methane. The new IPCC guidelines take into account all sources and sinks (methane recovery) in a wastewater treatment line. The IPCC methane equation is given in the following Figure 110:

EQUATION 6.1 (UPDATED)
CH_4 EMISSIONS FROM DOMESTIC WASTEWATER FOR EACH TREATMENT/DISCHARGE PATHWAY OR SYSTEM, *J*

$$CH_4\ Emissions_j = \left[\left(TOW_j - S_j\right) \bullet EF_j - R_j\right]$$

Figure 110: IPCC equation for methane emissions from WWT systems or discharge pathway

Where:
CH_4 Emissions$_j$ = CH_4 emissions from treatment/discharge pathway or system, j, in inventory year, kg CH_4/yr
TOW_j = organics in wastewater of treatment/discharge pathway or system, j, in inventory year, kg BOD/yr.
S_j = organic component removed from wastewater (in the form of sludge) from treatment/discharge pathway or system, j, in inventory year, kg BOD/yr.
j = each treatment/discharge pathway or system
EF_j = emission factor for treatment/discharge pathway or system, j, kg CH_4/kg BOD.
R_j = amount of CH_4 recovered or flared from treatment/discharge pathway or system, j, in inventory year, kg CH_4/yr. Default value is zero.

For the discharge of treated wastewater, the TOW should reflect the organics in the wastewater as discharged and there is no sludge removal (Sj = 0) and no CH4 recovery (Rj = 0).

The equation for the emission factor for treatment/discharge pathway or system is given in Figure 111:

EQUATION 6.2
CH_4 EMISSION FACTOR FOR
EACH DOMESTIC WASTEWATER TREATMENT/DISCHARGE PATHWAY OR SYSTEM

$$EF_j = B_o \bullet MCF_j$$

Figure 111: IPCC equation for methane emission factors

Where:
EF_j = emission factor, kg CH_4/kg BOD
j = each treatment/discharge pathway or system
B_o = maximum CH_4producing capacity, kg CH_4/kg BOD
MCF_j = methane correction factor (fraction).
Since the digester is not constructed yet and no data is available for the B_o, the default B_o suggested in the IPCC guidelines will be adopted in this work. Same goes for the methane correction factor, where the factor for discharge to reservoirs, lakes, and estuaries Environments (slow flowing water bodies) will be selected which better fits the case in Al Saff Canal, where carbon accumulates in sediments have higher potential for methane generation. Both figures are presented as follows in Table 7 and Table 8:

Table 7: Default maximum methane production

Default maximum CH_4 producing capacity (B_o) for domestic wastewater
0.6 kg CH_4/kg BOD
0.25 kg CH_4/kg COD

Table 8: Methane emission factors

Discharge into slow flowing waters	MCF	EF kg CH_4/kg BOD	EF kg CH_4/kg COD
	0.19	**0.114**	**0.048**
Centralized Aerobic treatment plant	MCF	**EF kg CH_4/kg BOD**	**EF kg CH_4/kg COD**
	0.03	**0.018**	**0.0075**

Since very limited data is available on sludge characterization (the laboratories are waiting for the requested equipment), the IPCC guidelines were further followed to estimate the required sludge data inputs as shown in Figure 112:

EQUATION 6.3B (NEW)
ORGANIC COMPONENT REMOVED AS SLUDGE FROM AEROBIC TREATMENT PLANTS

$$S_{aerobic} = (S_{mass} \bullet K_{rem} \bullet 1000)$$

Figure 112: IPCC equation for organics removed in the form of sludge from aerobic treatment plants

Where:
$S_{aerobic}$ = organic component removed from wastewater (in the form of sludge) in aerobic treatment plants, kg BOD/yr
S_{mass} = amount of raw sludge removed from wastewater treatment as dry mass, tons/year
K_{rem} = sludge factor, kg BOD/kg sludge.
1000 = conversion factor for tons to kilograms

Finally, the emissions from the anaerobic sludge digester, where the focus will be mainly on methane as the IPCC guidelines assume nitrous oxides from digester to be negligible. The following equation is set by the IPCC to calculate methane emissions from the digester as shown in Figure 113:

EQUATION 4.1
CH_4 EMISSIONS FROM BIOLOGICAL TREATMENT

$$CH_4\ Emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3} - R$$

Figure 113: IPCC equation for methane emissions from biological treatment

Where:
CH_4 Emissions = total CH_4 emissions in inventory year, Gg CH_4
M_i = mass of organic waste treated by biological treatment type i, Gg
EF = emission factor for treatment i, g CH_4/kg waste treated
i = composting or anaerobic digestion
R = total amount of CH_4 recovered in inventory year, Gg CH_4 (if these gases are used for energy, then associated emissions should be reported in the Energy Sector, hence, the recovered gas will be expressed only in the indirect emissions savings)

The CH_4 Emission Factors (g CH_4/kg waste treated) is given in the IPCC for anaerobic digester on a dry weight the range given is 0-20, and on wet weight basis the recommended value is 0.8. The underlying assumptions on the waste treated were: 25-50% degradable organic matter (DOC) in dry matter, 2% N in dry matter, moisture content 60%. The emission factors for dry waste are estimated from those for wet waste assuming moisture content of 60% in wet waste. Other reasonable assumptions were made to reach the required inputs. Digestion of the primary and surplus sludge produces 45% biogas (in terms of the COD load in the primary and surplus sludge, i.e. in the digester's influent) that can be used in energy generation in combined heat and power plants (CHPs)[1].

The final methane emissions will be emissions from soil application and methane emissions from the suggestion mentioned above about taking emissions from sludge drying and storage into consideration.

[1] Sewage sludge treatment: evaluation of the energy potential and methane emissions with COD balancing, by C. Schaum; D. Lensch; P.-Y. Bolle; P. Cornel published in Journal of Water Reuse and Desalination (2015) 5 (4): 437–445, 2015.

c. Indirect emissions

Indirect emissions in this project are equivalent to emissions equivalent due to energy consumption. According to the Egyptian Engineering Agencies (EEA) Annual Report 2011, for Cairo Zone electricity grid the custom Emission Factor for EEA Cairo Zone Production is CO2e: EFEEA = 0.5 $kgCO2_e$/kWh. The average electricity consumption of the current situation will be used along with the estimated power consumption of the future expansions, and an extrapolation will be assumed for the power consumption of stage I only. The power consumption is divided into three main components:

- Power consumption of the WWTP.
- Power consumption of the irrigation pumping station.
- Power consumption and production of the future anaerobic digester.

The irrigation pump station's consumption is large, and somewhat won't drastically change from the case in the baseline. Hence, this work will view the irrigation pumping station's emissions separately. Since the digester is still a suggested scenario, no data is available for it, hence, reasonable assumptions will be made depending on the guidelines given by the German Association for Water Management, Sewage and Waste[1].

The only element remaining in the given energy consumption is the energy consumption of the sludge digester and mechanical dewatering system. The following is an approach shown in Equation 1 to calculate energy consumption by the digester to heat the sludge to 38˚C for digestion (DWA, 2015):
Where:

$$E_{heat,fs} = Q_{RS} * \Delta T * e_{spec} \qquad \text{Equation 1}$$

E_{heat} : daily consumption of heat for the digester [kWh/d]
QRS : raw sludge amount [m^3/d]
ΔT : temperature difference between digested sludge and raw sludge [C or K]
e_{spec} : specific energy consumption [kWh/m^3/degree temperature]

For this work we will assume an average yearly temperature of 26°C and digester temperature of 38°C. Finally, a combined heat and power engine CHP is assumed as the means to energy recovery in the anaerobic sludge digester. The CHP unit generates both heat and electrical energy, we will assume the heat energy is used to heat the sludge and the electrical energy is fed into the WWTP network. The following steps are the estimation of the electrical and heat energies according to DWA guidelines; where first the caloric value of the produced gas is calculated as in Equation 2 then based on it the electrical Equation 3 and thermal Equation 4 energies are estimated:

[1] DWA, 2015. Arbeitsblatt DWA-A 216 Energiecheck und Energieanalyse – Instrumente zur Energieoptimierung von Abwasseranlagen [Energy Check and Energy Analysis -Instruments for energy optimization of wastewater facilities], German Association for Water Management, Sewage and Waste.

$$E_{Cv,D.G-production} = Q_{D.G} * Cv * N_{CHP}$$ Equation 2

Where:
$E_{Cv,D.S-production}$: Caloric value of the methane production [kWh/d]
$Q_{D.G}$: amount of methane from digestion [m^3/d]
$C\upsilon$: caloric value of the methane [kWh/m^3]
N_{CHP} : percent of the electrically converted digester gas [-]

$$E_{elec,CHP} = \eta_{elec} * E_{Cv,D.G-production}$$ Equation 3

Where:
$E_{elec,CHP}$: electric energy produced in CHP [kWh/d]
η_{elec} : electrical efficiency of the CHP [-]
$E_{Cv,D.S-production}$: Caloric value of the methane production [kWh/d]

$$E_{th,CHP} = \eta_{th} * E_{Cv,D.G-production}$$ Equation 4

Where:
$E_{th,CHP}$: thermal energy (heat) produced in CHP [kWh/d]
H_{th} : thermal efficiency of the CHP [-]
$E_{Cv,D.S-production}$: Caloric value of the methane production [kWh/d]

$$E_{elec,centrifuge} = Q_{RS} * e_{spec}$$ Equation 5

Where:
$E_{elec,centrifuge}$: energy consumption for sludge dewatering [kWh/d]
Q_{RS}: sludge amount [m^3/d]
e_{spec}: specific energy consumption [kWh/m^3]
In the DWA-216 guidelines (DWA, 2015) the given range of e_{spec} is 1-1.6 kWh/m^3 and since the information needed to determine e_{spec} is not available, we will assume a value on the lower end of the given range as the project will be very modern and high tech is expected.

The assumptions taken in this work are shown in the following Table 9:

Table 9: Assumption to calculate energy production in the digester

Parameter	Adopted value
N_{CHP} [-]	0.9
Cv [kWh/m3]	9.97
η_{elec} [-]	0.5
η_{th} [-]	0.58

The electrical efficiency of the CHP is taken 0.5 as the project is a very modern and such efficiency is much higher than typical past values as the technology is more advanced, same case as in Gabal Al Asfar WWTP; where the energy recovery can reach 75% of the consumption.

d. Emissions timeline and Data input

The following Table 10 summarizes the key inputs in the carbon foot print model of Helwan WWT system, baseline and future expansion scenarios. The baseline is subdivided into two stages, stage I and stage II, while the future expansions are predicted to commence operation in 2024 and the carbon foot print will be modeled till 2037. The three sludge treatment scenarios are:

- **Scenario 1** : Anaerobic Digestion for only 250,000 m^3/day , mechanical dewatering for sludge produced from the extension of 250,000 m^3/day + one third of the mixed sludge produced from the existing WWTP (550,000 m^3/day)
- **Scenario 2**: Anaerobic Digestion for 800,000 m^3/day , mechanical dewatering for sludge produced from the extension of 250,000 m^3/day + one third of the mixed sludge produced from the existing thickeners of the current WWTP (550,000 m^3/day)
- **Scenario 3**: Anaerobic Digestion for 800,000 m^3/day, mechanical dewatering for sludge produced from the extension of 250,000 m^3/day+ all mixed sludge produced from the existing thickeners of the current WWTP (550,000 m^3/day)

Table 10: summary of key inputs in carbon footprint model

	1990-2010 (1st stage)	2010-2024 (1st+2nd stage)	2024-2037 (Future extensions)
Served population capita	~1 million	1.6 million	2.25 million 2,368,584 (2037)
Design capacity WWT	350,000 m^3/day	(+200,000 m^3/day) 550,000 m^3/day	(+250,000 m^3/day) 800,000 m^3/day
Real / expected flow	-	661,822 m^3/day (2020)	847,525 m^3/day (2037)
Treatment	Secondary treatment	Secondary treatment	Tertiary treatment
Sludge to thickening/ dewatering kg/d	182,888 (estimated)	287,395 (given data)	114,152 (250,000 m^3/d extension) 401,547 (Total/ given data)
Sludge treatment	Thickening tanks, Drying beds	Thickening tanks, Drying beds	Scenario 1:Anaerobic Digestion 250,000 m^3/day, mechanical dewatering 250,000 m^3/day + one third of the mixed sludge produced from the existing WWTP (550,000 m^3/day)
			Scenario 2: Anaerobic Digestion 800,000 m^3/day, mechanical dewatering 250,000 m^3/day + one third of the mixed sludge produced from the existing WWTP
			Scenario 3: Anaerobic Digestion 800,000 m^3/day, mechanical dewatering 250,000 m^3/day + all of the mixed sludge produced from the existing WWTP (550,000 m^3/day)
Sludge drying beds	(64% A_{total}) 121.6 feddan	A_{total}(A1+A2+A3) 190 feddan	Scenario 1: (-A2) 131.7 feddan
			Scenario 2: (-A2) 131.7 feddan
			Scenario 3: 0
Irrigation pump station flow m^3/d	350,000	550,000	800,000
Average total power consumed	14,284 kW/year	22,446 kW/year	40,402 kW/year (without energy recovery)

4. Results

The model was year step based, from year 1990 till 2037. Missing data was assumed by proportion of the available data. The following section will illustrate the carbon footprint model results. Generally, more direct emissions are expected to occur per year due to the increase in WW flow rates. Also, Due to the upgrade in technology of WW treatment, it is expected that more nitrogen will be removed in the sludge, hence, more nitrous oxide emissions from the sludge land applications. Note that the WW flow input were the design values only, for when the model was built with actual flow and interpolations, the trends in the change in carbon footprint were confusing and not clearly visible. Hence, working with the design flows is very helpful in both decision making and assumptions formulation.

4.1 Direct emissions

Table 11 summarizes the different direct emissions results from Arab Abu Sa'ed WWTP, for the different stages and scenarios of the project, both cumulative emissions in ton CO_2 equivalent during each period of the project's stages and the emissions equivalent of the average one year (yearly) during the corresponding period of each project's stage. This representation in results can show both the total emissions and the trend in emissions for better comparisons. Note that the three scenarios suggested will not affect the nitrous oxide emissions, only the methane ones. The only difference in direct emissions between scenario 2 and 3 will appear in the amount of sludge in drying beds and storage piles. The sum results are done twice: once that includes only IPCC guidelines scopes (no storage emissions) and another with the all emissions elements including the storage and drying beds (SDB). The recovered methane in the three scenarios is going to be used to generate thermal and electric energy, hence, according to the IPCC guidelines, it will be integrated in the energy section (here the indirect emissions). Also, it I important to note that, even though soil application emissions are part of the IPCC scope; in Arab Abu Sa'ed's project case the sludge is sold to private contractors, whose activity is only restricted by the Egyptian law and not by the WWTP, i.e sludge can be used in a variety of activities. Hence, the sludge soil application emissions will be estimated theoretically but will not be summed in the total emissions for the later reasons and also because in Arab Abu Sa'ed WWTP they are considered scope III emissions and are not obligated to be reported by the WWTP, but to be reported by the contractors themselves according to the application the sludge will be used for.

Table 11: Summary of Direct emissions results

Emissions ton CO_2 equivalent	1990-2009	2010-2023	2024-2037		
			Scenario 1	Scenario 2	Scenario3
N_2O - WWTP					
Cumulative period	5,958	6,554	9,533	9,533	9,533
Average yearly	298	468	681	681	681
N_2O - Effluent					
Cumulative period	68,706	75,577	48,858	48,858	48,858
Average yearly	3,435	5,398	3,490	3,490	3,490
N_2O - soil Application					
Cumulative period	14,623	16,085	22,474	22,474	22,474
Average yearly	731	1,149	1,605	1,605	1,605
CH_4 - WWTP					
Cumulative period	19,485	33,420	13,928	13,928	13,928
Average yearly	974	2,387	995	995	995
CH_4 - Effluent					
Cumulative period	6,367	7,004	8,150	8,150	8,150
Average yearly	318	500	582	582	582
CH_4 - Digester					
Cumulative period	-	-	15,020	28,727	28,727
Average yearly	-	-	1,073	2,052	2,052
yearly average of					
All N_2O emissions	4,464	7,015	5,776	5,776	5,776
All CH_4 emissions	1,293	2,887	2,650	3,629	3,629
N_2O+ CH_4 (without SDB)					
Total (Yearly average)	5,026	8,754	6,821	7,800	7,800
Total cumulative	100,517	122,555	95,488	109,195	109,195
N_2O Storage + drying beds					
Cumulative period	50,038	57,939	38,626	38,626	-
Average yearly	2,634	4,138	2,759	2,759	-
CH_4 Storage + drying beds					
Cumulative period	167	193	129	129	-
Average yearly	9	14	9	9	-
SBD sum (N_2O+ CH_4)					
Sum cumulative	50,205	58,132	38,755	38,755	-
Sum Yearly average	2,642	4,152	2,768	2,768	-

N2O+ CH4 (with SDB)					
Total (Yearly average)	7,668	12,906	9,589	10,568	7,800
Total cumulative	150,722	180,687	134,243	147,950	109,195

4.2 Indirect emissions

In this section emissions equivalent due to energy use, which is generated by the consumption of fossil fuel mainly, will be displayed in Table 12. Note that the total and net energy consumption of the WWTP is displayed separately from the energy consumption of the irrigation pumping station, for better comparisons of alternatives and clearer understanding of the effect of the WWT scenario settings on the carbon footprint. An assumption of 16 working hours a day and 365 working days was made in converting kW to kWh, and the percent savings of the energy in scenario 1 compared to only the new extension energy consumption was 60%, **which matches the updated cost study report**. Note that the additional mechanical dewatering of sludge energy consumption is only added to Scenario 2 and 3 as it was already included in the given data for the first scenario.

Table 12: Summary of indirect emissions results

Emissions ton CO_2 equivalent	1990-2009	2010-2023	2024-2037		
			Scenario 1	Scenario 2	Scenario3
Energy consumption WWTP					
Cumulative period	834,158	917,574	1,646,673	1,646,673	1,672,630
Average yearly	41,708	65,541	117,620	117,620	119,474
Energy consumption Irrigation P.S					
Cumulative period	1,160,617	1,276,678	1,856,987	1,856,987	1,856,987
Average yearly	58,031	91,191	132,642	132,642	132,642
Thermal Energy consumption digester					
Cumulative period	-	-	142,440	361,311	361,311
Average yearly	-	-	10,174	25,808	25,808
Thermal Energy Production digester					
Cumulative period	-	-	437,779	837,288	837,288
Average yearly	-	-	31,270	59,806	59,806
Net thermal energy	-	-	"+ ve"	"+ ve"	"+ ve"
Recovered Methane (m^3/year)	-	-	13,939,566	26,660,548	26,660,548
Electric Energy Production digester					
Cumulative period	-	-	437,779	837,288	837,288
Average yearly	-	-	31,270	59,806	59,806
Net Energy (without Irrig. P.S)					
Cumulative period	834,158	917,574	1,208,894	809,386	835,342

Yearly Net average	41,708	65,541	86,350	57,813	59,667
% Yearly Energy Savings (WWTP without Irrig. P.S)	-	-	27	50.8	50.1
Net Energy (With irrigation PS.)					
Cumulative period	1,994,775	2,194,252	3,503,660	3,503,660	3,529,616
Yearly Net average	99,739	156,732	218,992	190,455	192,309

4.3 Total emissions and collective Carbon footprint

The following Table 13 summarizes the total carbon footprint results of Arab Abu Sa'ed WWTP project.

Table 13: Total carbon footprint results of Arab Abu Sa'ed WWTP project

Emissions ton CO_2 equivalent	1990-2009	2010-2023	2024-2037		
			Scenario 1	Scenario 2	Scenario3
Total Direct Emissions					
Cumulative period	150,722	180,687	134,243	147,950	109,195
Average yearly	7,668	12,906	9,589	10,568	7,800
Total Indirect Emissions					
Cumulative period	1,994,775	2,194,252	3,503,660	3,503,660	3,529,616
Average yearly	99,739	156,732	218,992	190,455	192,309
Total Carbon Footprint WWTP + Irrig. PS.					
Cumulative period	2,145,496	2,374,939	3,637,903	3,651,610	3,638,811
Average yearly	107,407	169,639	228,580	201,023	200,109

5. Verification and Discussion

This section will compare the results of the carbon footprint model of Arab Abu Sa'ed WWTP and system with similar Projects results. The results will then be further discussed and analyzed in order to draw conclusions which will help set recommendations for further decision making.

5.1 Verification

In their work Wang et. al[64], they presented a typical electricity intensity and GHG emission (of energy use) of WWTP's in the United Stated of America by studying many WWTP with different capacities ranging from approximately 14,000 m^3/day to the largest WWTP review with capacity within the range of Arab Abu Sa'ed WWTP of 1000,000 m^3/day. The following Figure 25 shows the emission factors of energy use of these plants and the emission factor of Arab Abu Sa'ed WWTP that was resulted by modeling its carbon footprint.

[64] Comparative analysis of energy intensity and carbon emissions in wastewater treatment in USA, Germany, China and South Africa, 2016.

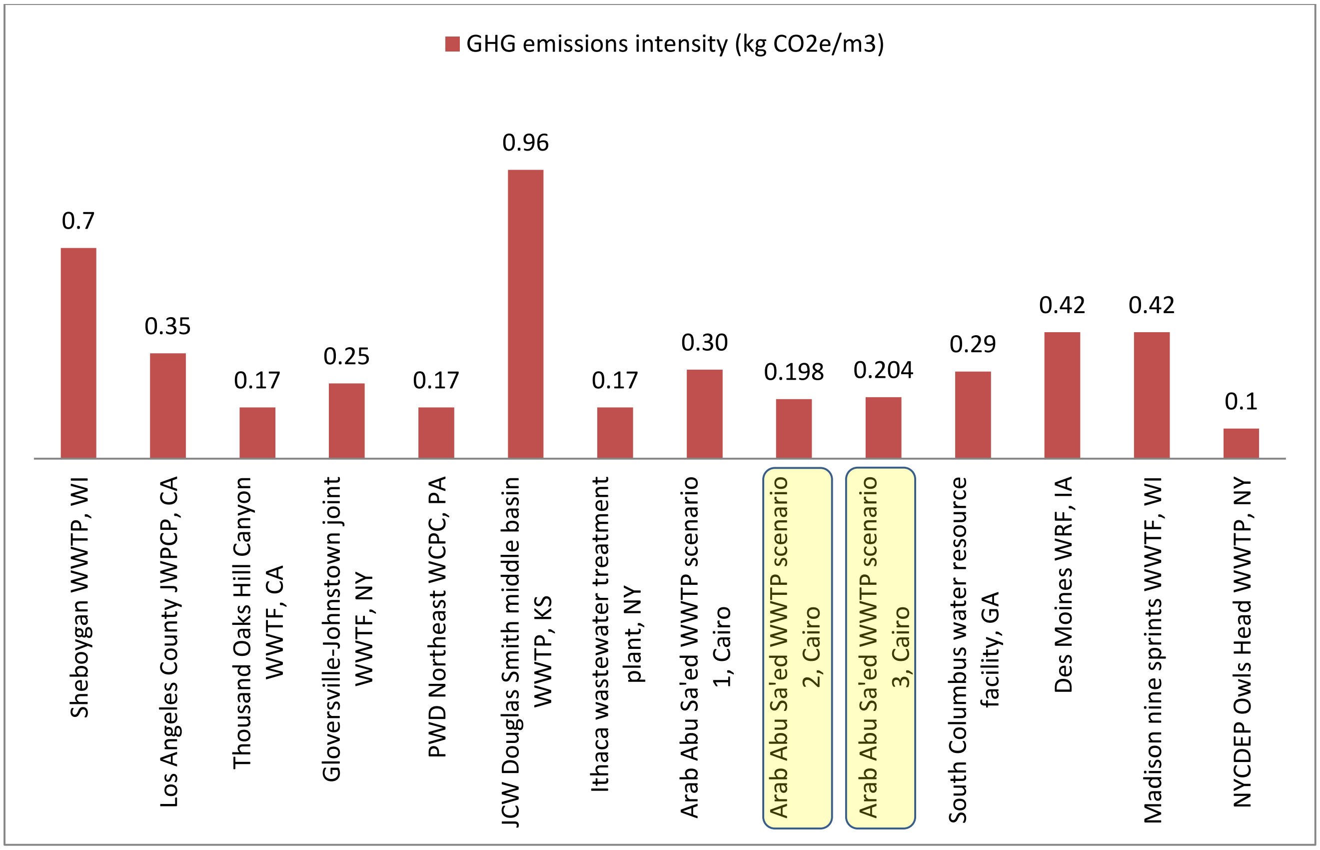


Figure 25: Comparison of energy emissions equivalent per treated m3 of sample WWTP in the USA and Arab Abu Sa'ed WWTP scenario 1 and 3

It is apparent that the results fall well inside the emission factors of the other studied WWTP's, note that scenario 3 has much less energy intensity than scenario 1, where scenario 3 is with all the WWTP sludge load anaerobically digested against only the new extension's sludge in scenario 1. They also illustrated electricity intensity and GHG emission of typical technologies in South Africa, the activated sludge system was of an average of 0.33 kg CO_2e/m^3 of treated wastewater, which is very close to the results of the two scenarios 1 and 3 of Arab Abu Sa'ed WWTP of 0.3 and 0.2 kg CO_2e/m^3 respectively.

Another comparison is with the very recent work of Gómez-Llanos and the other authors 2020[65], where they assessed the carbon footprint (IPCC guidelines were utilized among others) and water footprint of four activated sludge WWTP with and without anaerobic digestion in Spain, the BOD load of the plants ranges from approximately 220 to 100 mg/l. the following Table 14 shows carbon dioxide equivalent per m^3 of treated wastewater for the four assessed plants and Arab Abu Sa'ed WWTP scenario 1 and 3.

[65] Wastewater treatment plants assessment by quantifying the carbon and water footprint, Eva Gómez-Llanos, Agustín Matías-Sánchez and Pablo Durán-Barroso, 2020.

Table 14: Carbon Dioxide equivalent per treated m^3 of sample WWTPs from spain compared to Arab Abu Sa'ed WWTP scenario 1 and 3

WWTP	Yearly average kg CO_{2eq}/m^3
Cuacos	0.39
Tejeda	0.22
Villanueva	0.27
Torremenga	0.26
Arab Abu Sa'ed scenario 1	0.33
Arab Abu Sa'ed scenario 3	0.23

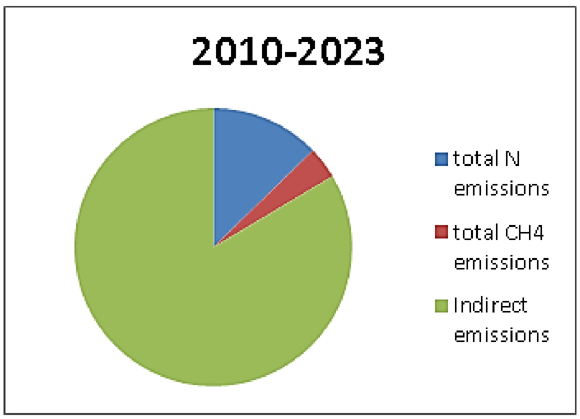
The model of the carbon footprint with the initial assumptions mentioned above was modified within the suggested ranges of factors to give better fit into similar projects' results. Hence, we can deduce that the current model of the carbon footprint is relevant and the carbon footprint results fits within the range of findings of other WWTP projects.

6. Conclusions and recommendations

This section will look with more depth into the results of the carbon footprint of Arab Abu Sa'ed WWTP and draw conclusions based on that, to be able to finally suggest future recommendations that can aid in decision making.

6.1 Discussion

The following pie charts in Figure 26 indicate that indirect emissions are the dominant emissions source in both current situation and future plans. This fact emphasizes that savings in energy consumption, i.e. energy recovery using anaerobic digestion will have great impact on the emissions in total.



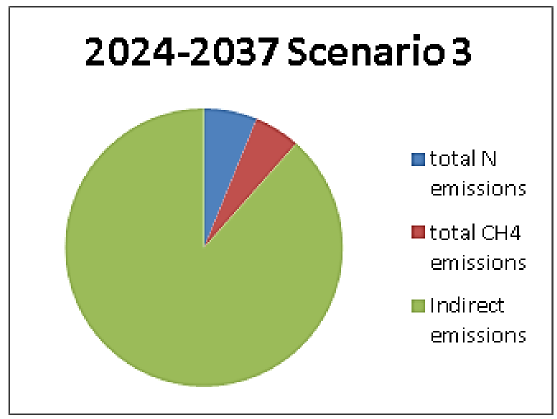


Figure 26: Percent distribution of bulk emission sources for the present and future plans

The following Figure 27**Error! Reference source not found.** illustrates the average yearly CO_2 equivalent direct emissions in tons. The effluent emissions factors were adjusted for better fit, for both the nitrous oxide and the methane, were the lowest factors of the suggested range of the IPCC guidelines were applied. We can note that emissions equivalent due to nitrous oxide are the most dominant in all the WWTP stages. Also, effluent emissions from both nitrous oxide and methane both declined sharply with the new extensions even though there was a drastic increase in flow rate and hence the loads. This is due to the decrease in pollutant load in the effluent due to the tertiary treatment.

Another very important finding is that the drying beds and storage piles can represent a significant emissions source, especially nitrous oxides. Scenario 3 of future extensions, which suggests all the sludge to be mechanically dewatered then anaerobically digested, has significantly lower direct emissions due to the removal of drying beds. Furthermore, the emissions from the digester were relatively high for escape emissions when calculated with the initial emissions factor, hence, a smaller emission factor of 0.5 g CH_4/kg waste treated was applied, which is very relevant to the slip emission factor given by Daelman, 2014[66] work of 0.8% kg CH_4 /kg $COD_{digester}$.

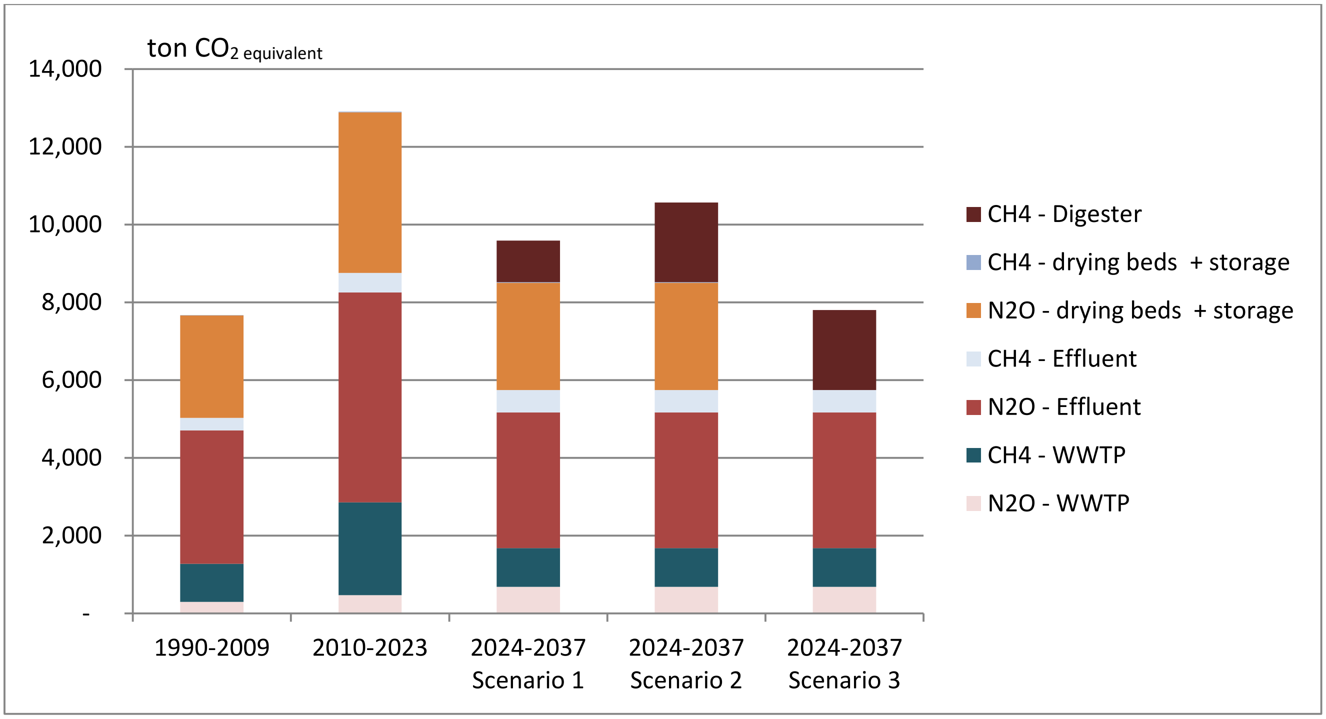


Figure 27: Average Yearly direct emissions in tons CO2 equivalent

For the indirect emissions, the following **Error! Reference source not found.**Figure 28 shows that the irrigation pumping station is a major energy consumer. If we set this consumer aside, it is very apparent that energy recovery (will be subtracted in later figure) has caused tremendous cut on energy consumption from grid (27%, 50.8% and 50.1% of energy savings compared to WWTP consumption without irrigation pump station in scenario 1, 2 and 3 respectively).

[66] DAELMAN, M. R. J., 2014. Emissions of methane and nitrous oxide from full-scale municipal wastewater treatment plants, s.l.: Delft University of Technology.

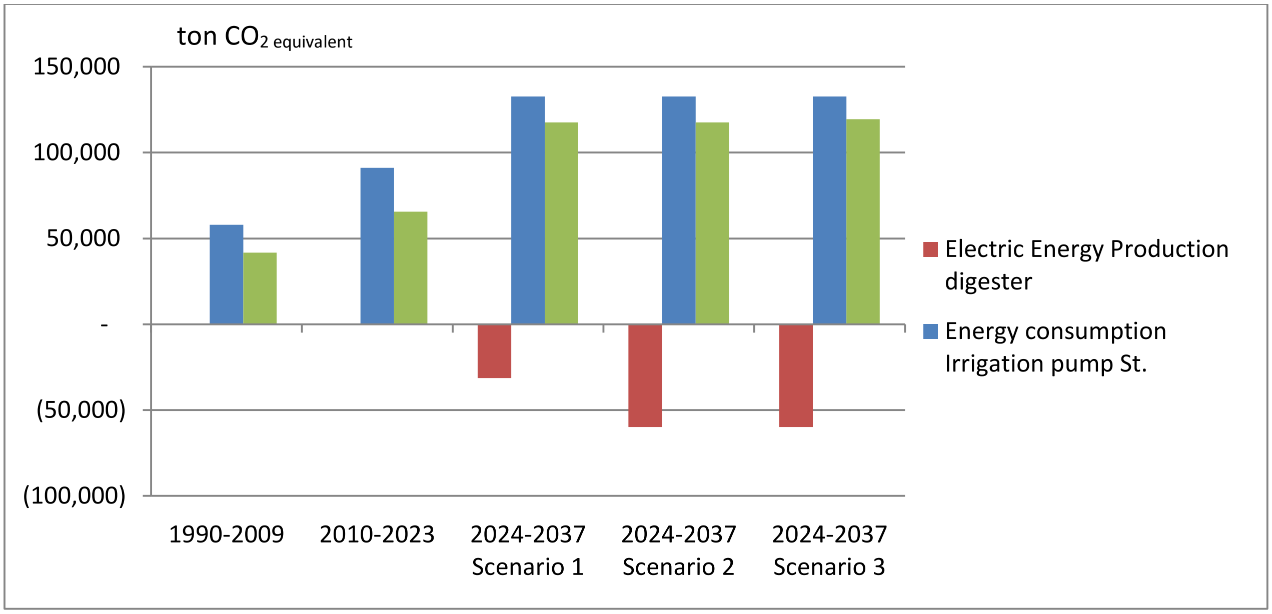


Figure 28: Average yearly indirect emissions due to energy consumption and production in Arab Abu Sa'ed WWTP

Another result worth mentioning is the fact that shifting from sludge drying beds to mechanical dewatering is also a shift from one form of emissions that is direct and is typically very difficult to control, to the indirect emissions which can be further reduced with energy recovery and renewable energy reuse. Not only that but also, completely replacing the sludge drying beds and storage by mechanical dewatering will reduce the emissions equivalent of the sludge dewatering process to more than half as shown in the following Figure 29.

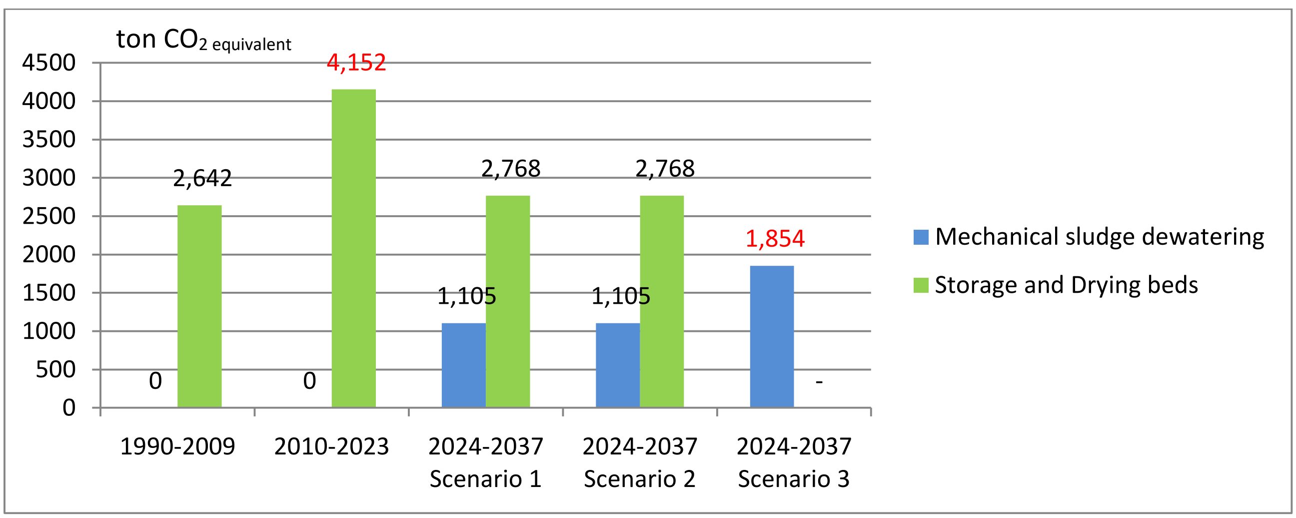


Figure 29: Emissions equivalent comparison SDB vs. Mechanical sludge dewatering

The thermal energy consumed and produced by the digester shown in Figure 119, where the thermal energy consumed is always much less than the thermal energy produced by the digester, this might be due to several reasons: that the temperature difference most of the year in Egypt is on average not very large, and the fact that heat efficiency is much high than electrical efficiency in the CHP.

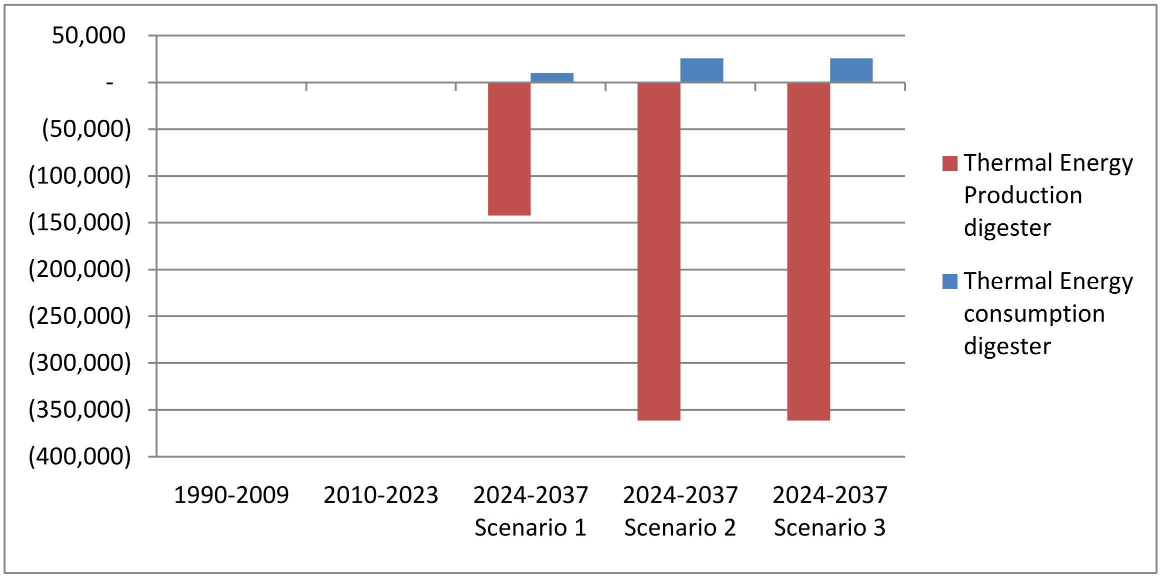


Figure 119: Thermal energy consumption and production in the digester

The following Figure 31 illustrates the indirect emissions due to energy consumption in the WWTP only without the irrigation pump station and without the thermal energy consumption and production by the digester. It is very clear that emissions were lowered significantly (halved in scenario 2 and 3) with energy recovery using anaerobic sludge digestion.

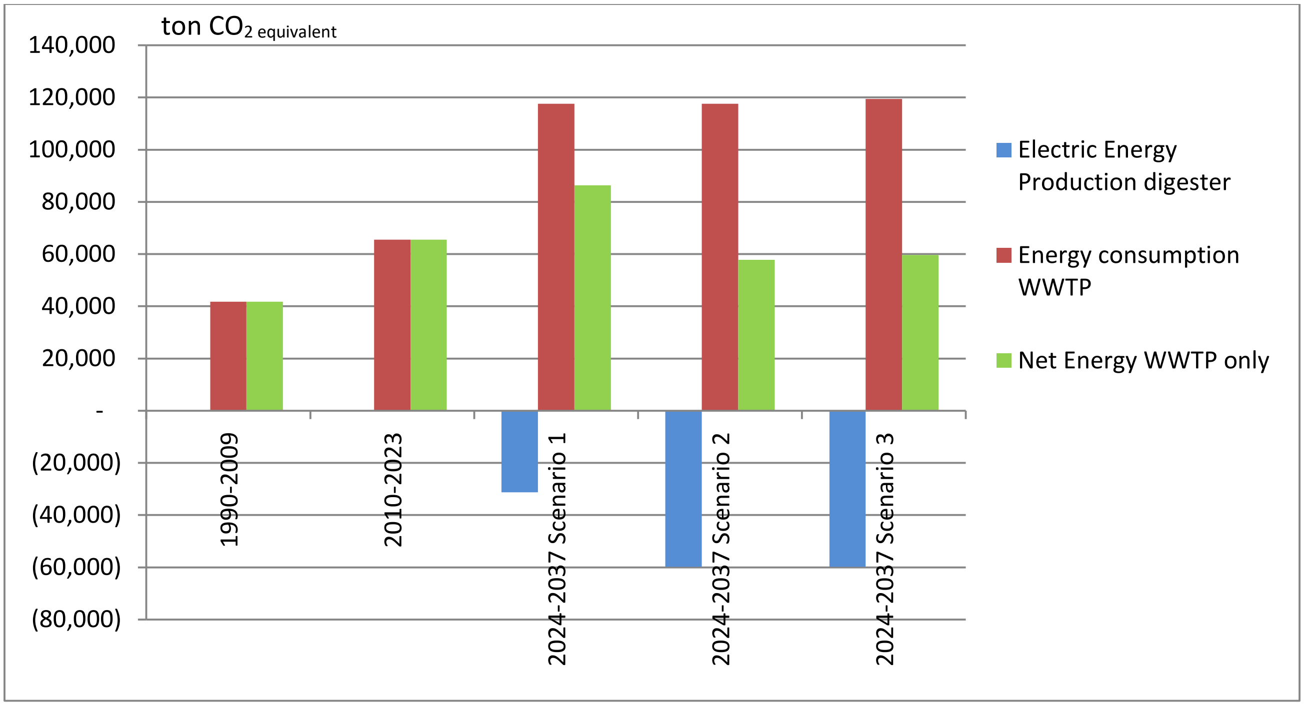


Figure 31: Indirect emissions due to electric energy consumption and production in the WWTP only and net electric energy

For the total general comparison as shown in Figure 32, the major emission source is the energy use, that's why there has been a drastic decline in the indirect emissions when introducing the digester, especially the full plant capacity energy recovery. Nitrous oxides are the second major emissions gas followed by the methane. Even though the flow has increased in the last three scenarios, the emissions decreased that's due to two major causes:

1. The introduction of energy recovery by sludge digestion.
2. Introduction of tertiary treatment which decreased the effluent emissions greatly.
3. The removal of the extensive sludge drying beds impacted a remarkable decrease in nitrous oxide emissions.

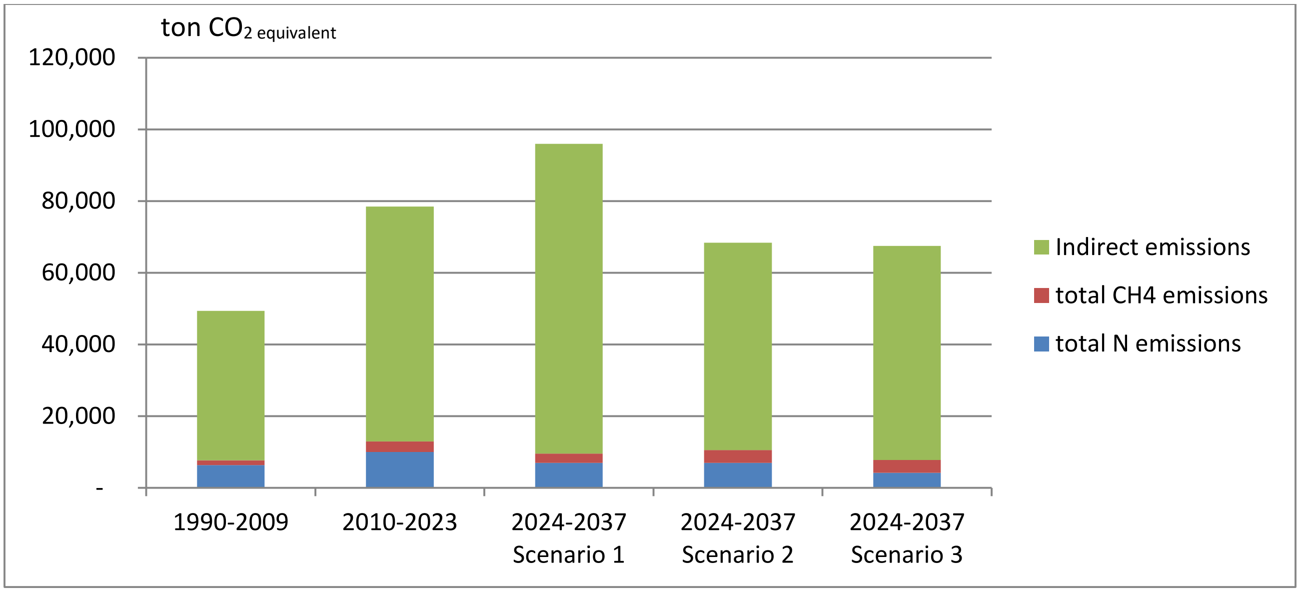


Figure 32: Total average yearly direct and indirect emissions Arab Abu Sa'ed WWTP

Finally, as shown in Figure 33 below, the total plant emissions per served population (carbon dioxide equivalent per capita) is drastically decreasing due to the introduction of the future expansions, with the digester and the tertiary treatment.

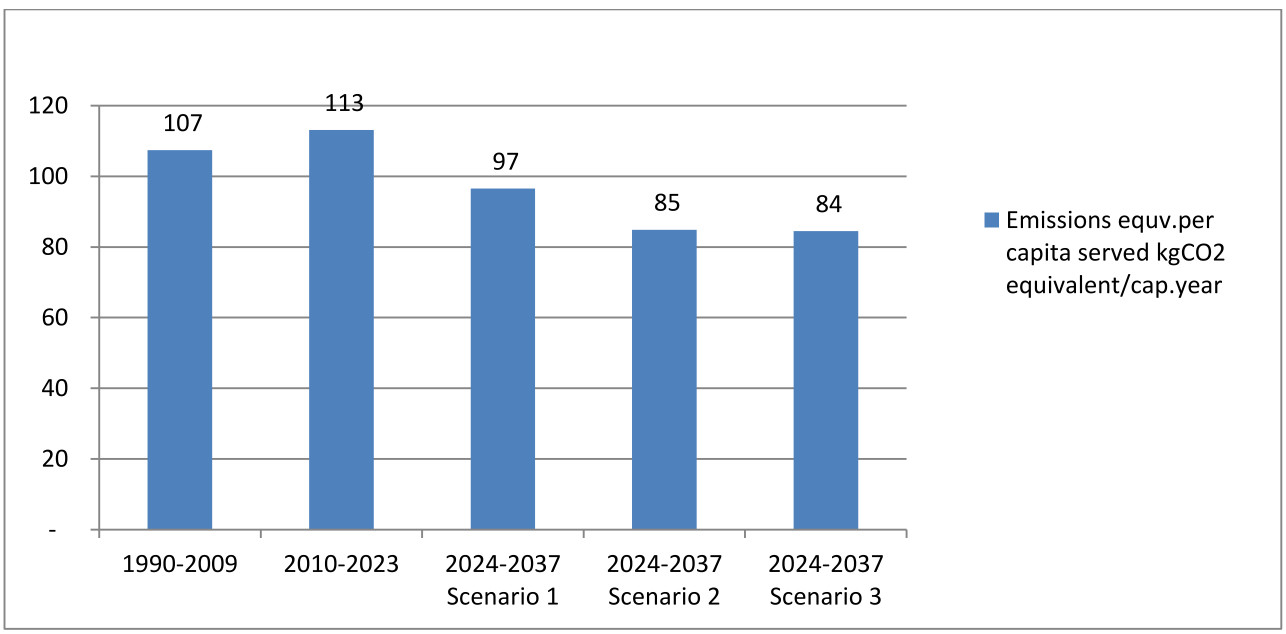


Figure 33: Emissions per capita served of Arab Abu Sa'ed WWTP present and future plans

6.2 Recommendations

Carbon footprint is a very effective tool in decision making process. After reviewing the result of this carbon foot print model of Arab Abu Sa'ed WWTP we can draw several recommendations:

1. The introduction of the anaerobic sludge digestion is a very effective tool in both emission reduction and sludge quality treatment. Egypt is already in the strategic direction of applying such technology to major wastewater treatment plants, and has already been successful operating digestion for decades in Al Gabal Al Asfar WWTP and other major WWTP such as Alexandria WWTP.
2. The replacement of sludge drying beds is recommended, not only due to its technical difficulties in operation and maintenance and its low final sludge quality. It is also proved that it has major impact on nitrous oxide direct emissions. The replacement of the drying beds along with the introduction of the digesters can be easily implemented gradually, where one third of the capacity can be dewatered mechanically and demolishing its drying beds while a digester for each next one third of the capacity of the plant and so on. This will help in gradually accomplishing capacity building and allows being able to observe the results and predict further outcomes for future decisions.
3. Tertiary treatment is highly needed to raise the quality of the effluent treated wastewater and is considered a very good decision not only emission wise but also for the economical and agricultural future of the area.

Annex III

Climate Change Resiliency and Vulnerability Assessment

1. Introduction

Global average temperature has been in an increasing trend throughout the past century. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), climate has been has been changing significantly, where the global average temperature in the period between year 1880 till 2012 has increased by 0.85°C, and the mean average annual temperature in the period between year 2003 till 2012 has increased by 0.78°C compared with the period between year 1850–1900. Furthermore, the global temperatures projections are in a rising trend.

Climate change has its various tangible influences represented in more frequent and intense extreme events such as rainfall, storms, draught. Not only did the natural disasters increase in intensity and frequency, but also, human exposure and vulnerability, with both the developmental and societal aspects, have increased. All of those factors combined have led to an increase in economic damage and life loss/injuries. Hence, climate change aspects of any project have become a prerequisite for sustainable development.

The Arab Republic of Egypt is one of the countries which are directly affected by climate change. Egypt occupies large area, but not vast enough to have extremely diverse climate; as it can be subdivided into 3 general type of regions: inland Deserts areas, Coasts and coastlines and Nile riverine. Each region is with distinct regional economic characteristics, and there are economic and climatic gaps between regions. Therefore, each region faces differing challenges caused by climate change; and each region needs its own strategies to cope with the changes and effects.

The Climate resiliency and vulnerability assessment aims at developing resilient wastewater infra-structure against the changing climate. In order to be able to do that, the vulnerable elements of the project will be identified and which threat is facing each item. The first step will be to assess the relevant baseline conditions and trends of the climatic aspects of the region such as:

- Temperature increase
- Precipitation
- Sea level rise (when relevant)
- Wind (when relevant)

Climate change impacts the entire water system including water availability, and the quality and maintenance of water supply, wastewater conveyance networks, and wastewater treatment plants/systems. The more relevant impacts of climate change to the latter systems are (among others): heat waves, cold events, changing precipitation patterns, and increase in the number and duration of droughts and floods. And the risks posed on the infra-structure of the project can be of the following examples when relevant:

- Power outages during peak demand which can cause property or equipment damage.
- Severe Drought.

- More Frequent & Intense Wild Fires.
- Landslides.
- Emergency Fuel Depletion.
- Localized Flooding which can cause erosion, which can in term limit accessibility and cause inundation.
- Coastal Flooding, High Tides, Storm Surges (If relevant)
- Prolonged Power Outage or Lack of Fuel which can cause process disruption and quality deterioration.

The climate change aspects of this project are assessed in this part of the report to minimize the risk of significant negative climate change impacts and illustrate the positive impact of the project in the aspect of adaptation to climate change, as follows:

1. The observed climate change trends in the area of the project (Cairo).
2. The impacts and potential consequence of the active climate change aspects on the project (the waste water control system, the water resource protection activities and other project activities).
3. Suggest adaptation measures for identified key risks.

4. Climate change in the project area

Generally the Egyptian climate is hot desert climate in summers which start from May till October and mild winters start from November till April. Generally, an amount between 20 mm to 200 mm of annual precipitation averagely falls along the Mediterranean coasts of Egypt. Not only temperature rise has been observed over the past decades, but also a significant rise in extreme weather events over the last ten years has caused economic loss and human casualties[67]. This rise in temperature and increase in intensity and frequency of extreme events could happen faster in Egypt than at a global scale, hence Egypt is considered a potential climate change hot-spot[68].

The project consists of the wastewater conveyance network and the wastewater treatment plant(s). The network extends from Maadi all the way down to Helwan and beyond, while the wastewater treatment plant of Arab Abu Sa'ed is in Helwan and the potential future plant of Al Kurimat lies on the desert road further south. From this geographic context we can assume that the project is within the Greater Cairo region and follows similarly its climatic conditions.

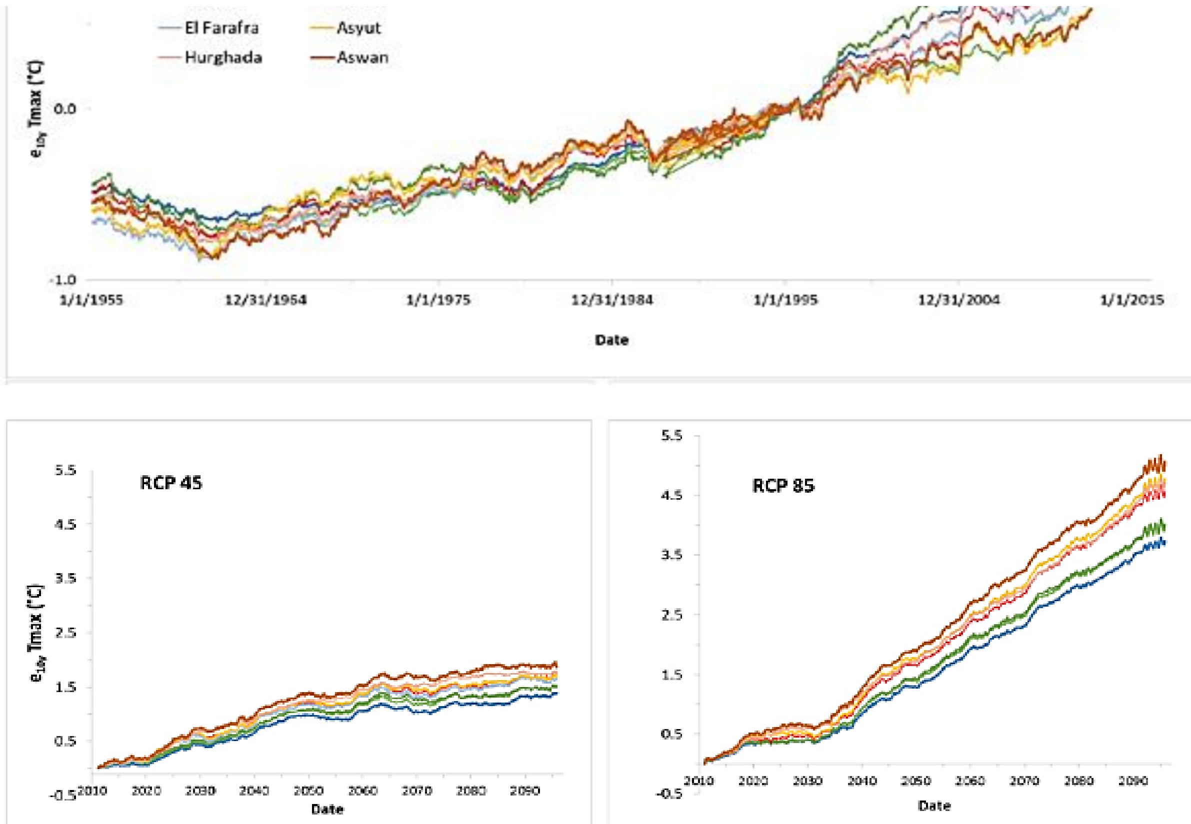
4.1 Temperature

Temperatures vary extensively in the non-coastal desert inland regions, where in summer; they range from 7°C at night to 43°C during the day. While in winter, the temperatures variation in the inland region is less, yet they can be as low as 0°C at night and as high as 18°C during the day. Over the years, increase in temperature trends was observed. **Error! Reference source not found.** shows annual trends of temperature in Cairo 1990 and 2015[1].

Researchers also studied historical data and the trend Results of the analysis of the data of the 1980–2017 period are shown in **Error! Reference source not found.**, where the slopes of the T_{max} trends are expressed in ^oC per decade ($^oC/10y$). The researchers also used models to predict future temperature trends in two climate change scenarios: RCP4.5 and RCP8.5 scenarios, where the first represents a future where climate policies limit and achieve stabilization of greenhouse gas concentrations by 2100 and the latter is the business-as-usual scenario, where high emissions of greenhouse gases continue in the absence of climate change policies[2].

[67] Egypt's First Biennial Update Report to the United Nations Framework Convention on Climate Change, Published by Ministry of Environment, Egyptian Environmental Affairs Agency, 2018.
[68] Past (1950–2017) and future (--2100) temperature and precipitation trends in Egypt, Amira N. Mostafa, et. al., Journal of Weather and Climate Extremes, 2019.

Figure 123: Past (upper panel) and future (lower panels) temporal evolution of the Tmax anomalies at the 8 sites of the mentioned study. The decade of reference is 1990–1999 for the past period and 2006–2015 for the future.



So it is clear that there is a temperature rise trend that is occurring currently and in the future in the project's area.

4.2 Precipitation

Generally Egypt is dominated by arid desert climate and does not receive rain; rainfall is more concentrated over Alexandria and Rafah. **Error! Reference source not found.** shows annual trends of rainfall on Cairo 1990 and 2015. Researcher also analyzed past data of rain fall and no significant trend in rainfall was observed. On the contrary to that, when assessing the two climate scenarios for future predictions; a significant decrease in the annual precipitation over Cairo is predicted, under the worst case scenario RCP8.5, of (-0.22) mm/year.

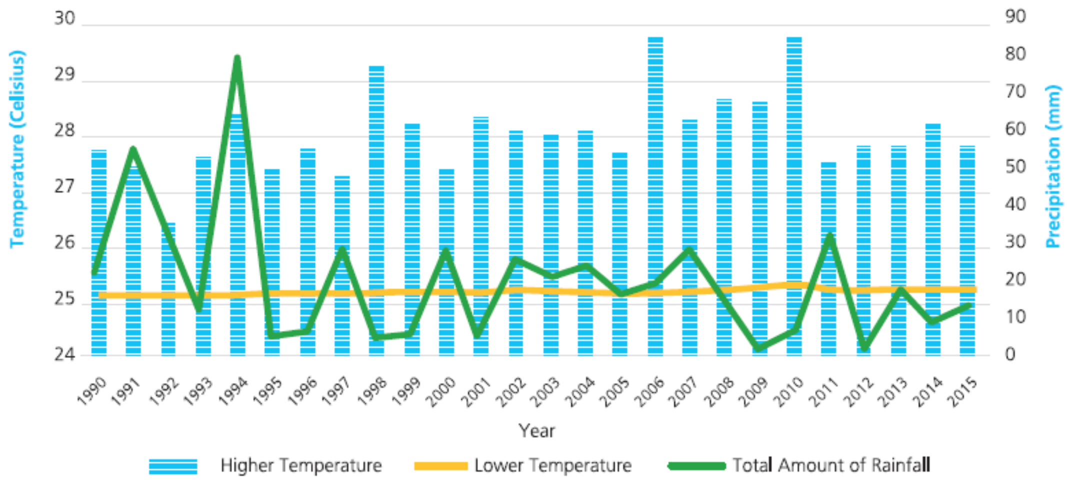


Figure 124: Average annual temperature and precipitation trends in Cairo, 1990-2015

4.3 Extreme Weather Events:

Over the past decade, the number of extreme weather events has increased in Egypt. This has caused both casualties in life and economic loss. The following are examples of the observed extreme events[69]:

- **Extreme heat**: according to historical data collected by the Central Laboratory for Agricultural Climate from the eleven agro-ecological zones representative governorates in Egypt, two extreme heat temperatures occurred in the period between the years 1990-2015. The first event occurred in 1998 and the second in 2010. According to the statistics of the Agricultural Economic Affairs Sector, those events had significant negative impact on strategic crops production. There was an average increase above normal in the minimum, maximum and mean temperatures in the winter of 2010 at different stations in Egypt, which caused decrease in wheat yield in Egypt during crop season 2010 as compared with crop season 2009. The Upper Egypt Governorates had the highest decrease in wheat yield by -21.2% and the Nile Delta Governorates had the lowest decrease by -8.2%[70].
- **Extreme cold temperature**. In 2008 a cold wave occurred, where the maximum and minimum temperatures during January were below normal. 50% of citrus crops, 40% of beans crops, 40% of bananas, 30% of mangos, 20% of tomatoes, and 2% of potatoes crops were damaged as a result.

[69] Egypt's First Biennial Update Report to the United Nations Framework Convention on Climate Change, Published by Ministry of Environment, Egyptian Environmental Affairs Agency, 2018.
[70] A.A. Khalil and M. K. Hassanein (2016). "Extreme weather events and negative impacts on Egyptian agriculture, International Journal of Advanced Research, 2016.

- **Extreme wind**. In 2004 an unprecedented change in wind direction caused a locust attack on various regions in Egypt causing great damage to the agricultural areas. The extent of related damage has not been quantified.
- **Flash floods and floods**. In January 2010, heavy rain exceeding 80 mm/day, led to the worst flash-floods in Egypt since 1994. This event caused 15 deaths, evacuation of 3500 people and estimated material losses of 25.3 million US dollars. The floods affected the Sinai Peninsula, Red Sea coast, and Aswan Governorate in Upper Egypt[71]. Also, flooding may contaminate water bodies, which poses risks to drinking water quality and increases costs for treatment.
- **Snow and rain storms**. In December 2010, snow and rain storms caused temperatures to plunge to below freezing in some places with wind speeds up to 60 km per hour, ending weeks of unseasonably warm and dry dust storms. Eighteen people were killed and 59 injured in traffic accidents associated with bad weather, several ports and airports were closed, and traffic in the Suez Canal was disrupted[1].

[71]State of the Climate in 2010, Sidebar 7.6 - Adverse Weather in Egypt, S. M. Attaher and M. A., Bulletin of the American Meteorological Society, 2011.

- **Prolonged Draughts**. In the analysis of the work of A. Zeidan and her colleagues[72], several droughts with various severities were detected in the Eastern Nile basin during the period 1965-2000, such drought directly affect water management in Egypt. Their results showed that the year 1984 was the worst case vulnerable to drought during 1965-2000 as shown in **Error! Reference source not found.**. Gamal Elsaeed at his work[73] also concluded that the future hydropower dam operation in the upstream part of the Nile basin may have an impact on the Nile basin if future climate scenarios materialize such impact can be higher and more severe low flows, but droughts of less frequency over the mid to longer term.

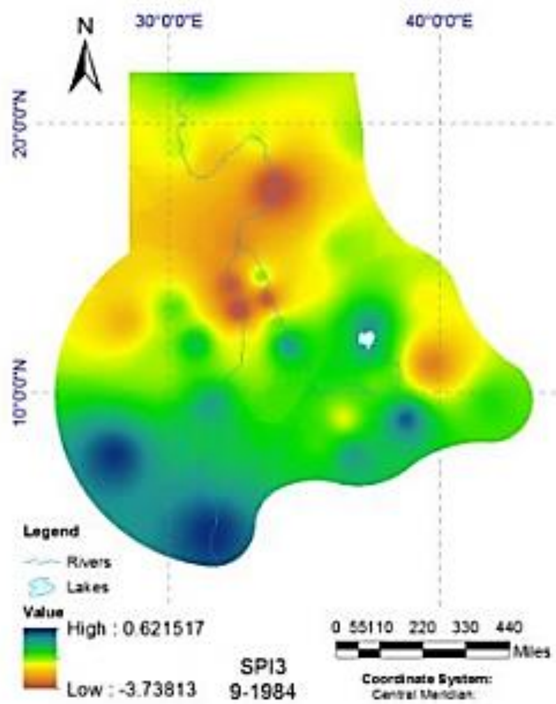


Figure 125: Spatial drought 1984 for the Eastern Nile basin

72 Climate Change Impact on Water Resources Planning and Management for Drought Mitigation in Egypt, Bakenaz A. Zeidan, Mosaad Khadr, Mohamed Said Elkollaly, 2017.

73 Chapter 30 Effects of Climate Change on Egypt's Water Supply, Gamal Elsaeed, 2011.

5. Potential impacts and risks of climate change for project activities

Wastewater systems are sensitive to climate change, especially that the efficient functioning of wastewater collection, treatment and disposal systems are directly linked to sustainable and climate resilient water supply systems. The primary climate change risks that impacts the project are: increase in temperature, prolonged drought, and extreme rainfall. Some other impacts that can indirectly relate to the project are: sea level rise. Increase in rainfall intensity and prolonged droughts can lead to lower-than-optimal capacity utilization of conveyance network and reduced treatment performance of wastewater treatment plants due to lowered flows and increased organic loading/intensive sudden water flows and over capacity flow.

5.1 Water resources scarcity

Egypt's population is growing fast (90 million as of year 2015) and 95% of them live on only 4% of its total surface area in the Nile valley and its delta. The majority of the population is of youth of median age of 24, where half of the population is younger than 25 years old, according to the CPMAS statistics for year 2015. The demographics with the economic growth aspirations strain the natural resources available, employment opportunities, infrastructure, education system, and health care.

The river Nile is the major source of water in Egypt; the agreed international treaties share of the Nile to Egypt is 55.5 billion cubic meters (BCM) per year. Groundwater aquifers, reuse of agricultural drainage and treated wastewater, rain and floods, and desalination supply an additional 20 BCM of water. The available water per capita is declining sharply with the growing population. According to the international water management institute map, Egypt is predicted to be in physical water scarcity as shown in **Error! Reference source not found.**. Combined with the impacts of climate change on water pollution and other geopolitical factors (Grand Ethiopian dam) this water stress is expected to aggravate even more. Hence, The Egyptian Government is employing a significant investment program towards efficient, reuse, and generation of new water sources as a national priority.

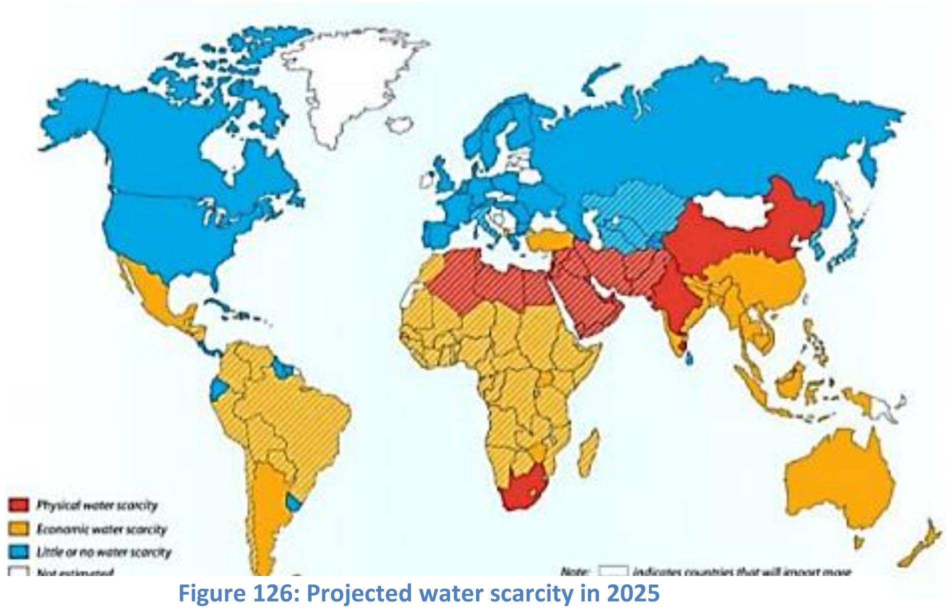


Figure 126: Projected water scarcity in 2025

5.2 Increased temperatures

Increased temperature generally leads to accelerated microbial growth in water and on the other hand, increased wastewater treatment requirements due to lowered dissolved oxygen and the increase in biological activity. Higher temperatures can also reduce efficiency of mechanical and electrical equipment. Also, high temperature degrades materials used in infrastructure and equipment of pumping stations faster. Residential and commercial average daily water consumption and peak water increase. Wastewater volume needing treatment may increase, at an increased cost, and additional wear and tear on equipment.

5.3 Extreme low temperature weather

Pipes or joints may be damaged due to soil freezing, where pipes may crack or joints may leak, leading to water loss. Infrastructure may require more frequent maintenance and higher budgets.

5.4 Increased intensity of rainfall and storms

Higher frequency and intensity of extreme rainfall events may lead to service delivery disruption and interruption in urban water and wastewater systems, and also higher emergency and breakdown maintenance costs due to possible damage to infrastructure.

5.5 Floods

Due to floods conditions, pump stations, instruments and facilities may be damaged. Furthermore, flow entering wastewater treatment facilities may increase. Maximum carrying capacity of wastewater conveyance networks and wastewater treatment facilities may be exceeded causing flooding, pollution, property damage, lowered economic productivity, health risks and potential loss of life from subsequent disease. At times, intense rainfalls and floods cause interruption of power supply. Treatment capacity may be reduced or ceased and contamination accidents may happen due to system shutdown.

5.6 Prolonged Draughts

Droughts may lead to decreased wastewater flow which in turn leads to increased organic loading in wastewater systems, and silt deposition in pipelines. Drought will also stress the need for additional source creation and diversification which will come with additional costs.

5.7 Sea level rise in Nile Delta

Climate change is expected to be a source of pressure on the coastal zones, particularly the Nile Delta, which many predictions and models expect large extent of inundation through the years due to the sea level rise. This would negatively impact ecosystems, human health, the reliability and operating costs of water and sanitation infrastructure. Also, sea level rise in the Delta will result in salt intrusion and this will cause many agricultural lands to become unproductive.

6. Potential adaptation measures

According to the Intergovernmental Panel on Climate Change, adaptation is a response to climate change that seeks to reduce the vulnerability of social and biological systems to relatively sudden change and thus offset the effects of climate change. Adaptive capacity is closely linked to social and economic development.

In this section, adaptation measures against climate change impacts that will affect the project will be suggested. Not only that, but this section will also illustrates how the project is helping its surrounding environment and served population adapt to climate change effects.

6.1 Water resources supplementation

Another adverse impact of climate change is the overall decrease in rainfall amounts and prolonged drought periods; this combined with the already existing water stress in Egypt creates a real water crisis. This project alleviate some of the adverse effect of this impact of climate change by providing tertiary treated wastewater with unrestricted irrigation quality to Al Saff canal. The plant total capacity is 800,000 m^3/day of discharged flow that would have been otherwise withdrawn from the river Nile; this flow will be used in agricultural, which creates a new supplementary high quality agricultural water resource.

6.2 Increase in temperatures/extreme hot days and power cutoffs

The number of extreme hot days will increase due to climate change, this increases the probability of power cutoffs due to overload on the grid. Among the suggested scenarios of this project is the energy recovery from sludge digestion. Such technology will reduce the WWTP dependency on the network with up to more than 50%. Such energy recovery alleviates the effect of such climate risk on the project.

Increased temperature generally leads to accelerated microbial growth in water, this can be bad news for drinking water supply, but for wastewater treatment this most probably means faster treatment rate. Also, this project uses upgraded oxygen diffusers in the extension capacity which will increase the available oxygen in the wastewater for the increased microbial activities and decreased saturation due to higher temperatures. High temperature degrades materials used in infrastructure and equipment of pumping stations. Infrastructure and equipment aging may be accelerated. This may require more frequent repair and higher maintenance budgets.

6.3 Extreme low temperature weather

Pipes or joints may be damaged due to soil freezing. Pipes may crack or joints may leak, leading to water loss. Infrastructure may require more frequent repair and higher maintenance budgets.

6.4 Increase the capacity of water conveyance network

One of the adverse impacts of climate change is the increase in the intensity and frequency of extreme events such as storms and rainfall, which can cause overflow and street inundation and expose many lives and properties to high risks. This project helps compact that risk as it increases the capacity of the wastewater network starting Maadi all the way to Helwan and beyond. Such increased capacity in the network can assist in decreasing rainfall overflow in the street by containing volumes of it.

6.5 Floods

The area where Arab Abu Sa'ed WWTP is not directly adjacent to the Nile flood plains and no record of flooding of the facility due to storm exits. Hence, it is very unlikely that direct flood is a risk to the wastewater treatment plant, only extra maintenance for the network might be needed in emergency flow of floods.

6.6 Sea level rise and Delta agricultural

The project will allow significant agricultural reclamation, as it will provide unrestricted irrigation water quality to vast areas around Al Saff canal that are not reclaimed yet due to the current lack of water resources. This will help adapting to the loss of agricultural land in Delta due to sea level rise.

To highlight an important aspect, all the proposed project outputs and components may be considered as a reduction to the vulnerability to climate change as the project will:

- Increase the wastewater conveyance network capacity, which will help contain more intense rainfall and storms/floods.
- Supply unrestricted irrigation quality water with additional 800,000 m^3/day, which would have otherwise been extracted from the Nile, which will help compact droughts and shortage of water resources.
- Will improve wastewater treatment quality to compact the climate change impacts.
- Compact the damage and halt in service due to power cutoffs by depending less on the national grid by utilizing energy recovery in sludge digestion.
- Decreasing the carbon footprint per capita served by utilizing energy recovery and tertiary treatment.
- Increasing the WWTP capacity along with upgrading to tertiary treatment will allow for more containment to the peak average daily water consumption increase as temperatures increase.

Annex IV (a)

Helwan WWTP

Influent flow 2019/2020

Wastewater Quality laboratory data

(July –October 2020)

Incoming Raw Water Flow Rate

Month	2019	2020
	AVG FLOW(M3/D)	AVG FLOW(M3/D)
JAN	608797	538133
FEB	612490	534433
MAR	603683	580594
APR	600286	558290
MAY	634985	560213
JUNE	671245	564668
JULY	693958	597130
AUJ	633813	607129
SEPT	615667	622013
OCT	621413	593594
NOV	599068	567510
DEC	575900	540530

شركة الصرف الصحى للقاهرة الكبرى

قطاع الجنوب وحلوان .. محطتى المعالجة والرى بحلوان

تقرير المعمل عن شهر يولية لسنة 2020

أخر نقطة معالجة

DATE	Inlet المدخل PH	TSS mg/l	BOD mg/l	COD mg/l	Sett ml/l	Settled بعد الإبتدائى TSS mg/l Nor	TSS mg/l sou	BOD mg/l Nor	BOD mg/l sou	SLUDGE LINE NORTH LINE SV	MLSS	RAS	SVI	SOUTH LINE SV	MLSS	RAS	SVI	Final بعد النهائى TSS mg/l Nor	sou	AVG	BOD mg/l Nor	sou	AVG	COD mg/l Nor	sou	AVG	REMOVAL TSS %	BOD %	COD %	End Poient TSS mg/l	BOD mg/l	COD mg/l
1	7.3	292	303	430	2	94	113	98	111	656	1.9	4.3	345	620	2.3	5.2	270	16	22	19	21	27	24	38	46	42	93	92	90	19	24	44
2	7.4	203	266	396	2	94	97	100	106	575	2.1	4.0	274	475	2.2	5.1	216	17	21	19	21	25	23	38	44	41	91	91	90	23	29	47
3	7.5	197	246	366	1	100	98	106	130	580	2.0	4.2	290	595	2.4	5.4	248	18	20	19	23	26	25	35	40	38	90	90	90	22	40	45
4	7.6	191	202	330	2	106	99	126	109	590	2.2	4.9	268	715	2.6	5.7	275	18	21	20	23	27	25	36	44	40	90	88	88	20	25	39
5	7.4	246	226	456	2	97	126	104	116	730	2.3	4.9	317	840	2.5	4.6	336	21	19	20	26	24	25	48	39	44	92	89	90	23	26	45
6	7.6	256	250	420	2	110	101	105	95	720	2.2	5.2	327	465	2.2	4.8	211	16	19	18	21	25	23	38	42	40	93	91	90	18	28	44
7	7.5	239	222	484	3	103	99	123	112	500	2.3	5.1	217	650	2.4	5.4	271	23	17	20	23	21	22	42	34	38	92	90	92	18	24	39
8	7.4	271	282	410	4	148	196	126	143	520	2.4	6.1	217	460	2.2	5.9	209	19	23	21	25	29	27	42	48	45	92	90	89	17	22	40
9	7.3	264	224	432	3	118	124	136	146	590	2.2	3.9	268	360	2.2	4.9	164	34	45	40	32	47	40	47	65	56	85	82	87	43	49	68
10	7.3	244	240	396	4	102	108	111	119	520	2.3	4.1	226	400	2.4	5.0	167	31	40	36	26	28	27	43	45	44	85	89	89	39	32	52
11	7.4	190	201	322	2	89	71	104	96	510	2.1	4.5	243	260	2.0	4.8	130	17	23	20	21	25	23	35	39	37	89	89	89	19	22	34
12	7.3	224	222	366	4	117	123	122	131	650	2.2	4.9	295	560	2.4	5.4	233	18	26	22	22	28	25	35	46	41	90	89	89	29	32	51
13	7.3	202	228	366	3	92	77	104	91	560	2.1	4.8	267	640	2.4	5.3	267	25	21	23	33	27	30	51	42	47	89	87	87	20	25	38
14	7.4	277	290	482	4	117	126	133	137	560	2.0	3.2	280	240	1.9	5.1	126	20	24	22	25	28	27	41	46	44	92	91	88	22	27	45
15	7.5	278	266	486	3	100	89	95	86	530	1.9	4.2	279	450	2.3	5.1	196	21	19	20	20	18	19	43	40	42	93	93	91	23	24	46
16	7.3	219	236	366	2	104	110	88	94	530	1.9	4.9	279	390	2.2	5.7	177	17	18	18	18	19	19	30	33	32	92	92	91	21	20	37
17	7.5	202	218	354	2	94	98	110	126	405	1.2	3.6	338	380	1.8	4.6	211	16	17	17	19	21	20	31	34	33	92	91	91	20	23	38
18	7.6	239	281	416	3	87	99	95	110	240	1.3	3.4	185	450	1.6	4.4	281	18	20	19	21	29	25	36	42	39	92	91	91	19	25	40
19	7.6	264	273	456	4	118	123	123	144	380	1.6	4.4	238	320	1.8	4.8	178	21	24	23	26	30	28	42	46	44	91	90	90	26	33	48
20	7.6	250	236	446	3	102	104	88	94	750	1.8	4.0	417	650	2.8	5.1	232	22	19	21	21	23	22	44	41	43	92	91	90	23	26	47
21	7.4	227	195	242	2	105	113	101	108	460	2.3	4.4	200	360	2.4	5.5	150	18	19	19	19	21	20	40	42	41	92	90	83	22	25	44
22	7.2	376	310	522	4	113	123	133	148	490	1.9	4.2	258	520	2.1	6.1	248	18	25	22	25	32	29	41	52	47	94	91	91	23	30	49
23	7.4	276	295	436	3	112	132	120	129	690	2.3	5.2	300	610	2.7	4.9	226	18	23	21	22	27	25	34	42	38	93	92	91	23	28	41
24	7.3	244	311	450	2	99	105	105	112	567	2.2	4.7	258	540	2.4	5.0	225	22	21	22	20	23	22	40	41	41	91	93	91	22	26	42
25	7.5	213	298	492	3	87	79	103	98	445	2.1	4.3	212	475	2.2	5.1	216	25	22	24	29	26	28	45	43	44	89	91	91	24	22	41
26	7.4	269	270	485	3	88	91	98	104	795	2.3	5.5	346	790	2.6	5.5	304	23	20	22	27	24	26	46	42	44	92	91	91	22	24	41
27	7.6	258	213	406	4	86	94	110	119	690	2.5	6.0	276	600	2.4	5.6	250	25	19	22	27	36	32	44	35	40	91	85	90	21	23	31
28	7.6	277	242	436	4	119	91	121	102	760	2.5	4.8	304	650	2.5	6.2	260	21	18	20	26	22	24	42	32	37	93	90	92	20	28	44
29	7.4	482	366	654	6	118	114	128	124	590	2.8	5.4	211	550	2.4	5.6	229	20	18	19	27	25	26	45	43	44	96	93	93	17	23	41
30	7.5	221	264	387	4	109	104	90	94	560	2.7	5.1	207	720	2.7	5.6	267	19	17	18	24	26	25	39	36	38	92	91	90	21	26	41
31	7.4	258	278	376	3	102	108	100	108	540	2.5	5.0	216	620	2.4	5.2	258	22	24	23	23	25	24	34	37	36	91	91	91	24	27	43
min	7.2	190	195	242	1	86	71	88	86	240	1.2	3.2	185	240	1.6	4.4	126	16	17	17	18	18	19	30	32	32	85	82	83	17	20	31
max	7.6	482	366	654	6	148	196	136	148	795	2.8	6.1	417	840	2.8	6.2	336	34	45	40	33	47	40	51	65	56	96	93	93	43	49	68
avg	7.4	253	257	421	3	104	108	110	114	570	2.1	4.6	270	528	2.3	5.2	227	21	22	21	24	26	25	40	42	41	91	90	90	23	27	43

										2020 تقرير المعمل عن شهر أغسطس لسنة												قطاع الجنوب وحلوان .. محطتى المعالجة والرى بحلوان										أخر نقطة معالجة		
	Inlet المدخل					Settled بعد الإبتدائى				SLUDGE LINE								Final بعد النهائى									REMOVAL			End Poient		
DATE	PH	TSS	BOD	COD	Sett	TSS mg/l		BOD mg/l		NORTH LINE				SOUTH LINE				TSS mg/l			BOD mg/l			COD mg/l			TSS	BOD	COD	TSS	BOD	COD
		mg/l	mg/l	mg/l	ml/l	Nor	sou	Nor	sou	SV	MLSS	RAS	SVI	SV	MLSS	RAS	SVI	Nor	sou	AVG	Nor	sou	AVG	Nor	sou	AVG	%	%	%	mg/l	mg/l	mg/l
1	7.6	209	266	421	4	121	110	104	116	700	2.7	5.5	259	475	2.2	4.3	216	19	17	18	24	23	24	40	38	39	91	91	91	20	25	42
2	7.4	290	306	486	5	116	107	108	114	475	2.4	5.2	198	375	2.0	4.1	188	18	15	17	21	20	21	41	39	40	94	93	92	23	23	48
3	7.3	210	296	471	3	96	95	99	104	400	2.2	4.3	182	160	1.3	2.4	123	22	18	20	23	22	23	39	37	38	90	92	92	21	24	40
4	7.4	235	255	399	5	110	116	102	109	515	2.3	3.7	224	350	1.7	3.9	206	18	21	20	25	28	27	34	39	37	92	90	91	22	29	41
5	7.6	224	276	422	5	111	120	102	106	300	1.9	3.8	158	545	2.0	4.5	273	19	23	21	23	25	24	45	49	47	91	91	89	25	28	51
6	7.3	216	269	394	5	104	117	102	122	230	1.6	3.7	144	365	2.0	4.1	183	20	22	21	24	27	26	38	42	40	90	91	90	26	31	49
7	7.5	229	310	440	5	107	110	100	112	255	1.6	3.4	159	275	1.6	4.3	172	18	21	20	22	24	23	40	43	42	91	93	91	24	23	46
8	7.6	265	330	486	6	112	114	96	93	280	1.7	3.6	165	290	1.4	4.3	207	16	19	18	23	26	25	38	41	40	93	93	92	22	29	44
9	7.5	216	290	410	4	101	119	89	96	350	1.7	3.7	206	290	1.3	3.8	223	20	25	23	26	29	28	41	44	43	90	91	90	47	32	52
10	7.4	203	259	418	4	89	83	99	95	525	2.0	4.0	263	455	2.0	4.3	228	20	18	19	31	24	28	42	39	41	91	89	90	17	22	38
11	7.6	211	230	365	5	91	106	92	96	480	1.9	3.7	253	600	2.2	4.3	273	22	24	23	23	28	26	37	43	40	89	89	89	26	32	46
12	7.6	247	265	388	6	100	120	98	104	520	1.6	3.3	325	590	1.9	4.3	311	17	23	20	20	28	24	29	41	35	92	91	91	41	23	70
13	7.5	217	222	333	5	94	108	116	130	580	1.8	3.6	322	425	1.7	4.2	250	18	22	20	21	26	24	34	41	38	91	89	90	24	29	45
14	7.5	216	283	434	5	104	116	101	106	600	2.0	3.8	300	460	1.8	4.1	256	24	26	25	28	31	30	48	52	50	88	90	85	27	33	49
15	7.3	245	264	436	5	97	108	93	106	650	2.1	3.5	310	525	1.7	3.4	309	27	29	28	27	35	31	46	51	49	89	88	89	28	32	47
16	7.5	223	276	439	4	105	118	108	110	640	2.3	4.0	278	565	2.2	3.4	257	15	20	18	18	21	20	32	37	35	92	93	92	22	24	39
17	7.6	236	202	314	5	106	128	115	138	656	1.9	3.4	345	525	1.8	4.0	292	27	32	30	27	32	30	50	56	53	88	85	83	17	30	52
18	7.5	208	229	337	4	96	112	92	102	680	2.0	3.8	340	680	1.7	4.0	400	21	25	23	23	30	27	36	42	39	89	88	88	26	33	45
19	7.4	254	291	438	6	106	113	99	101	745	1.7	4.1	438	665	1.7	4.0	391	22	23	23	26	29	28	42	46	44	91	91	90	25	31	47
20	7.6	234	281	456	4	94	96	122	126	810	2.3	4.9	352	640	2.2	3.8	291	15	18	17	20	24	22	32	40	36	93	92	92	19	25	41
21	7.5	260	258	400	4	100	112	108	114	740	2.2	4.2	336	620	2.0	3.6	310	20	24	22	22	28	25	34	46	40	92	90	90	21	30	43
22	7.6	214	250	346	5	92	98	83	88	650	2.1	4.1	310	425	1.5	3.4	283	18	21	20	23	27	25	33	39	36	91	90	90	24	31	43
23	7.4	211	221	334	5	96	115	95	96	740	1.8	4.4	411	690	1.8	4.3	383	17	22	20	20	24	22	29	38	34	91	90	90	23	29	41
24	7.3	257	232	386	6	109	115	97	102	404	2.1	4.5	192	675	2.0	4.3	338	19	20	20	23	27	25	33	37	35	92	89	91	22	32	41
25	7.6	278	217	421	8	105	117	94	108	740	2.3	4.0	322	620	1.7	4.7	365	14	18	16	20	25	23	27	34	31	94	90	93	23	30	43
26	7.5	240	202	388	7	114	109	100	106	790	2.4	4.8	329	700	2.5	4.1	280	24	19	22	22	21	22	38	32	35	91	89	91	25	26	42
27	7.4	252	266	402	6	99	102	84	92	710	2.2	3.3	323	750	2.5	5.4	300	21	16	19	28	26	27	48	35	42	93	90	90	20	32	48
28	7.5	225	212	337	5	100	109	104	116	625	2.1	3.7	298	540	1.9	4.8	284	18	22	20	20	23	22	31	37	34	91	90	90	24	26	41
29	7.5	234	286	440	5	108	85	98	76	625	2.0	4.2	313	385	1.5	4.4	257	23	26	25	27	29	28	48	50	49	90	90	89	27	31	52
30	7.3	219	270	369	4	102	111	112	114	780	2.1	4.9	371	690	2.2	5.0	314	24	20	22	29	25	27	43	38	41	90	90	89	22	28	41
31	7.5	167	206	294	4	93	78	86	98	830	2.0	4.7	415	620	2.2	5.6	282	25	22	24	25	23	24	36	32	34	86	88	88	24	26	39
min	7.3	167	202	294	3	89	78	83	76	230	1.6	3.3	144	160	1.3	2.4	123	14	15	16	18	20	20	27	32	31	86	85	83	17	22	38
max	7.6	290	330	486	8	121	128	122	138	830	2.7	5.5	438	750	2.5	5.6	400	27	32	30	31	35	31	50	56	53	94	93	93	47	33	70
avg	7.5	230	259	400	5	103	109	100	106	581	2.0	4.1	285	515	1.9	4.2	272	20	22	21	24	26	25	38	41	40	91	90	90	24	28	45

تقرير المعمل عن شهر سبتمبر لسنة 2020																		قطاع الجنوب وحلوان .. محطتى المعالجة والرى بحلوان														أخر نقطة معالجة		
DATE	Inlet المدخل					Settled بعد الإبتدائى				SLUDGE LINE								Final بعد النهائى									REMOVAL			End Poient		
	PH	TSS	BOD	COD	Sett	TSS mg/l		BOD mg/l		NORTH LINE				SOUTH LINE				TSS mg/l			BOD mg/l			COD mg/l			TSS	BOD	COD	TSS	BOD	COD
		mg/l	mg/l	mg/l	ml/l	Nor	sou	Nor	sou	SV	MLSS	RAS	SVI	SV	MLSS	RAS	SVI	Nor	sou	AVG	Nor	sou	AVG	Nor	sou	AVG	%	%	%	mg/l	mg/l	mg/l
1	7.6	222	227	348	2	102	121	96	102	815	2.0	4.3	408	400	1.6	3.7	250	24	17	21	28	23	26	42	31	37	91	89	90	26	32	48
2	7.4	236	284	366	3	94	113	100	112	475	2.7	5.1	176	880	2.2	4.2	400	26	15	21	35	27	31	49	37	43	91	89	88	27	34	42
3	7.5	258	261	399	4	95	99	112	119	850	2.5	4.7	340	515	2.1	4.7	245	23	16	20	26	21	24	44	36	40	92	91	90	21	23	40
4	7.4	219	242	376	3	102	111	102	114	830	2.1	4.1	395	585	2.2	4.5	266	24	20	22	23	20	22	40	33	37	90	91	90	22	23	39
5	7.3	214	210	355	3	269	119	118	102	825	1.6	4.8	516	650	2.0	4.3	325	19	17	18	24	21	23	36	31	34	92	89	91	21	26	38
6	7.5	216	226	341	2	99	107	79	94	825	2.3	4.9	359	415	1.8	5.1	231	18	15	17	22	19	21	33	28	31	92	91	91	19	29	41
7	7.6	175	182	318	3	94	100	86	97	820	2.0	4.5	410	415	1.7	4.1	244	22	18	20	18	14	16	40	32	36	89	91	89	19	23	35
8	7.5	204	228	354	4	92	86	85	81	790	2.0	4.7	395	415	1.8	4.7	231	23	20	22	26	22	24	40	35	38	89	89	89	22	23	38
9	7.4	195	205	386	3	84	95	91	102	700	2.2	4.4	318	515	2.1	3.3	245	19	20	20	25	21	23	38	37	38	90	89	90	21	28	38
10	7.5	181	201	300	3	85	109	90	98	780	2.2	4.6	355	435	1.6	3.5	272	19	17	18	22	20	21	34	30	32	90	90	89	22	27	38
11	7.4	215	244	402	4	93	104	82	96	650	2.1	4.4	310	400	1.5	3.8	267	20	16	18	25	21	23	40	36	38	92	91	91	23	26	42
12	7.6	242	278	439	5	95	100	85	93	595	2.2	4.2	270	275	1.4	4.0	196	23	17	20	26	22	24	41	32	37	92	91	92	25	31	46
13	7.3	184	202	324	4	73	89	79	92	725	2.3	4.9	315	325	1.4	3.4	232	15	21	18	19	23	21	28	35	32	90	90	93	21	26	39
14	7.5	197	233	366	4	101	93	105	96	655	2.5	4.6	262	505	1.9	4.4	266	20	16	18	28	22	25	41	38	40	91	89	88	19	25	40
15	7.7	202	192	289	3	79	73	73	66	255	1.6	3.8	159	640	1.8	3.5	356	22	20	21	29	26	28	42	39	41	90	86	86	24	24	32
16	7.5	228	262	412	5	102	99	97	92	665	2.4	4.8	277	665	2.0	4.9	333	25	17	21	28	23	26	42	36	39	91	90	91	25	26	43
17	7.5	211	266	412	5	104	101	111	99	700	2.5	4.2	280	690	2.2	5.3	314	24	22	23	26	23	25	42	39	41	89	91	90	26	29	48
18	7.4	223	263	422	4	103	100	97	91	650	2.2	4.3	295	645	2.0	5.0	323	22	23	23	25	27	26	39	42	41	90	90	90	23	30	44
19	7.5	244	260	432	6	104	98	95	91	615	2.3	4.4	267	600	1.8	4.8	333	18	20	19	21	25	23	35	38	37	92	91	92	21	26	40
20	7.3	213	256	418	5	94	84	86	92	750	2.2	5.0	341	680	2.1	5.9	324	17	16	17	22	23	23	34	38	36	92	91	91	18	25	38
21	7.4	211	254	424	5	136	89	95	86	670	2.1	4.0	319	480	1.8	3.9	267	32	21	27	31	29	30	55	43	49	87	88	88	28	36	47
22	7.5	331	343	584	10	107	92	94	87	750	2.3	5.1	326	575	1.9	4.4	303	21	17	19	26	23	25	40	32	36	94	93	94	21	27	41
23	7.2	260	254	422	6	88	94	87	90	670	2.0	5.0	335	525	1.9	3.7	276	23	22	23	28	25	27	46	41	44	91	90	90	24	31	50
24	7.5	204	236	388	5	91	108	80	88	500	2.3	5.0	217	630	2.3	5.0	274	17	18	18	22	24	23	34	37	36	91	90	91	22	24	41
25	7.3	222	248	400	5	88	101	98	102	575	2.4	4.9	240	485	2.2	4.5	220	18	17	18	25	26	26	40	44	42	92	90	90	21	27	43
26	7.4	238	248	412	6	83	91	80	89	650	2.5	4.7	260	340	2.1	3.9	162	20	19	20	28	27	28	41	40	41	92	89	90	20	30	42
27	7.4	198	256	396	4	96	82	92	98	525	2.4	5.0	219	670	2.4	5.9	279	26	23	25	30	28	29	47	45	46	88	89	88	27	29	49
28	7.4	215	242	398	3	121	111	90	96	575	2.7	5.8	213	575	2.6	4.3	221	28	18	23	29	22	26	52	33	43	89	89	89	21	27	39
29	7.4	211	226	370	4	118	121	102	112	590	2.2	4.4	268	415	2.1	3.9	198	30	21	26	24	21	23	46	38	42	88	90	89	28	25	41
30	7.3	205	230	384	3	94	98	100	104	560	2.7	4.9	207	520	2.4	5.1	217	18	20	19	22	24	23	42	46	44	91	90	89	21	28	45
min	7.2	175	182	289	2	73	73	73	66	255	1.6	3.8	159	275	1.4	3.3	162	15	15	17	18	14	16	28	28	31	87	86	86	18	23	32
max	7.7	331	343	584	10	269	121	118	119	850	2.7	5.8	516	880	2.6	5.9	400	32	23	27	35	29	31	55	46	49	94	93	94	28	36	50
avg	7.4	219	242	388	4	103	100	93	96	668	2.3	4.7	302	529	2.0	4.4	269	22	19	20	25	23	24	41	37	39	91	90	90	23	27	42

شركة الصرف الصحى للقاهرة الكبرى

قطاع الجنوب وحلوان .. محطتى المعالجة والرى بحلوان

أخر نقطة معالجة

تقرير المعمل عن شهر أكتوبر لسنة 2020

DATE	Inlet المدخل					Settled بعد الإبتدائى				SLUDGE LINE								Final بعد النهائى									REMOVAL			End Poient		
	PH	TSS	BOD	COD	Sett	TSS mg/l		BOD mg/l		NORTH LINE				SOUTH LINE				TSS mg/l			BOD mg/l			COD mg/l			TSS	BOD	COD	TSS	BOD	COD
		mg/l	mg/l	mg/l	ml/l	Nor	sou	Nor	sou	SV	MLSS	RAS	SVI	SV	MLSS	RAS	SVI	Nor	sou	AVG	Nor	sou	AVG	Nor	sou	AVG	%	%	%	mg/l	mg/l	mg/l
1	7.4	223	282	416	5	116	99	102	108	590	2.2	4.8	268	625	2.5	5.0	250	17	19	18	23	25	24	38	40	39	92	91	91	20	26	41
2	7.5	215	264	399	5	103	93	84	86	650	2.4	4.9	271	650	2.3	4.9	283	21	18	20	28	23	26	48	39	44	91	90	89	22	25	41
3	7.4	207	235	388	4	91	84	88	79	705	2.3	4.3	307	675	2.6	4.8	260	23	20	22	27	23	25	43	38	41	90	89	90	24	29	44
4	7.6	247	265	411	6	108	88	94	98	690	2.7	5.0	256	780	2.8	5.2	279	27	22	25	24	22	23	45	35	40	90	91	90	29	27	48
5	7.4	234	288	422	5	110	103	116	102	705	2.6	5.3	271	830	3.1	5.6	268	21	15	18	25	21	23	39	28	34	92	92	92	21	29	40
6	7.3	202	223	381	4	80	104	96	93	775	2.4	5.1	323	765	2.7	4.9	283	22	23	23	23	25	24	41	43	42	89	89	89	30	34	53
7	7.4	219	242	385	5	97	98	90	91	725	2.5	5.0	290	710	2.0	4.3	355	16	17	17	20	24	22	38	41	40	92	91	90	20	29	43
8	7.4	222	265	396	6	93	90	98	90	490	2.1	5.1	233	510	1.8	3.7	283	18	17	18	26	21	24	40	38	39	92	91	90	20	28	42
9	7.3	220	221	406	5	94	87	102	106	460	2.0	4.3	230	525	1.7	3.6	309	19	16	18	22	20	21	40	38	39	92	90	90	22	27	46
10	7.5	218	266	402	5	95	85	103	95	405	2.0	3.5	203	535	1.8	3.7	297	18	15	17	26	21	24	33	28	31	92	91	92	21	28	40
11	7.4	230	274	425	6	97	92	116	122	540	1.7	5.0	318	485	1.8	3.9	269	19	18	19	28	26	27	35	33	34	92	90	92	20	29	38
12	7.5	226	229	411	6	84	74	88	80	450	1.9	3.9	237	465	1.6	3.5	291	19	17	18	25	22	24	35	32	34	92	90	92	21	28	39
13	7.4	210	239	402	5	121	102	101	98	385	2.2	4.7	175	475	1.7	3.9	279	33	25	29	34	28	31	55	48	52	86	87	87	31	31	52
14	7.5	219	248	396	4	105	102	102	98	410	2.2	4.9	186	600	2.1	4.8	286	30	25	28	33	28	31	50	48	49	87	88	88	25	30	49
15	7.5	206	277	402	5	108	91	115	99	590	2.1	4.8	281	465	1.9	3.6	245	20	16	18	27	20	24	45	35	40	91	92	90	21	23	49
16	7.4	200	305	465	4	103	86	98	83	570	2.0	4.9	285	455	1.7	3.8	268	22	18	20	28	25	27	45	40	43	90	91	91	23	30	49
17	7.3	194	230	388	4	97	73	87	78	550	2.0	5.0	275	450	1.8	4.1	250	25	17	21	29	23	26	48	35	42	89	89	89	20	25	39
18	7.3	151	210	352	3	104	91	80	88	690	2.2	4.9	314	610	1.7	5.2	359	31	20	26	25	21	23	48	39	44	83	89	88	27	27	43
19	7.3	197	228	366	5	103	78	113	102	635	2.1	4.7	302	395	1.6	4.2	247	25	17	21	30	22	26	47	40	44	89	89	88	23	26	44
20	7.4	189	386	344	4	112	75	119	89	810	2.6	4.6	312	495	2.0	4.6	248	21	19	20	32	20	26	41	33	37	89	93	89	20	23	37
21	7.4	182	235	354	4	101	71	98	72	700	2.2	4.2	318	775	2.0	4.9	388	30	24	27	32	28	30	49	46	48	85	87	87	26	29	47
22	7.5	201	219	355	5	109	79	98	78	590	2.3	4.3	257	615	2.4	4.2	256	24	18	21	31	24	28	51	34	43	90	87	88	24	27	43
23	7.4	209	193	320	6	93	86	89	83	400	2.2	3.8	182	460	2.1	4.8	219	23	20	22	22	20	21	36	32	34	90	89	89	22	25	38
24	7.3	195	186	374	5	113	81	113	103	315	1.6	3.5	197	465	1.7	4.4	274	27	14	21	38	32	35	49	26	38	89	81	90	19	30	46
25	7.4	203	202	396	5	114	103	104	116	365	1.8	3.6	203	595	1.9	3.7	313	25	19	22	26	22	24	38	28	33	89	88	92	21	26	39
26	7.5	261	278	422	4	93	107	92	95	505	1.9	3.2	266	480	2.1	4.8	229	33	31	32	36	33	35	59	57	58	88	88	86	32	31	56
27	7.4	200	208	386	4	102	98	100	94	370	1.8	4.4	206	495	2.2	4.6	225	25	14	20	31	27	29	52	36	44	90	86	89	24	32	50
28	7.5	193	188	340	5	98	77	80	76	330	1.8	4.5	183	555	1.9	4.6	292	21	16	19	22	20	21	37	28	33	90	89	90	19	21	33
29	7.4	198	202	386	5	76	72	78	82	375	1.1	3.9	347	480	1.6	4.2	300	17	14	16	25	24	25	38	36	37	92	88	90	20	27	42
30													####				###			0			0			0	#####	####	####			
31													####				###			0			0			0	#####	####	####			
min	7.3	151	186	320	3	76	71	78	72	315	1.1	3.2	####	395	1.6	3.5	###	16	14	0	20	20	0	33	26	0	#####	####	####	19	21	33
max	7.6	261	386	465	6	121	107	119	122	810	2.7	5.3	####	830	3.1	5.6	###	33	31	32	38	33	35	59	57	58	#####	####	####	32	34	56
avg	7.4	209	244	389	5	101	89	98	93	544	2.1	4.5	####	566	2.0	4.4	###	23	19	20	28	24	24	44	37	38	#####	####	####	23	28	44

Annex IV (b)

Sludge samples laboratory results for heavy metals and E. coli of Helwan WWTP Nov. 2020

والري

y of Health & Population
Preventive Sector
tral Health Laboratories

ـحة والسـكـان
ـع الطب الوقائي
الإدارة المركزية للمعامل
قسم المياه

نتيجه التحليل لمياه الصرف الصحى المعالج

المعمل 1056239

و السرى

الجهة الراسلة: اداره الصحه الصحيه - مكتب عرب ابو

مكان اخذ العينة: محطه الصرف الصحى بعرب ابو ساعد

ص المطلوب: تطبيق القرار ٣٨٣ من الكود المصرى ٥٠١ لسنه ٢٠١٥ لتاريخ الاستلام 2020-11-25

mg الفحص الكيماوي

الفحص	النتيجة	الحد المسموح به	الفحص	النتيجة	الحد المسموح
الأيدروجيني	7.6	6 9	ايون البيكربونات HCO3	268	400
العالقة T.S.S	10	30	كتيونات الصوديوم Na	180	230
ص الحيوى الممتص B.O.D	30	30	كتيونات الماغنسيوم Mg	24	100
ت الكلى PO4	3.4	30	ايون الكالسيوم Ca	88	230
نت	50	500	الاملاح الذائبة الكلية T.D.S	900.0	2000
يات F	0.28	1.5	البورو	0.1	2.5

ص المبيدات و المواد العضوية

الفحص	النتيجة	الحد المسموح به
	لم يستدل	0.002

mg فحص المعادن الثقيلة و السيانيد

الفحص	النتيجة	الحد المسموح به
Al	4.5	5
As	0.00029	0.1
Cu	0.00206	0.2
Fe	0.09	5
Mn	0.02334	0.2
Ni	0.00185	0.2
Pb	0.00081	5
سيلينيوم Se	0.00017	0.02
Cd	0.00010	0.01
Zn	0.03800	5
Cr	0.00419	0.1
Hg	0.002	0.002
Mo	0.00036	0.01

ل العينة مطابقة لمعايير المعادن الثقيلة المدونة بالدرجة (ب) من المعالجة طبقا للقرار ٣٨٣ من الكود المصري ٥٠١ لسنة ٢٠١٥

ص الميكروبيولوجي

الفحص	النتيجة	الحد المسموح به
ـتمالى لبكتريا ايشريشيا كولاى لكل ١٠٠ ملى	معدوم	100

ـده للمعايير الميكروبيولوجيه

ـ النهائي

مطابقة لدرجة المعالجة (ب) من القرار رقم ٣٨٣ من الكود المصرى رقم ٥٠١ لسنة ٢٠١٥

مدير ادارة الميكروبيولوجى مدير ادارة الكيماوى

يعتمد ...

٢٠٢٠/١١/٢٠

Annex V

Hydraulic Capacity of Al-Saff Canal

English Summary

Hydraulic Study

Hydraulic Capacity of Al-Saf Canal after increase the existing capacity of wastewater treatment plant in Arab Abo-Saad from 550,000 m3/day to be 800,000 m3/day

Hydraulic Research Institute

November 2020

1. Introduction

The Construction Authority for Potable Water & Wastewater (CAPW) aims to increase the existing capacity of wastewater treatment plant in Arab Abo-Saad from 550,000 m3/day to be 800,000 m3/day. The treated wastewater is being discharged into the Al-Saff canal. An integrated study was carried out to check the canal efficiency and capacity to carry the additional water volume. The Hydraulics Research Institute had carried out the hydraulic modeling study for the canal capacity. The study objectives are:

- Determine the bottlenecks' location in the Al-Saff canal after increasing the discharge capacity due to the new additional water discharges from Arab Abo-Saad WWTP, considering the existing conditions of canal water levels and its banks level as well.
- Study the increasing of Al-Saff canal capacity by dredging the canal bed level and bank protection works.
- Find different alternatives to increase the canal capacity (in case of difficulties that hinder receiving the additional water discharges after the dredging operations). This can be done by widening existing cross-sections if available.

2. Description of Study Area

Al-Saff canal has some problems related to the increase of the groundwater table in the surrounding agricultural lands, leading to bank failure in different places. The canal length is about 51 km and divided into three parts. The first part started from the canal upstream and extended about 24 Km downstream ward. This part receives about 550,000 m^3/day treated wastewater effluent from Arab Abo-Saad WWTP. The second part started from Kilometer 24 to kilometer 45 and received its water from the Al-Hager canal by Ghammaza pump station. The third part of the Al-Saff canal started from kilometer 45 to the downstream end at kilometer 51 and received its water from the pumped water by the Ghammaza pump station with a total discharge of 500,000 m^3/day.

1 Scope of the Study

To achieve the objectives mentioned above, the scope of the study were as follows:

- Data collection included the designed water discharges and their corresponding water levels of the canal, besides the designed dimensions of all existing hydraulic structures along the study area.
- Field measurements were carried out and included a bathymetric and topographic survey for the canal bed levels and the banks level. Hydrographic measurements of currents, water levels, and discharges were also carried out.

- Development of 1D numerical model to simulate the canal and its existing structures. The model was calibrated using field measurements.
- After model calibration, different scenarios were carried out to find the bottlenecks' locations along the simulated reaches and simulate the proposed solutions to the canal capacity to accommodate the additional discharges.

2 Numerical modeling Study

SOBEK 1-D Channel Flow model was used for this study. The model can simulate the flow in rivers, drains, and estuary systems. It has been developed by Deltares, The Netherlands. It is a tool based on knowledge and experience gained from many rivers and estuaries in the world. On the other hand, SOBEK-Overland flow is a modeling system that supports engineers' work related to flood studies. In a typical application, the program is used to simulate floodwaters' progression and the depth of flooding in an area along a river or a canal. The program calculates water depths and velocities in the flooded area.

As for open channel simulations, the most relevant models that can be used are the Flow Module and the Overland Flow Module. The Flow Module is capable of simulating a fully unsteady flow in the channel. The Overland Module is capable of simulating the progression of floodwaters and the depth in River Valley and Delta.

SOBEK-Channel Flow and SOBEK-Overland flow can be applied to the following cases:

- Flood prediction and control (simulation of flood and tidal-wave propagation, reservoir operation, risk and damage assessment, etc.) and flood routing (forecasts, peak level estimation, etc.)
- Hydraulic structures (impact on the river system, managing controllers, hydraulic boundary conditions, etc.)
- Disaster management
- Evacuation planning
- Flood Damage assessment
- Risk analysis

The model was set up to simulate the study area, as shown in figure 1. Field measurements were used to set up the model through:

- 247 cross-sections covering about 51 km of the old Al-Saff canal.
- 120 cross-sections covering about 23 km of the new Al-Saff canal.
- All existing hydraulic structures (weirs, regulators, bridges, intakes and syphons) on both old and new Al-Saff canal.

The field measurements including discharges and water levels in Al-Saff old and new canal were used to calibrate the model. Manning roughness was adjusted as a calibration parameter to achieve best matching between calculated and measured data. Figure 2, shows the results of model calibration.

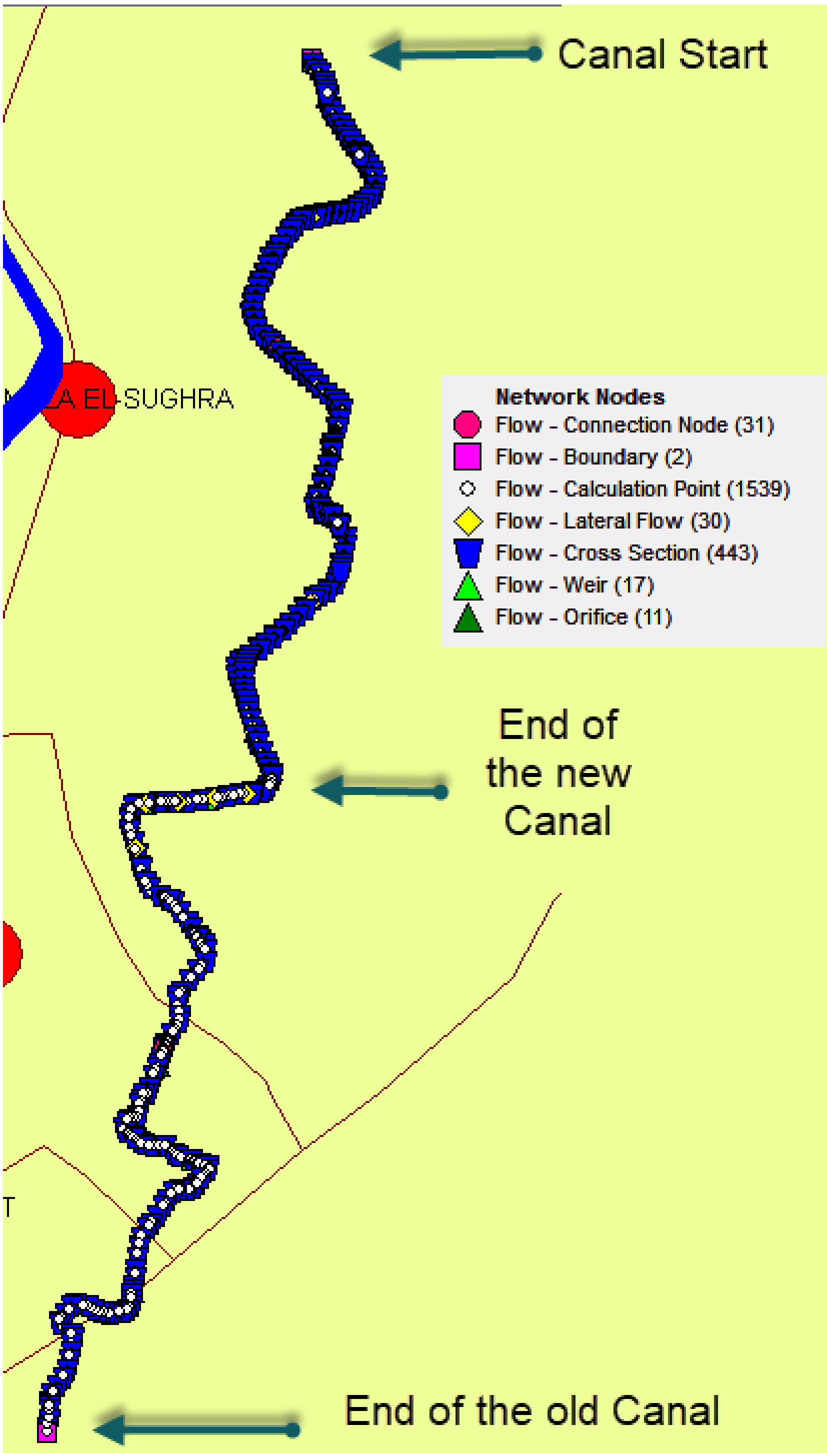


Figure 38: Plan layout of simulated area in the numerical model

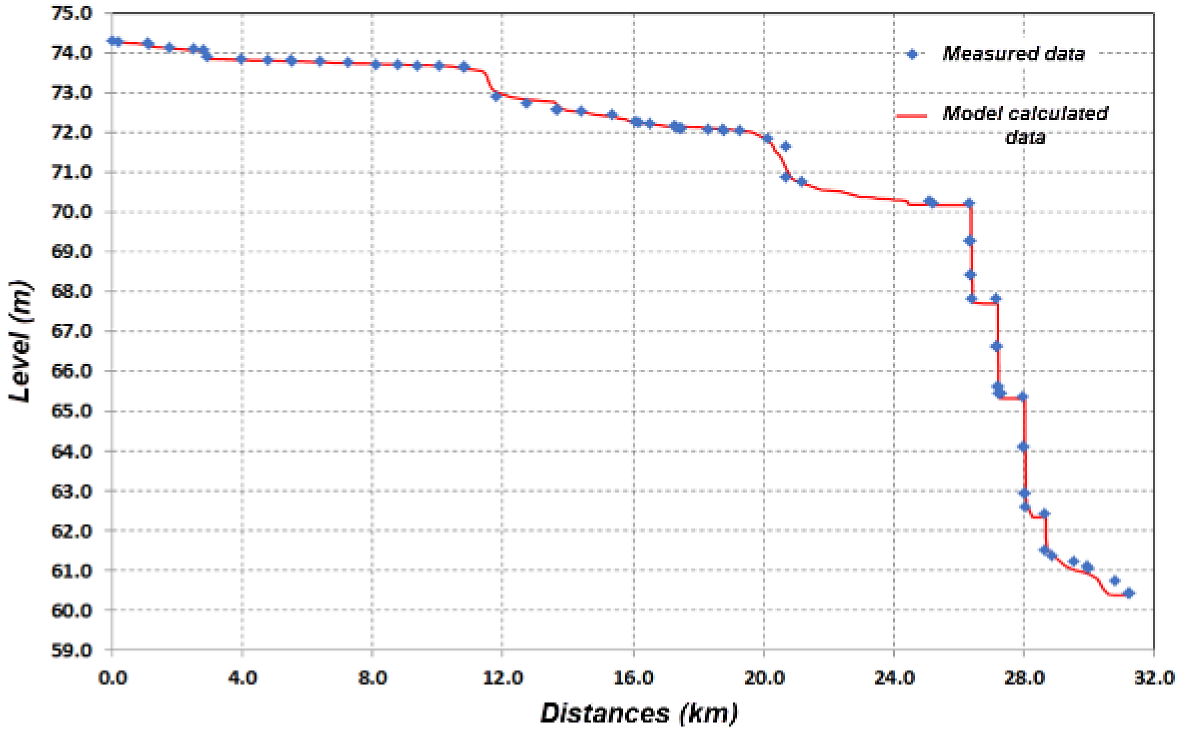


Figure 39: Comparison between measured and calculated water level of Al-Saff old canal

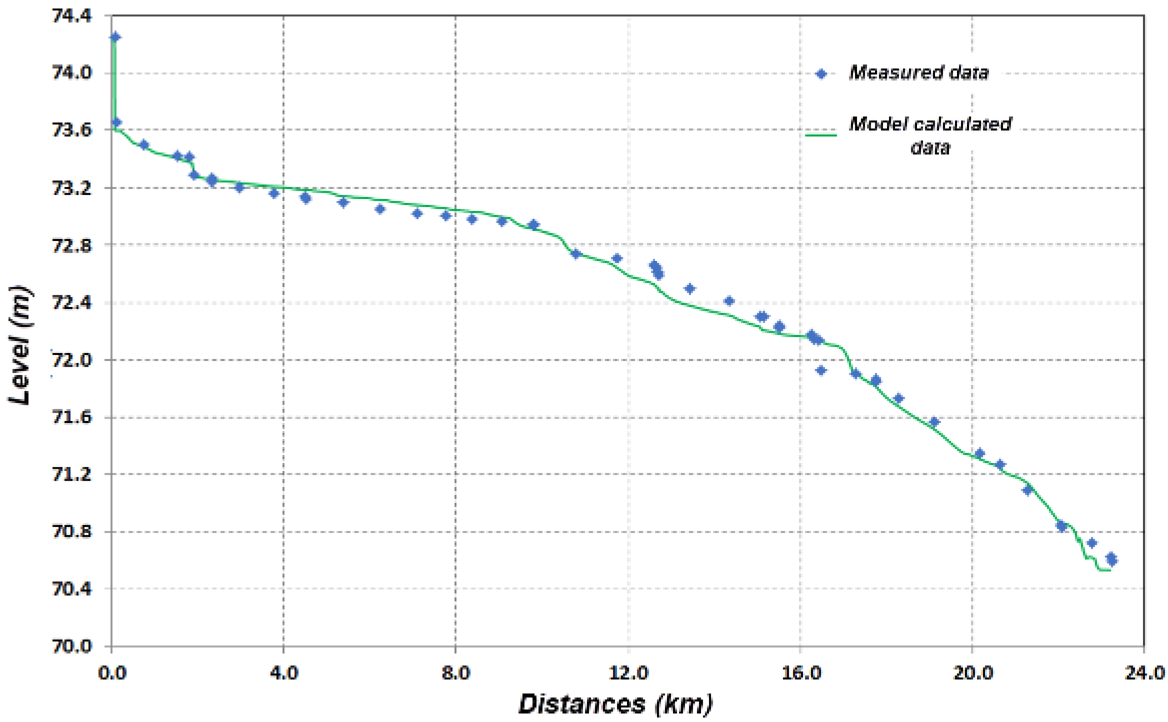


Figure 40: Comparison between measured and calculated water level of Al-Saff new canal

2.1 Model Scenarios and Results

Six model scenarios were carried out to study the existing canals situations and the situations after the additional treated wastewater effluents.

- **Scenario-1** studied the existing condition hydraulic capacity of the canal with the received discharges of **550,000 m^3/day from the WWTP**. The results of model scenario showed no flooding problem over the canal banks in both new and old Al-Saff canals.
- **Scenario-2** studied the existing condition hydraulic capacity of the canal after increasing the effluent discharge to be **800,000 m^3/day** from the WWTP. The results of this model scenario showed particularly flooding problem over the banks of new Al-Saff canal (from kilometer 20.6 to the canal end).
- **Scenario-3** studied the hydraulic capacity of the canal after modifying the diameters of some syphons with the new proposed effluent discharge of **800,000 m^3/day from the WWTP**. The results of model scenario showed no flooding problem over the canal banks in both new and old Al-Saff canals.
- **Scenario-4** studied the hydraulic capacity of the canal with the new proposed effluent discharge of **800,000 m^3/day from the WWTP**, and considering there are no withdrawal of water from the intakes. The results of this model scenario showed particularly flooding problem over the banks of old Al-Saff canal (from kilometer 15.66 to kilometer of 17.4 and from kilometer 20.5 to the end of the canal). Also, the model results showed flooding problems over the banks of new Al-Saff canals from kilometer 15.9 to the end of the canal.
- **Scenario-5** studied the hydraulic capacity of the canal with the new proposed effluent discharge of **800,000 m^3/day** from the WWTP after modifying the diameters of some syphons and considering there are no withdrawal of water from the intakes. The results of this model scenario showed particularly flooding problem over the banks of old Al-Saff canal (from kilometer 21.8 to kilometer of 23.1 and from kilometer 28.1 to the end of the canal). On the other hand, there are no flooding problems over the banks of new Al-Saff canals.
- **Scenario-6** studied the hydraulic capacity of the canal with the new proposed effluent discharge of **800,000 m^3/day** from the WWTP after modifying the diameters of some syphons, the removal of all encroached syphons with replacement by bridges, considering there are no withdrawal of water from the intakes and modifying the canal bed width. The results of this model scenario showed particularly flooding problem over the banks of old Al-Saff canal (from kilometer 21.8 to kilometer of 23.1 and from kilometer 28.1 to the end of the canal). On the other hand, there are no flooding problems over the banks of new Al-Saff canals.

Figures 4 and 5 show 00 between the results of model scenarios 1, 2, 3 and 4 to Al-Saff old canal and new canal, respectively.

Figures 6 and 7 show comparison between the results of model scenarios 4 and 5 to Al-Saff old canal and new canal, respectively.

Figures 8 and 9 show comparison between the results of model scenarios 4 and 6 to Al-Saff old canal and new canal, respectively.

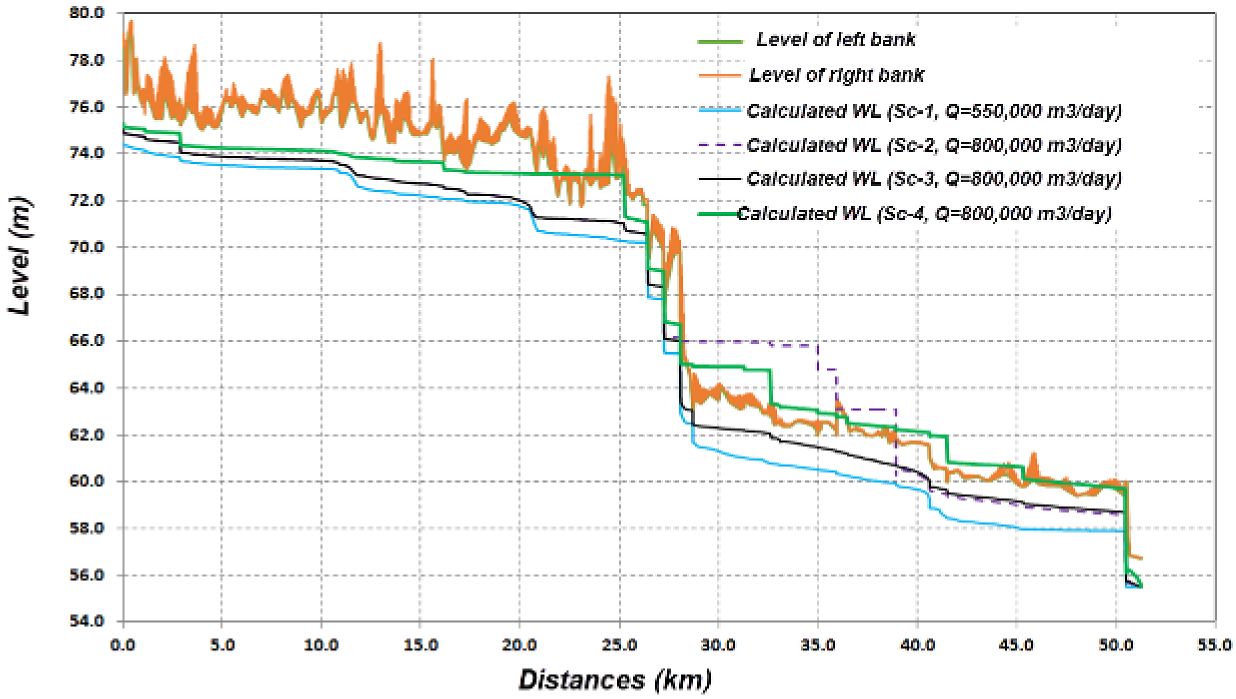


Figure 41: The water level results to Al-Saff old canal in model scenarios (1, 2, 3 and 4)

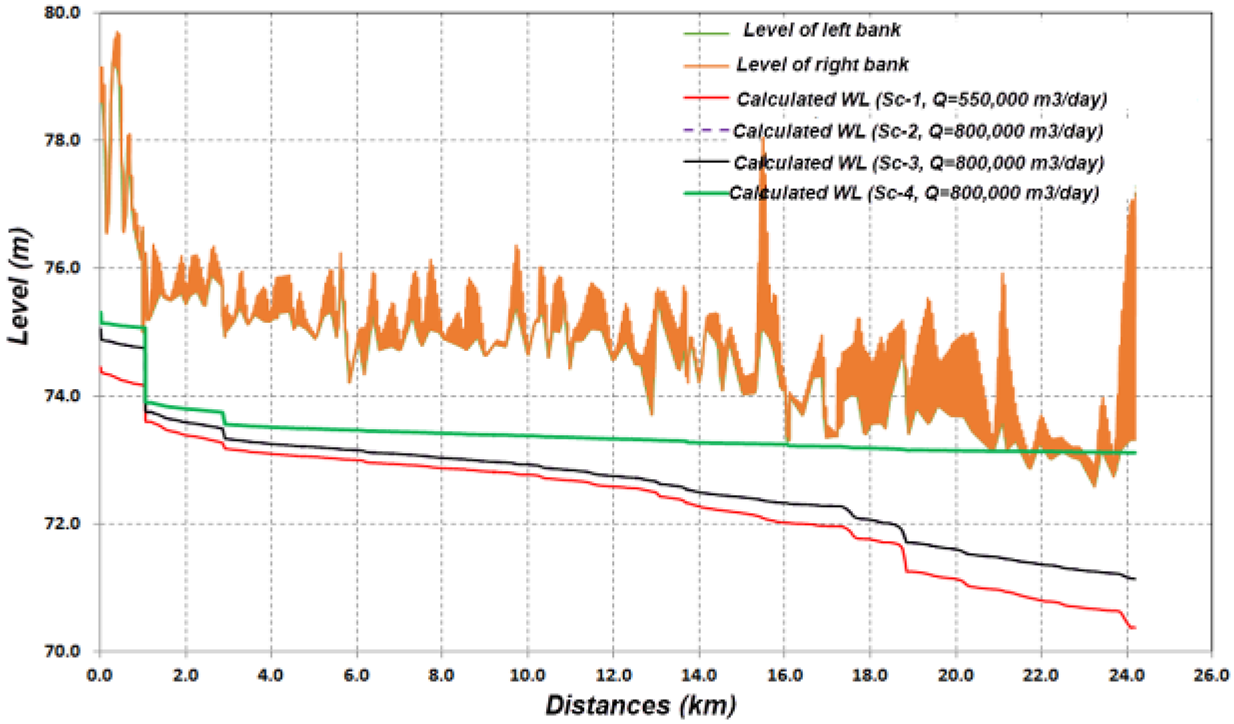


Figure 42: The water level results to Al-Saff new canal in model scenarios (1, 2, 3 and 4)

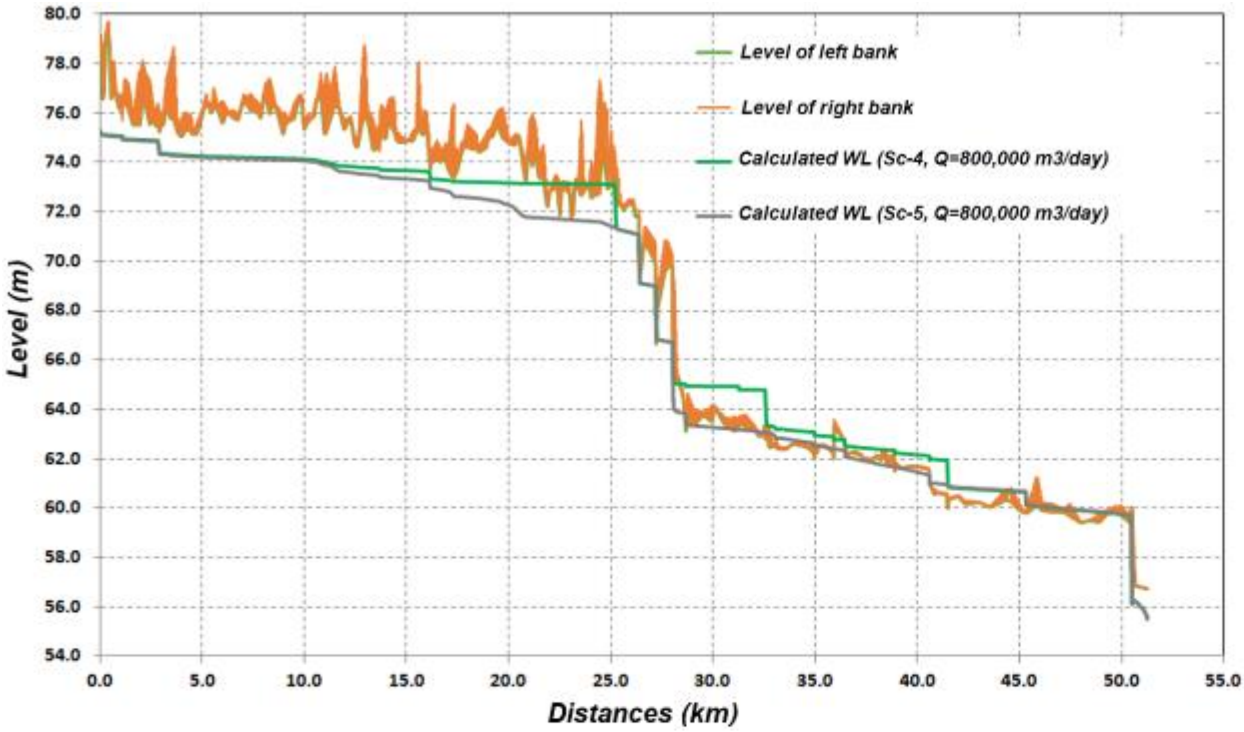


Figure 43: The water level results to Al-Saff old canal in model scenarios (4 and 5)

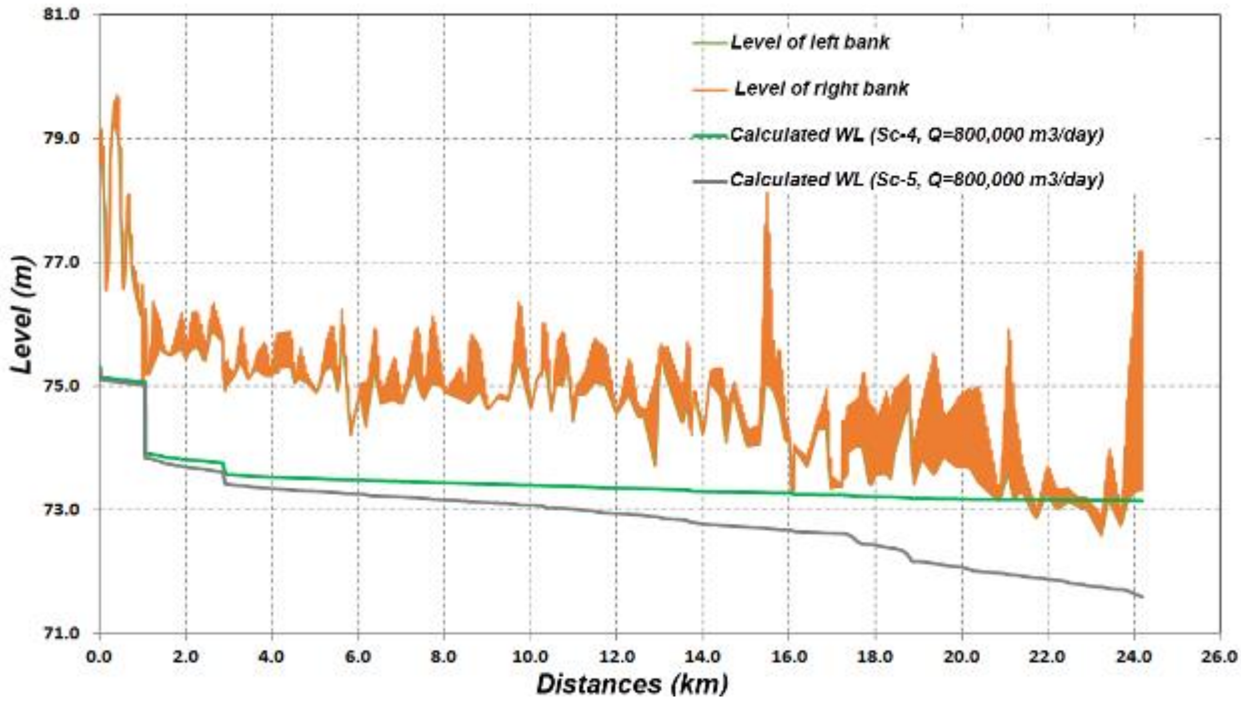


Figure 44: The water level results to Al-Saff new canal in model scenarios (4 and 5)

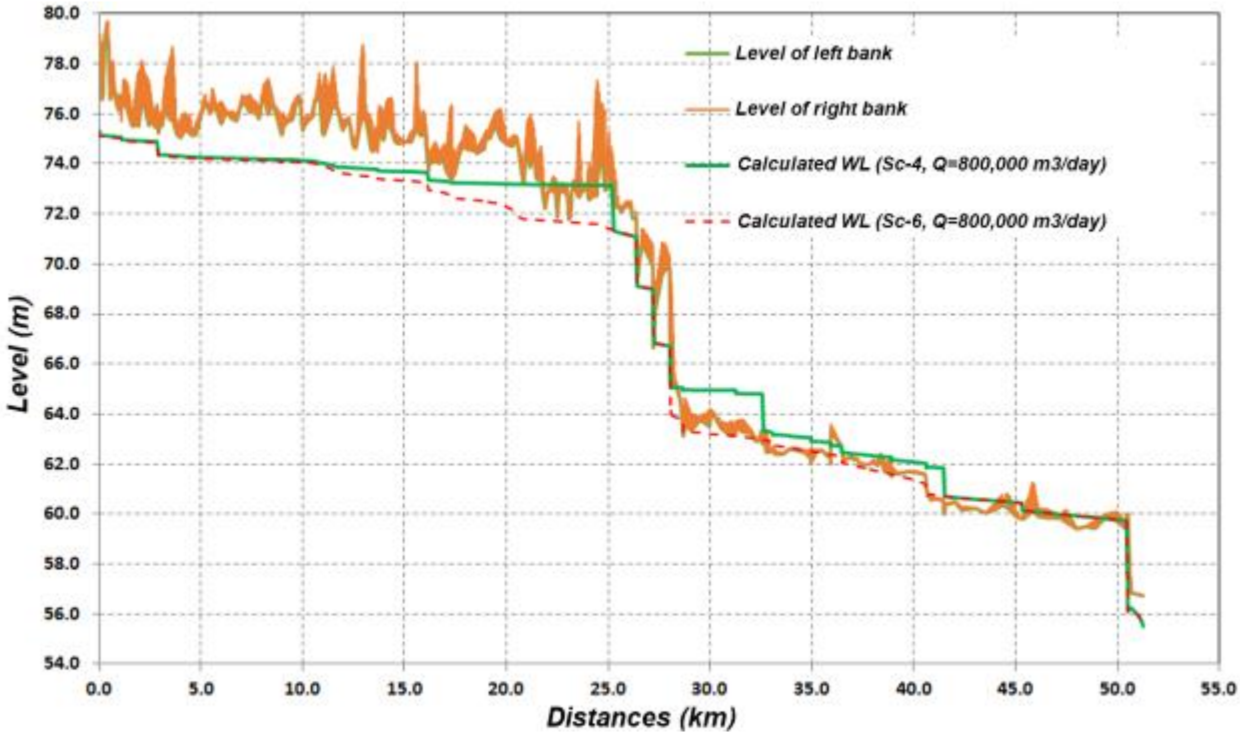


Figure 45: The water level results to Al-Saff old canal in model scenarios (4 and 6)

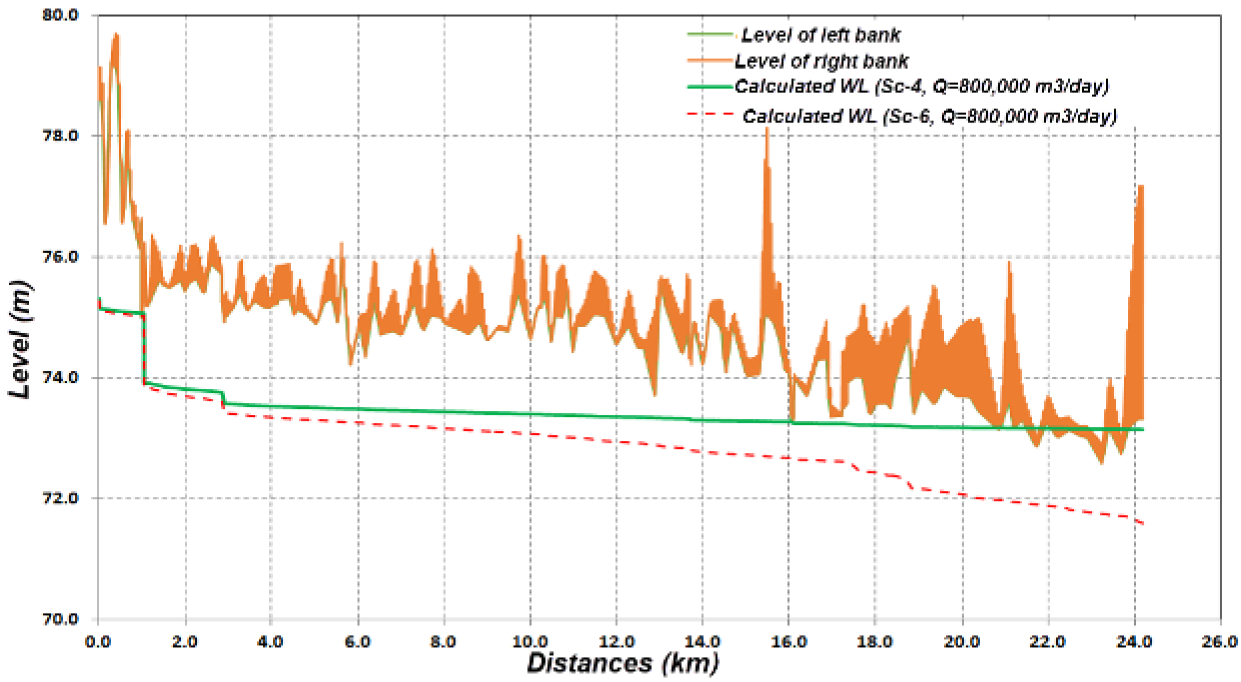


Figure 46: The water level results to Al-Saff new canal in model scenarios (4 and 6)

3 Conclusion

- The Hydraulics Research Institute conducted field studies in two phases, where the first phase included measuring canal banks and bed levels with a length of 51.15 km for the old Al-Saf canal and 23.15 km for the new Al-Saf canal, while the second phase measurements included measuring the behavior and water levels in front and behind the existing water structures in the same study area.
- A one-dimensional mathematical model was created using (SOBEK-ID) program representing the two channels "Al-Saf old and new canals" and was calibrated to ensure its readiness to perform the required scenarios. Six scenarios were tested for the study, including the current and future status of the canal.
    - In scenario No. (1), the canal's hydraulic efficiency was tested in its current condition, with a discharge of 550,000 m3 / day for the WWTP.
    - In scenario No. (2), the canal's hydraulic efficiency was tested in its current condition, with the required discharge of 800,000 m3 / day.
    - In scenario No. (3), the canal's hydraulic efficiency was tested after modifying the pipe diameters of some siphons with a discharge of 800,000 m3 / day.
    - In scenario No. (4), the canal's hydraulic efficiency was tested after modifying the pipe diameters of some siphons, assuming that there is no withdrawal of water from the intakes with a discharge of 800,000 m3 / day.
    - In scenario No. (5), the canal's hydraulic efficiency was tested after modifying the pipe diameters of some siphons, assuming that there was no withdrawal of water from the intakes and modifying the canal bed width with a discharge of 800,000 m3 / day.
    - In scenario No. (6), the canal's hydraulic efficiency was tested after modifying the pipe diameters of some siphons and removing all the unsafe siphons, and replacing them with bridges assuming that there was no withdrawal of water from the intakes, as well as modifying the canal bed width with a discharge of 800,000 m3/day.
- The results of the study showed the possibility for El-Saff canal to accommodate the excess discharges from the Arab Abu Saad WWTP after modifying the diameters of some of the siphons pipes, in addition to the required repair and maintenance of canal banks and the concrete sector of the canal in some places with a recommendation to conduct a construction study for the needed repairs. In case additional flow with

4 Recommendations

Based on the results of the study, the institute sees from the hydraulic point of view, for the canal to accommodate the required discharge of 800,000 m3 / day, the following recommendations must be implemented:

First, in the case of a draw from the legal intakes only:

- ✓ The necessity of restoring the current concrete sector of the canal in places that collapsed by flood events.
- ✓ The necessity of repairing and strengthening the existing canal banks along the two canals in the places shown in the following table:

Table (3): Places of Canal banks collapses

Region	Start of collapse (km)	End of collapse (km)	Canal bankside
One	1.45	2.5	Right and Left
Two	3	3.1	Right
Three	3.14	3.26	Right
Four	3.18	3.5	Left
Five	5.56	8.58	Right and Left
Six	12	12.72	Right and Left
Seven	14.76	17.44	Right and Left
Eight	21.3	23.3	Right and Left

- ✓ The necessity of modifying the diameter of Al-Desami siphon pipes at the Km 38.87, as well as changing the diameters of the unsafe siphons at km (34.93- 35.78 - 40.75 - 41.07 - 42.72 - 43.42 -44.05) to become 3.00 meters instead of the current diameters that were established on the canal by the illegally to make a pedestrian bridge as these pipes with their present diameters impede the flow of water and cannot accommodate excess discharges. **Or remove all the unsafe siphons and replace them by constructing bridges.**
- ✓ The necessity to conduct a structural study for the required repairs to the collapsed areas' concrete sector.

Second: In case of no withdrawal from all intakes, whether legal or illegal:

This case potentially could happened in winter season. The following recommendations **must be added** to the above so that the canal can accommodate the required WWTP discharge of 800,000 m3/day:

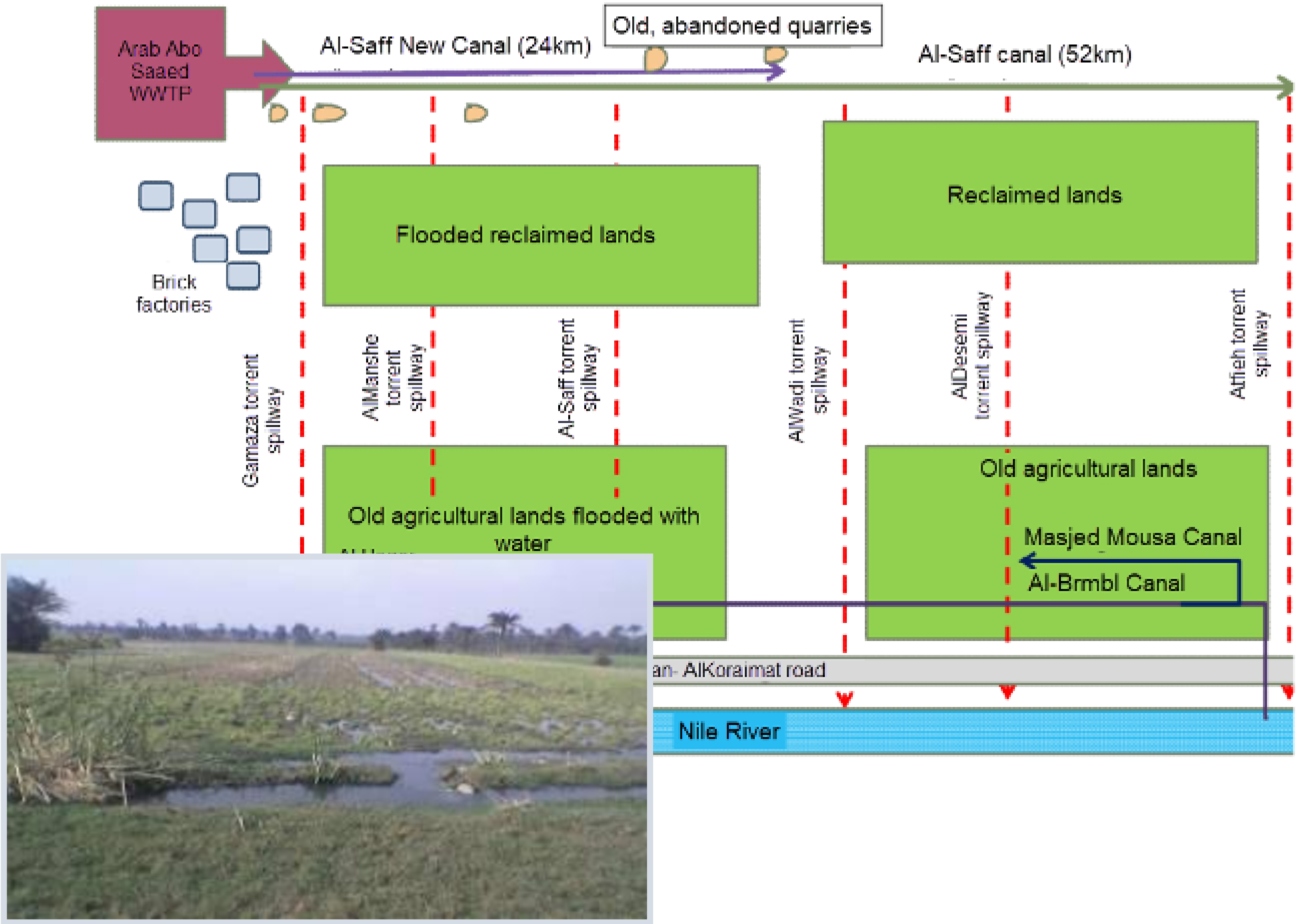
- ✓ The necessity to increase the canal's bed width to about 6.00 meters in the places of Al-Wadi siphons at km 32.00 and Al-Desami at km 38.87 after modifying them so that each siphon consists of two pipes, each is 3.00 meters in diameter.
- ✓ Removing all the unsafe siphons at km (34.93- 35.78 - 40.75 - 41.07 - 42.72 - 43.42 -44.05) and replacing them by constructing bridges.
- ✓ Increasing the bank levels in Al-Saf old canal by about 0.75 meters in km (21.80 to 23.10), (28.40 to 31.80), (35.80 to 40.50).
- ✓ Increasing the bank levels in Al-Saf old canal by about 1.25 meters in km (31.80 to 35.80), (40.50 to the end of the canal).

Annex VI

El Saff drainage network study

English Summary

Hydraulic Capacity Study



Hydraulic Capacity of Al-Saf drains after increase the existing capacity of wastewater treatment plant in Arab Abo-Saad from 550,000 m3/day to be 800,000 m3/day

Drainage Research Institute

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1 Introduction

The need for adequate water sources to reclaim new lands in desert areas in the region of Markaz Al-Saff and Atfih in Giza governorate led to the depletion of underground reservoirs and the deterioration of the quality of available surface water. In view of these conditions, the General Authority for Reconstruction Projects and Agricultural Development affiliated to the Ministry of Agriculture studied, planned and designed the path of the El-Saff Canal, along the 52 km east of the Nile, in 1983, to utilize treated wastewater (second-class treatment) and the output from the waste water treatment plants in South Cairo to cultivate An estimated 4,200 feddans are being reclaimed in the East Markaz Al Saff area, where the water of Al-Saff Canal was used in irrigation and cultivation of lands of the region and with the continuation of irrigation of these lands a problem appeared in the flooding of large areas of land adjacent to the canal and the ponds therein in addition to the rise in ground water levels in the old agricultural lands adjacent to the river Nile in addition to the rise in ground water levels within the residential areas in the region due to water infiltration within the soil and the direction of water To the old low-lying lands shown by figure 1 which has become a natural drainage for the eastern highlands, adjacent to the canal, where ground water levels have risen, which helped in flooding the soil and the emergence of drainage problems such as hindering the growth of most plants, salinization of agricultural soil, and the collapse of the productivity of crops, trees and palms in the region Picture No 1.

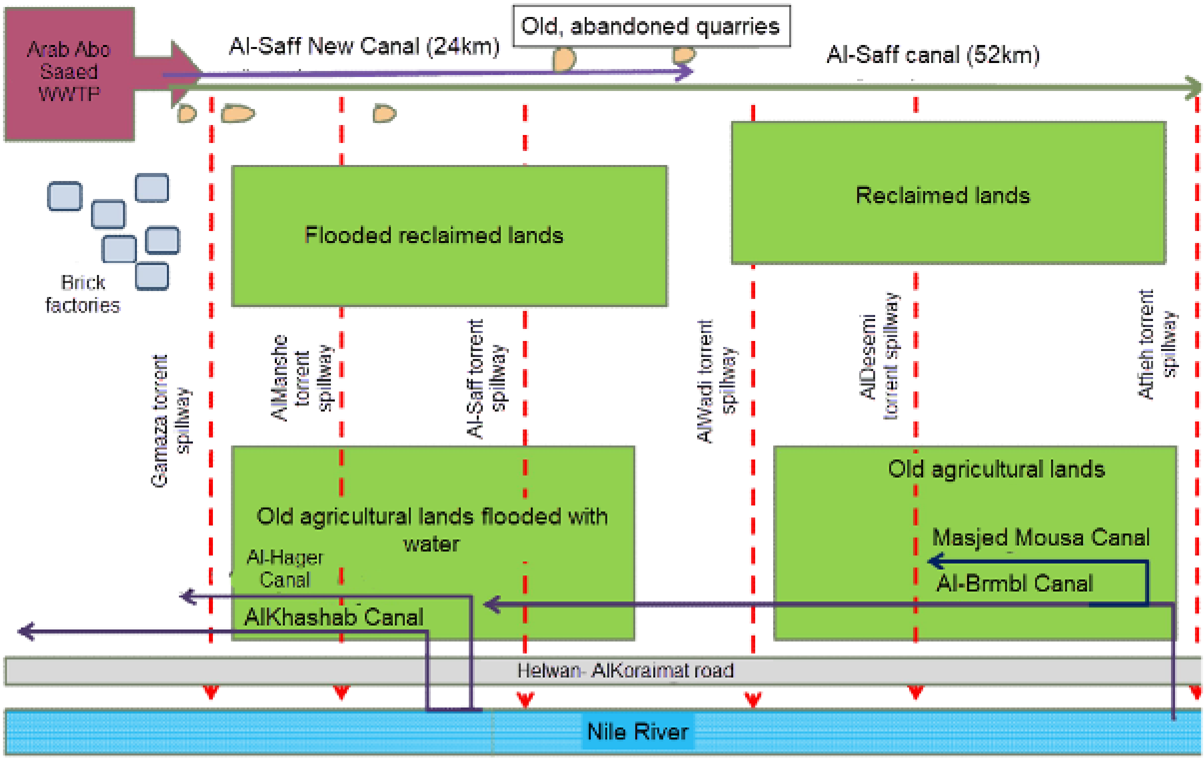


Figure 47: Schematic diagram of Al-Saff and Atfih area and irrigation methods

Photo 1: Palm trees affected by leachate water

Regarding the study being prepared by the Executive Authority for Drinking Water and Wastewater to expand the Arab Abu Saed treatment plant to receive 800,000 m3/day instead of 550,000 m3/day by adding a new phase with a capacity of 250,000 m3/day, which is recommended for the National Water Research Center, represented by Drainage Research Institute, Hydraulics Research Institute, Construction Research Institute, Climate Change Research Institute, and Central Laboratories conducting studies on increasing the capacity of old and new AlSaff Canal resulting from the expansion of the Arab Abu Saed WWTP from 550,000 m3/day to 800,000 m3/day

2 Description of Study Area

The study area is confined between the El-Saff Canal course and the ancient lands east of the Nile River. It is a desert region consisting of non-flat plateaus and semi-mountainous areas whose levels descend westward towards the Nile from about 100 meters above sea level in the east to about 40 meters above sea level in the west, where the ancient agricultural lands are located. The slopes are irregular, and there are also some internal depressions and ponds in the area.

The area depends on its reclamation on the El-Saff Canal water, which is fed from the output of the WWTP west of Abu Musaed, with a capacity of 550,000 m3/day. It is planned to increase it to 500,000 m3/day in the future by adding a new phase with a capacity of 250,000 m3/day. The canal extends from the Ghamaza area South of the WWTP south of Cairo (Helwan) located in the Arab Abu Saed area to the southern Atfih area, and the canal is roughly parallel to the Nile River, and its farthest distance from the Nile is about 11 km and the closest distance from the Nile is about 3 km. The area is approximately 42,000 feddans, the average land level at the start of the canal is (77.00) meters above sea level, and the average level of the land at its end is (55.00) meters. The length of the Al-Saff canal is 52 km, and it is divided into 3 sections. The first starts from km 0.0 to km 24.00 and is fed through the Arab Abu Sa'ed WWTP with wastewater treated with disposal of 580,000 m3/day to irrigate 16,000 feddans of tree forests. The second starts from km 24 to km 45 and is fed from Gamaza pump station "A", which is taken from the Al-Hajer canal, which feeds the canal with the Nile River's waters to irrigate the surrounding areas. The third starts from km 45 to km 52 at the end and is fed from Gamaza pump station "B" with fresh water in the Nile, with a discharge of 500,000 m3/day, which is sufficient to irrigate the target areas. There is also a group of drains of torrent spillways that go from east to west to flow into the Nile River, and they act as main open drains on which the drains that will be established will be poured, and these routes intersect with the Al-Saff canal by siphons passes down the canal, which is as follows: (Figure 3).

1. Ghamaza Al Kubra torrent spillway
2. Al-Manshi torrent spillway (Al-Aqwaz)
3. Al-Saff torrent spillway
4. AlWadi torrent spillway
5. Al-Desmi torrent spillway
6. Atfih torrent spillway

The Drainage Research Institute has planned and designed a network of open drains to serve the study area consisting of 6 cut-off drains parallel to the El-Saff canal, as shown in Figure 3, to collect leachate water, which was found to be produced from the reins of the El-Saff canal with high levels in the eastern side, which is fed from the output of the wastewater treatment plant west of Abu Musaed has a capacity of 550,000 m3/day.

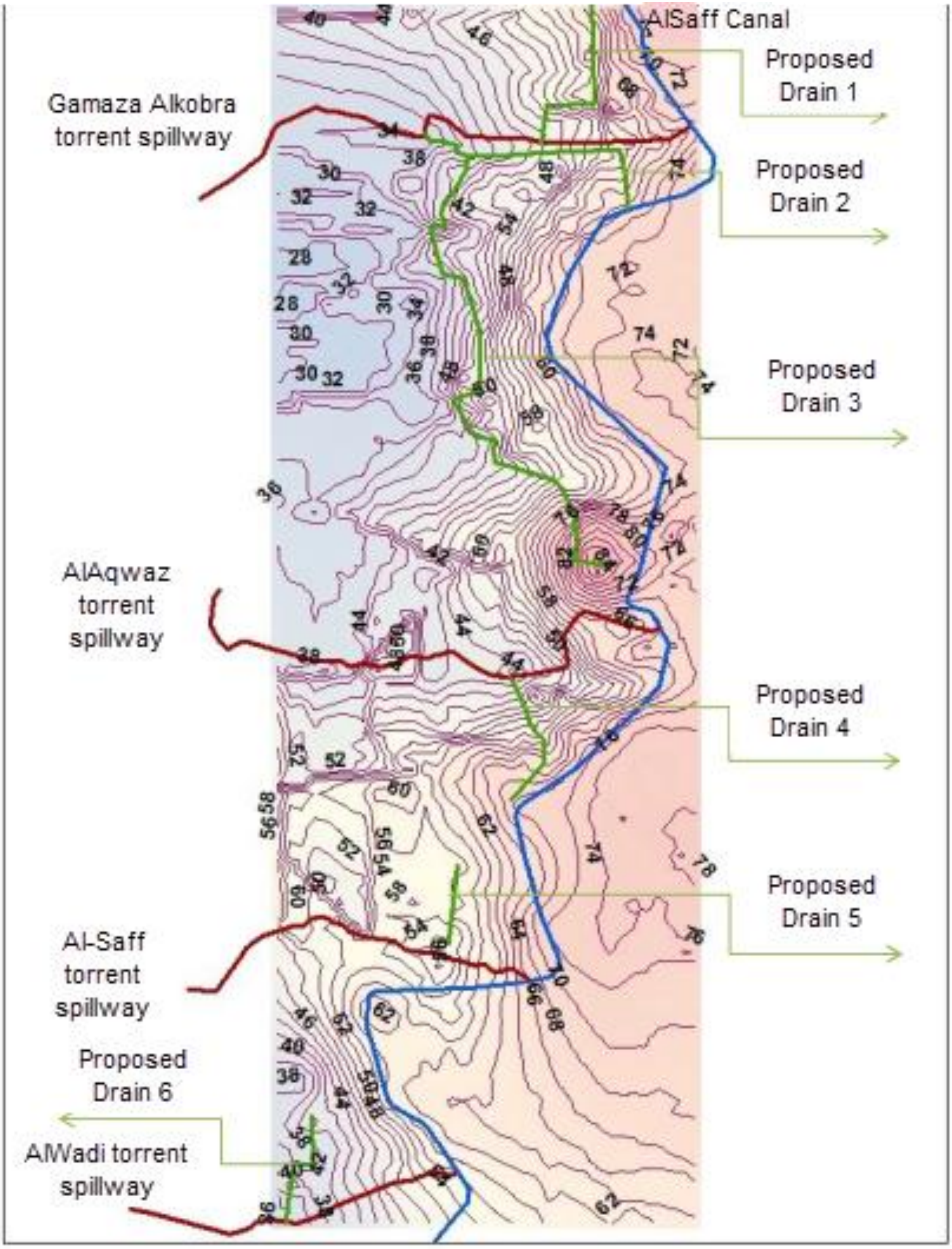


Figure (3) Al-Saff canal and the locations of the drains to be established to serve the Al-Saff area

3 Problem definition

The area relies on its reclamation on the water of the El-Saff canal, which is fed by the output of the WWTP west of Abu Musaed with a capacity of 550,000 m3/day, and it is intended to increase its capacity to 800,000 m3/day by adding a new phase with a capacity of 250,000 m3/day and as is intended to study the impact of this increase on each of:

- Drainage network in the Al-Saff area.
- The stability of the canal and its banks.
- Environmental impact.
- The quality of the water passing through the canal.

The Drainage Research Institute will study the effect of this increase on the planned drainage network in Al-Saff area.

4 Aim of the study

The study aims to:

- Study the water balance of the area after increasing the drainage of the Al-Saff canal.
- Redesigning the proposed cut-off main drains parallel to the Al-Saff canal and preparing the longitudinal and cross-sections of it and the industrial works required on these drains, such as drains, bridges, estuaries, siphons, etc.
- Study the cross-sections of torrent spillways that will receive the water of the proposed drains after their redesign and study the extent of the need for the Al-Saff canal region to establish subsurface drainage networks to complete the drainage process in the area.

5 Methodology

The methodology includes studying the effect of increasing the new Al-Saff Canal capacity from 550,000 m3/day to 800,000 m3/day on the proposed drains to be established within the region of the Al-Saff Canal. To achieve the objectives of the study mentioned above, this approach will include the implementation of the following activities:

- Study the quantities of covered irrigation water after increasing the drainage of the Al-Saff canal and the water needs of crops to be planted in the future and estimating the drainage coefficient for the upstream of each drain.
- Redesigning the area's main drains to accommodate the drainage water required to be collected after increasing the Al-Saff canal drainage.
- Study the extent of the need to implement a subsurface drainage network for cultivated lands now and in the future, and determine the sites for their implementation and priorities.

6 Results

4.1 Exploratory visits and inspections

A team of the Institute's engineers made field visits to collect and update the various data required for the study and to determine the state of the region, including the feeding canals and drains, as well as inspecting the surrounding areas and their impact on groundwater, as shown in photo (2). And photo (3).

Photo (2) the ponds spread over the study area

Photo (3) waterlogging and salinization of lands in the study area

4.2 The expected amount of drainage water after the El-Saff canal accommodated the additional flow of the WWTP in Arab Abu Saed (water balance)

To calculate the amount of wastewater expected to be received from the study area after the El-Saff canal accommodated the additional flow of the WWTP in Arab Abu Saed, a simplified mathematical model based on the water balance equation was used to estimate the amount of drainage water produced by the area.

6.1.1 Mathematical model input

- <u>The amount of irrigation water</u>

Contact was made between the Irrigation Authority and the Hydraulics Research Institute to obtain the design data and the maximum actions passing through the Al-Saff Canal.

It was found that the maximum design discharge of the canal at km 0.0 (the start of the canal) is 8.5 m3 / s and at km 25.87 (the end of the study area) is 5.18 m3 / s. Thus, the amount of water that will enter the study area's control through the canal is estimated at 3.32 m3 / s. The El-Saff canal discharge has also been measured in the field in some cross sections by the Hydraulics Research Institute as from the start of the canal km 0.0 to km 23.14, the discharge becomes zero, and there is no water in the canal. From the measurements of the Hydraulics Research Institute, about 3.55 m3 / s entered the study area.

Accordingly, the amount of irrigation water that reaches the study area after the El-Saff canal accommodated the additional discharge of the WWTP in Arab Abu Saed may reach about 253500 m3/day, and thus the irrigation regulation determined for the project area will be estimated at 30 m3/feddan/day, and according to the total cultivated areas, the amount of water expected to be added to each drain was calculated.

- The amount of rainwater

According to the meteorological data in the study area, the rate of rainfall over the area is minimal, and therefore it can be neglected.

- The amount of vertical infiltration water to the study area

Due to an impermeable layer more than 10 meters deep, there is no filtration from top to bottom and vice versa.

- Runoff

The surface runoff was measured in Photo (4) with the control of each proposed drain using a volumetric device, where it was found that the surface runoff of the drains is as follows:

- Proposed drain 1: 12,500m3/day
- Proposed drain 2: 11333 m3/day
- Proposed drain 3: 10800m3/day
- Proposed drain 4: 4320 m3/day
- Proposed drain 5: 4450m3/day
- Proposed drain 6: 5400 m3/day

Photo (4) shows surface water runoff towards low-lying areas in the study area, forming ponds

- Amount of side leakage water from drains

As previously mentioned, there is a side leakage towards the west of the study area in the proposed drains' direction. It was estimated by installing leachate groups along the El-Saff canal from the intakes to km 23.14, where the canal becomes dry, and thus the discharge value is zero, as previously shown. Below is shown the infiltration values for each drain in the region:

- Proposed drain 1: 1250 m3/day
- Proposed drain 2: 2125 m3/day
- Proposed drain 3: 2825 m3/day
- Proposed drain 4: 850 m3/day
- Proposed drain 5: 825 m3/day
- Proposed drain 6: 1057.5 m3/day

6.1.2 Mathematical model output

- Crop water consumption

To calculate the water consumption of crops in the region, the mathematical model (Crop wat) was applied. The climatic elements were used, which are: wind data (direction and speed), relative humidity, radiation, temperature, rain rate, etc. From the nearest meteorological station (Helwan city). The most water-consuming crops were used, which were counted for the winter and summer seasons, which are trefoil and maize, respectively, and their stay in the land was used according to the

Ministry of Agriculture publications and the Food and Agriculture Organization (FAO). Also, soil data collected from the study area were used.

By applying the mathematical model Crop Wat, the water consumption of the cultivated crops that were selected in the study area, which has an area of 8,450 feddans, was estimated, and it was found that the value of total water consumption of the area of reclaimed land is about 49010000 m3 / year, which is equivalent to 134284.0 m3/day.

- The amount of evaporation water from canals in the study area

Evaporation losses in canals reach about 2812 m3/day.

6.1.3 Study area drains discharge

Using the previous factors and applying the mathematical model, the amount of wastewater expected to be discharged from each of the six drains was estimated, and it was 33974.9 – 27815.8 – 28749.5 – 22563.9 – 22044.9 – 19637.5 m3/day for drains 1-2-3-4-5- and 6 respectively with an average drainage rate of 5mm/day.

6.1.4 Design drainage rate

The average rate of drainage for the study area was estimated at an average value of about 21 m3/feddan per day as a safety factor for drains.

6.1.5 Side slopes

According to the results of soil analysis that were carried out on the paths of these drains, whose results indicated that the soil is predominantly sandy and silt, the inclination of the sides of the drains must be implemented with a value of 2: 1, where 2 is the horizontal inclination for the cross-section to be hydraulically safe.

6.1.6 Designing the drains after the canal accommodate the additional discharge

The Drainage Research Institute designed the open drains network for the study area before adding the discharge of the WWTP in Arab Abu Saed based on the drainage discharge 20 m3/feddan per day as safety factors for the drains and to design the open drain cross-sections after the additional discharge of the WWTP in Arab Abu Saed. The new drainage discharge was calculated for each drain in the study area, where the average value of it was about 21 m3 /feddan per day, which is approximately equal to the value of the drainage discharge before the al-Saff canal accommodated the additional discharge of the WWTP in Arab Abu Saed and as a result, there will be no change in the design of the drains network as well as the proposed hydraulic structures to be established on those drains, which will serve the study area. Below are the longitudinal profile of the proposed drains.

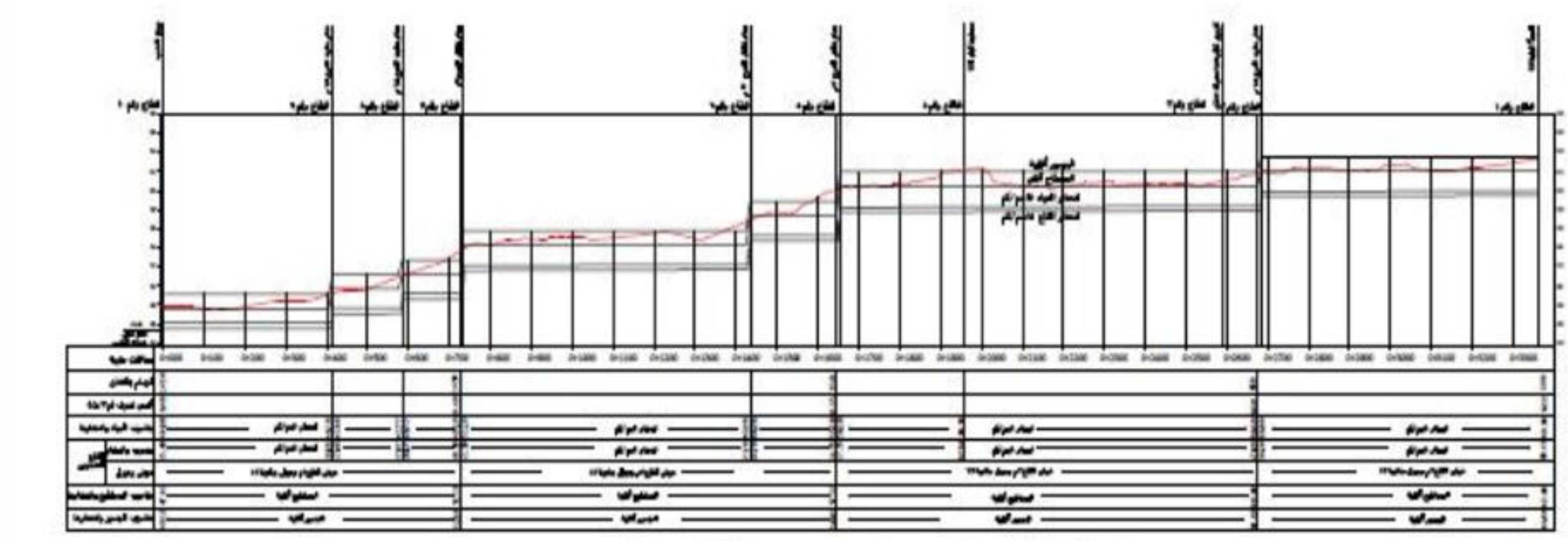
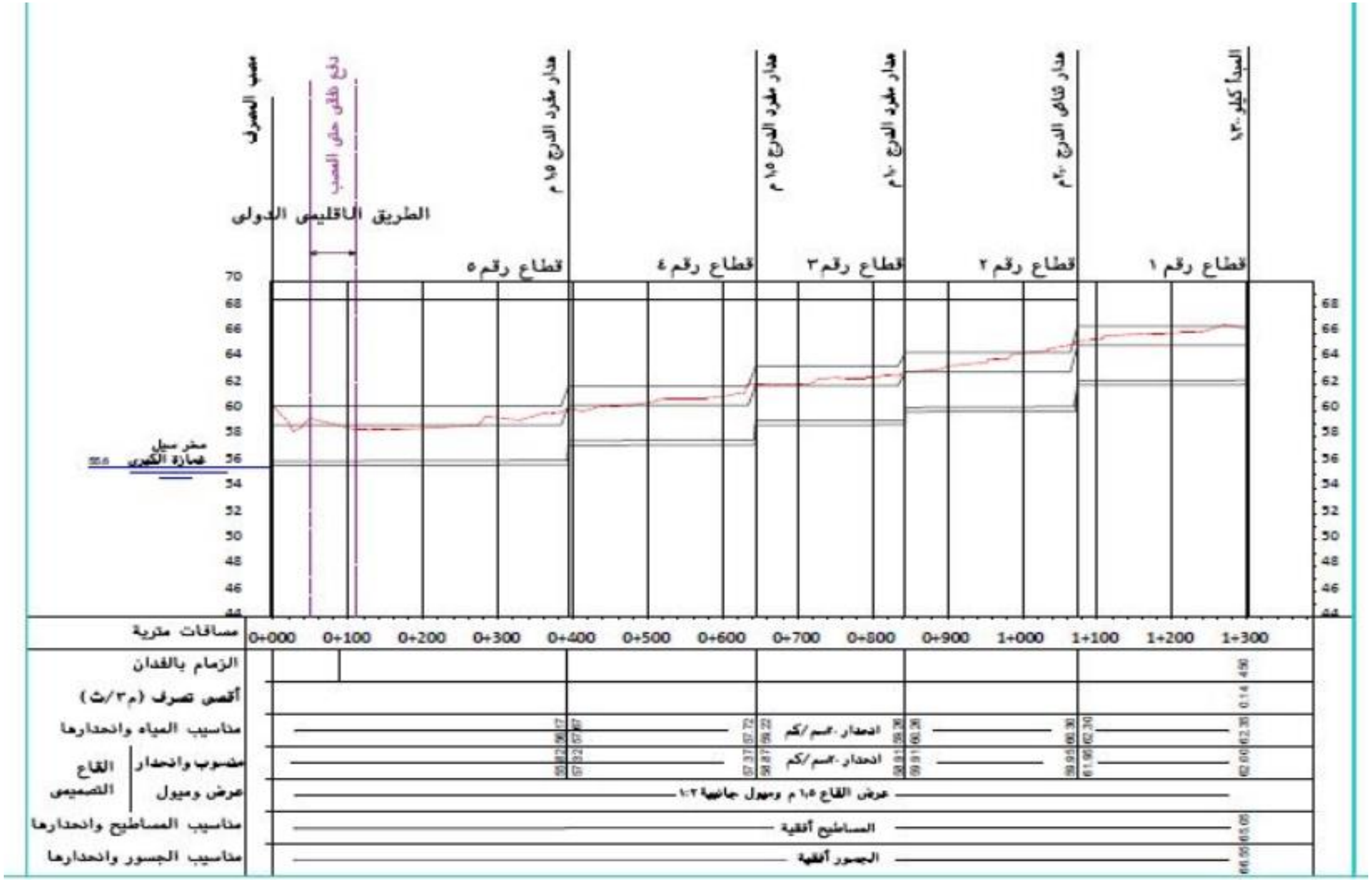


Figure 4: The longitudinal profile of the proposed drain 1


الطريق الاقليمى الدولى
قطاع رقم ٥
قطاع رقم ٤
قطاع رقم ٣
قطاع رقم ٢
قطاع رقم ١
مسافات مترية
0+000
0+100
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0+800
0+900
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1+100
1+200
1+300
الزمام بالفدان
أقصى تصرف (م٣/ث)
مناسيب المياه وانحدارها
منسوب وانحدار
عرض وميول
القاع التصميمى
مناسيب المساطيح وانحدارها
مناسيب الجسور وانحدارها
المساطيح أفقية
الجسور أفقية

Figure 5: The longitudinal profile of the proposed drain 2

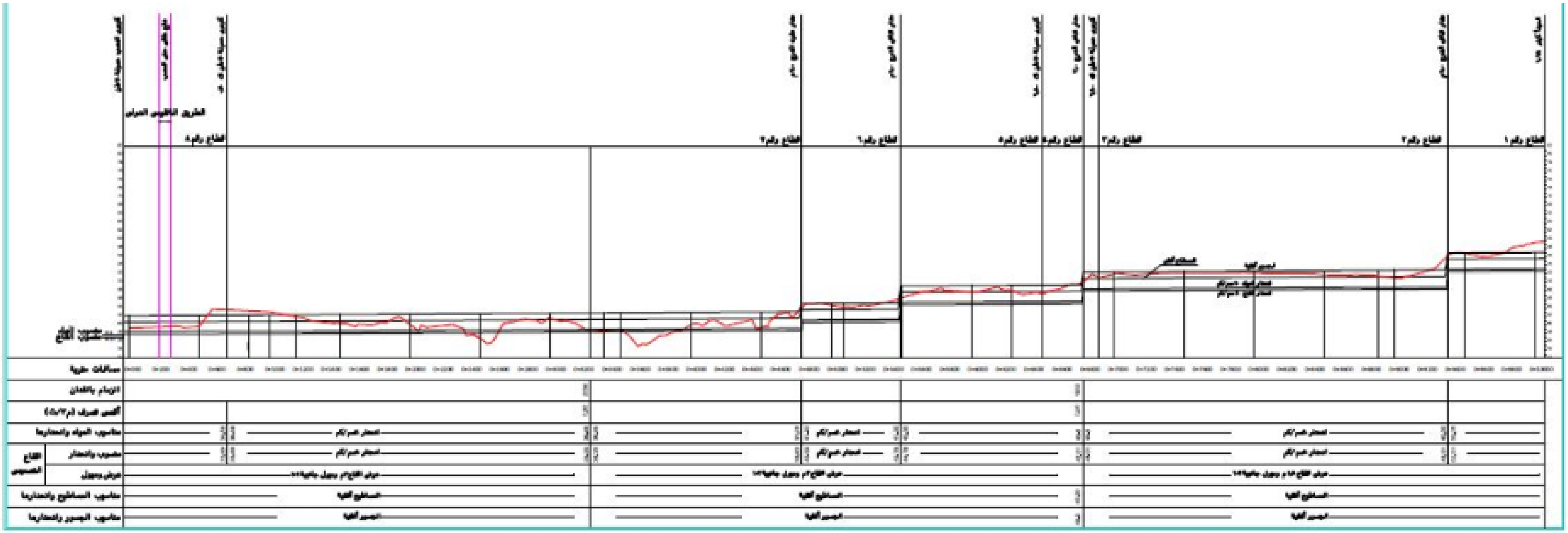

Figure 6: The longitudinal profile of the proposed drain 3

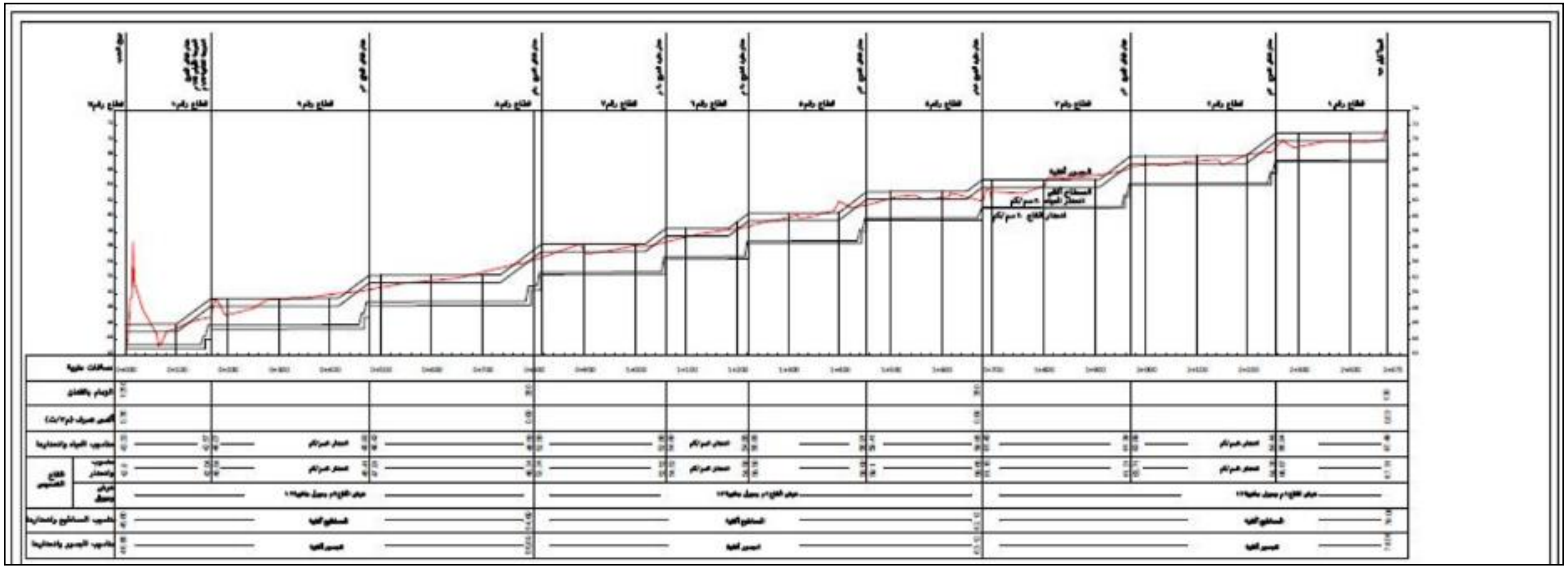

Figure 7: The longitudinal profile of the proposed drain 4

Figure 8: The longitudinal profile of the proposed drain 5

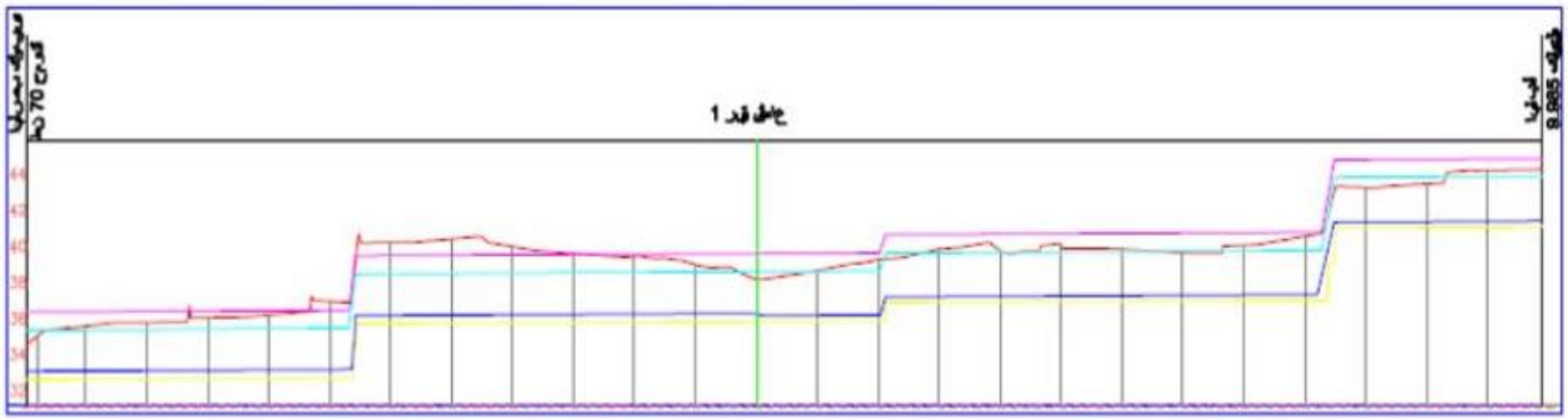

Figure 9: The longitudinal profile of the proposed drain 6

4.3 Torrent spillways cross-sections

Some cross-sections of the torrent spillways were surveyed at the start of the spillway and at the end to study the condition of the torrent spillways in the region and the possibility of drainage of the proposed drains. Based on the above, it was concluded that:

- The irregularity of some of its sections and the presence of remnants in it.
- Widenings in some cross-sections.
- The presence of sediments obstructing the spillway.

Therefore, reconfiguring the actual sections of the spillways to be similar to what was in the design situation will increase the efficiency of drainage in the area. The design of the estuaries of all the proposed drains has been taken into account when the water level is higher than the water level in the spillways.

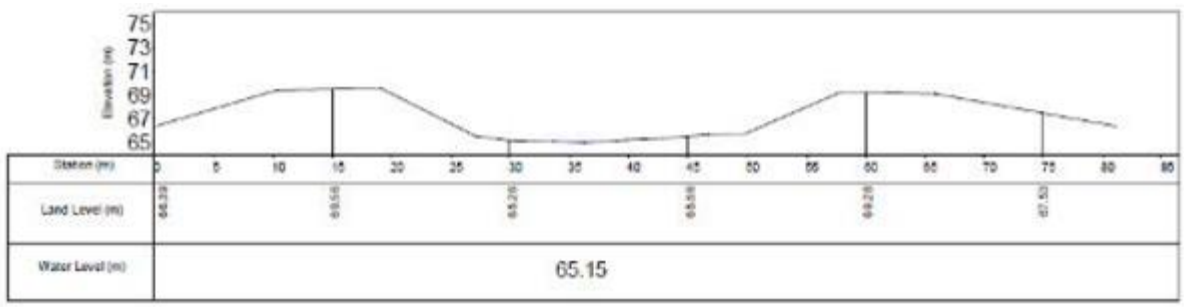

Figure 10: Cross-section at the start of Gamaza Spillway km 11

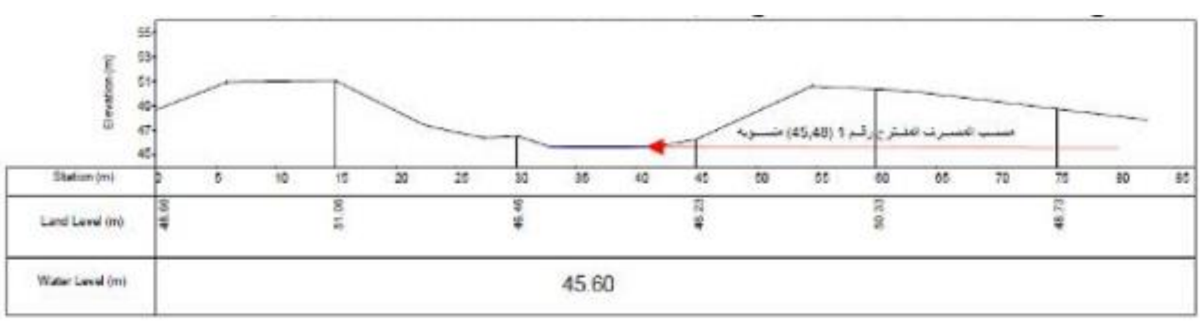

Figure 11: Cross-section at the end of proposed drain 1 on Gamaza Spillway km 8.1

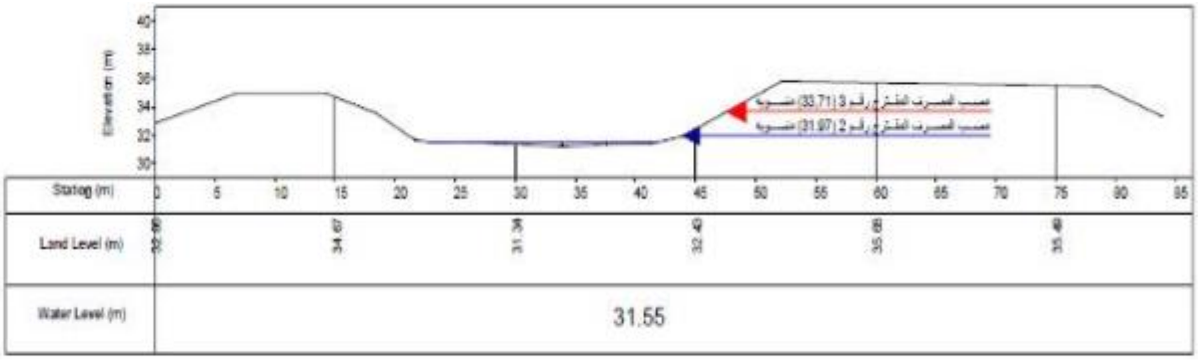

Figure 12: Cross-section at the end of proposed drains 2 and 3 on Gamaza Spillway km 5.27

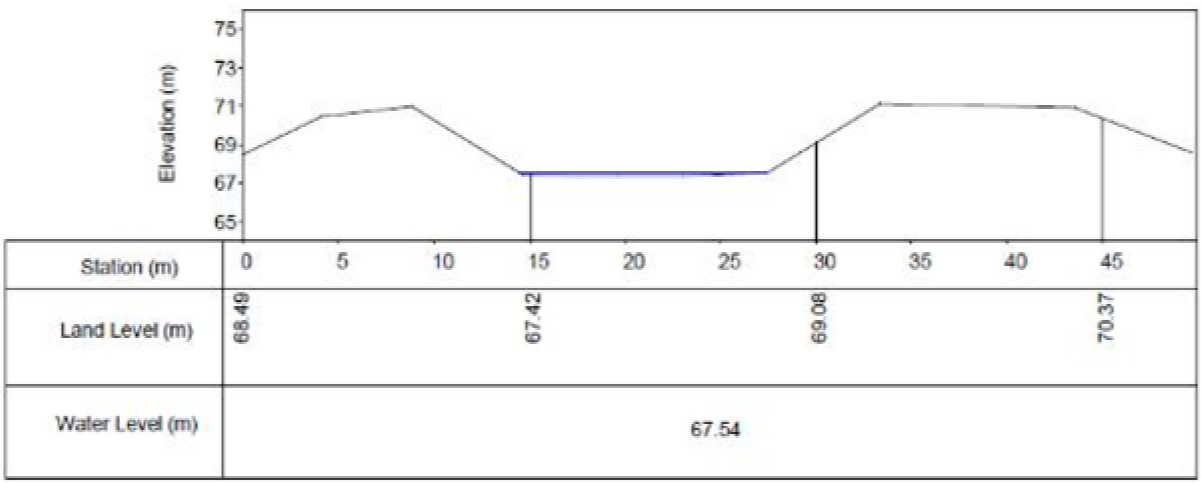

Figure 13: Cross-section at the start of AlMansha Spillway km 14.9

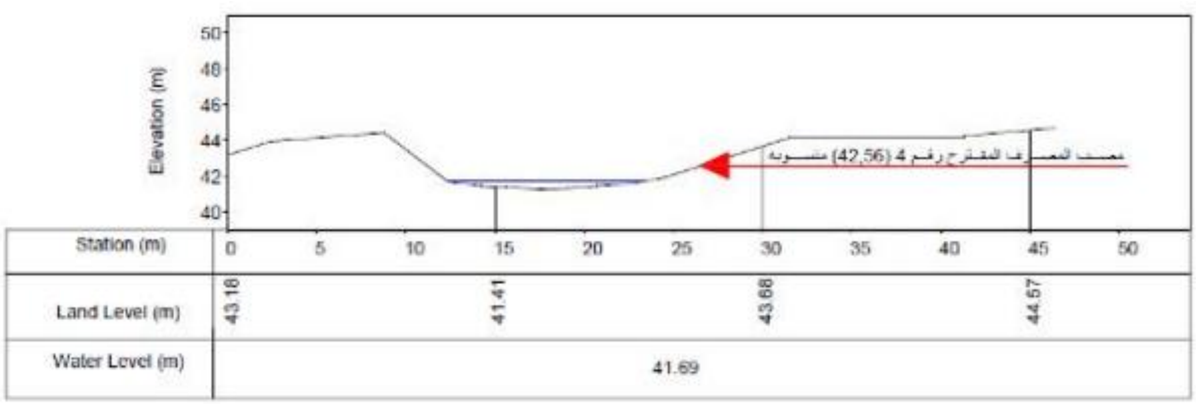

Figure 14: Cross-section at the end of proposed drains 4 on AlMansha Spillway km 14.9

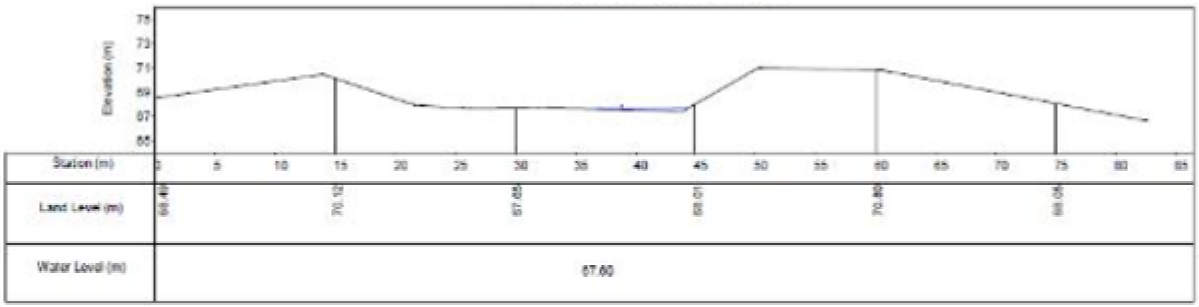

Figure 15: Cross-section at the start of AlSaff Spillway km 7.81

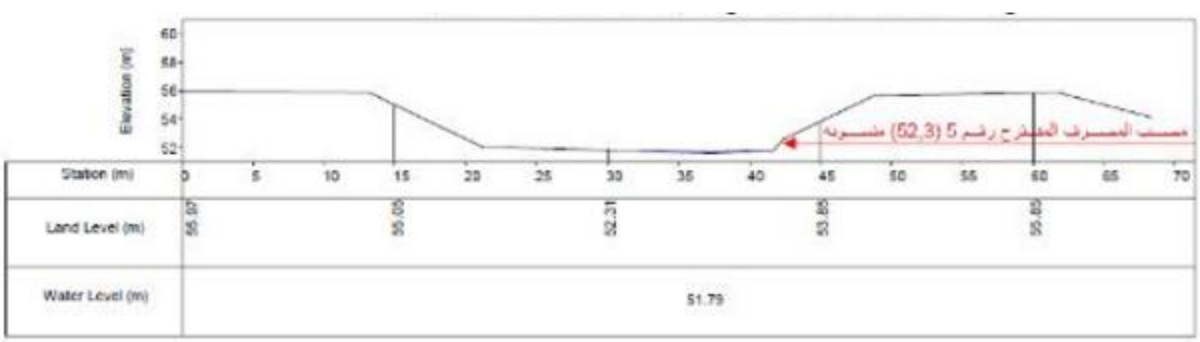

Figure 16: Cross-section at the end of proposed drains 5 on AlSaff Spillway km 5.79

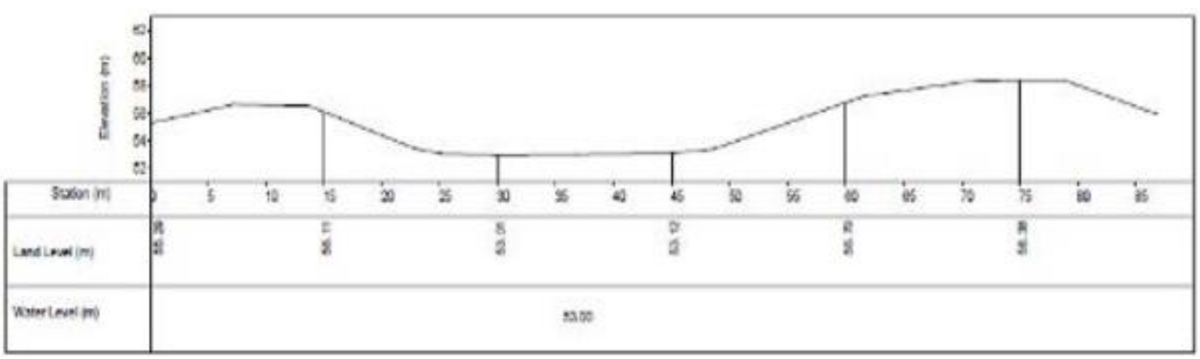

Figure 15: Cross-section at the start of AlWadi Spillway km 6.84

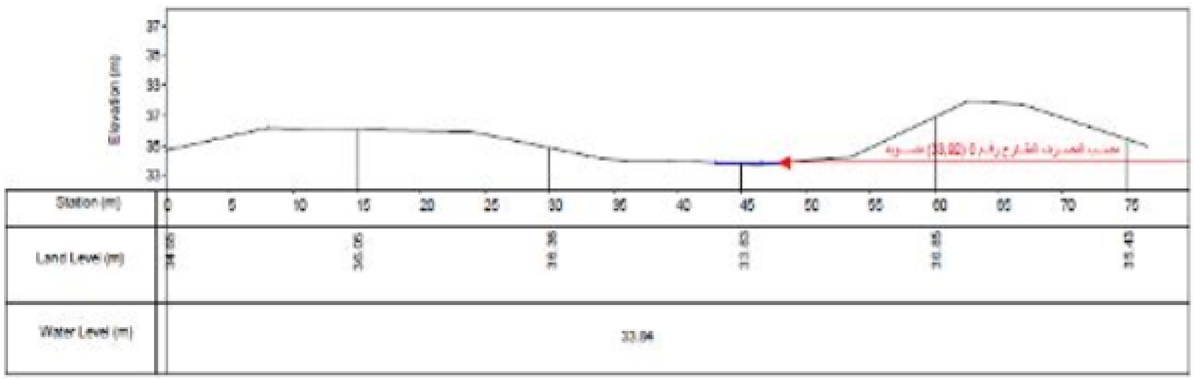

Figure 16: Cross-section at the end of proposed drains 6 on AlWadi Spillway km 3.13

4.4 The need to implement a subsurface drainage network

Wastefulness and failure to rationalize the use of irrigation water in agriculture lead to large quantities of it leaking into the groundwater, causing a rise in the groundwater level and a concentration of salts at different depths, which leads to a deterioration of soil productivity, and then it becomes necessary to establish subsurface drainage networks. The productivity and area of agricultural lands, facilitating service using agricultural machinery, saving in irrigation and drainage regulations, and the cost of maintenance per feddan, removing excess salts by periodic washing of the soil, and the health effects of eliminating endemic diseases in the environment.

To study the extent of the need to implement the subsurface drainage networks of cultivated lands now and in the future, and to determine their implementation sites and priorities, it must be taken into account that the open drainage network in the study area was designed as an essential and necessary solution to reduce the water level in the study area and as cut-off drains that prevent water leakage of the old valley lands and neighboring residential areas with the need for subsurface drainage network, taking into consideration the study of the following factors:

4.4.1 The depth of the surface groundwater

During the study of the design of the open drains network in the area of Al-Saff, which was carried out by the Drainage Research Institute in 2015, a number of 39 wells were installed to monitor the surface groundwater, their coordinates and levels were monitored, as well as the depth of the groundwater was measured, and the groundwater levels were periodically assessed. The results of the measurements showed the height of the groundwater level in the study area up to a depth of 20 cm from the surface of the soil, especially in the wells of the drainage path No. 1 and 2 and drain 4 in the study area, while the depth of the groundwater in the wells of the drainage path No. 3, 5 and 6 ranged between 50 to 180 cm below the soil surface.

4.4.2 Groundwater salinity

The groundwater salinity was measured at the sites where the groundwater was found, as it is evident from these values that the degree of salinity of the groundwater in the monitoring wells of Drains No. 1 and 2 ranged between 1.2 dS/m and 13 dS/m. With drain No. 3, it ranged between 9 dS/m. The drain number 4 ranged from 5 dS/m to 100 dS/m. While at a drain of 5 and 6, it ranged between 3.8 dS/m and 24 dS/m and considered high salinity levels. The absence of a draining network in the study area led to a rise in the groundwater level and the accumulation of salts in the soil's surface layers.

4.4.3 Soil salinity

Soil salinity and pH number were measured, and the average values were calculated in the previous sites, as it is evident from these values the high degree of soil salinity, where the average values of soil salinity were about 24.4 dS/m, while the lowest and largest values of soil salinity ranged between 1.5 dS/m to 224 dS/m. This is due to the rise in the groundwater level and the accumulation of salts in the soil's surface layers, thus the high salinity of the soil.

Due to the high level of groundwater in the study area, as well as the high salinity of the groundwater, which results in high soil salinity, therefore a covered drainage network must be implemented, provided that it is implemented with the region of drain 1, drain 2 and drain 4, followed by the implementation of the network in each of the drain 3, drain 5 and drain 6.

5 Conclusion

Based on the previous results, the study concluded the following:

- After the recommendations of the Hydraulics Research Institute of the ability of Al-Saff canal to accommodate the additional discharge of the WWTP in Arab Abu Saad, provided that the necessary measures are taken in accordance with the scenarios presented by the Institute in the previous report, there will be no change in the standards and rates of drainage flow as a result of the excess discharge that would lead to an adjustment in designing the proposed network of drains and thus the proposed hydraulic structures to be established on that drains, which will serve the study area.
- The necessity of the maintenance and reshaping of the current cross-sections of the torrent spillways to be identical to the design situation. This is to accommodate the discharge of the open drains.
- The necessity to study the implementation of the subsurface drainage network for the proposed drains 1, 2, and 4, then to be followed by studying the implementation of the covered drainage network for the proposed drains 3, 5, and 6 after implementing the open drainage network to complete the disposal of leachate with these areas.

- The Al-Saff canal's efficiency must be improved by preventing the illegal irrigation from the canal and preventing the placement of conveyor irrigation pumps on the banks of the canal, as well as through lined irrigation sides parallel to the canal on the right and the left.
- Emphasis should be placed on monitoring and making field and laboratory measurements of the quality of the final discharge of the wastewater treatment plant in Arab Abu Saed to ensure its compliance with local laws' standards.
- Banning the surface irrigation system by flooding as it leads to a tremendous waste of irrigation water quantities more than the quantities that are actually utilized, causing a rise in the groundwater level and soil salinization.
- The drip irrigation system must be generalized, especially in the new reclamation lands, as it saves irrigation quantities with a homogeneous distribution. It is also best suited for irrigation with treated water.