Environmental & Social Impact Assessment (ESIA) for Drilling New Wells and Associated Infrastructure Works – Dubaydib Well Field / Disi

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List of Acronyms and Abbreviations

AED	Annual Effective Radiation Dose
amsl	Above Mean Sea Level
ASEZA	Aqaba Special Economic Zone Authority
BGR	German Institute for Geosciences and Natural Resources
BRGM	Bureau de Recherches Géologiques et Minières
BRNA	Brown & Root North Africa
CAPEX	capital expenditure
CBO	Community Based Organizations
CN	Curve Number
CO_2	Carbon dioxide
CRVA	Climate Risk Vulnerability Assessment
CH	Critical Habitat
DAOM	Disi Amman Operation and Maintenance Company
DEM	Digital Elevation Model
DIWACO	Disi Water Company
DoA	Department of Antiquities
DoS	Department of Statistics
EHS	Environmental, Health, and Safety
EIB	European Investment Bank
EPSG	European Petroleum Survey Group
ESIA	Environmental and Social Impact Assessment
ESS	Environmental and Social Standard
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
ESP	Electrical Submersible Pump
GHGs	Greenhouse Gases
GoJ	Government of Jordan
IBA	Important Birds Area
IFC	International Finance Corporation
km	Kilometer
kWh	kilowatt-hour
L/s	Liter per Second
MCM	Million Cubic Meters
MCM/yr	Million Cubic Meters per Year
MEMR	Ministry of Energy and Mineral Resources
mm	millimeter
MoA	Ministry of Agriculture
MoEnv	Ministry of Environment
MWI	Ministry of Water and Irrigation
NDC	Nationally Determined Contributions
NGO	Non-Governmental Organization
OE	Owner's Engineer
OPEX	Operating Expenses
O&M	Operation and Maintenance
PGA	Peak Ground Acceleration
PS	Performance Standard
RSCN	The Royal Society for The Conservation of Nature
RSS	Royal Scientific Society
SCS	Soil Conservation Service
SWK	Scott Wilson Kirkpatrick
ToR	Terms of Reference

UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
UNRWA	United Nations Relief and Works Agency for Palestine Refugees in the Near East
US DFC	United States International Development Finance Corporation
WAJ	Water Authority of Jordan
WMS	Watershed Modelling System

1 EXECUTIVE SUMMARY

1.1 Introduction

The Disi Water Conveyance Project is owned by the Government of Jordan, represented by the Ministry of Water and Irrigation (MWI) and the Water Authority of Jordan (WAJ). The project is implemented under a Build-Operate-Transfer (BOT) contract. DIWACO (Disi Water Company) holds ownership of the project facilities during the concession period, which began with commercial operation on January 27, 2014. Originally set for 25 years. DIWACO has subcontracted DISI Amman Operation & Maintenance (DAOM) to operate and maintain the entire conveyance system—from the wellfield in southern Jordan to the Greater Amman Area. After the extended concession period, ownership and operational responsibility will be transferred to the Government of Jordan (GoJ).

The Disi Mudawarra to Amman water conveyance system is supplying potable water to the Greater Amman Area from the Disi aquifer in the south of Jordan. Water is abstracted from the 'fossil' aquifer and carried approximately 325 kilometers (km) to Amman via a pipeline. The system is conveying an annual flow of 100 million cubic meters (MCM); 40 MCM to a new tank in Abu Alanda and 60 MCM to an existing tank in Dabuk.

The project started operation in 2014, it is part of the GOJ's larger regional framework of water management and development of new resources.

The Ministry of Water and Irrigation (MWI) asked Disi Water Company (DIWACO) to increase the annual output of the wellfield to 120 MCM/year, which will require the construction of additional production wells.

As part of the project scope, AJi for Water and Environment team has been commissioned by DIWACO to conduct the Environmental and Social Impact Assessment (ESIA) for drilling the new wells and associated infrastructure works in accordance with the national requirement as well as the lender's requirement.

The project is categorized as Category ''1'' with respect to the classification of the Ministry of Environment (MoEnv), as per the ESIA Regulation No. 69/2020 and its amendments, where Category "1" projects shall undergo a comprehensive ESIA study.

1.2 Project Description

The Disi project wellfield has been producing about 97 to 100 MCM/year. It comprises 55 production wells (initially started with 46 wells in operation and 9 standby wells, recently the Disi project activated 4 of the standby wells to be 50 abstraction wells and 5 standby wells), and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM in 2023 and since 2024, production increased to 115 MCM. The wells have a total depth ranging from 394 to 600 m.

The production target for each new production well has an average of 70 L/s, with a maximum of 80 L/s, with the aim of increasing the current wellfield production up to about 120 MCM/year. Thus, new additional production wells are required. The identification of the most suitable location and design for these wells have been identified based on the Bureau de Recherches Géologiques et Minières (BRGM) report, published in 2023[1].

[1] Additional production well targeting and well design for the Dubaydib wellfield -Jordan, BRGM Final Report, June 2023

Project components:

The proposed project includes the following activities which will be covered in the ESIA study:

- Drilling new groundwater wells which includes the drilling of the well shafts, and installation of well casing, screens, and pumping equipment, headworks and borehole compound.
- Extend the wellfield collector pipeline network, valve chambers and surge vessels as required
- Extend the internal road network to connect the new wells with the existing parts of the project.
- Expansion of the overhead power line system to connect the new wells.

Twelve (12) new well locations have been identified and confirmed within the Dubaydib wellfield. Out of the 12 proposed well locations, two require clearance from the MWI due to their positions outside the current land lease agreement, with one situated at the border of a designated 'no-drill' zone. DIWACO is not planning to utilize the two uncleared locations until the other proposed wells are either fully operational or abandoned.

In addition, two wells (No.9 &No.10 as presented in **Table 5**) are situated within the Rum protected area buffer zone, these two wells are not among the wells proposed for drilling in this environmental study and must obtain the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the relevant authorities' clearance if the decision is made to proceed for drilling them in the future. Drilling activities are tentatively scheduled to commence in January 2026 and continue through July 2027 for the completion of the first four additional wells. Additional wells will be drilled as needed to ensure that three redundant wells are always available to support the continuous and reliable pumping of 120 million cubic meters **The ESIA will cover the following phases:**

- The reinstatement phase, where aspects such as landscape and generated waste management, vegetation cover, soil, and wadi streams were considered.
- The construction phase includes drilling the new groundwater wells, connection to the existing pipeline network and/or new network, electricity network, and the service roads within the wellfield area.
- The operation phase for the different newly constructed facilities throughout the project.
- The decommissioning phase of the project.

1.3 Legal and Regulatory Framework

This ESIA Study was conducted in compliance with the national requirements as well as International Finance Corporation (IFC) and lenders' (European Investment Bank (EIB), United States International Development Finance Corporation (US DFC), and Proparco (France)) requirements.

1.4 Alternatives of the Proposed Project

One of the most significant contributions an ESIA can offer to enhance decision-making is a comprehensive, unbiased, and transparent evaluation of alternatives from an environmental, social, technological, and economic perspective before the start of project activities. This would maximize the project's environmental and social benefits.

The analysis for this project contains two alternatives that are the "No Project" and the "Project" alternatives which will help balance the benefits of increased water supply with potential

environmental and social consequences, ensuring informed and sustainable decision-making. On the other hand, the alternatives of wells' locations and extraction scenarios were analyzed through a systematic approach.

1.4.1 Wells Locations Alternatives

A systematic approach was used to prioritize well construction locations, starting with an initial review of 47 potential sites, followed by a ranking system based on 11 criteria in five risk categories. Expert input and field visits further ensured the selection of optimal sites for wells.

1.4.2 Abstraction Scenarios

The groundwater model for the Dubaydib wellfield, which taps into the Ram Group aquifer system, has undergone progressive updates between 2022 and 2024 in order to evaluate the long-term impacts of current and planned abstraction levels. These updates have provided essential input for strategic water resource management in the Disi region, particularly as the aquifer is being mined with negligible recharge.

In 2023, attention shifted to identifying new production well sites to support an increase in abstraction up to 120 MCM/year. A total of 47 candidate sites were evaluated using a multi-criteria framework that considered hydrogeological suitability, water quality, infrastructure connection costs, and border proximity constraints. A shortlist of 12 optimal well sites was generated, and the model was updated accordingly. Stakeholder workshops and field surveys conducted in mid-2023 validated the selected locations. Modeling results from this update indicated that expanding production would add approximately 5 to 10 meters of drawdown in certain parts of the wellfield by 2065. The long-term viability of new wells varied based on depth and geological setting, emphasizing the importance of careful design and operational planning[2].

By 2024, the model had been further refined using the latest groundwater level observations and production data collected up to mid-year. This latest update revisited five abstraction scenarios between 100 and 120 MCM/year, extending projections through 2065. The revised model closely matched observed trends in both monitoring and production wells. It confirmed that under current and projected abstraction, the water table would continue to decline at an average rate of 1.2 to 1.5 meters per year.

By 2038, the piezometric depression is expected to deepen by approximately 20 meters under the 100 MCM/year scenario, and up to 25 meters under the 120 MCM/year scenario, By 2065, drawdowns are projected to reach 50 to more than 60 meters, extending into the agricultural areas of Al Mudawarra and Al Disi, which are also drawing from the same aquifer. Several production wells, including W01, W02, and P1, were projected to fall below pump intake levels by 2035, necessitating either reconfiguration or replacement. Under more intensive abstraction scenarios of 115 to 120 MCM/year, over ten wells could require intervention by 2050. In addition to operational risks, long-term impacts could include aquifer deconfinement, potential leakage from overlying strata, and reduced water quality. It is also important to note that the model assumes consistent productivity from all wells and does not incorporate aging-related degradation, suggesting that actual performance might decline sooner than predicted[3].

Collectively, the results of the three modeling phases highlight the significant long-term pressures on the Ram aquifer and underscore the importance of sustainable abstraction planning. While the model

[2] Simulations of abstraction scenarios for the Dubaydib wellfield, Final Report, BRGM/RC-73853-FR, 2023
[3] Simulations of abstraction scenarios for the Dubaydib wellfield, Final Report, BRGM/RC-73853-FR, 2024

provides a robust basis for future decision-making, adaptive management strategies and periodic model updates will be essential to mitigate risks and ensure long-term water security in the Disi region.

1.5 Environmental and Social Baseline Conditions

All available baseline information sources were reviewed, site visits and surveys were conducted, and relevant information was extracted, and analyzed, including:

- The physical environment, including metrological and climate data, air quality, noise measurement, topography, geology, and soil attributes:
  - **Meteorology and Climate**: The meteorological data for the study area for the period of 2014-2022 was obtained from the Department of Statistics (DoS) for the Jafer weather station, where the average annual climate data are:
    -Avg. Monthly Mean Temperature: 19.73 ºC
    -Avg. Monthly Rainfall Amount: 3.36 mm
    -Avg. Mean Monthly Wind speed: 4.16 Knots
  - **Air Quality**: The baseline air quality in the Disi Wellfield is expected to be generally good, given that it's a remote location, far from residential areas, human activity, and industrial facilities. Temporary and localized air quality impacts may arise from emissions generated by maintenance vehicles; however, these effects are localized and transient. In addition, higher PM2.5 and PM10 dust emissions are expected in this desert environment, due to naturally occurring wind and sand storms.
  - **Noise**: Ambient Noise monitoring was conducted to collect the baseline noise data for 24 hours at four locations within the project site. The noise measurement results were evaluated based on the noise levels of the Jordanian Instructions for Prevention of Noise of 2003, for “Residential areas in villages, “where the findings indicate that all ambient noise levels measured were comfortably within the prescribed national limits.
  - **Topography**: The project area is located in the Disi-Ram Highlands, which are characterized by cliff-faced sandstone buttes and masses, with wide valleys running north-south. The region experiences aridic moisture and thermic temperature regimes, with rainfall being too sparse for cultivation. However, occasional precipitation is directed into wadis, basins, and sandy fans, supporting a significant cover of shrubs that provide important browse. The dominant soils are Torripsamments, reflecting the extensive Aeolian dunes and sand sheets.
  - **Geology**: The Disi wellfield falls under two (2) geological area, the Jabal Ladghayn / Dubaydib area which is characterized by bedrock primarily from the Ordovician Ram Group and the overlying Khreim Group as well as Jabal Umm Sahm and Bir as Saladih area, which characterized by significant superficial deposits from the Cenozoic, Quaternary, Holocene-Pleistocene periods. The paleo valleys filled with these sediments are primary targets for drilling wells due to their water retention capabilities. The landscape, shaped by resistant sandstone ridges and softer siltstone beds, supports the accumulation of these deposits.
  - **Hydrogeology**: The Project area is located within the Jordan Disi Ground Water Basin, which is located in southern Jordan, 300 km south of Amman. It is one of the shared water basins between Jordan and Saudi Arabia. The exposed area of this basin in Jordanian territory is three thousand km2 and about sixty-six km^2 in Saudi territory. This basin is crucial for the region’s water supply and is characterized by a high degree of permeability, making it a valuable source of groundwater. The natural flow of groundwater

predominantly moves from south to north. The annual safe yield of the basin is 125 MCM, but the current abstraction has reached 178.97 MCM, resulting in a deficit of approximately 53.97 MCM, as per the MWI report for the year 2022.

- **Hydrological and water resources studies:** The baseline study included hydrological analysis using a Digital Elevation Model (DEM) to assess topographic characteristics at existing and proposed well sites within the Disi Wellfield. Results indicated that the sites lie within potential water flow paths, posing risks of flooding and erosion. Morphological and meteorological studies were also conducted to evaluate how terrain and climatic factors affect water resources and quality. The findings highlighted the need for a detailed hydrological and hydraulic study to estimate peak flood events and design protective measures. These assessments are essential to ensure optimal groundwater use and minimize environmental impacts on the surrounding hydrological system.

- Biological environment where desktop study was conducted and followed by field assessment to collect data for biogeographic zones, vegetation types, fauna, sensitive habitats, and ecosystem services within the project area and its vicinity.
  - Biogeographic Zones: The project site is situated within two biogeographic zones: the Sudanian zone, which is characterized by extremely hot summers, with temperatures ranging from 15 to 45°C, and relatively warm winters and Saharo-Arabian zone, which is characterized by extremely arid conditions, with very poor soils that are generally saline, sandy-loam, or Hammada in texture.
  - Vegetation Types: Sand Dune, Acacia and Rocky Sudanian, and Hammada Vegetation types are the dominants within the project area.
  - Fauna:

  Reptiles: A total of 35 reptile species, representing nine different families, have been documented from previous studies within the project area and its vicinity. Thus, reflecting the adaptability of reptile species to the arid desert environment, where they play an essential role in the local ecosystem. Among these species, two are of special conservation concern according to the IUCN Red List. Despite the rich diversity of reptiles in the project area, no reptiles were recorded during the field visit.

  Mammals: A total of 26 different species of mammals were observed and documented from previous studies. The conservation and ecological significance of a number of species is particularly noteworthy. No mammal species were recorded during the survey. This absence of mammalian observations could indicate two possibilities: the presence of human activity within the area deterring wildlife or the areas surveyed lacking sufficient habitat features to support a visible population of mammals.

  Avifauna: About 8 soaring bird species that may be found within the project area have been documented by Birdlife International, while a total of 18 bird species were recorded during the field visit, reflecting the avian diversity of the project area. Two observed species are of special conservation concern according to the IUCN Red List. The remaining bird species identified during the survey are considered common and resident to the area, indicating a stable avian population adapted to the local desert ecosystem.

  - Critical Habitat:

    Based on the findings of the Critical Habitat Screening Report (**Annex 12**), no areas within the project footprint meet the criteria for critical habitat as defined by IFC Performance Standard 6 and EIB Environmental and Social Standard 4. Although the project area supports some desert-adapted species and is in proximity to ecologically sensitive areas such as the Rum Important Bird Area (IBA), it does not contain habitats that meet the thresholds for:

- Critically Endangered or Endangered species
- Endemic or restricted-range species
- Migratory or congregatory species
- Highly threatened or unique ecosystems
- Key evolutionary processes
- Ecosystems of significant importance to local communities

As such, the project does not trigger formal critical habitat designation. Nevertheless, the project will continue to apply the mitigation hierarchy and implement precautionary measures to avoid and minimize potential impacts on biodiversity and ecosystem services, particularly near sensitive areas such as the Rum IBA.

- Sensitive Habitats:

Protected Area: The closest protected area to the project site is the Rum Protected Area, located approximately 18 kilometers away. Rum Protected Area is a vital habitat for numerous species, including some that are of conservation concern. The project site does not fall within the boundaries of this protected area, However, its proximity to Rum Protected Area is notable due to the ecological significance of the region. The distance from the project suggests that direct impacts on the protected area are unlikely, but indirect effects, such as disturbances to wildlife corridors or migration patterns, were considered during the assessment process.

Important Bird Areas: The Rum Important Bird Area (IBA) is a vital site for avian conservation in Jordan. Its diverse landscape, dominated by rugged mountains, vast sandy plains, and deep valleys, provides a variety of habitats that are crucial for both migratory and resident bird species. Among the notable species found here are the Sooty Falcon and the Sinai Rose Finch, both of which are of high conservation concern due to their specialized adaptations to the harsh desert environment. Additionally, the area's high cliffs offer essential nesting grounds for raptors such as the Lappet-faced Vulture and the Egyptian Vulture, which depend on the scarce water sources found in some valleys for their survival.

As part of the project, two wells, W69 and W98, are situated within the boundaries of the Rum IBA, highlighting the need for careful consideration of potential impacts on the area's bird populations and habitats. These wells lie in a region of the IBA that is essential for both resident and migratory bird species. The remaining wells in the project are located close to the IBA's eastern borders, further underscoring the importance of implementing measures to minimize disturbances to the surrounding environment.

Rangeland Reserves: Jordan has established 20 rangeland reserves, which play a role in conserving the country's fragile desert ecosystems and supporting sustainable management practices. These reserves are essential for maintaining the health and productivity of natural rangelands. The project site is located approximately 15 kilometers from the nearest rangeland reserve, Al Mudawara, which plays a vital role in preserving the delicate balance of the desert ecosystem and ensuring that natural resources are used sustainably. Ensuring that the project does not disrupt these efforts is crucial to maintaining the ecological and economic benefits provided by rangeland reserves.

Ecosystem Services: The location of the project, which is situated within the arid desert ecosystems of Jordan, offers a wide range of ecosystem services that, despite their inconspicuous nature, significantly contribute to the preservation of environmental health and the provision of support for both human and wildlife populations. The regulation of water resources is one of the most important ecosystem services that the region provides because of its importance. Seasonal wadis and water collection points serve a crucial role in recharging

groundwater, which is essential for supporting limited plant life, wildlife, and human activities. Additionally, the project site offers regulating services, such as carbon sequestration and soil stabilization, which are important in mitigating the effects of desertification and climate change.

- **Socio-economic environment**

  The Disi aquifer spans two governorates in southern Jordan, Ma'an and Aqaba. It covers the Jafer sub-district in Ma'an and the Disi and Quairah sub-districts in Aqaba. This summary outlines key socio-economic conditions in the project area, including population, infrastructure, economic activities, and vulnerable groups.

  Population and Demographics: As of 2023, Jordan's total population is estimated at 11.5 million, with 90.3% living in urban areas. The gender distribution is approximately 52.5% male and 47.5% female. The Disi aquifer intersects the Jafer sub-district in Ma'an and the Disi and Quairah sub-districts in Aqaba. Ma'an is the country's largest governorate by area, while Aqaba is a key southern hub, encompassing Jordan's only seaport.

  The wellfield area spans in three main localities: Disi, with a population of approximately 7,381 people; Jafer, home to around 9,430 people; and Quairah, which has the largest population among the three, with about 27,166 people.

  Refugees: Jordan hosts one of the world's highest refugee populations per capita, mainly Syrians, with smaller groups from Iraq, Yemen, Sudan, and Somalia. Refugees are mostly urban-based. Ma'an and Aqaba host 1.4% and 0.7% of the national refugee population, respectively. While no formal camps exist in Disi or Jafer, dispersed refugee presence may be present, with many involved in agriculture and construction.

  Vulnerable Groups: Women make up nearly half of the populations in Disi (47.9%) and Jafer (43.6%), reflecting national demographics. In 2017, low-income households were common: 22% in Ma'an and 21.5% in Aqaba earned JOD 2,500–5,000 annually. People with disabilities face significant barriers in remote areas, especially regarding healthcare, education, and employment.

  Education: The education system in Jordan is managed primarily by the Ministry of Education. In the 2022/2023 academic year, Jordan had over 7,500 schools and 2.27 million enrolled students. In Ma'an, 46,619 students were enrolled across 236 schools with an 11:1 student-teacher ratio. Aqaba had 54,477 students enrolled in 157 schools, with about 14 students per teacher. Both governorates have almost equal numbers of boys and girls in schools, although most teachers are women (about 70%).

  Healthcare Services: Jordan has a relatively well-developed health system, though the refugee crisis has significantly increased pressure on services. In 2023, the country had 119 hospitals and over 16,000 beds. Ma'an has 2 Ministry of Health hospitals with 232 beds and 87 health centers. Aqaba has 4 hospitals (2 public, 2 private) with 320 beds and an equal number of health centers.

  Economic Conditions: Jordan's economy is classified as lower-middle-income, with a GDP growth rate of 2.5% in 2022 and inflation at 4.23%. Key sectors include finance, manufacturing, trade, and public services. In the first quarter of 2024, the finance and manufacturing sectors contributed the most to GDP.

  Aqaba stands out as a logistics and tourism hub, anchored by the Aqaba Special Economic Zone. Its economy benefits from port activities, industry, and tourism. In contrast, Ma'an is emerging as a renewable energy and industrial center, driven by the Ma'an Development Area.

  Employment and Income: The national unemployment rate in Q1 2024 was 21.4%, with a wide gender gap (34.7% for females vs. 17.4% for males). University graduates face high

unemployment (25.8%). Unemployment in Ma'an and Aqaba is significantly lower than the national average: 1.9% and 1.5% for Jordanians, respectively.

Household income varies: Aqaba's average annual household income is JOD 10,400, while Ma'an averages JOD 8,600. Expenditures mirror this gap, with JOD 9,200 in Aqaba and JOD 6,500 in Ma'an.

Agriculture: Agriculture remains a key livelihood in both regions. As of 2017, approximately 85,000 dunums in Aqaba's Quairah district were used for crop and livestock farming, with 94% of the land irrigated. In Ma'an Qasabah and other districts, over 158,000 dunums were cultivated using a mix of irrigated and rainfed practices. Disi in Aqaba was also identified as a notable agricultural zone, utilizing groundwater for cultivation.

Public Services

- Water Supply:

Jordan's severe water scarcity impacts all sectors. Ma'an receives 15.73 MCM/year, and Aqaba 22.72 MCM. Ma'an's supply comes mainly from Al Tahooneh, Samneh, and Jitheh wellfields. Aqaba's network includes Disi and Mnaishier, with additional supply from desalination and pumping systems.

- Sewer Systems:

Only 35% of Ma'an households are connected to sewer networks, compared to 87.5% in Aqaba. Ma'an relies more heavily on cesspits due to its rural nature.

- Water and Sewer Vulnerability:

According to UNICEF's 2018 vulnerability maps, Disi is categorized as low-risk. In contrast, Ma'an and Jafer are high-risk areas, while Aqaba is moderately vulnerable, emphasizing the need for infrastructure investment.

Transportation: Ma'an and Aqaba together account for over 17% of the national road network. The area is served by Highway 5, a major route linking northern Jordan to the Saudi border. Aqaba also hosts Jordan's only seaport and an international airport, making it a critical logistics corridor.

Tourism: Aqaba is a Red Sea tourism hotspot, with 101 hotels and over 12,000 beds. It provides access to Wadi Rum, a world-renowned desert destination and UNESCO site with extensive archaeological significance. Ma'an is home to Petra, one of the New Seven Wonders of the World and Jordan's flagship heritage attraction. In contrast to Aqaba, Ma'an hosts 104 hotel with the majority of them (101 hotels) located In Petra.

- **Solid Waste Management**

  The wellfield spans the Aqaba Governorate and the Jafer municipality in Ma'an Governorate, which, according to the DoS (2022), it contributes a small fraction, around 1.31 %, of the Kingdom's overall municipal waste. In the Ma'an Governorate, the waste production rate is 0.5 kg/person, resulting in a total of 31,218 tons of municipal waste collected annually. This accounts for approximately 0.75 % of the total waste collected across the Kingdom. In contrast, the Aqaba Governorate has a lower waste production rate of 0.3 kg/person, with a total of 23,671 tons of municipal waste collected annually. This represents about 0.57% of the total waste collected in the Kingdom.

- **Climate risk**: Jordan faces significant climate change challenges due to its arid climate, limited water resources, and dependence on transboundary water. Rising temperatures, reduced precipitation, and increased frequency of extreme events like droughts and flash floods are intensifying water scarcity and threatening key sectors such as agriculture and health. The water sector, consuming 11–14% of the country's total energy, , primarily for Municipal and Agricultural water pumping, treatment, and distribution purposes, making it a notable

contributor to greenhouse gas (GHG) emissions (TNC, 2014[4]). Jordan has committed to a 31% GHG reduction by 2030 and is actively promoting energy efficiency, renewable energy, and the use of treated wastewater. Climate projections indicate higher temperatures, more frequent droughts, and reduced rainfall, further pressuring water resources. National strategies and adaptation measures, including green growth investments and infrastructure resilience, aim to mitigate climate impacts and sustain long-term development.

- **Archaeology and cultural heritage**:
  Literature reviews, including the findings of the previous ESIA (2004) and its addendum 2008[5] and relevant references and databases such as Jordan Antiquities Database and Information System (MEGA), were reviewed to identify and document any nearby archaeological and cultural heritage sites where it was found that the closest site is located more than 3 kilometers from the nearest proposed new well, minimizing the likelihood of direct impacts on cultural heritage sites. In addition, a field survey was conducted by the Department of Antiquities (DoA) for the proposed new wells to assess the archaeological and cultural heritage aspects of the project areas. Subsequently, a DoA official letter (Annex 8) has been issued confirming that there are no archaeological sites, features, or material remains within the proposed project zones. However, Immediate notification to the DoA is required if any artifacts or archaeological evidence are uncovered during construction activities.

1.6 Stakeholder Engagement

Stakeholder engagement is an ongoing process throughout both the construction and operation phases of the project, ensuring compliance with local and international ESIA requirements. Stakeholders are defined as individuals or groups affected by or interested in the project's outcomes.

A stakeholder engagement session was held on August 20, 2024, as part of the ESIA process. Official invitations were issued by the Ministry of Environment (MoEnv) to relevant stakeholders, including representatives from government ministries, institutions, academia, local municipalities (Disi and surrounding communities), the Royal Society for the Conservation of Nature (RSCN), and other interested parties.

Key concerns raised during the session included:

- Impacts on farming operations and aquifer sustainability
- Cultural and archaeological heritage preservation
- Land subsidence risks due to groundwater extraction
- Occupational health and safety
- Social impacts, including community development and water availability
- Project security, theft, and vandalism risks

Community Consultation and the Role of DPAC

The Disi Project Advisory Committee (DPAC) was established to oversee environmental performance and facilitate stakeholder engagement. Chaired by a representative from the Ministry of Water and

[4] Ministry of Environment. (2014). Jordan's Third National Communication on Climate Change (https://www.moenv.gov.jo/ebv4.0/root_storage/ar/eb_list_page/jordans_third_national_communication_report.pdf?utm_source=chatgpt.com)

[5] Environmental and Social Impact Assessment of Disi-Mudawara to Amman Water Conveyance System,2004

Irrigation (MWI), the DPAC Environmental Committee includes the Project Company's Environmental Manager and may include a representative from MoEnv. Its key responsibilities include:

- Annual review of Environmental and Social Management Plan (ESMP) implementation
- Setting environmental performance indicators
- Recommending necessary resources
- Approving the Annual Environmental Report for submission to MWI

In May 2024, the DPAC was formally reactivated to address emerging local community needs, as documented in Annex 1. This includes water access, support for education, transportation services, and community infrastructure. The DPAC plays a central role in ensuring that community concerns from Disi and Mudawara are considered in project decision-making, fostering continuous dialogue, transparency, and trust.

Stakeholder Engagement Plan (SEP)

A comprehensive Stakeholder Engagement Plan (SEP) has been developed and is being implemented by the project operator, DAOM, to ensure ongoing and effective communication with all identified stakeholders during the Operation and Maintenance (O&M) phase. The SEP includes procedures for engagement, grievance redress, and defines DPAC's role in addressing community and institutional issues. It is a living document, regularly updated based on stakeholder feedback, new project developments (e.g., the addition of new wells), and emerging environmental or social issues.

DAOM's SEP is presented in Annex 13 and is complemented by a separate SEP prepared by the project company, forming a cohesive stakeholder engagement framework.

Grievance Mechanism

A grievance mechanism has been established to receive and address complaints from employees, subcontractors, and the external community. Grievances are recorded in a dedicated register and managed according to established procedures:

- Employee grievances are handled through DAOM's HR policies.
- Community grievances are directed to the project company, which coordinates with MWI in accordance with the Project and O&M Agreements.
- Subcontractor grievances are managed by DAOM's supervisors and Procurement Department.

The grievance mechanism is accessible to all affected or interested individuals, including transient or vulnerable groups, ensuring inclusive and transparent conflict resolution.

1.6.1 Impact Assessment

An impact assessment was undertaken following the full characterization of the environmental, social and health baseline, and identification of all project aspects. The scope of the assessment covers all project area and was undertaken in accordance with relevant MoEnv regulations and applicable local, national, IFC, and EIB standards and guidelines. In addition, this assessment has used the World Bank Group EHS Guidelines for Water and Sanitation (2007) as a reference to ensure that all identified impacts and mitigation measures reflect international best practices. However, for monitoring and compliance, national legislation and standards have been applied as the primary basis.

1.6.1.1 The Environmental and Social Positive Impacts

The key positive impact of the project is to enhance the water supply infrastructure to meet the growing demands of Amman, Jordan's capital, and its surrounding regions which is crucial for ensuring a consistent and reliable water supply, enhancing access to clean water thereby, contributing to better public health conditions and living standards. While there are concerns related to naturally occurring radioactivity in the Disi aquifer, the project incorporates measures for regular monitoring and water quality control. MWI is the responsible authority for water quality, including implementation of the blending strategy to ensure water quality standards are met in Amman.

Additionally, the project is aligned with the Government of Jordan's broader regional water management strategy, contributing to the long-term sustainability and resilience of the country's water resources.

Table 1 summarizes the key benefits of the proposed project.

Table 1: The Key Benefits of the Proposed Project

Aspect		Potential Environmental and Social Impact
Water demand and availability		The implementation of the proposed project will provide Amman with an additional amount of water source from the Disi aquifer to address the increased water demand and to relief reliance on overstressed resources.
Socioeconomic	Health	Enhancing access to clean water will improve health and sanitation aspects, and consequently living standards.
	Employment	The project is expected to provide short-term job opportunities during the construction phase and very limited permanent opportunities during the operation phase, prioritizing skilled locals for these job opportunities, if their qualifications match the needed requirements. In addition, better access to the water sources in Amman would potentially enhance education outcomes, which in turn can create better employment opportunities. The construction phase (including drilling new groundwater, extending the wellfield collector pipeline network, extending the internal road network, and expanding the overhead power line system)for each well is expected to last approximately 12-18 months and will involve around 100 workers, including engineers, specialists, suppliers, as well as construction workers, . The construction employment opportunities will be intermittent as the wells will be constructed gradually. For the operation phase, it is expected that only two guards will be employed at each new well.

1.6.1.2 The Environmental and Social Negative Impacts

According to the ESIA study, certain negative environmental and social (E&S) impacts can be effectively managed through the implementation of appropriate management systems and continuous on-site monitoring. The ESMP, as outlined in Chapter 10, provides a structured framework for mitigating potential risks across all project phases, ensuring compliance with best practices and regulatory requirements.

Table 2 illustrates potential impacts during the construction, reinstatement, and operation phases.

Table 2: Potential Environmental and Social Negative Impact

Aspect	Project Phase	Impact Significance	Potential Environmental and Social Impact
Physical Environment			
Air Quality & GHG Emissions	Construction	Medium	Dust generation resulting from earthworks, and exhaust emissions of Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), and Particulate Matter with a diameter of 10 micrometers or less (PM_{10}) would be attributed predominantly to the use of equipment for drilling the new groundwater wells and the associated infrastructure and road vehicles such as the movement

Aspect	Project Phase	Impact Significance	Potential Environmental and Social Impact
			of trucks and vehicles during construction works that may cause local degradation of air quality.
		Low	The drilling rig and camp generator would be the primary source of GHG emissions during the construction period. The total emissions are 122 ton of Carbon dioxide (CO_2) /Year/well, which is contribute to 0.0005 % /Year/well of Jordan's overall CO_2 emissions.
	Operation	Low	Dust generation will be limited to vehicular movement during the maintenance operations.
		Low	The primary source of CO2 emissions from well operations would be the indirect emissions from electricity use, according to historical well records at the Dubaydib wellfield, the total emissions would be 56 ton/Year/well, which is contribute to 0.00024 % of the Jordan's overall GHG emissions.
Noise	Construction	Medium	The main source of noise during the construction phase would result from construction and site preparation activities such as earth moving, site excavation, well-drilling, transportation of equipment and materials to and from the site through the surrounding road network, and installation of equipment. This will be limited to the construction period and will be short-term. The additional wells will be drilled as required to ensure the continuous availability of three redundant wells at all times while pumping 120 MCM per year.
	Operation	Low	The noise would result from the movement of heavy machines and pumps operation. It will be localized and not expected to impact off-site receptors.
Soil	Construction	Medium	Negative impacts on soil are anticipated, particularly related to soil creep, stability, and potential contamination. These issues are of particular concern for the proposed new roads, pipelines, boreholes, power networks, and construction camps. Soil contamination may result from fuel and lubricant leaks, as well as improper waste handling and storage.
	Operation	Medium	The Contamination of soil is anticipated as a result of fuel leakage and lubricant storage, and improper waste management. Soil management plan and spill response procedure/plan and waste management plan must be developed to eliminate risks.
Water Resources (Surface water)	Construction	Medium	A flood risk is anticipated at the wells site, which would potentially lead to flooding, soil erosion, and sediment transport. A comprehensive hydrological study and hydraulic design are required for the location of the new wells and its components to estimate the maximum flood flow values at 50, 100-yr. return periods and to determine the maximum peak flow and depth. Hence, propose suitable flood mitigation measures and erosion/scouring protection works.
	Operation	Medium	
Water Resources (Groundwater)	Construction	Medium	Potential contamination of groundwater may result from the use of drilling fluids, such as lubricants, hydraulic oils, and chemical additives (e.g., corrosion inhibitors, and surfactants), which are commonly employed during the drilling process to reduce friction, cool equipment, and stabilize the borehole. Additionally, the risk of improper handling or disposal of these substances and generated waste could pose a

Aspect	Project Phase	Impact Significance	Potential Environmental and Social Impact
			threat to groundwater quality if appropriate safeguards and containment measures are not implemented.
	Operation	High	Based on the groundwater model and simulation for the future abstraction rate for the Dubaydib wellfield, conducted in 2024, under current abstraction 100 MCM/year, the water table is declining at approximately 1.2 meters per year. Increasing abstraction to 120 MCM/year is expected to increase the rate of decline to about 1.5 meters per year, representing an additional drawdown rate of 0.3 meters per year compared to the baseline. Focusing on the incremental impact, by 2038, the piezometric depression under the 100 MCM/year scenario is expected to deepen by around 20 meters compared to 2024 levels. Under the 120 MCM/year scenario, the drawdown could deepen by up to 25 meters, the additional 20 MCM/year abstraction contributes approximately 5 meters of extra drawdown during this period. On the long term, by 2065, drawdowns in the wellfield are projected to reach approximately 50 meters under the 100 MCM/year scenario, and up to 60 meters under the 120 MCM/year scenario.
		Low	In general, excessive groundwater extraction may result in long-term land subsidence due to the compaction of aquifer sediments. This could damage infrastructure such as roads, pipelines, and buildings, and alter surface drainage patterns. Based on geological evidence for the Disi aquifer specifically, it can be concluded that the risk of significant land subsidence is low. However, dedicated land subsidence monitoring is recommended if future evidence emerges [6,7] .
Biological Environment			
Flora and Fauna	Construction	Medium	The construction activities would have significant impacts on flora and fauna, primarily due to physical disturbances and habitat alterations. For instance, increased noise and human activity during the construction phase, including workers and machinery, could disturb local wildlife behavior, including feeding, breeding, and migration patterns, and could also contribute to further degradation of plant habitats, particularly in sensitive areas like wadis. In addition, improper waste disposal could accumulate in the area, leading to long-term pollution affecting flora and fauna. Moreover, birds and other wildlife that perch on power lines or towers may be at risk of electrocution, particularly larger birds that may span across conductive components.
	Operation	Medium	The project's operational activities including the operation of wells, roads, and transmission lines as well as maintenance activities would have potential ongoing impacts on flora and fauna. Such activities may prevent the natural regeneration of vegetation in disturbed areas, compact soil, displace wildlife, and alter the

[6]UN-ESCWA & BGR Report entitled “Inventory of Shared Water Resources in Western Asia”, for the year 2013

[7] BRGM. (2023, June). Additional production well targeting and well design for the Dubaydib wellfield – Jordan: Final Report. Orléans, France: Bureau de Recherches Géologiques et Minières (BRGM).

Aspect	Project Phase	Impact Significance	Potential Environmental and Social Impact
			nesting and breeding behavior of sensitive species, especially if regular maintenance activities increase human presence in the area as well as it would further compact the soil. This also may promote the spread of invasive plant species, which further degrade the ecosystem as well as it may provide easier access to remote areas, increase the risk of illegal hunting, and threaten vulnerable wildlife species in the area. Larger birds and migratory species that might perch on power lines or towers would continue to be at risk of colliding with overhead power transmission lines.
Sensitive habitat	Construction	Low	The infrastructure development near or within the Rum IBA as well the encroachment of the work sites away from the proposed project components would pose a significant disturbance to bird populations, particularly species of conservation concern. Increased noise, vibrations, and human presence can disrupt key behaviors such as nesting, feeding, and migratory stopovers. Sensitive species may abandon their nesting sites or experience lower breeding success due to these disturbances, leading to long-term population declines. Also, migratory birds, which rely on the IBA as an essential stopover during their journeys, may be forced to alter their routes or stop at suboptimal locations, further impacting their survival. Additionally, large raptors, which are particularly sensitive to human activity, could face habitat abandonment, diminishing the ecological value of the IBA for bird conservation. Moreover, birds and other wildlife that perch on power lines or towers may be at risk of electrocution, particularly larger birds that may span across conductive components within the vicinity of two wells situated within Rum IBA, W69, and W98. On the other hand, Rum protected area is the closest protected area to the project site and it is located about 18 km away while Al Mudawara rangeland reserve is the closest rangeland reserve and it is located approximately 15 km from the project site. The project site does not fall within the boundaries of the Rum protected area or Al Mudawara rangeland reserve, thus, direct impacts on the protected area and rangeland reserve are considered unlikely.
	Operation	Low	The project poses ongoing risks to sensitive habitats, particularly in areas like Wadis and the Rum Important Bird Area. Habitat fragmentation is considered a key concern, as the presence of infrastructure such as roads and transmission lines can disrupt wildlife corridors and reduce the connectivity of key habitats. Moreover, it would limit the movement of migratory birds and other wildlife, leading to isolated populations and reduced biodiversity, consequently reducing breeding success and altering migration patterns of species, particularly those of conservation concern due to ongoing human disturbance and infrastructure presence. In addition, operational and maintenance activities would continue to pose the risk of disturbance to wildlife and the potential spread of invasive species, which could further degrade these crucial habitats.

Aspect	Project Phase	Impact Significance	Potential Environmental and Social Impact
Ecosystem services	Construction	Medium	The project's activities are likely to affect several ecosystem services including water regulation, particularly in desert environments where water is scarce as well as soil stabilization.
	Operation	Medium	Operational activities would have permanent impacts on key ecosystem services, particularly water regulation as well as soil stabilization which would have ongoing disturbance of flora around operational infrastructure, increasing the risk of erosion and land degradation. In addition, ecosystem services related to carbon sequestration could also be impacted by the removal or degradation of vegetation over time. As native plants are slow to recover in arid conditions, any long-term damage to flora may further reduce the ecosystem's capacity to sequester carbon. The degradation of sensitive habitats may also diminish their ability to provide essential services like habitat provision for wildlife, further disrupting the ecological balance and affecting the local communities surrounding the project site, particularly those that depend on the rangelands as an essential source of their livelihood. These lands provide an important grazing area for livestock, which is a primary source of income, food, and cultural identity for many nomadic and semi-nomadic communities in Jordan. The natural vegetation in the rangelands, such as Acacia and other drought-resistant species, offers forage for sheep, goats, and camels, helping to sustain local economies and preserve traditional ways of life. The well-being of these rangelands directly affects the economic stability of the local communities, as overgrazing or land degradation can lead to diminished forage availability.
Socio-economic Environment			
Air Quality and Noise	Construction	Medium	The proposed project is far from the nearest farm by 2 Km and from residential areas by more than 5 km. Thus, subject to prudent and well-defined management, there would be no potential nuisance impacts on the farm or the residential areas.
	Operation	---	No impact is expected
Traffic	Construction	Low	There would be limited short-term adverse impacts on traffic due to the transport of equipment and materials to and from the site through the surrounding road network. There are no residential areas within the wellfield boundaries. Thus, the impacts are mainly considered occupational impacts.
	Operation	---	No impact is expected
Community, Health, Safety and Security	Construction	Low	The potential impacts on community, health, safety, and security are not expected during construction and operational activities as there are no residential areas within the wellfield boundaries.
	Operation		
Occupational Health, Safety and Security	Construction	Medium	There would be potential impacts on workers' health and safety due to exposure to risks through construction activities, including site preparation, infrastructure and utilities installation, and building structures, that lead to accidents causing injuries or death.

Aspect	Project Phase	Impact Significance	Potential Environmental and Social Impact
	Operation	Medium	The operational and maintenance staff may be exposed to hazards related to working in confined spaces and a variety of hazardous chemical agents during maintenance works, these agents may cause acute poisoning, chemical accidents (e.g., skin burns, injury to the eyes, etc.), damage to the respiratory system, allergies, or chronic diseases. Other common hazards include electric shock, explosions, and entanglement in moving machinery.
Farmers & Agricultural Activities	Operation	High	Under the current permitted abstraction of 100 MCM/year, groundwater levels in the Disi wellfield are projected to drop by about 20 meters by 2038 and over 50 meters by 2065. This ongoing decline will affect nearby agricultural areas like Al Mudawarra and Disi, where farmers already rely on the same aquifer. Increasing abstraction to 120 MCM/year would deepen the drawdown by about 5 meters more by 2038 and up to 10 meters more by 2065. it could accelerate stress on agricultural wells and bring forward the need for adaptation measures.
Community, Health, Safety, and Security	Construction Phase	Low	The potential impact on community, health, safety, and security is not expected for the construction phase.
	Operation Phase	Medium	There is a potential risk for localized long-term radiation-related health impacts on the rural and agricultural communities in Disi and Mudawara
Vulnerable Groups	Construction	Low	No vulnerable groups reside within the wellfield.
	Operation	Low	No direct impact is expected. DPAC will remain active to address local community needs through stakeholder engagement, grievance handling, and support programs targeting vulnerable groups.
Indigenous Populations	Construction	Medium	Drilling and site activities may temporarily disrupt seasonal grazing. Increased machinery movement and restricted access could make it harder for shepherds to reach grazing land, causing challenges for livestock.
	Operation	Low	As the wellfield becomes an operational site, access to certain areas may remain restricted, while Bedouin and shepherd groups pass through the area seasonally, their grazing activities are unlikely to be significantly affected.
Waste Management			
Waste Management	Construction	Medium	Potential impacts from improper housekeeping practices are expected such as improper management of waste streams, improper storage of construction material and hazardous material, and illegal disposal of waste to land, including hazardous and non-hazardous wastes. In addition, drilling fluid wastes could be a source of contamination which has the potential to invade freshwater aquifers near the wellbore and cause localized salinization or contamination.
	Operation	Medium	Potential impacts are expected, including the possibility of spills from oils, fuel, lubricants, and chemicals utilized in the maintenance activities.
Labor Right			
Labor Right	Construction	Medium	Common activities during construction such as excavations, lifting, movement of heavy machinery, or

Aspect	Project Phase	Impact Significance	Potential Environmental and Social Impact
			handling chemicals, can introduce occupational health and safety risks to workers.
	Operation	Medium	During the operation phase of the groundwater wells in the Disi area, activities such as the operation and maintenance of pumps, monitoring water levels and quality, and regular inspection of equipment may introduce occupational health and safety risks to workers. These risks could include exposure to noise, vibration, and potentially hazardous chemicals used in maintenance.
Climate Risk			
Climate Risk	Construction	Medium	Prolonged heat waves and higher ambient temperatures may pose health risks to workers, leading to heat stress and reduced labor productivity. Furthermore, the use of water for dust suppression and other activities may exacerbate local water scarcity issues. Proper implementation of energy-efficient practices, sustainable material use, and worker safety measures is necessary to mitigate these impacts.
Archaeology and Cultural Resources			
Archaeology and Cultural Heritage	Construction	Low	Based on the archaeological survey conducted by the Department of Antiquities there are no archaeological and/or cultural heritage sites are foreseen within the proposed project area, across the well field. However, the contractor shall be responsible for notifying the Department of Antiquities in the case that antiquities are encountered in any area during construction
	Operation	----	No impact is expected during operation activities

1.7 ESIA Conclusion and Recommendations

The project is critical for Jordan's national water security, but it requires stringent mitigation measures to manage its environmental and social risks. The project must comply with Jordanian environmental and social regulations and relevant lender standards to ensure sustainable implementation—balancing immediate water supply needs with long-term resource conservation.

Potential adverse environmental and social impacts are anticipated, with significance ranging from low to high. Low to medium adverse impacts can be managed effectively through the mitigation and monitoring measures provided in Section 10.2 and the periodic monitoring plans outlined in the ESMP. However, high-significance impacts relate to the long-term sustainability of the Disi aquifer, particularly under higher abstraction scenarios. Addressing these impacts will require coordinated action by both the project company and the Ministry of Water and Irrigation (MWI).

The project company is responsible for implementing all mitigation measures outlined in the ESMP, including monitoring and reporting across all project phases. It may also support local communities—such as agricultural groups—through corporate social responsibility initiatives, including training and capacity-building via DPAC.

MWI holds a strategic national role in groundwater management, encompassing regulatory enforcement, stakeholder coordination, integration of hydrogeological data into planning, and oversight of sustainable abstraction practices. While this ESIA primarily covers the project's operational phase (expected to 2038, possibly extending to 2048), aquifer drawdown projections extend to 2065. As such, long-term sustainability falls under MWI's jurisdiction.

To support this, the ESIA outlines the Environmental and Social Management Framework (ESMF) presented in **Annex 14** that may serve as a strategic reference for MWI in strengthening groundwater governance. The ESMF is intended to inform adaptive planning, stakeholder coordination, and cumulative impact oversight. Its indicative components include:

- Oversight of abstraction limits
- Enforcement of water extraction and aquifer protection regulations
- Coordination of stakeholder engagement and public communication
- Integration of transboundary water management considerations
- Long-term monitoring of environmental and social indicators
- Review and adjustment of water quality and blending practices
- Community-level mitigation and livelihood support in affected areas
- Adaptive management of abstraction rates beyond 2038, considering projections to 2065

This ESIA recommends that, if deemed appropriate, MWI could incorporate the ESMF into its national groundwater planning strategy to help safeguard the Disi aquifer for future generations.

Responses to lenders' environmental and social comments, including cross-references to the ESIA, are consolidated in **Annex 15**, which forms part of the final ESIA package. In addition, the MWI's 2023–2024 radioactivity monitoring report for the Disi wellfield is included as **Annex 16** and supports the findings of the water quality assessment presented in this ESIA

2 INTRODUCTION

2.1 Overview of the Project

The Disi Water Conveyance Project is owned by the Government of Jordan, represented by the Ministry of Water and Irrigation (MWI) and the Water Authority of Jordan (WAJ). The project is implemented under a Build-Operate-Transfer (BOT) contract. DIWACO (Disi Water Company) holds ownership of the project facilities during the concession period, which began with commercial operation on January 27, 2014. Originally set for 25 years, the concession has been extended by an additional 5 years, bringing the total to 30 years. DIWACO has subcontracted DAOM to operate and maintain the entire conveyance system—from the wellfield in southern Jordan to the Greater Amman Area. After the extended concession period, ownership and operational responsibility will be transferred to the Government of Jordan.

The Disi Mudawarra to Amman water conveyance system is supplying potable water to the Greater Amman Area from the Disi aquifer in the south of Jordan. Water is abstracted from the 'fossil' aquifer and carried approximately 325km to Amman via a pipeline. The system is conveying an annual flow of 100 MCM; 40 MCM to a new tank in Abu Alanda and 60 MCM to an existing tank in Dabuk.

Provision was made for five emergency turnouts from the conveyance pipeline to supply demand centers along the conveyance route (Ma'an, Tafila, Karak, and Madaba city and Madaba bridge pump station), following the construction of the infrastructure, these turnouts can only be used temporarily and in an emergency situation when the demand center in question cannot be supplied with enough water supply from the current source.

The project is considered as part of the GOJ's larger regional framework of water management and development of new resources. The project started operation in 2014 and it comprises of 55 production wells (46 operational and 9 standbys). Recently the Disi project activated 4 of the standby wells to be 50 abstraction wells and 5 standby wells, and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM and since 2024, production has been increased to 115 MCM. Water is collected from each of the wells via a 'dendritic' collector network and delivered to a collector tank north of the well field by a main spinal collector.

An ESIA for the project was completed in 2004 by Consolidated Consultants Group. In 2007 Dar Al-Handasah Consultants were assigned by GAMA Enerji A.S. to conduct a review of project ESIA to determine:

- If the changes to the project design since 2004 were sufficient to invalidate all or part of the ESIA
- If there were any changes to the national framework since 2004 that would necessitate revision of all or part of the ESIA.

As a result of the ESIA review, an Addendum to the ESIA was submitted and approved in 2008 by the MWI and MoEnv.

Recently, DIWACO plans to increase the annual output of the wellfield to 120 MCM/year, which will require the construction of additional production wells. Twelve (12) new well locations have been identified and confirmed within the Dubaydib wellfield.

These locations result from the most appropriate trade-off between geoscientific criteria and stakeholders' requirements. Out of the 12 proposed well locations, two require clearance from the MWI due to their positions outside the current Land Lease Agreement, with one situated at the border of a designated 'no-drill' zone. DIWACO is not planning to utilize the two uncleared locations until the other 10 wells are either fully operational or abandoned. DIWACO will start soon working with the consultant for the network design to use up to 9 locations out of 12 proposed. The ultimate plan of DIWACO is to drill wells for holding redundancy at the level of 3-4 standby wells at any point in time.

The following section represents the Additional Water Project's main components:

- Drilling new groundwater wells.
- Constructing the relevant infrastructure to collect and transfer water to the existing wellfield collector tank.
- Establish the internal road network to connect the new wells with the existing parts of the project in the Mudawarra area.
- Expansion of the overhead power line system to connect the new wells.

Thus, in compliance with the Jordanian Environmental Classification and Licensing Regulation Number No.69 for the year 2020 and its amendment, MWI/Water Authority of Jordan (WAJ) has submitted letter No.12306/2/7 on 22/6/2023 to MoEnv requesting the classification and the requirements to implement the additional project activities (the new wells).

The MoEnv confirmed its need for ESIA prior to the drilling of new wells and classified the project as Category 1, requiring a comprehensive ESIA. The MoEnv classification letter No.6116/7/4 dated August 31st, 2023, is attached in Appendix 1 in the Terms of Reference (ToR) report. As part of the project scope, AJi Water and Environment has been requested to conduct a comprehensive ESIA for the new project phase.

2.2 Scope of Work

AJi was appointed by DIWACO to prepare the Comprehensive ESIA study for “drilling new wells and associated infrastructure works – Dubaydib well field / Disi” during the three project phases: construction, operation and decommissioning in order to support the application for an environmental permit from MoEnv.

In accordance with MoEnv’ s requirements, the ESIA assignment will consist of the following phases:

- Preparation of preliminary ToR.
- Attending and documenting scoping sessions with stakeholders.
- Finalizing and submitting ToR following input from MoEnv. along with the scoping statement.
- Perform ESIA study and prepare ESIA report - including ESMP. (This Report).
- Disclosure session will be conducted in line with the lenders requirements to present the ESIA findings and enclose additional comments within the final ESIA.
- Finalizing and submitting the ESIA study following input from MoEnv. to obtain the environmental permit.

2.3 ESIA Objectives

This ESIA study aims to:

- Identify and assess the potentially significant existing and future environmental and social impacts resulting from project activities during the three phases of the project;
- Determine the measures needed to avoid and/or minimize potential environmental and social impacts, and identify mitigation measures and opportunities for the project that Ensure that the project is socially and environmentally sustainable;
- The project respects the rights of affected workers/personnel on site and local communities;
- Ensure that the project is designed and operated in compliance with the IFC and EIB requirements and applicable local and national regulatory requirements and good international practice,
- Support the application for environmental approval from the MoEnv in line with the ESIA regulation 69/2020 and its amendments.

2.4 The Project Proponent

DIWACO is the proponent for the proposed project "Drilling new wells and associated infrastructure works – Dubaydib well field / Disi", and may be contacted at:

Khalil Al-Wazir

Technical Manager

Amman, Jordan

Telephone: +962 79 500 0213

E-mail: kalwazir@gamaenergy.com

2.5 The Consultant

AJi Infrastructure and Environment has prepared this ESIA report on behalf of the project proponent DIWACO in accordance with the MoEnv. guidelines, IFC and EIB requirements. The primary contact for AJi Infrastructure and Environment is:

Ghada Jaber

Project Manager

Amman, Jordan

Telephone: +962 79 662 2644

E-mail: Ghada_Jaber@ajigroup.com

2.6 ESIA Reporting

This draft ESIA report has been prepared in compliance with the requirements stated in the Jordanian ESIA regulation 69/2020 and its amendments, and lenders' requirements as shown in **Table 3**.

Table 3: ESIA Reporting

No.	ESIA Section	Description
1	**Executive Summary**	Summary of the project, main findings, and recommendations
2	**Introduction**	Overview and purpose of the project and scope of the ESIA
3	**Project Description**	A clear and concise description of different activities over the life of the project from mobilization, construction, and operation through to decommissioning. The description should be sufficient to allow the risks and impacts to be identified, described, and evaluated
4	**Policy, Legal and Institutional Framework**	Details of the applicable legislation and regulations in Jordan and lenders' requirements with potential implications to the project. And legislation gap analysis
5	**Environmental and Social Baseline Conditions**	Assessment of the baseline conditions against which the impacts of the project can be assessed based on desktop studies and fieldwork.
6	**Stakeholder Identification and Engagement**	Summary of the stakeholder engagement process which identifies the affected parties and details how the project will communicate, inform, and discuss the substantive issues with all interested and affected parties.
7	**Environmental and Socio-Economic Aspects and Receptors**	Identification of key physical, biological, occupational, and socio-economic receptors potentially impacted by project activities. The section summarizes interactions, key issues, and potential impacts across all phases, including unplanned events.
8	**Analysis of Project Alternatives**	A comparison of the project alternatives considered and their potential impacts.
9	**Environmental and Social Impacts including the cumulative impacts**	Assessment of the impacts of the project and a discussion of the possible negative and positive impacts of the project on the environment and social fabric, including socio-economic effects.
10	**Environmental and Social Management Plan**	The main ESMP components are presented in this section. Details of specific activities to be carried out during different phases of the project to ensure the identified mitigation measures are implemented are provided through the ESMP.
11	**Overview of Environmental and Social Management System (ESMS) and Auditing Protocol**	overview of the project's ESMS framework and auditing procedures, outlining its development and implementation to manage risks throughout the project lifecycle. It also summarizes key findings from the ESIA, highlighting all concerns.
12	**References**	A listing of all the references used in the ESIA study.
13	**Annexes**	This section includes supporting documents referenced in the ESIA, such as the approved Terms of Reference, Climate Risk Vulnerability Assessment (CRVA), Biodiversity Study, and Noise Monitoring Report.

3 PROJECT DESCRIPTION AND BACKGROUND

3.1 General Overview & Project's Justification

DIWACO is contracted to MWI/WAJ, and subcontracted the operation of the Dubaydib wellfield to DAOM. The principal objective of this project is to facilitate the resolution of the water supply problem experienced at Amman, the capital city of Jordan, and the surrounding area. Thus, increasing the supplied water to Amman and accordingly improving public health conditions.

As per the existing project agreement terms, DIWACO is required to deliver up to 100 MCM of water per year to Abu Alanda and Dabuk in Amman from the Dubaydib well field.

However, MWI asked DIWACO to raise the water delivery quantities to 120 MCM for the longer term (2025 onwards) due to the high demand, particularly in the summer. After conducting an infrastructure evaluation, DIWACO verified that the project could accommodate the addition of new wells to meet the quantity need of 120 MCM/year.

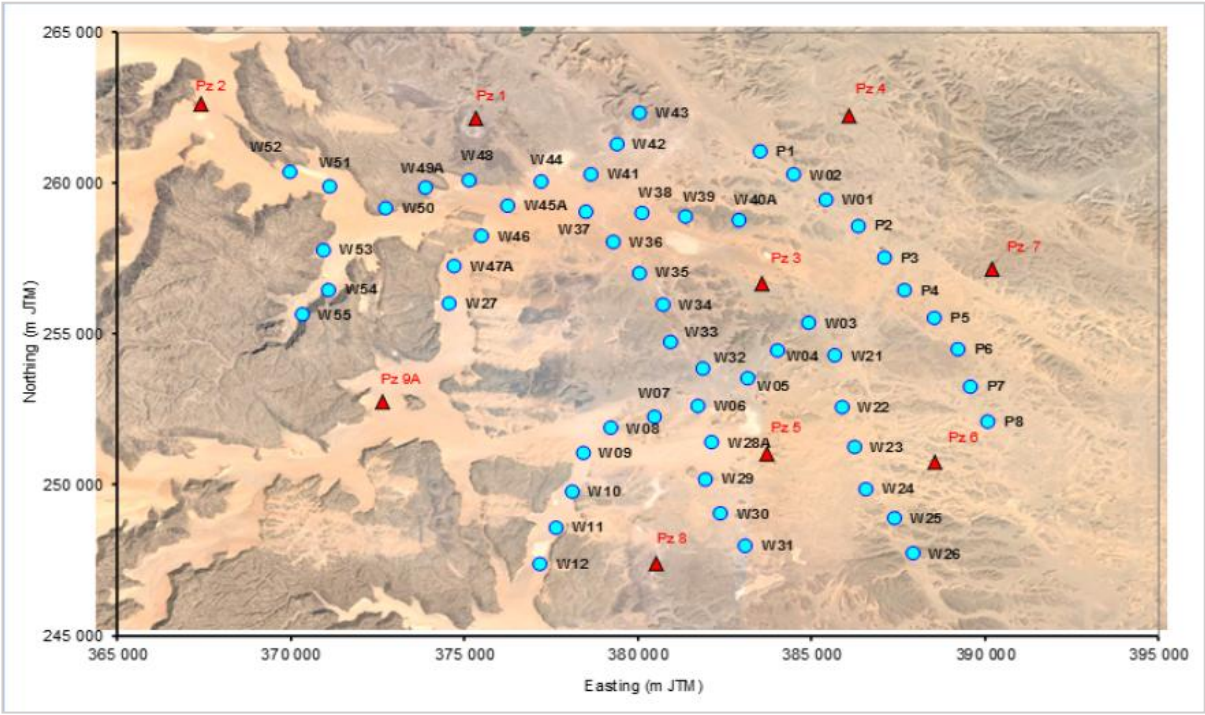
To reliably meet the increased water quantity requested by MWI/WAJ (up to a total of 120 MCM/yr), DIWACO is planning to conduct additional activities described in the following subsection. These additional activities are herein referred to as "The Proposed wells "which will be covered in the ESIA.

3.2 Project Description

3.2.1 Existing Disi–Amman Project

The existing Disi-Amman System involves 55 production wells (46 abstraction wells and 9 standby wells) to abstract water from the fossil aquifer in southern Jordan. (Wells map is presented in **Figure 1**). In addition, the project includes 9 piezometer wells and operational facilities including water tanks and pump stations conveying the water for a distance of approximately 325 km to supply 100 MCM per year of water to Amman. The water is received at two tanks, at Dabuk and Abu Alanda in western and eastern Amman respectively. Recently the Disi project activated 4 of the standby wells to be 50 abstraction wells and 5 standby wells, and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM and since 2024, production has been increased to 115 MCM.

Disi is a fossil aquifer extending from the southern edge of the Dead Sea in Jordan to Tabuk in northwest Saudi Arabia. Significant exploitation of the Jordanian part of the aquifer started in 1980.

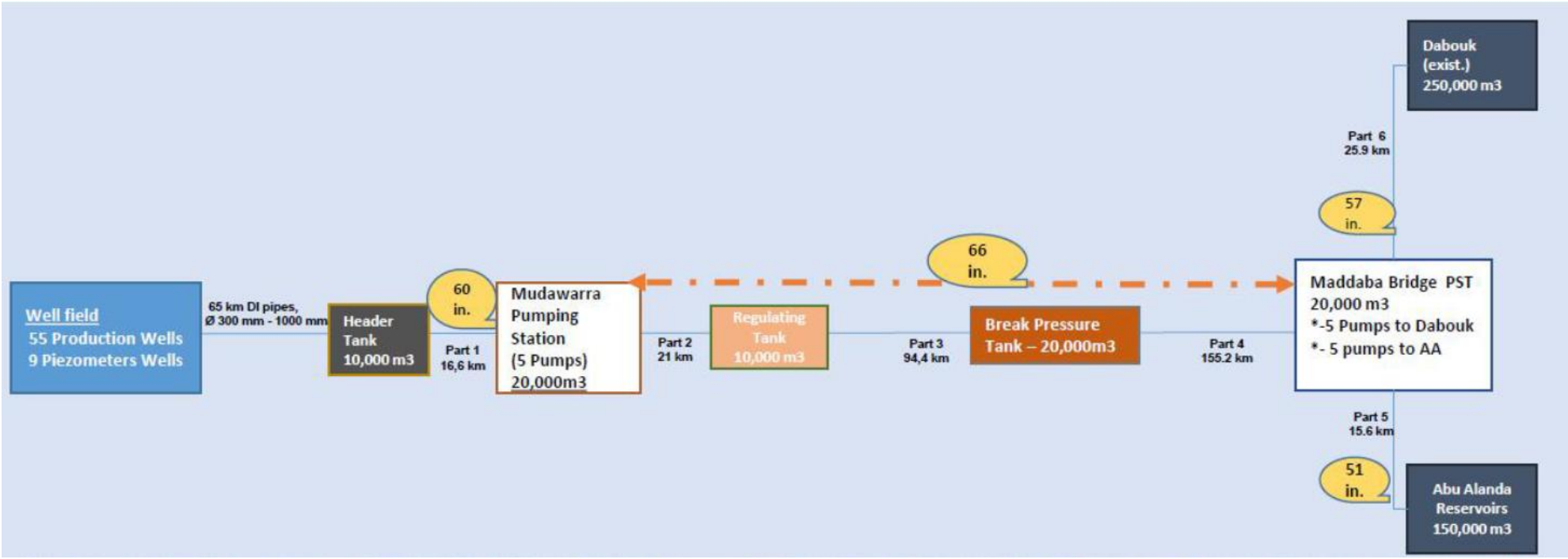


Source: DIWACO

Figure 1: Well-field Map

The Major existing components of the Disi-Amman Project include the following:

- Well field consisting of 46 abstraction wells and 9 standby wells. (Recently the Disi project activated 4 of the standby wells to be 50 abstraction wells and 5 standby wells), and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM.
- Well field collection network
- Main pipeline
- Break pressure and regulating tanks
- Two Pumping stations
- Tanks (Abu Alanda and Dabouk tanks)
- Associated ancillary buildings
- Power supply and communications infrastructure
- Access and Service Roads



Source: DIWACO

Figure 2: Layout for the major components of the Disi–Amman Project

The Existing Project Location

The project area is the area between the Disi wellfield and Greater Amman and passes through Governorates of Greater Amman, Madaba, Karak, Tafileh, Ma'an, and Aqaba. **Figure 3** shows the constructed alignment of the conveyor to Amman.

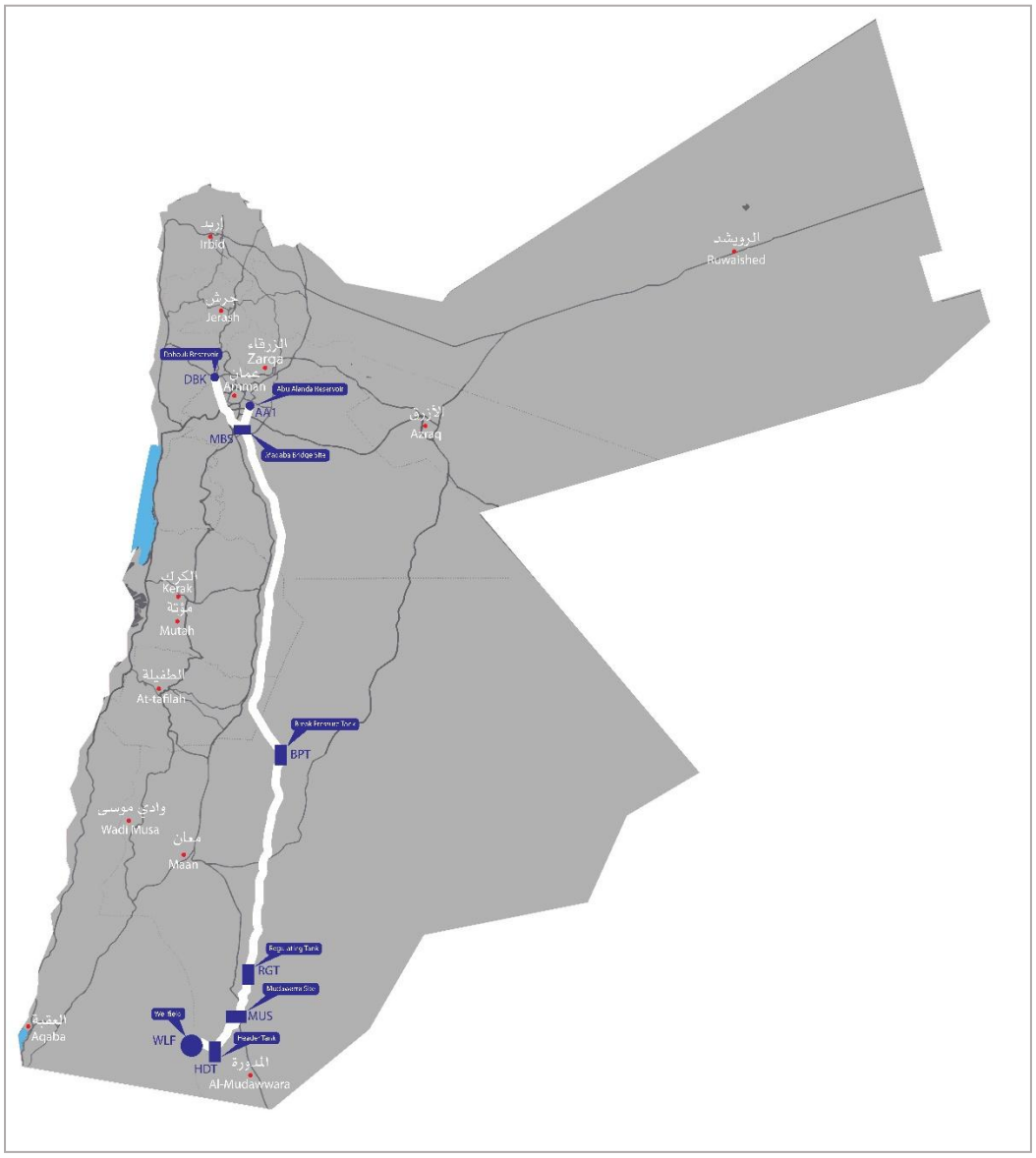


Figure 3: Constructed alignment of the Disi-Mudawarra to Amman water conveyance system

Land Ownership

The area in which the project is located was previously under the jurisdiction of the Aqaba Special Economic Zone Authority (ASEZA). However, as per the official letter No. (Q R / 186 / 9842) dated May 22, 2008, ownership of these lands was transferred to the Ministry of Water and Irrigation.

This transfer was carried out in accordance with formal procedures for allocating land designated for strategic projects in the water sector, ensuring optimal land use in alignment with national water resource management plans. This change is documented in the official records provided in Appendix 2 in the ToR, which detail the decision and the accompanying legal procedures.

Accordingly, all construction and operational activities related to the project will be conducted within land owned by the Ministry of Water and Irrigation, ensuring compliance with applicable legislation and regulations governing the use of public land for vital infrastructure projects.

3.2.2 The Proposed wells

The Disi project wellfield has been producing about 97 to 100 MCM/year. It comprises 55 production wells (initially started with 46 wells in operation and 9 standby wells, recently the Disi project activated 4 of the standby wells to be 50 abstraction wells and 5 standby wells), and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM in 2023 and since 2024, production increased to 115 MCM). The wells have a total depth ranging from 394 to 600 m.

The production target for each new production well has an average of 70 L/s, with a maximum of 80 L/s, with the aim of increasing the current wellfield production up to about 120 MCM/year. Thus, new additional production wells are required. The identification of the most suitable location and design for these wells have been identified based on the BRGM report, published in 2023 [1].

Project components:

The proposed project includes the following activities which will be covered in the ESIA:

- Drilling new groundwater wells (will involve drilling of the well shafts, installation of well casing, screens and pump head).
- Drilling activities are tentatively scheduled to commence in January 2026, and continue through July 2027 for the completion of the first four additional wells (Contingent upon financial security conditions, the approval of study results by all relevant parties, and the GoJ approval of the ESIA). Additional wells will be drilled as required to ensure the continuous availability of three redundant wells at all times, while pumping 120 MCM per year. . Constructing the relevant infrastructure, including wellheads, compounds, pipelines and electricity networks to collect and transfer water to the existing collection tank.
- Extend the internal road network to connect the new wells with the existing parts of the project.
- Expansion of the overhead power line system to connect the new wells.

Detailed Description of the New Wells Components in the Disi Basin

Wells in the Disi Basin will be drilled using advanced techniques such as direct rotary drilling with polymer-based drilling fluids or reverse circulation using formation water assisted by air, depending on site-specific conditions. A rapid penetration drilling method will be adopted to ensure a perfectly vertical borehole with minimal erosion and collapse, thereby enhancing operational efficiency and the quality of extracted water.

Well development activities will be carried out to ensure efficient water flow, including production tests to measure discharge rates, monitor dynamic water levels, and calculate the specific capacity of each well.

1. Production Wells

Each well will be drilled to a total depth ranging between 500 and 600 meters, with a pump casing installed from 300 to 360 meters. The well design incorporates several essential elements to ensure efficient water extraction, including:

- Drilling a 32-inch borehole down to 40 meters using a polymer-based drilling fluid.

- Drilling a 17½-inch borehole down to the required depth of 500 meters using a suitable drilling fluid based on the geological conditions.
- Drilling a 24-inch borehole followed by the installation and fixation of an 18⅝-inch outer diameter carbon steel casing to a depth of 300–360 meters to achieve the required total well depth.
- Using approved materials for main well components, such as casings and screens, supported by certified test reports and subject to inspection by representatives of the Ministry of Water and Irrigation and the Jordan Water Authority.
- Ensuring a minimum hydraulic efficiency of 70% for each well based on step-drawdown test results.
- If screen completion is adopted, a 10¾-inch outer diameter screen will be installed along with a gravel pack. The grain size of the gravel will be selected based on the analysis of drilling cuttings. The screen will have an open area of at least 10%, and the water upflow velocity in the screened section must not exceed 1.5 m/s.

2. Casing and Screening

- Installation of 26-inch low carbon steel casing to the required depth, with precise alignment to ensure well stability.
- Use of wire-wrapped stainless-steel screens (304L) along with a gravel pack to improve water filtration.

Figure 4 illustrates the typical design of production wells.

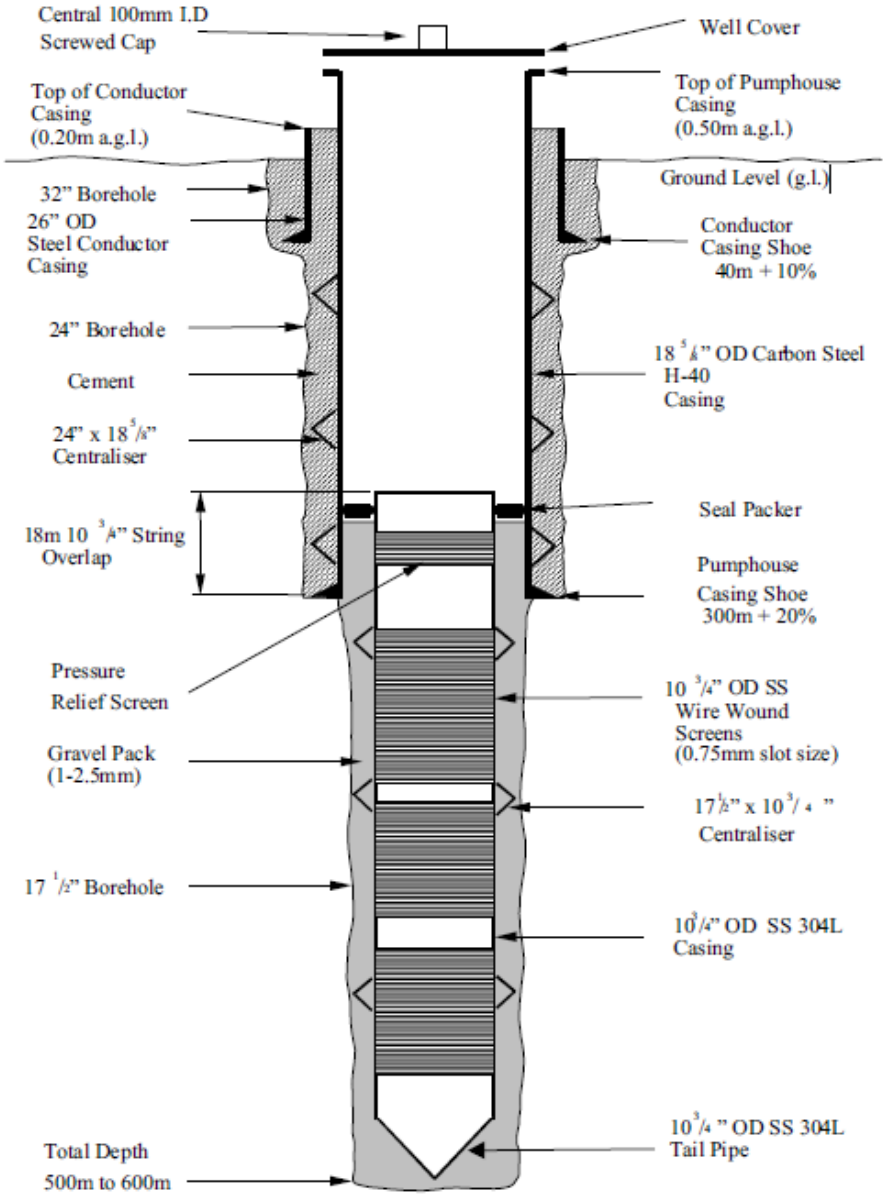


Figure 4: Typical Design of Production Wells

3. Pump and Piping System Design

Well pumps, riser pipes, and wellhead piping will be designed to lift groundwater from the aquifer and convey it to the water collection network at a pressure sufficient to ensure flow toward the main storage reservoir at the wellfield pumping station. All materials used will be selected to withstand environmental conditions and operating pressures, including hydraulic pressure surges, throughout the project's design life.

4. Access Road Construction

Access roads will be constructed to support drilling operations and pipeline installation, connecting the new wells to existing project infrastructure. These roads will be designed to withstand the heavy loads of construction equipment and to minimize maintenance needs post-construction. The roads will be surfaced with natural, crushed rock material free of harmful substances, in accordance with British Standard BS 1377. The road structure will consist of three layers:

- A base layer with a minimum thickness of 150 mm.
- A sub-base layer ranging from 0 to 100 mm.
- A fill layer ranging from 0 to 300 mm, depending on the California Bearing Ratio (CBR) of the subgrade soil.

Road widths will range between 3.5 and 7.5 meters, with side drainage channels constructed along the higher elevation of the road.

5. Power Supply for the Wellfield

The wellfield's power substation and pumping station will be supplied with electricity via the Electricity Distribution Company (EDCO). Medium-voltage power lines will be extended from the EDCO grid to the wellfield. Appropriate protective measures will be implemented to safeguard the electrical infrastructure from fluctuations and outages. The existing EDCO power grid is presented in **Appendix 3** of the TOR. According to the official Diwaco communication with EDCO **(Annex 2),** it was confirmed that the current station has the ability to cover the expected total load within the wellfield for the additional wells.

Below is a figure illustrating the nearest existing electrical network in relation to the proposed well locations.

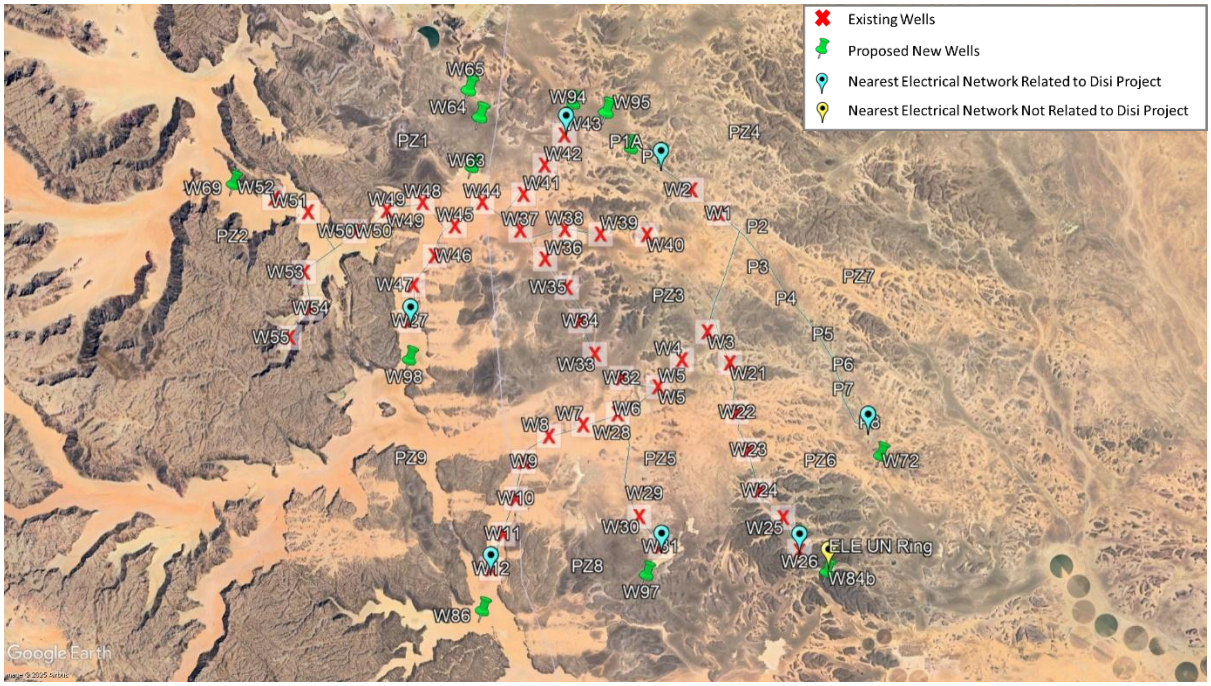


Figure 5: Proposed New Wells and Nearest Available EDCO Network

Table 4 presents the electricity network requirements for each individual well.

Table 4: New Proposed Wells Electricity Network Requirements

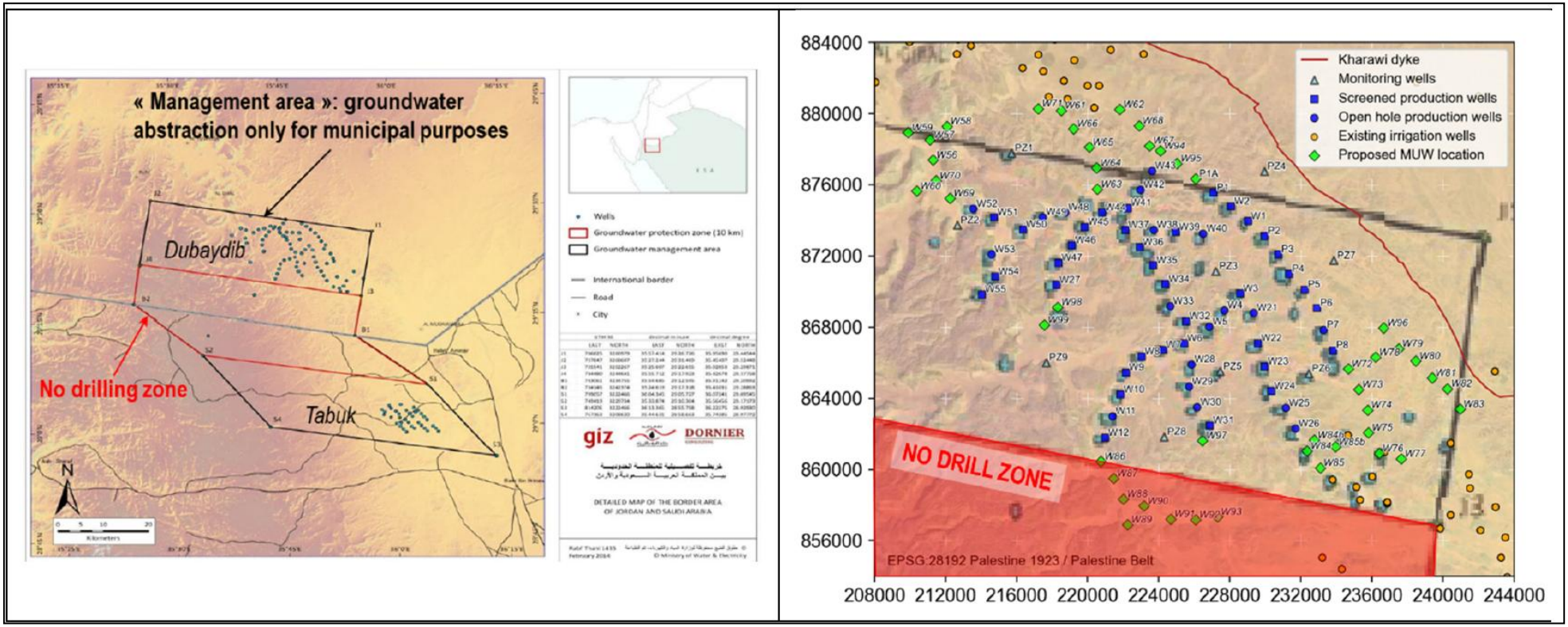
Well Name	Electricity Requirements
W97 GT	• Proposed W97 GT can be supplied with electricity through existing W31 using Disi electrical network ring. • The aerodynamic distance is 1,076 m.
W63 GT	• Proposed W63 GT can be supplied with electricity through existing W44 using Disi electrical network ring • The aerodynamic distance Well W-1,208 m.
W84b GT	• Proposed W84b GT can be supplied with electricity through existing W26 using Disi electrical network ring. • The aerodynamic distance is 1,209 m. • There is a power line close to proposed W84b GT not related to Disi power network. The aerodynamic distance is 36 m.
W72 GT	• Proposed W72 GT can be supplied with electricity through the line between existing P8 and W26 in ring. • The aerodynamic distance is 475 m.
W94 GT	• Proposed W94 GT can be supplied with electricity through the ring between existing P1 & W43 in ring. • The aerodynamic distance is 511 m. • There is power line close to proposed W94 GT not related to Disi power network. The aerodynamic distance is 36 m
W64 GT	• Proposed W64 GT will be supplied through existing W63 GT respectively.
P1A GT	• Proposed WP1A GT can be supplied with electricity through the line between existing P1 & W43 in ring • The aerodynamic distance is 93 m
W86 GT	• Proposed W86 GT can be supplied with electricity through existing W12 using Disi electrical network ring • The aerodynamic distance is 1,053 m
W98 GT	• Proposed W98 GT can be supplied with electricity through existing W27 using Disi electrical network ring. • The aerodynamic distance is 1,263 m.
W69 GT	• Proposed W69 GT can be supplied with electricity through existing W52 using Disi electrical network ring. • The aerodynamic distance is 1,575 m.
W95 GT	• Proposed W95 GT can be supplied with electricity through the ring between existing P1 & W43 in ring. • The aerodynamic distance is 201 m. • There is power line close to Proposed W95 GT not related to Disi power network. • The aerodynamic distance is 50 m
W65 GT	• Proposed W64 GT will be supplied through proposed W63 GT respectively.

Jordan/KSA agreement for managing of the Disi/Saq groundwater

In 2015, Jordan and Saudi Arabia signed an "Agreement for the Management and Utilization of the Groundwater in the Disi-Saq aquifer" (Disi Agreement, 2015). Amongst several articles, this agreement includes the definition of a "Management area", where groundwater abstractions should be dedicated for municipal purposes only, and a "No drill zone" area, where drilling for groundwater abstractions should be prohibited.

The no-drill zone (**Figure 6**) encompasses the south-western area of the Dubaydib wellfield, thus preventing to consider any new production wells in this area.

Appendix 3 in the ToR report illustrates the agreement between the Government of Jordan and the government of Saudi Arabia in order to manage and investing groundwater in the Al-Saq layer Disi. Appendix 4 in the ToR report illustrates the agreement map while Appendix 5 and Appendix 6 in the ToR report, present the official signed approval of Jordan and Saudi Arabia for this agreement. respectively.



Source: BRGM Final Report 2023 [1]

Figure 6: "No drill zone" defined in the 2015 Jordan-KSA agreement and close-up view of the Dubaydib wellfield

Criteria and Selection of Wells Locations

The identification of the most suitable location of the new wells has been studied and identified in 2023 by BRGM[1] based on the topography and a mean distance between wells of 1,250 m as illustrated in the following three stages.

First Stage:

In the first phase, all available geoscientific data from the Dubaydib wellfield have been reviewed to build a robust conceptual model of the groundwater tank. The information included well reports, geological and geophysical logs, production data to date, groundwater levels in production and observation wells, historical consultancy reports, and site-specific constraints. Following this analysis, eleven (11) criteria of relevance for well-siting have been retained, corresponding to five (5) main risks including groundwater quantity, groundwater quality, well completion, pipeline costs, and external factor related to a specific agreement between Jordan and Saudi Arabia, which prohibits drilling in the southern edge of the wellfield). Each new well location was given a rating with respect to each criteria.

Second Stage:

In the second stage, a total rating of all the criteria was calculated for each well, as the weighted sum of each criteria. This weighted approach indicates a risk management perspective and whether stakeholders are more or less comfortable with a specific risk.

Third Stage:

In the third stage, a collective workshop was held in Amman with the Dubaydib wellfield's main stakeholders. Twelve locations were decided upon, to be further assessed in the field. Locations were confirmed and/or appropriately adjusted during the field visit (June 2023).

Proposed Wells Locations

The new well locations have been identified and confirmed within the Dubaydib wellfield. These locations result in the most appropriate trade-off between geoscientific criteria and requirements of the stakeholders. **Table 5** presents the coordinates of the new wells and the drilling priority, while **Figure 7** illustrates the wells' locations. It is worth noting that Wells No. 9 and 10 are not among the wells proposed for drilling in this study, and drilling in these wells will not take place unless all the necessary permits are obtained from the relevant authorities, should a decision be made to proceed with them in the future.

Table 5: Locations of The New Wells and Recommended Drilled Priority (DP)

Recommended DP	Original Wells Name	Wells Name	GPS Elevation (m amsl)*	Coordinates in decimal World Geodetic System 1984 (WGS84) system (European Petroleum Survey Group (EPSG) 4326)	
				X	Y
1	W97 GT	$W_{DP\,1}$	892.13	29.339564	35.790387
2	W63 GT	$W_{DP\,2}$	861.82	29.467421	35.732639
3	W84b GT	$W_{DP\,3}$	808.59	29.340959	35.855645
4	W72 GT	$W_{DP\,4}$	816.83	29.376162	35.870822
5	W94 GT	$W_{DP\,5}$	848.43	29.486488	35.768032
6	W64 GT	$W_{DP\,6}$	864.83	29.479227	35.73164
7	P1A GT	$W_{DP\,7}$	867.24	29.472573	35.787571
8	W86 GT	$W_{DP\,8}$	905.22	29.333002	35.736758
**9	W98 GT	$W_{DP\,9}$	930.99	29.408731	35.707753
**10	W69 GT	W_{DP10}	867.29	29.46167	35.643365
11	W95 GT	W_{DP11}	854.62	29.48011	35.776918
12	W65 GT	W_{DP12}	869.07	29.487706	35.727821

Source: BRGM Final Report 2023 [1]

*asml: Above mean sea level

** Wells No. 9 and 10 are not among the wells proposed for drilling in this study.

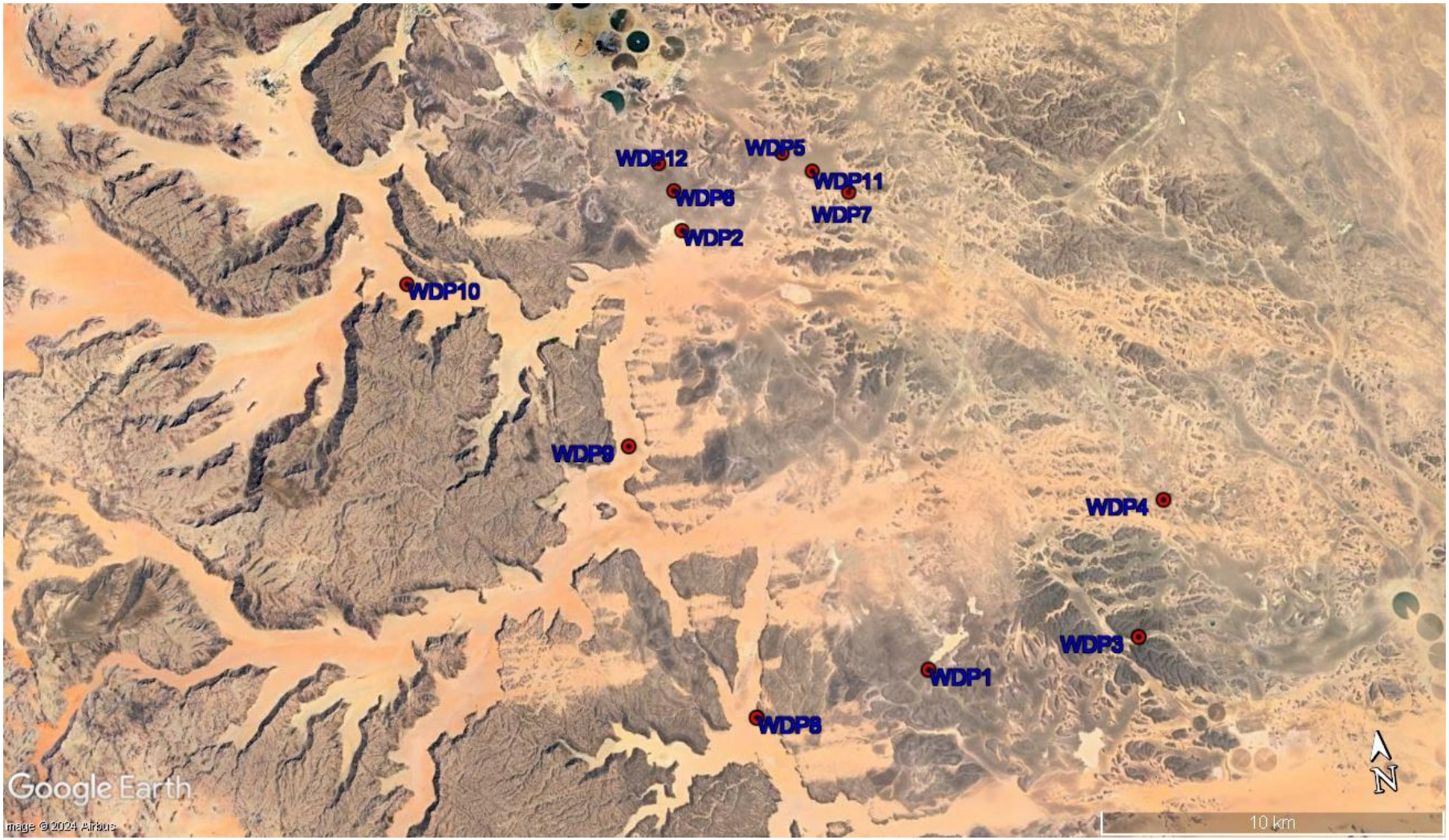


Figure 7: Map of the new drilling well's locations

Construction of the new wells will involve drilling of the well shafts, installation of well casing, screens and pump head with all necessary valves, pipes and instruments). In addition to wellhead components (including mechanical works, electrical and control rooms, transformers, lifting equipment, and fence). Associated service roads and electricity company connections are also included.

Appendix 7 in the ToR illustrates the wellhead general layout plan.

Project's Area of Influence

The Project is situated in the Disi-Mudawarra area south of Jordan, near the border with Saudi Arabia. It is part of the larger Disi aquifer, a significant source of ancient, non-renewable fossil groundwater. This region has gained prominence due to its strategic water resources, especially in a country like Jordan, which faces chronic water scarcity. The area experiences an extremely dry, desert climate, with hot summers and mild winters. The waters of the Disi Basin are hydrologically non-renewable waters with an average age of 10-30 thousand years. The Tabuk-Mudawara-Disi region extends from the Tabuk Plain in Saudi Arabia to the Wadi Rum Desert in Jordan, between the Disi, Mudawara and Al-Jafer regions.

Figure 8 below illustrates the wellfield boundary, along with 1 km and 5 km buffer zones. The map indicates that the nearest communities are located more than 5 km from the project boundary. Additionally, it shows two farms situated within the 1 to 5 km buffer zone, and the Rum Protected Area is approximately 14 km away from the wellfield boundary. However, its designated buffer zone extends into the project area and includes Wells No. 9 and No. 10. As these wells fall within the protected area buffer, they require a special permit and are therefore excluded from the scope of this study.

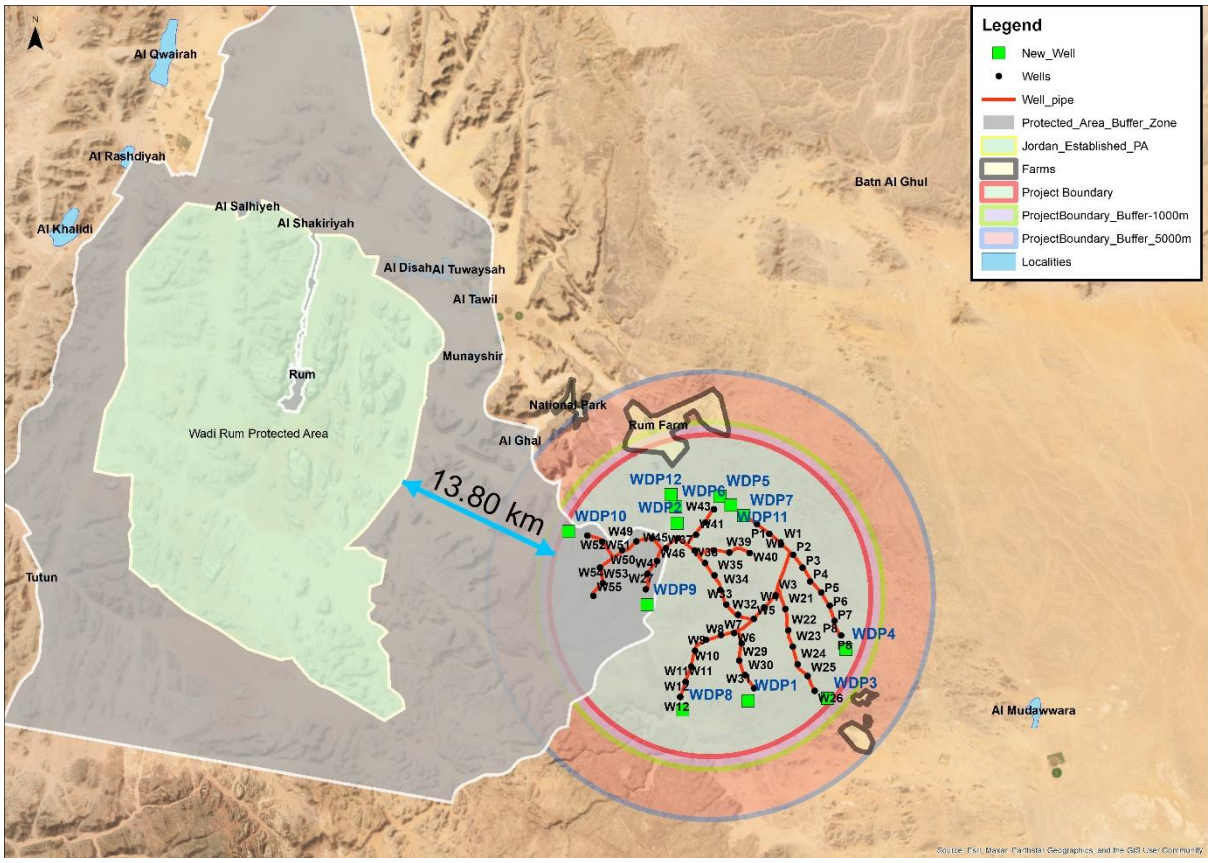


Figure 8: Map of the Project's Area of Influence

Key Stakeholders Relevant to the Study:

- **Owner**: GoJ represented by the MWI/WAJ,
- **Other governmental stakeholders**: relevant ministries.
- **DIWACO**: Disi water company, the owner of the project facilities during the concession period of 25 years since the commercial operation date January 27th, 2014 under the BOT contract signed with MWI/WAJ.
- **Technical Expertise**: Owner's Engineer (OE) will be appointed by DIWACO and will seek technical advice from external experts.
- **Lender (Investor):** EIB, US DFC and Proparco.
- **ESIA Study Consultant:** AJi Water and Environmental will prepare the comprehensive ESIA.
- **Beneficiaries**: Amman City which will utilize the Disi water for domestic needs, the cities along the Disi conveyor route will be provided with emergency turn out.
- **The Operator:** DAOM is responsible for operating and maintaining the entire Disi Conveyance System starting from the well field in the south of Jordan all the way up to the Greater Amman Area.

The ESIA will cover the following phases:

- The construction phase which includes drilling the new groundwater wells, connection to the existing pipeline network and/or new network, electricity network, and the service roads within the wellfield area.
- The operation phase for the different newly constructed facilities throughout the project.
- The decommissioning phase of the project.

4 POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

This section outlines the national legislations and guidelines relevant to the natural environment of the Hashemite Kingdom of Jordan and describes relevant international conventions and treaties signed and ratified by Jordan and incorporated into the national law. The legislative framework presented in this section is relevant to the proposed "Drilling New Wells and Associated Infrastructure Works – Dubaydib Well Field / Disi" project, and it also describes the lenders performance requirements and relevant EU directive that the project is committed to comply with during its lifecycle.

4.1 Relevant Environmental Related Institutions

Ministry of Environment

The Jordanian MoEnv is the principal environmental institution in Jordan and is responsible for the evaluation of the environmental impacts of the project and issuance of associated project licenses and clearances. MoEnv was established in 2003, and its mission is to maintain and improve Jordan's environmental quality through sustaining and conserving environmental resources, thus contributing to sustainable development. MoEnv develops environmental policies that are implemented and enforced throughout the Kingdom. Moreover, it is dedicated to ensuring that legislation is enforced through raising public awareness, inspection and monitoring, encouraging cooperation with national, regional, and international bodies.

MoEnv has the legal strength of environmental law that provides the Ministry with the tools to perform its duties. The Environmental Protection Law was one of the temporary laws issued in 2003, and it was officially endorsed by the Jordanian Parliament in 2006, updated in 2017, and issued as Law No. 6 for the Year 2017.

The law considers MoEnv to be the competent authority for the protection of the environment in the Kingdom. Official and national authorities shall be bound to implement the instructions and resolutions issued under the provisions of this law, that gives the Ministry all the judicial powers it requires to implement the law.

Law No. 6 provides the Ministry with the legal power to inspect any facility and gives the Ministry the right to order a facility shutdown until the proper mitigation and control measures are implemented and any environmental violation eliminated. This inspection system was further strengthened with the establishment of the Royal Department for Environment Protection (Rangers) in 2007 where the Rangers are now acting as an implementation tool and a full partner in the implementation of the environmental law.

The Environmental Protection Law also introduced a system of an environmental "pre-emptive" assessment of all economic and developmental projects to be established in Jordan. This process is known as the ESIA where any developmental or economic project should carry out a detailed assessment of the expected environmental impacts potentially arising from the implementation of the project, and how these impacts can be mitigated through remedial action at the technical, legislative, and public levels.

According to the Environmental Protection Law, the ESIA study should be done before the project is initiated and submitted to MoEnv where it will be reviewed. The classification and permitting

regulation No. 69 year 2020 and its amendments classify projects into four categories according to their environmental impacts:

- Category 1: Projects of high risk that require a comprehensive environmental impact assessment.
- Category 2: Projects of medium risk and potential damage that require an initial environmental impact assessment.
- Category 3: Projects of low risk that require environmental approval.
- Category 4: Projects of low risk that do not need to apply for environmental approval or any other permits.

As per the Jordanian ESIA Regulation No.69 Year 2020 and its amendments, the proposed project of drilling new wells and associated infrastructure works – Dubaydib Well Field / Disi is categorized as Category ''1'' by MoEnv in their letter No. 4/7/6116 dated August 31, 2023. Per the classification and permitting regulation No. 69/2020, Category "1" projects shall undergo a full ESIA study. This assignment will be carried out considering the following requirements:

- Applicable local, national, and regional requirements, including those related to environmental and social impact assessments.
- EIB environmental and social standards dated 2nd February 2022.
- The Performance Standards (PSs) of the IFC Sustainability Framework (2012), which build upon the World Bank Environmental and Social Policies.
- The World Bank Group Environmental, Health, and Safety (EHS) Guidelines
- Relevant international conventions and protocols relating to environmental and social issues, as transposed into national legislation.
- This full ESIA is consistent with applicable requirements in the ESIA regulation No. 69/2020 and its amendments.

If the environmental impact assessment study is approved, the project will obtain the proper license and start its implementation program while adhering to the environmental mitigation and management systems specified and approved in the study. Any deviation from those guidelines would render the project to violation of laws and regulations.

- ESIA Regulation in Jordan

According to the Jordanian ESIA Regulation No. 69 year 2020, this project is classified as Category 1, i.e., it needs a full ESIA. AJi, as the responsible entity for obtaining the environmental permit, submitted a preliminary ToR for the ESIA Study. MoEnv invited the project owner and all concerned individuals or representatives of a public or private party that may be potentially affected by the project to participate in investigating the preliminary ToR and to identify the significant impacts of the project on the environment. This was carried out through a Scoping Session. AJi provided all the available information on the project and its surrounding environment to all concerned parties within an appropriate time prior to the date of the scoping session.

After the Scoping Session, AJi submitted a summary of the scoping session's discussions and deliberations as well as a list of the parties/stakeholders who attended, and the key issues of concern/comments that were raised during the session (scoping session report – provided as **Annex**

3 of this ESIA report), which was then attached to the Final ESIA ToR and submitted to MoEnv. The Final ToR was reviewed by the technical committee at the MoEnv which will make recommendations to the project developer (if deemed necessary). If the Minister approves the Final ToR of the project ESIA, the project developer shall advise the consultant team to prepare the draft of the ESIA document. For this project, the Final ToR and Scoping Report were approved by the MoEnv. on March 23, 2025 via an official approval letter (Ref. No.4/7/1717) as shown in **Annex 4.**

The decision related to the ESIA study shall be announced to the public in the manner that MoEnv deems appropriate.

Ministry of Water and Irrigation/ Water Authority of Jordan

MWI is the official body responsible for the overall monitoring of the water sector; water supply, wastewater systems, and related projects. MWI is responsible for planning and management, the formulation of national water strategies and policies, research and development, information systems, and procurement of financial resources. Its role also includes the provision of centralized and standardized water-related data.

- MWI embraces the two most important entities dealing with water in Jordan:
- WAJ: responsible for water and sewage systems;
- Jordan Valley Authority (JVA): responsible for the socio-economic development of the Jordan Rift Valley, including water development and distribution of irrigation water.

According to Article 3 of the Water Authority Law No.18 of 1988, WAJ was established as an autonomous corporate body that carries full responsibility for public water supply, wastewater services, and related projects as well as for overall water resources planning and monitoring, construction, operations, and maintenance.

Ministry of Energy and Mineral Resources

The responsibilities of the Ministry of Energy and Mineral Resources (MEMR) were amended to include a comprehensive planning process for the energy sector and setting general plans and ensuring their implementation in a way that achieves the general objectives of the energy sector. The most important objectives are providing energy, in its various forms, for development, organizing industry affairs, exchanging electric power with neighboring countries, and attracting international capital for energy investments, especially for the generation of electric power, the production of oil derivatives, transportation of oil and gas, and utilization of local energy sources.

The main strategic objectives of the Ministry are to ensure energy efficient practices in all sectors, promote energy efficiency projects, and development and efficient exploitation of local energy sources such as renewable energy.

The Electricity Distribution Company (EDCO):

EDCO is responsible for distributing electricity across southern and eastern Jordan, covering around 55% of the country's geographic area, including Al Karak, Al Tafilah, Ma'an, Al Aqaba, the Jordan Valley, and areas extending to the Iraqi border. EDCO's core objectives include ensuring reliable electricity supply, expanding and maintaining the distribution grid, improving efficiency, and reducing

losses. It also focuses on building internal capacity to support emerging energy models, particularly the integration of renewable energy systems into the grid.

Ministry of Agriculture

The Ministry of Agriculture (MoA) is responsible for managing public rangelands and forests; protecting soil, pasture-land, and flora; providing agricultural loans; supporting farmers; and granting permits for the import and export of agricultural products of plants and animals, veterinary medicines and vaccines, and live birds. MoA is also responsible for the establishment and renewal of licenses for companies, factories, shops, galleries, nurseries and agricultural farms, and olive presses, providing training for farmers, protecting and managing wildlife, and issuing fishing and hunting licenses and regulations.

Ministry of Health

The Ministry of Health undertakes all health affairs in the Kingdom, and its tasks and duties include: maintaining public health by offering preventive treatment and health control services; organizing and supervising health services offered by the public and private sectors; providing health insurance for the public within available means; establishing and controlling the management of health educational and training institutes and centers according to relevant provisions of the legislation enacted; and working, in coordination with concerned parties, to raise public health standards.

In terms of this project, the Ministry of Health will have a supervisory and monitoring role through enforcing all applicable legislation to ensure owners' compliance with all relevant aspects and provisions of the General Health Law No. 47 of 2008 and its amendments (Law No. 11 of 2017).

Ministry of Local Administration

The Ministry of Local Administration has a supervisory role over the activities of the Municipalities and the Joint Services Councils operating across Jordan. The main duties of the Ministry are to provide the various facilities to the municipalities to enable them to perform their functions and support them in improving the efficiency; oversee, coach, and monitor the financial, administrative, and organizational performance of the municipalities; enhance the institutional capabilities of the sector; manage financial transactions and arrange with the relevant parties to provide the necessary funding for programs and projects; set, develop, and implement the legislative, administrative, financial, and institutional frameworks that are effective for municipal operations; prepare regional, organizational, and detailed construction plans for the municipalities; monitor and control the implementation of regulations, policies, and instructions of the municipalities and joint services councils; draw up regulatory skills of the municipal affairs sector; review and supervise infrastructure projects of the municipal councils; develop designs, technical specifications, and tender documents; and sustain and develop inhabited clusters that have no municipal councils.

Ministry of Public Works and Housing

The Ministry of Public Works and Housing aims to develop a network of public roads in the Kingdom; linking towns, villages, and communities and sites of industrial production, agricultural, and tourist areas and archaeological sites. The Ministry also aims to link the Kingdom and neighboring countries and sustain this network and keep it at a good technical level. The Ministry is also upgrading the quality of roads and promoting safety requirements in addition to keeping abreast of the latest technologies used in modern road construction and lighting.

Ministry of Transport

The Ministry of Transport assumes the following responsibilities under the Transport Law No. 89 year 2003 and authorizations needed to carry out its mission, including: devising the general policy for transportation and overseeing its implementation in coordination and cooperation with all related parties; regulating and monitoring the road freight transport sector and its services; issuance of necessary permits for individuals and companies operating in the sector; regulating and monitoring the freight transport by rail sector and its services, as well as issuing necessary permits for operating in the sector and many other responsibilities.

Jordan Standards and Metrology Organization

The Jordan Standards and Metrology Organization plays a proactive role in protecting the interests, health, and safety of citizens and the environment and enhancing the competitiveness of Jordanian products in the national, regional, and international markets. The Jordan Standards and Metrology Organization prepares, approves, revises, amends, and monitors the implementation of standards and technical regulations covering all services and products (with the exception of pharmaceutical and food products, medicines, veterinary medicines, serums, and vaccines).

Department of Antiquities

The official institutional authority mandated by law responsible for the protection, conservation, and preservation of antiquities.

The two main policies are:

- For the protection of antiquities, conservation measures that do not require physical intervention of the remains are preferred as the first choice where possible.
- For the preservation of antiquities, including research, survey, excavation, and site management.

Department of Land and Survey

The Department of Land and Survey plays a vital role in preserving land property rights and solving any conflicts concerning rights in land or water. The Department represents Jordan's land information bank.

Among its numerous duties and tasks, the Department of Land and Survey is responsible for the registration of land property rights, maintaining and facilitating their use. The department also administers, protects, rents, accredits, and updates records of state land, as well as expropriation of land for public interest. In addition, the department is responsible for establishing a comprehensive land valuation system and maintaining records of transactions and archiving and maintaining land registry records.

Ministry of Labor

The Ministry of Labor has undertaken the responsibility of accomplishing the general objectives of labor and laborers affairs and issues in Jordan. To keep pace with social and economic development, Labor Law No. 8 of 1996 and its amendments of 2019 was issued and the administrative regulation No. 38 year 1994 was established, along with its amendments.

4.2 National Laws and Guidelines

4.2.1 Laws

- Environment Protection Law No. 6 of 2017
- Protection of Cultural Heritage and Sites Law No. 5 of 2005
- Roads Law No. 24 of 1986 and its amendments
- Transportation Law No. 89 of 2003 and its amendments
- Waste Management Framework Law No. 16 of 2020
- Local Administration Law No. 22 of 2021
- Water Authority Law No. 62 of 2001 and its amendments (Law No. 22 of 2014)
- Agricultural Law No. 13 of 2015 and its amendments
- Public Health Law No. 47 of 2008 and its amendments (Law No. 11 of 2017)
- Renewable Energy and Energy Efficiency Law No. 13 for 2012 and its amendment Law No. 33, of 2014, and Law No. 12 of 2024 amending the Renewable Energy and Energy Efficiency Law
- Traffic Law No. 49 of 2008 and its amendments of 2020
- Labor Law No. 8 of 1996 and its amendments of 2019
- Civil Defense Law No. (90) of 2003; read with Law No. (18) of 1999
- Cultural Heritage & Antiquities Law No. (21) of 1988 and its Amendment Law No. (55) of 2008
- Professional Licensing Law No. 28 of 1999 and its amendments
- Monitoring and Control of Economic Activities Law No. 33 of 2017
- Industry and Trade Law No. 18 of 1998
- Temporary General Electricity Law No.64 of 2002 and its amendments
- Management of Natural Resources Law No. 19 of 2018
- Industry & handicraft law No. 16 of 1953
- Municipalities Law, No. 14 of 2017
- Anti-human trafficking Law No. (9) of 2009
- Land Transport Regulatory Authority Law (2011)

4.2.2 Regulations

- Regulation of Mandatory Recruitment of Jordanian Labor in the Governorates at Construction Projects No. 131 of 2016
- Regulation of the Environmental Classification and Licensing No. 69 of 2020 and its amendments.
- Regulation of the Joint Services Councils No. 113 of 2016
- Regulation of the Protection of the Environment from Pollution in Emergency Situations No. 26 of 2005

- Regulation of Soil Protection No. 25 of 2005
- Regulation of Natural Reserves and National Parks No. 29 of 2005
- Regulation of Air Protection No. 28 of 2005
- Regulation of Groundwater Monitoring and its amendment No. 85 of 2002.
- Regulation of Hazardous Materials and Waste Management[8] No. 68 of 2020
- Regulation of Solid Waste Management No. 27 of 2005
- Regulation of Land Use Planning No. 6 of 2007
- Regulation of Hazard Prevention, Charges, and Waste Collection Fees within Municipalities Areas No. 68 of 2016
- Regulation of Protection and Safety from Industrial Tools and Machines and Worksites No. 43 of 1998[9]
- Regulation for the Establishment of Occupational Health and Safety Committees and Supervisors in Institutions No. 33 of 2023[10].
- Regulation for Occupational Safety & Health and Prevention of Occupational Hazards in Institutions No. (31) of 2023[11]
- Bird Protection and Hunting Regulation No. (13) of 1973 and all amendments
- Regulation for the licensing and permitting of excavation and infrastructure network projects No. 112 of 2007
- Regulation of Environmental Protection No. 37 of 2018.
- Regulation of 2013 on the instructions of the use, import, and export of ozone-depleting substances.
- Regulation of Harmful and Hazardous Substances Management No. 24 of 2005
- Regulation No. (85) of 2020.of Environmental Information and Control System for Waste Management
- Regulation of Climate Change No.79 of 2019 issued pursuant to Article 30 of the Environmental Protection Law No.6 of 2017.

4.2.3 Instructions

- Instruction for the Limitation and Control of Noise of 2003
- Instructions for the Management and Handling of Hazardous Waste of 2019
- Spent Mineral Oils Management and Handling Instructions of 2014 and its amendments Instruction No. 1 of 2013 for the preventing of occupational hazards related to health hazards

[8] issued in accordance with Articles 6 and 7 of Environmental Protection Law No. 6 of 2017
[9] Issued by the virtue of the provisions of Paragraph (c) of Article (85) of the Labor Law No. 8 of 1996 and its amendments
[10] Issued in accordance with Paragraph (a)Article (85) of the Jordanian Labor Law No. 8 of 1996 and its amendments
[11] Issued in accordance with Paragraph (b)Article (85) of the Jordanian Labor Law No. 8 of 1996 and its amendments

resulting from labor housing units onsite, issued in accordance with article (49) of the Public Health Law No. 47of 2008

- Instructions for the General Health Conditions for Industries of 2019
- Instructions for Solid Waste Management of 2019
- Instruction for Controlling the Use of Substances that Deplete the Ozone Layer for the year 2003, issued in accordance with the Protection of the Environment Law No. 1 / 2003, Articles 9 through15
- Instructions for birds and wildlife protection and organizing their hunting and trafficking of 2021.
- Instructions for Disposal of Industrial and Commercial wastewater into the sewage network of 2017
- Instructions for the Selection of locations for Development Activities for 2007 issued in accordance with paragraph (d) of Article (4) of the Environmental Protection Law no. 52 of 2006.
- Instructions on the Prevention of Health Nuisances related to Health Hazards resulting from Housing Units of Labor Groups No. (1) of 2013
- Instructions of Protection of Workers from Workplace Hazards of 1998
- Instructions for the Protection of Water Resources for the Year 2011 and its Amendments for the Year 2019.
- Instructions for Agricultural Land Protection No. (Z/11) of 2022.
- Instructions for regulating and managing the government forests and forest trees growing on treasury lands and forest lands No. (Z/1) of 2017.

4.2.4 Guidelines and Policies

- Guidelines for the protection of migratory birds from the danger of electric shock
- Policy of the National Climate Change of the Hashemite Kingdom of Jordan (2022-2050).

4.2.5 Standards

- Standard for Ambient Air Quality No. 1140/2006
- Standards for the Maximum Allowable Limits of Air Pollutants Emitted from Stationary Sources No. JS 1189/2011
- Standards for Lighting — Lighting levels in work environment No. JS 524/1987
- Standards for Motor Vehicles — Emission - Diesel Engines No. JS 1054/1998
- Standards for Reclaimed Domestic Wastewater No. JS 893/2021
- Standards for Drinking Water No. JS 286/2015
- Standards for Storage – General precautionary requirements for storage of hazardous materials No. JS 431/1985

- Standards for Motor Emissions No. JS 1052/1998.
- Standards for Motor Vehicles (Noise Levels) No. JS 1059/1998
- Standard for heat levels allowed to be exposed to in the work environment No. JS 525/1987
- Standard for Graphical symbols - Safety colours and safety signs Part 1: Design principles for safety signs and safety markings JS 17-1/2021
- Standard for Graphical symbols - Safety colours and safety signs Part 3: Design principles for graphical symbols for use in safety signs JS 17-3/2021
- Ergonomics of the thermal environment - Analytical determination and interpretation of heat stress using calculation of the predicted heat strain No. JS 2310 / 2021.
- Ergonomics of the thermal environment — Analytical determination and interpretation of heat stress using calculation of the predicted heat strain (ISO 7933/2004).

4.2.6 International Treaties and Conventions of Which Jordan is a Party/Signatory

- Basel Convention of Transboundary Movements of Hazardous Wastes and Their Disposal — 1989. Designed to reduce the movement of hazardous waste between countries and specifically to prevent the transfer of hazardous waste from developed to undeveloped countries. Jordan signed on this convention in 1989, but it went into effect in 1992.
- Convention on Biological Diversity — 1992. The convention was dedicated to promote sustainable development. It recognizes that biological diversity is about more than plants, animals, and microorganisms and their ecosystems — it is also about people and their need for food security, medicine, fresh air, water, shelter, and a clean and healthy environment in which to live. Jordan signed this convention in 1992 and it became a party in 1994.
- Convention on the Conservation of Migratory Species of Wild Animals, Bonn Convention — 2000. The convention is aimed at protecting migratory species, their habitats, and migration routes.
- The United Nation Framework Convention on Climate Change — 1994. It is an international environmental treaty that aims to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.
- United Nations Convention to Combat Desertification — 1994. The convention aims to combat desertification and mitigate the effects of drought through national action programs that incorporate long-term strategies supported by international cooperation and partnership arrangements.
- Convention Concerning the Protection of the World Cultural and Natural Heritage (December 17, 1975);
- Convention on Wetlands of International Importance especially as Waterfowl Habitat (May 10, 1977);
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (March 14, 1979);
- Protocol to amend the Convention on Wetlands of International Importance, especially as Waterfowl Habitat (RAMSAR Convention) (October 1, 1986);

- Amendment to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (art. XI) (April 13, 1987);
- Protocol on Substances that Deplete the Ozone Layer (August 30, 1989);
- Convention for the Protection of the Ozone Layer (August 31, 1989);
- Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer (September 28, 1995);
- International Plant Protection Convention (April 24, 1970);
- International Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (December 26, 1996);
- International Labor Organization (ILO) Conventions, Jordan has ratified 26 ILO Conventions.

4.2.7 Lender's Requirement

In addition to the national requirements, the ESIA study will align with international environmental and social standards set forth by the lenders specifically:

1. The project complies with EU directives such as Directive 2011/92/EU on Environmental Impact Assessments by conducting thorough baseline studies, stakeholder consultations, and alternatives analysis and implementing mitigation measures to minimize adverse environmental impacts.
2. Measures have been incorporated to adhere to lenders Performance Standards,
3. The project supports Jordan's commitments under international treaties like the Convention on Biological Diversity and United Nations Framework Convention on Climate Change (UNFCCC) by integrating climate resilience strategies into its design.

The Performance Standards (PSs) of IFC's Sustainability Framework (2012)[12]: The IFC of the World Bank Group has established its Performance Standards on Environmental and Social Sustainability (2012) building on the World Bank Environmental and Social Policies. IFC's Sustainability Framework is represented by the following eight PSs that the client [13] is to meet throughout the life of an investment by IFC:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labor and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety, and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement (Land acquisition and resettlement are not triggered by the project. All project activities, including the drilling of new wells, are taking place on government-owned land already allocated for water infrastructure.
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Performance Standard 7: Indigenous Peoples
- Performance Standard 8: Cultural Heritage

[12] Performance Standards of IFC's Sustainability Framework (2012)

[13] Refers to the party responsible for implementing and operating the project that is being financed, or the recipient of the financing, depending on the project structure and type of financing

- The EIB Statement of Environmental and Social Standards of February 2, 2022[14]. The EIB Group Environmental and Social Sustainability Framework is an overarching policy framework that allows EIB to focus on sustainable and inclusive development, committing to a just and fair transition and supporting the transition to economies and communities that are climate and disaster resilient, low carbon, environmentally sound, and more resource-efficient.

It consists of an Environmental and Social Policy and a revised set of EIB Environmental and Social Standards (ESSs) which describe the requirements that all EIB-financed projects must meet. The standards are grouped in the following 11 thematic areas:

- Standard 1: Environmental and Social Impacts and Risks
- Standard 2: Stakeholder Engagement
- Standard 3: Resource Efficiency and Pollution Prevention
- Standard 4: Biodiversity and Ecosystems
- Standard 5: Climate Change
- Standard 6: Involuntary resettlement with relevance to this project, ESS 6 is irrelevant (Land acquisition and resettlement are not triggered by the project. All project activities, including the drilling of new wells, are taking place on government-owned land already allocated for water infrastructure).
- Standard 7: Vulnerable Groups, Indigenous Peoples and Gender
- Standard 8: Labor Rights
- Standard 9: Health, Safety, and Security
- Standard 10: Cultural Heritage
- Standard 11: Intermediated Finance With relevance to this project, ESS 11 is irrelevant

- The applicable World Bank Group EHS guidelines are General EHS Guidelines dated April 30, 2007 [15].
- The EHS Guidelines for Water and Sanitation dated December 10, 2007[16]

[14] The EIB Statement of Environmental and Social Standards of February 2, 2022
[15] The applicable World Bank Group Environmental, Health, and Safety (EHS) guidelines
[16] https://www.ifc.org/content/dam/ifc/doc/2000/2007-water-and-sanitation-ehs-guidelines-en.pdf

5 ENVIRONMENTAL AND SOCIAL BASELINE CONDITIONS

This section provides an overview of the findings of the data collection, literature review work, and site visits. A listing of the data obtained and reports reviewed are presented in the section below, and the physical, biological, socio-economic, and archaeological baseline conditions are described.

5.1 Data Sources and Literature Reviews

All available information sources were reviewed and relevant information was extracted, analyzed, and presented in the context of this study. A detailed list of reports and documents reviewed is presented at the references section. A literature review together with a field survey of the project area and its surroundings was conducted to summarize the most up-to-date data needed for the preparation of the project description and the environmental baseline. Documents of a more technical nature were reviewed to better understand the potential impacts and to propose mitigation measures for the proposed project's activities.

Information was collected from various sources to the extent possible. Sources include relevant government institutions such as the Jordanian DoS, Jordan Meteorological Department (JMD), MEMR, and DoA.

Some of the major topics reviewed as part of the literature review included:

- Hydrological, hydrogeological, and water resources studies
- Ecological studies and reports on the flora and fauna
- Archaeology
- Geology and soil of the area

5.2 Physical Environment

5.2.1 Meteorology and Climate

The climate of Jordan is predominately of the Mediterranean type in the west, gradually transitioning to a desert climate in the east and south. ; it is characterized by a hot dry summer and rather cool wet winter, with two short transitional periods; (The land is generally very arid), the first starts around October and the second around mid of April. The rainy season starts by October and ends by May.[17]

Winter temperatures in the southern and northern highlands range between 9-13°C, while the deserts regions range from 19-22°C. In the Jordanian Valley, summer temperatures range between 38-39°C, while in the desert regions, they vary between 26-29°C. About 75% of precipitation falls during the winter. Jordan's climate is influenced by the Dry Sirocco (Khamsin) winds, which can lead to large temperature anomalies, with increases of up to 15°C. The Shammal Winds are also an influencing factor, blowing from the north and northeast and causing high daytime temperatures.[18]

Rainfall patterns vary significantly across Jordan's three main ecological zones. The Jordan Valley receives moderate rainfall, typically ranging between 100–300 mm per year. In contrast, the Western Highlands experience relatively higher precipitation, with annual rainfall ranging from 300–600 mm.

[17] 21st Century Climate Change Projections of Precipitation and Temperature in Jordan
[18] World Bank Climate Change Portal

The Badia region, which constitutes over 80% of the country's land area, is characterized by arid and semi-arid conditions, receiving less than 50 mm of rainfall annually[19].

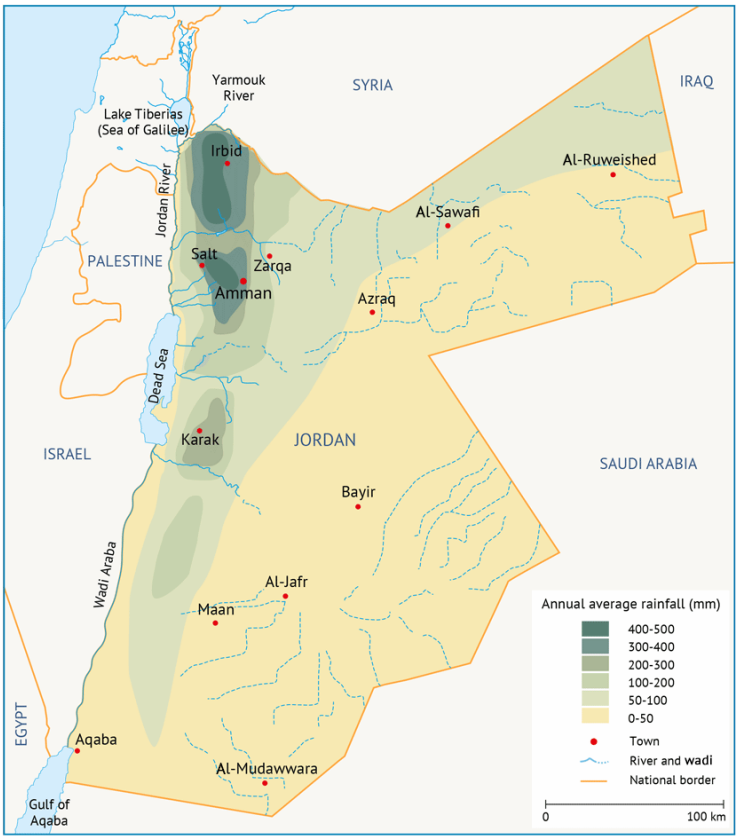


Figure 9: Annual Average Rainfall and Precipitation[20]

The meteorological data for the study area was sourced from the Jafer weather station, due to the absence of a closer weather station.

Table 6 below summarizes the average annual temperature, rainfall, humidity and wind speed readings in the period (2014 – 2022).

Table 6: Averages of Annual Climate Data for years 2014 – 2022

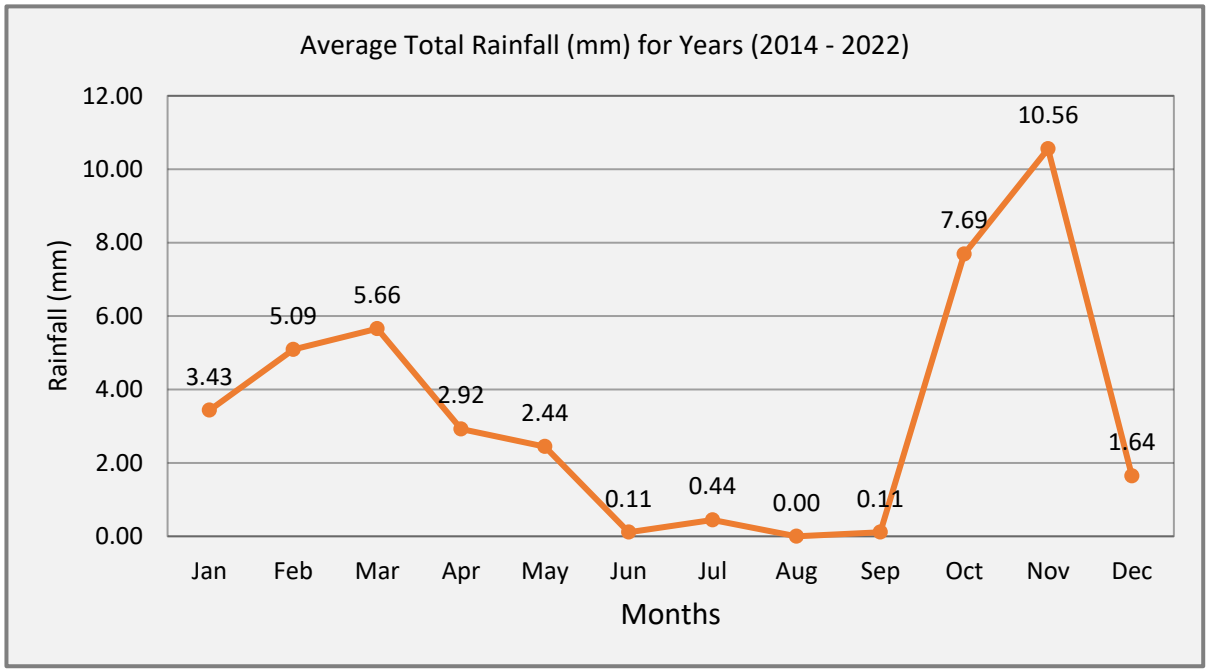
Climatic Parameter	Jafer Weather Station
Avg. Monthly Max Temp (ºC)	28.39
Avg. Monthly Min Temp (ºC)	11.76
Avg. Monthly Mean Temp (ºC)	19.73
Avg. Monthly Rainfall Amount (mm)	3.36
Avg. Total Annual Rainfall Amount (mm/year)	53.12
Avg. Monthly Relative Humidity	53.12
Avg. Mean Monthly Wind speed 'Knot'	4.16

Source: DoS

Figure 10 below shows the mean monthly rainfall pattern for Jafer weather station, from measurements taken for the years 2014 - 2022. A maximum average of about 10.56 mm rainfall is

[19] Jordan's Third National Communication on Climate Change. MoEnv (2014)
[20] Fanack Water, Jordan Water Report

witnessed in November, while approximately no rainfall occurs in the drier months from June to September.



Source: DoS

Figure 10: Jafer Monthly Rainfall Amount 2014 – 2022

5.2.2 Air Quality

Given its remote location, far from residential areas, human activity, and industrial facilities, the baseline air quality in the Dubaydib wellfieldis expected to be generally good. Temporary and localized air quality impacts may arise from emissions generated by maintenance vehicles; however, these effects are localized and transient, with nitrogen oxides (NOx), sulfur oxides (SOx), and carbon monoxide (CO) emissions anticipated to be minimal.

Diesel generators and pumps are also expected to be a potential source of air pollutants and GHG emissions; however, if these equipment's are maintained properly, the emissions should be kept to a minimum.

in addition, due to wind and sand storms naturally occurring higher $PM_{2.5}$ and PM_{10} dust emissions are expected in this desert environment.

No on-ground ambient air quality monitoring was conducted as part of this assessment. Instead, historical air quality data was obtained from IQAir for the period between April 17 and April 19, 2025, focusing on $PM_{2.5}$ concentrations as a key indicator. The data was assessed against the Jordanian Standard for National Ambient Air Quality (JS 1140/2006), which stipulates a maximum allowable limit of 65 µg/m³ for $PM_{2.5}$ (24-hour average). All hourly values recorded during the monitoring period were well below this threshold, with the maximum observed concentration being 20.2 µg/m³. This indicates that $PM_{2.5}$ levels during the reference period remained within acceptable limits.

Table 7 below presents the hourly $PM_{2.5}$ concentrations from April 17 to April 19, 2025, as recorded by IQAir for the Disi area.

Table 7: Hourly $PM_{2.5}$ Concentrations in Disi Area (17–19 April 2025)

Date	Time	$PM_{2.5}$ (µg/m³)	Average (24 Hr)	Max. Allowable Limit	Conformity
17/4/2025	14:00 - 15:00	17.0	16.6	65	Pass
	15:00 - 16:00	18.4			
	16:00 - 17:00	17.9			
	17:00 - 18:00	17.9			
	18:00 - 19:00	17.5			
	19:00 - 20:00	17.5			
	20:00 - 21:00	17.5			
	21:00 - 22:00	17.5			
	22:00 - 23:00	16.5			
	23:00 - 24:00	16.5			
18/4/2025	00:00 - 01:00	15.4			
	01:00 - 02:00	14.1			
	02:00 - 03:00	14.1			
	03:00 - 04:00	12.9			
	04:00 - 05:00	14.4			
	05:00 - 06:00	14.4			
	06:00 - 07:00	16.0			
	07:00 - 08:00	15.9			
	08:00 - 09:00	15.9			
	09:00 - 10:00	15.8			
	10:00 - 11:00	18.0			
	11:00 - 12:00	18.0			
	12:00 - 13:00	20.2			
	13:00 - 14:00	19.1			
	14:00 - 15:00	19.1	18.1	65	Pass
	15:00 - 16:00	18.1			
	16:00 - 17:00	18.6			
	17:00 - 18:00	18.6			
	18:00 - 19:00	19.1			
	19:00 - 20:00	18.6			
	20:00 - 21:00	18.6			
	21:00 - 22:00	18.1			
	22:00 - 23:00	18.8			
	23:00 - 24:00	18.8			
19/4/2025	00:00 - 01:00	19.4			
	01:00 - 02:00	19.1			
	02:00 - 03:00	19.1			
	03:00 - 04:00	18.7			
	04:00 - 05:00	18.1			
	05:00 - 06:00	18.1			
	06:00 - 07:00	17.5			
	07:00 - 08:00	16.6			
	08:00 - 09:00	16.6			
	09:00 - 10:00	15.6			
	10:00 - 11:00	16.7			
	11:00 - 12:00	16.7			
	12:00 - 13:00	17.8			
	13:00 - 14:00	17.8			

Source: IQAir. "Air Quality in Ad Disah, Aqaba, Jordan."[21]

[21] https://www.iqair.com/jordan/aqaba/ad-disah

5.2.3 Ambient Noise

No excessive noise levels were noted during the site visit to the proposed project Site. Ambient Noise Baseline data was collected based on ambient Noise monitoring, which was conducted by Al Shamil Air Quality Laboratory during April 2025, over a 24-hour monitoring period, at four locations illustrated in **Figure 11.**

The noise measurement results were evaluated based on the noise levels of the Jordanian Instructions for Prevention of Noise of 2003, for "Residential areas in villages "where the average noise values should be lower than the maximum allowable noise limits for daytime and night-time, presented in **Table 8.** Any additional noise generated from the project activities needs to be considered, and appropriate mitigation of adverse health impacts would be applied as illustrated in the ESMP.

Table 8: Maximum Allowable Noise Limits

Area	Allowable Limits for Noise Level (dB)	
	Day	Night
Industrial areas	50	40

Source: Jordanian guidelines for prevention of noise (2003).

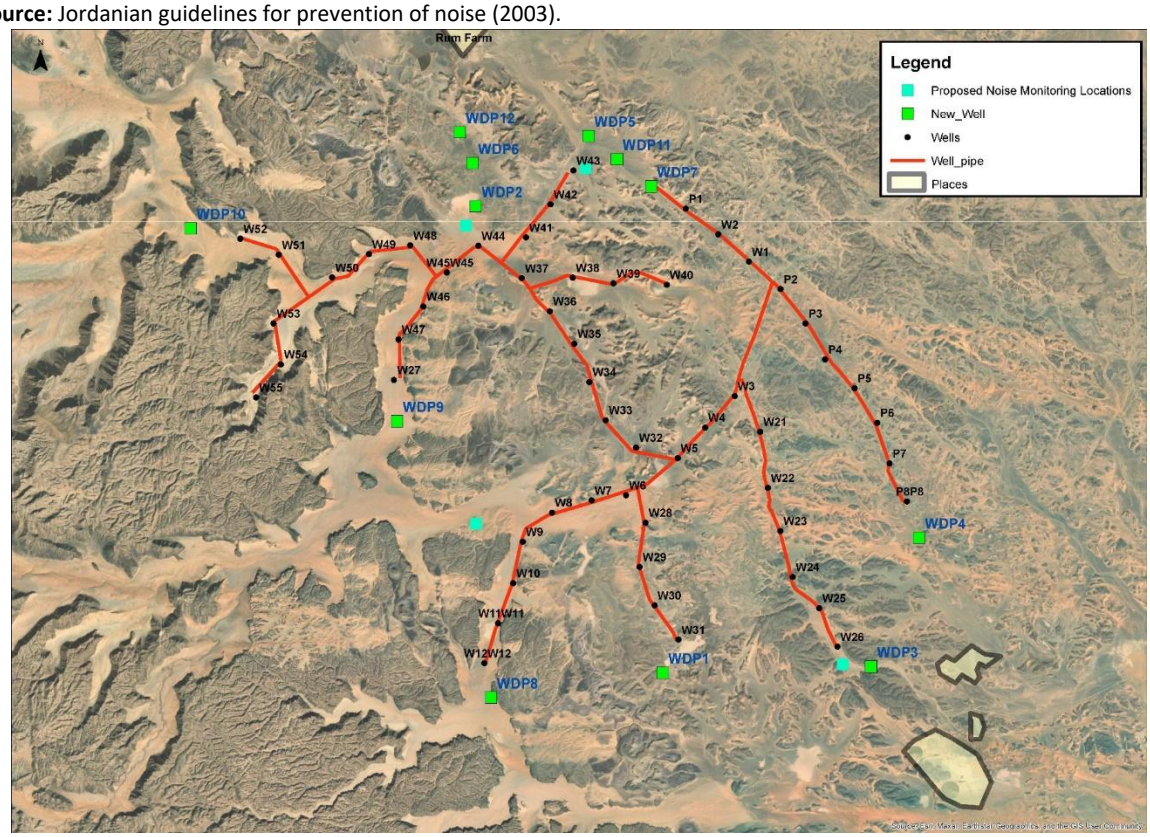


Figure 11: Four Locations for the Conducted Ambient Noise Monitoring

The findings, as detailed in **Table 9** below, indicate that all ambient noise levels measured were comfortably within the prescribed national limits (Refer to **Annex 5** for Noise Measurement Report).

Table 9: Ambient Noise Measurements

Date	Location	Day/Night	Result (dB(A))	Maximum Allowable Limits	Compliance	Test Method	Standard
8-9/April/2025	Point 1	Daytime	39.74	50	PASS	Sound Intensity Method	The Guidelines for Noise Reduction and Prevention for the year 2003
		Night-time	30.83	40			
	Point 2	Daytime	36.13	50			
		Night-time	32.81	40			
9-10/April/2025	Point 3	Daytime	48.40	50			

Date	Location	Day/Night	Result (dB(A))	Maximum Allowable Limits	Compliance	Test Method	Standard
		Night-time	33.52	40			
	Point 4	Daytime	38.74	50			
		Night-time	31.24	40			

5.2.4 Jordan Climate Change

National Context

Jordan's climate is predominantly arid and semi-arid, with hot, dry summers and cooler winters. The majority of the country, especially in the south and east, is desert, receiving less than 200 mm of rainfall annually. Only the northern highlands and parts of the Jordan Valley receive higher precipitation, but even in these regions, water resources are limited and highly variable from year to year.

Jordan is highly vulnerable to the impacts of climate change due to its geographical location and existing environmental challenges. Jordan's geographic position, combined with its high dependency on shared transboundary water resources, makes it particularly vulnerable to the impacts of climate change. Rising temperatures, declining and erratic precipitation, and the increasing frequency and severity of extreme weather events such as droughts, heatwaves, and flash floods threaten the country's water security, agricultural productivity, and overall economic stability.

The reduced availability of water, combined with a hotter climate, could impact agricultural output, reduce food security, and increase the cost of living, particularly for vulnerable communities. The social and economic consequences of these changes could lead to heightened competition over water resources, especially in rural areas, and may trigger increased migration from rural to urban centers, placing additional pressure on already strained urban infrastructure.

Rising temperatures, decreasing and erratic precipitation, and more frequent extreme weather events such as droughts and flash floods are expected to exacerbate the country's water scarcity. Projections indicate that the already dry regions will become drier, further stressing the water supply and agricultural productivity.

Water scarcity is Jordan's most critical environmental concern. The combination of climate change, over-extraction of groundwater, and inefficient water use is leading to a decline in water availability, which could severely impact both urban and rural populations, food security, and overall economic stability.

Jordan's social, economic, and ecological sectors are all vulnerable to climate change. The agricultural, water, urban, biodiversity, coastal, social and economic development, and health sectors are the seven sectors that the National Adaptation Plan (NAP)[22] has identified in order to assess their vulnerability and available adaptation options.

A strategic target was suggested for every sector, in addition to strategic programs, for the water sector, for instance, the sectoral strategic target is boosting sustainable water demand and supply through climate resilient measures. Several programs were identified, one of which is increasing the

[22] https://www.moenv.gov.jo/ebv4.0/root_storage/ar/eb_list_page/final_draft_nap-2021.pdf

contribution of non-conventional water resources to the national water budget. Promoting the use of unconventional water sources, particularly treated wastewater, for non-domestic water usage is one of the program's main objectives[22].

GHG and Water Sector

The overall GHG Inventory estimates for Jordan in 2016 were 31,063.32 Gg of CO_2-equivalent (CO_2-eq)[23]. A breakdown of Jordan's total emissions of GHGs by sector indicated that the energy sector was the major emitter releasing around 76% of total national emissions [24]. In Jordan, the water sector is a significant consumer of energy, responsible for 11-14% of the country's total energy use. This is primarily due to the energy-intensive nature of water extraction, desalination, treatment, and especially pumping water over long distances, given the arid climate and scarcity of local water sources. This sector contributes considerably to greenhouse gas (GHG) emissions, making energy management improvements a key priority for reducing climate impacts.

Energy use in the water sector predominantly comes from water pumping, which accounts for the majority of energy consumption, although energy is also used for water treatment and distribution. Key energy consumers in Jordan's water supply system include Miyahuna in Amman, followed by Yarmouk Water Company in the north, the Disi Project, and water facilities in Balqa, Karak, Maan, Tafileh, Aqaba, and the Samra Wastewater Treatment Plant. For example, the Disi Project alone consumed 289.6 Giga Watt Hour (GWh) of electricity in 2019[25], illustrating the significant energy demand involved in water extraction and distribution across the country.

The increased energy consumption raises energy expenses, primarily driven by electricity generated from fossil fuels. This reliance not only contributes to indirect greenhouse gas emissions from power plants but also to direct emissions from on-site machinery used for pumping.

According to National climate Change policy (2022- 2050)[26] it was reported that the GHG from the energy sector is 23,054.59 Gg of CO_2-eq. Within the water sector, emissions are to range between 2,536 and 3,227.6 Gg CO_2-eq (11% to 14% of Jordan's total energy). A significant portion of this energy consumption is attributed to water pumping, particularly for long-distance transport and extraction from deep aquifers like the Disi aquifer, which is essential due to the country's severe water scarcity.

Jordan has set ambitious GHG emission reduction targets compared to other MENA countries, committing in October 2021 to cut emissions by 31 percent by 2030, up from an initial 14 percent goal. Of this target, 26 percent is conditional on external financing and 5 percent unconditional, aiming to limit emissions to 30,291 CO_2-equivalent (Gg) compared to 43,989 CO_2-eq (Gg) under a business-as-usual scenario, based on a 2012 baseline. The government has launched strategies to decrease energy demand and emissions within the water sector, emphasizing energy efficiency and renewable energy. These initiatives include renewable energy projects for water pumping and treatment systems and implementing energy management systems across water utilities. The Ministry of Environment, as the national focal point for the UNFCCC, oversees Jordan's climate commitments, with recent contributions such as the Second Biennial Update Report (June 2021[27]) and the updated Nationally

[23] https://unfccc.int/sites/default/files/resource/Jordan%E2%80%99s%20Second%20Biennial%20Update%20Report%20for%20web%2010-5.pdf
[24] https://unfccc.int/sites/default/files/resource/FSV-13th-workshop-Jordan-rev.pdf
[25] https://mwi.gov.jo/ebv4.0/root_storage/ar/eb_list_page/energy_efficiency_and_renewable_-_energy_policy_for_the_water_sector.pdf
[26] https://www.undp.org/jordan/publications/jordans-2022-2050-national-climate-change-policy
[27] https://unfccc.int/sites/default/files/resource/Jordan%E2%80%99s%20Second%20Biennial%20Update%20Report%20for%20web%2010-5.pdf

Determined Contributions (NDC) document, raising Jordan's GHG reduction target to 31 percent by 2030[28].

Existing Policies for Mitigation and Adaptation

Jordan has taken significant steps toward addressing the impacts of climate change and improving its environmental sustainability. The country has ratified the Paris Agreement and has developed its National Climate Change Policy, which outlines key adaptation and mitigation priorities.

Jordan has been consolidating the strategic framework for implementing its climate commitments. Jordan adopted a National Green Growth Strategy in 2021 and developed the National Plan for Green Growth (2021–2025) to encourage investment in six priority areas: energy, water, transport, agriculture, tourism, and waste management. Jordan has also adopted a large body of general and sector-specific climate policies and strategies at national and sub-national levels.

In 2019, the country enacted Climate Change Bylaw No. 79 as the legal framework for climate action, focusing on four areas: (i) institutional processes, particularly establishing a National Climate Change Committee; (ii) developing the country-wide IT and technical infrastructure for Monitoring, Reporting, Verification (MRV) and National Registry for all Climate mitigation actions; (iii) developing sectoral strategies for achieving NDC goals by 2030 and towards the 2050 long-term strategy to achieve climate neutrality, and (iv) defining innovative financial and climate finance options to accelerate climate action.

The International Agreements on Energy and Climate Change include key treaties aimed at addressing global warming and environmental protection. The 1992 UNFCCC seeks to stabilize greenhouse gas concentrations to prevent harmful human impacts on the climate. The 1997 Kyoto Protocol builds on this by establishing legally binding commitments for industrialized nations to reduce four key greenhouse gases. Additionally, the 1987 United Nations Development Programme (UNEP) Montreal Protocol focuses on protecting the ozone layer by phasing out substances that contribute to its depletion. Together, these agreements form the foundation of international efforts to combat climate change.

Climate Projection

According to the Jordan's 4th national communication Report and the Think Hazard tool, the project climate change risks are as the following:

- **Temperature Increase**: Jordan is expected to experience more frequent heat waves and fewer frost days. A predicted rise in annual maximum temperature of up to 5.1°C and a rise in annual minimum temperature of 3.8°C by 2085, including an increase in the frequency of heat waves. In addition, Jordan's Fourth National Communication Report, future predicted heatwave events are more severe in terms of duration and magnitude, where the probability of occurrence increases to an average of 120 % by 2100. Thus, it is very likely that more severe threats are expected in terms of heatwave exposure intensity and duration. According to Think Hazard tool [29] extreme heat hazard is classified as **high** based on modeled heat information currently available to this tool. This means that prolonged exposure to extreme heat, resulting in heat stress, is expected to occur at least once in the next five years.

[28] https://www.unep.org/ndc/action-area/jordan
[29] https://www.thinkhazard.org/en/report/65717-jordan-aqaba-aqaba/EH

- **Drought Increase:** Jordan is expected to become increasingly drier, with a predicted 10-day increase in the number of consecutive dry days from 2040 to 2070. The most significant drought conditions are expected in the southern Aqaba region where some models also predict the greatest temperature increase. According to Think Hazard tool [30], the Mudawarah area is classified as **high** according to the information that is currently available to this tool. This means that droughts are expected to occur on average every 5 years. Based on this information, the impact of drought must be considered in all phases of the project, in particular its effect on personnel and stakeholders, and during the design of buildings and infrastructure.

- **Precipitation**: Precipitation projections are **highly** variable but, overall, are expected to decrease between 15% to 60 % from 2011 to 2099. The future trends indicate the probability of occurrence of potential intense precipitation, which seems to decrease with time. On the other hand, the severity is variable by location and tends to become more intense during the mid-21st century and reduces by the end of the 21st century [31].

These changes present significant risks to Jordan's water resources, since they may diminish the amount of water obtained from surface and groundwater sources and deteriorate the quality of the water. According to the Jordan National Water Strategy 2023-2040, Jordan is one of the most water-poor countries in the world for renewable freshwater with around 61 cubic meters per capita in 2021 which is far less than the 500 cubic meters per capita annually that is internationally recognized as the absolute water scarcity line. Climate change and overuse of water resources have further reduced groundwater and surface water resources, whereas in 2040 the annual renewable water resources per capita is expected to reach only 35 m^3.

According to the World Bank Climate Change Knowledge Portal (2021)[32], Jordan will be subject to the following vulnerabilities due to impacts of climate change:

- Summer months are expected to have high temperatures, prolonged heat waves, and expanded summer season. Heat waves, and increased frequency of the consecutive number of days above 39C^o are expected to occur throughout the country. Climate warming is also expected to shift boundaries of spring frosts with potential for adverse impacts on the agricultural sector.
- Climate change, specifically changes in precipitation patterns are likely to alter slope and bedrock stability, resulting in localized landslides. This is expected to be a high-degree hazard for southern and eastern parts of the country.
- Precipitation patterns and increased variability, land use, wind, glacial and snowmelt, and other climatic conditions will affect the river systems. Changed precipitation patterns and river flows have led to riverine flooding and are also associated with heavy rainstorms, mudslides and landslides.

According to Jordan Country Climate and Development Report (2022) [33], Four scenarios were examined to assess the impacts of climate change on Jordan's economy. Scenario No. 1 includes the effects of rising heat on agriculture yields and labor productivity in the baseline growth model, while Scenario No. 2 focuses on how worsening water scarcity affects the economy. Scenario No. 3 explores

[30] https://www.thinkhazard.org/en/report/65717-jordan-aqaba-aqaba/DG
[31] Jordan's Fourth National Communication on Climate Change (Jordan's Fourth National Communication on Climate Change | United Nations Development Programme)
[32] https://climateknowledgeportal.worldbank.org/
[33] https://openknowledge.worldbank.org/server/api/core/bitstreams/7c81ff9b-6f43-5648-be15-b2e2b25d1d33/content

the impact of adaptation measures to address water scarcity, and Scenario No. 4 examines the effects of a US$9.5 billion investment package from 2022 to 2030, excluding desalination and water conveyance projects. These scenarios, based on long-term growth projections, use macroeconomic modeling to simulate climate-related impacts under different climate scenarios up to 2050.

Scenario No. 2, "Impacts of Increasing Water Scarcity," highlights how escalating water shortages could hinder Jordan's long-term economic growth. Based on the 'Water in the Balance' (WiB, 2020)[34] report, the study models the impact of a 5%, 10%, and 20% rise in water scarcity on Jordan's real GDP growth, projecting a decrease of 0.5% to 6.8% by 2040. The worst-case scenario, where labor and capital are immobile, reveals the most severe economic consequences, particularly in water-dependent sectors, where the shadow price of water could surge by 550%, significantly raising business costs and reducing profitability.

Scenario No.3, "Water Scarcity Adaptation Measures," focuses on addressing Jordan's projected 200 MCM water gap by 2050, emphasizing the critical role of the Disi pipeline. It explores desalination and water conveyance projects modeled after the Disi pipeline's Public-Private Partnership (PPP) framework. The financial structure considers capital expenditure (CAPEX) uncertainties, including potential reductions through concessional financing and phased implementation, while operating expenses (OPEX) are heavily influenced by future energy prices, which are critical to the cost of desalination and water conveyance operations.

The CRVA for the project is attached in **Annex 6.**

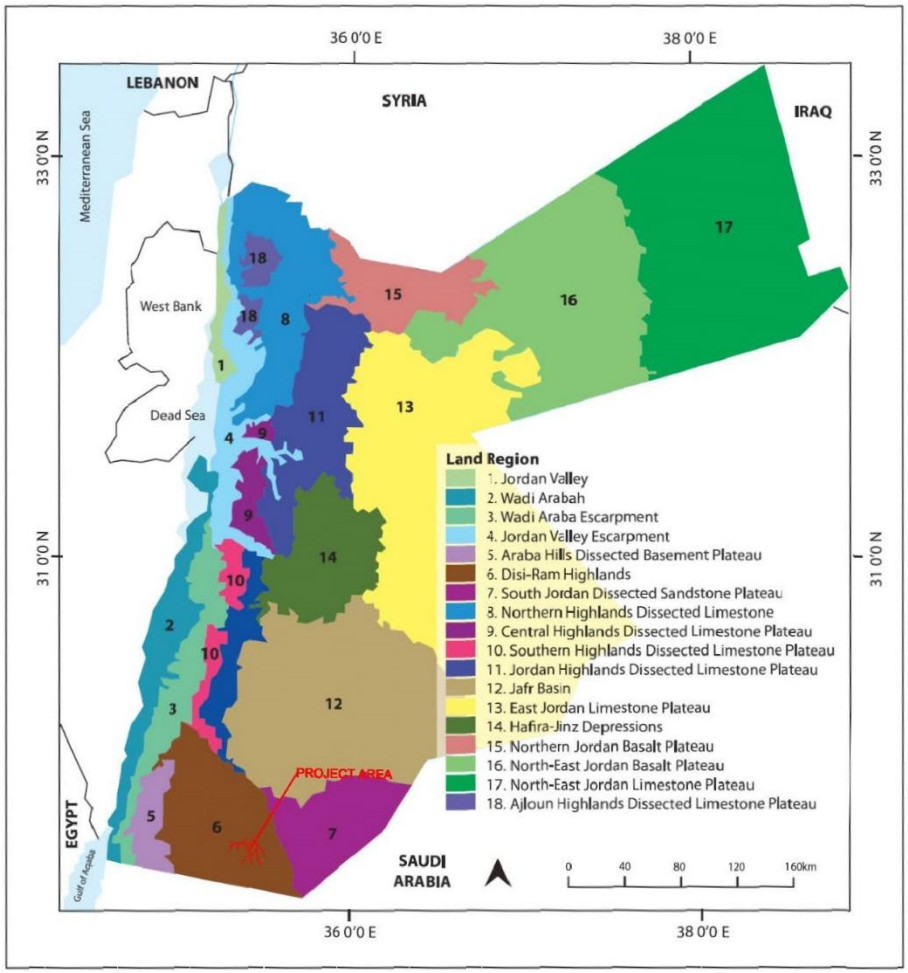
[34] https://documents1.worldbank.org/curated/en/614261600439036489/pdf/Water-in-the-Balance-The-Economic-Impacts-of-Climate-Change-and-Water-Scarcity-in-the-Middle-East-Technical-Report.pdf

5.2.5 Topography and Land Region

The project area is located in the Disi-Ram Highlands (land region No.6) as shown in **Figure 12**. This region features cliff-faced sandstone buttes and masses, with wide valleys running north-south. These valleys are filled with deep colluvial and alluvial deposits, including talus on the upper slopes and significant sandy alluvium, along with large mud-flats. Much of the slopes are covered by sandy Aeolian deposits, comprising both recent dunes and older sand sheets.

The region experiences aridic moisture and thermic temperature regimes, with rainfall being too sparse for cultivation. However, occasional precipitation is channeled into wadis, basins, and sandy fans, supporting a significant cover of shrubs that provide important browse.

The dominant soils are Torripsamments, reflecting the extensive Aeolian dunes and sand sheets. Calciorthids are found on colluvial fans, upper alluvial fans, and some depressions. Camborthids occur mainly in medium-textured alluvium and fine-textured alluvial depressions, while Torriorthents are present on the stony talus slopes and upper parts of colluvial and alluvial fans[35].



Source: MoEnv 2006, map produced by J. T. Al-Bakri

Figure 12: The Study Area with Respect to Land Regions in Jordan

[35] Al-Bakri, J. T. (2008, February). *Soils of Jordan*

5.2.6 Water Resources

Jordan is one of the most water-scarce countries in the world, with only 61 cubic meters of renewable fresh water available per capita per year. This amount is significantly below the 500 cubic meters per capita annually, which is internationally recognized as the threshold for absolute water scarcity. The country's water supply relies primarily on surface water, groundwater, and treated wastewater, each contributing differently to the overall water availability[36].

Surface water in Jordan is dominated by the Jordan River, which has historically been the most significant source. However, its flow has drastically diminished due to upstream over-extraction. Other rivers, such as the Yarmouk River, also contribute to the surface water supply but face similar stresses. To manage surface water, Jordan has constructed several dams, including the King Talal Dam and Wadi Arab Dam. These dams play a crucial role in capturing and storing water for agricultural, industrial, and domestic use[37].

Groundwater is Jordan's primary water resource, providing nearly 60% of the country's total water supply. The main aquifers include the Disi-Mudawwara, Amman-Zarqa, and Azraq Basins. Over-extraction has led to declining water tables, salinization, and reduced water quality in many areas [37].

Treated wastewater is increasingly used in Jordan, especially for agricultural irrigation in the Jordan Valley. This practice helps conserve freshwater resources but requires careful management to avoid environmental and health issues. In terms of renewable versus non-renewable resources, groundwater, base flow, and flood flow are considered conventional, while treated wastewater, brackish, and desalinated water are categorized as non-conventional resources[37].

Jordan's climate is arid to semi-arid, with annual rainfall ranging from less than 50 mm in desert areas to around 400 mm in the northern highlands. Due to this limited precipitation, only about 5% of rainwater infiltrates into the ground to replenish groundwater aquifers, while a slightly smaller amount transforms into direct flow. Over 90% of the annual rainfall is lost to evapotranspiration [38].

The distribution of water use in Jordan reflects the country's priorities and the challenges of managing its scarce resources. Approximately 55% to 60% of the total water is used for agriculture, while municipal uses—including drinking, sanitation, and domestic needs—account for about 30% to 35%. The industrial sector utilizes around 5% to 10% of the total water, and minor uses, such as recreational activities, make up the remaining 1% to 2%. This distribution underscores the intense pressure on Jordan's limited water resources and highlights the ongoing need for efficient management and conservation strategies[39].

The challenges Jordan faces include the unsustainable use of groundwater, particularly through the over-extraction of highland aquifers, leading to gradual depletion. The Disi Area, situated over the important Disi Aquifer, is critical for the Disi Water Conveyance Project, which began in 2013. While this project is vital for meeting Jordan's water needs, it also raises concerns about the long-term sustainability of the aquifer, emphasizing the need for careful management and sustainable practices[37].

[36] National water strategy 2023-2040 WGA EN_21 (mwi.gov.jo)
[37] Water resources in Jordan: A review of current challenges and future opportunities https://www.mdpi.com/2073-4441/15/21/3729
[38] Weather https://www.britannica.com/place/Jordan/Climate
[39] https://www.researchgate.net/publication/222136110_Water_shortage_in_Jordan_-_Sustainable_solutions

5.2.6.1 Surface Water

The team conducted a preliminary examination of surface water hydrology affecting the catchment area and its streams, which could pose a significant flood risk at the Dubaydib wellfield, and a study of the preliminary mitigation measures is discussed in the following section.

5.2.6.2 Hydrological Study

To initiate the hydrological analysis, a DEM was employed to delineate the topography of both the areas surrounding the existing wells and the proposed sites for new wells. This model provides a detailed visualization of the land surface, highlighting elevation variations and terrain features. By analyzing this topographical data, the study aims to map out the flow paths of local streams and assess how surface water moves across the landscape. Understanding these flow dynamics is crucial for evaluating how water transfer occurs and how it might impact the proposed well locations. The analysis helps to determine potential influences on groundwater recharge and ensures that new wells are strategically placed to optimize water extraction while minimizing adverse effects on surrounding hydrological systems.

Morphological and meteorological studies serve crucial purposes in understanding and managing water resources and land use. Morphological studies analyze terrain characteristics, such as elevation and landforms, to assess how they impact water flow, erosion, and site suitability for projects like well placement. These studies help predict changes in hydrology and inform decisions on erosion control and infrastructure design. On the other hand, meteorological studies examine precipitation patterns, temperature trends, and other climate variables to evaluate their effects on water availability and quality. By understanding how rainfall, temperature, and evaporation rates influence water resources, these studies support effective water management, climate adaptation strategies, and accurate planning for future resource needs. Together, they provide a comprehensive understanding of how physical and climatic factors interact to shape the landscape and affect water systems.

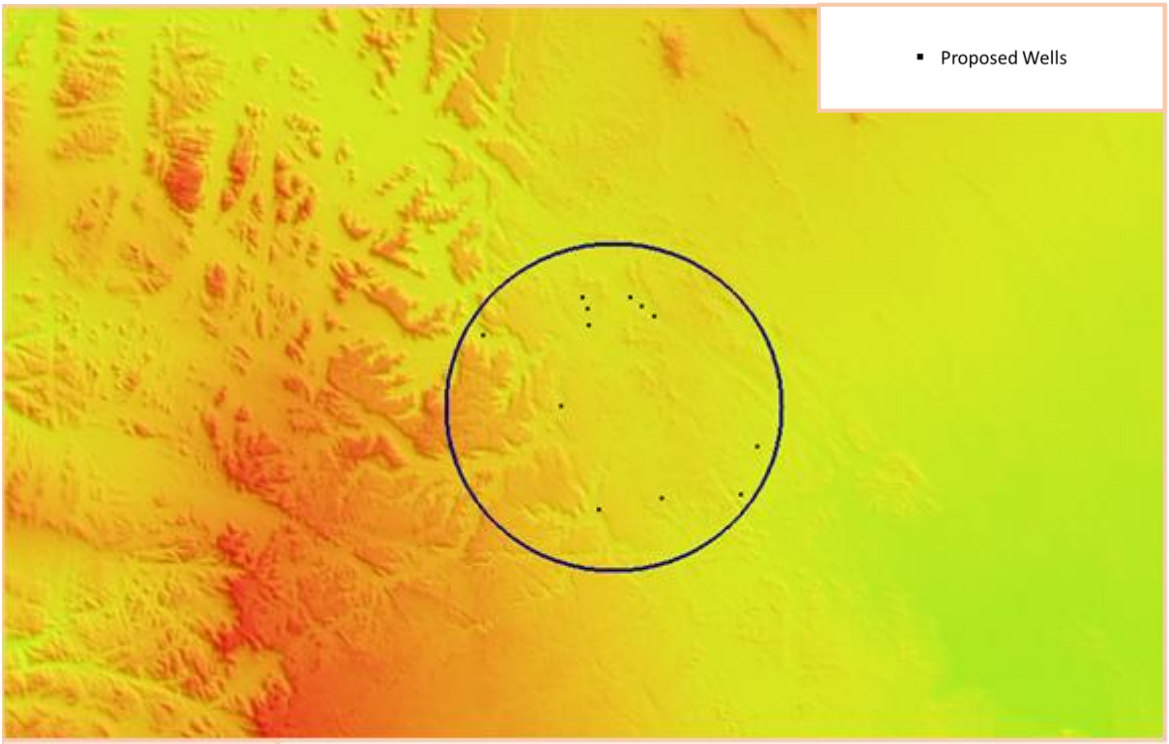


Figure 13: Topography of Proposed Wells and Surrounding Area

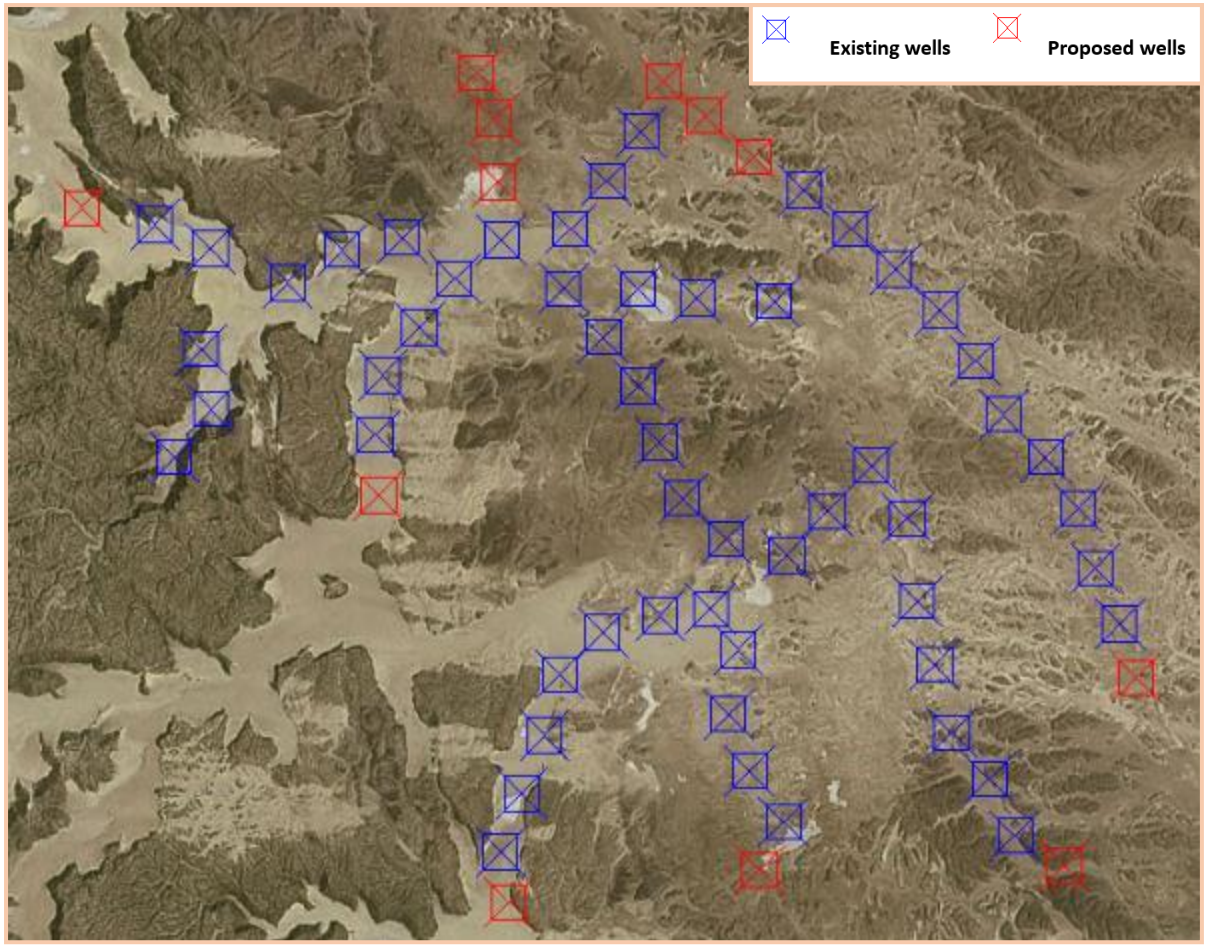


Figure 14: Location of Existing and Proposed Wells

Morphological Analysis

Physical parameters of the effective catchment area and streams are very significant for the hydrological analysis such as the length of the longest flow path and slope. The available DEM 12.5m as well as aerial photos and satellite images are delineated and verified with Google 3D to define the catchment area and its characteristics using applicable models and software (i.e.-Watershed Modelling System WMS version 11.1).

The delineated catchment area, a subset of the Disi catchment, along with its associated streams developed from a 12.5m DEM using WMS software, as shown in **Figure 15.** Additionally, **Table 10** below summarizes the key characteristics of the catchment area.

Table 10: Characteristics of Catchment Areas Developed

Catchment Area	Drainage Area (km^2)	Maximum Flow distance (m)	Maximum Flow Slope (m/m)
Catchment Area 1	339.77	47874.88	0.017
Catchment Area 2	73.53	20693.42	0.028
Catchment Area 3	42.97	16092.88	0.013
Catchment Area 4	143.82	30027.87	0.009
Catchment Area 5	159.48	30093.19	0.018

Figure 15: Catchment Areas Generated within the Site and Surroundings

In watershed modeling software, analyzing the flow path involves simulating how water moves across the landscape within a given watershed. The flow path analysis helps in understanding how precipitation and surface runoff travel through the watershed, from the point of rainfall to the outlets.

It provides insights into how water moves through a watershed, helping to predict and manage hydrological processes, assess watershed health, and optimize water resource management.

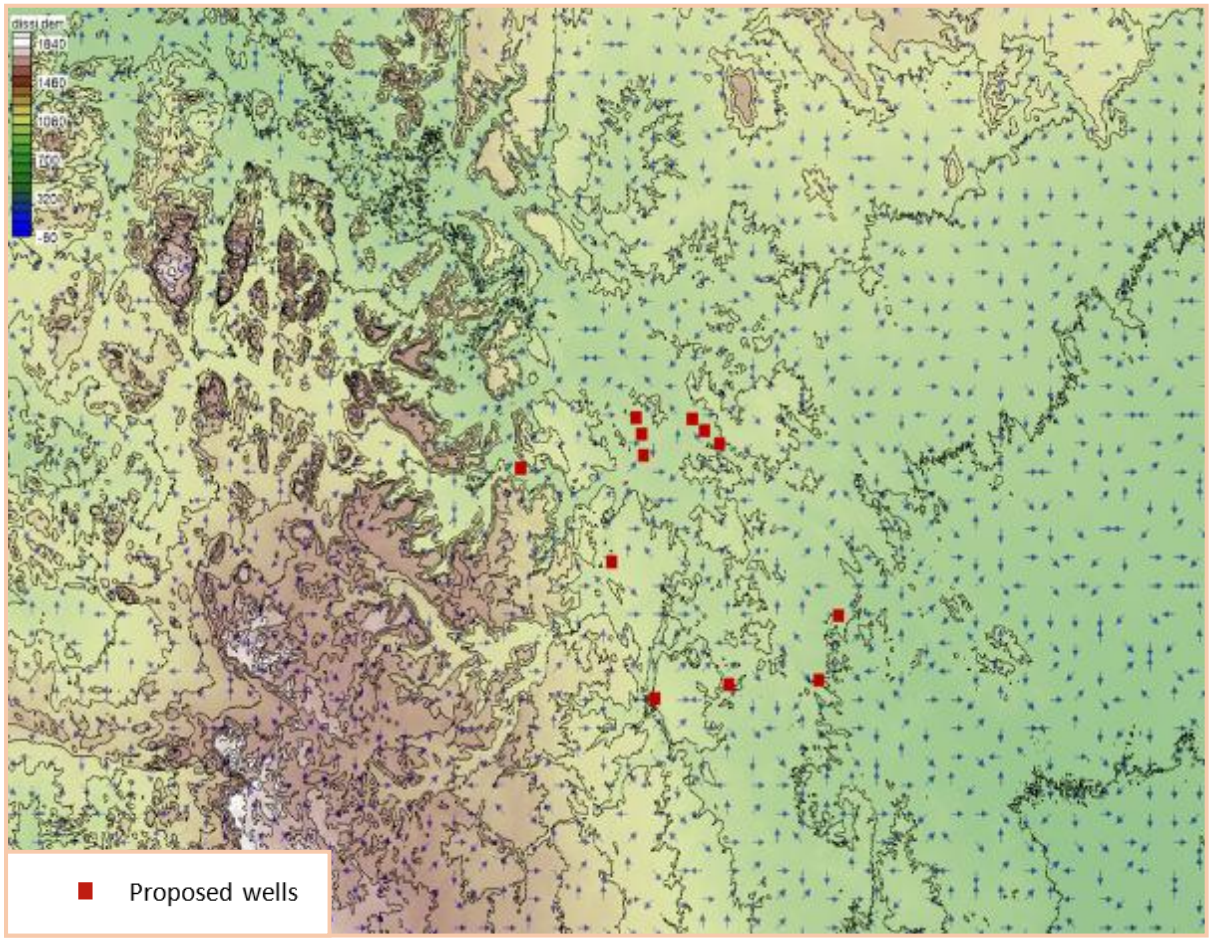


Figure 16: Flow Pattern with the Locations of the Proposed Wells

Meteorological Analysis

Rainfall data is an important factor in the hydrological study to compute the design floods and their frequencies. Meteorological analysis in hydrology involves collecting and interpreting weather data to understand its impact on water systems, model future scenarios, and manage water resources effectively precipitation Analysis by measuring and monitoring which involves collecting data on rainfall using gauges, radars, and satellites. In addition to understanding the intensity, duration, and frequency of precipitation which helps in assessing its impact on water bodies.

Analyzing how precipitation varies over time and space is crucial for understanding flood risks, drought conditions, and water supply availability as well. Meteorological data is integrated into hydrological models to simulate and predict water flow, runoff, and storage in various hydrological systems. The nearest rain gauges are shown in **Figure 17**.

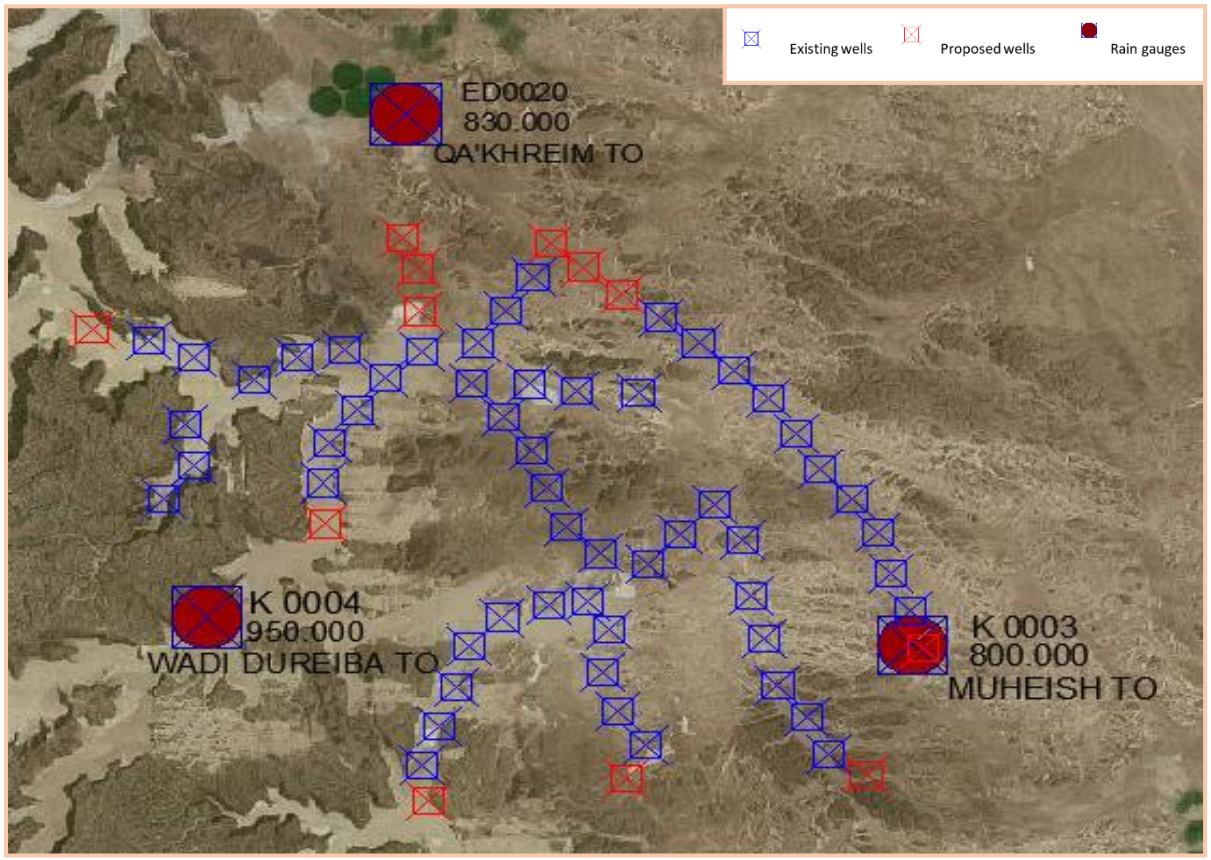


Figure 17: Location of Existing, Proposed Wells and Rain Gauges

The Thiessen Polygon method is utilized to determine the nearest rainfall stations and assign effective rainfall stations based on proximity. This method assigns values from known observation points to areas within their corresponding polygons, providing a way to estimate data for locations between these points. This is particularly useful when working with unevenly distributed meteorological stations.

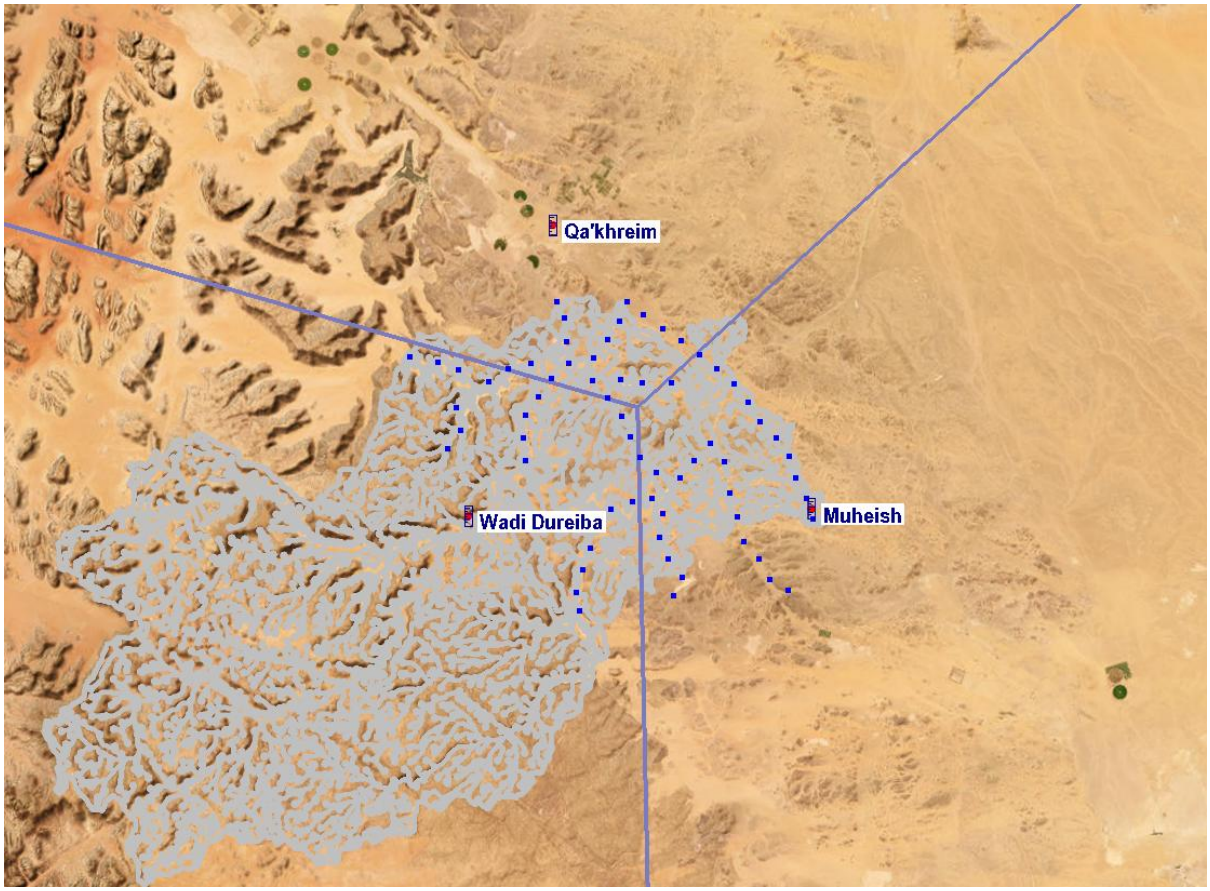


Figure 18: Thiessen Polygon Method Used to Determine Effective Rainfall Identification

Flood Flow Estimations

The Soil Conservation Service (SCS) method and the unit hydrograph method are related but distinct approaches used in hydrology for estimating peak flow and understanding runoff characteristics. Both methods are used to estimate peak flow and runoff, the SCS method focuses on direct runoff estimation using curve numbers, while the unit hydrograph method provides a detailed temporal distribution of runoff. They can be used together to provide a comprehensive understanding of watershed response to rainfall.

- **SCS method – Soil Conservation Service**

The SCS (now known as NRCS) peak flow method calculates peak flow as a function of drainage basin area, potential watershed storage, and the time of concentration and lag time. The graphical approach to this method can be found in TR-55. This rainfall-runoff relationship separates total rainfall into direct runoff, retention, and initial abstraction to yield the following equation for rainfall-runoff:

The SCS method (now known as the NRCS method) estimates peak flow by considering factors such as the drainage basin area, curve number (which reflects potential watershed storage and land use conditions), and the time of concentration. The graphical approach to this method is detailed in the NRCS publication TR-55. This rainfall-runoff relationship involves Separating total rainfall into direct runoff and infiltration (initial abstraction), and the method is based on the following equation for direct runoff:

$$Q_D = \frac{(P - 0.2S_R)^2}{P + 0.8S_R}$$

Where:

QD = Depth of direct runoff (total excess rainfall), mm (in),

P = Depth of 24-hour precipitation, mm (in),

SR = Retention, mm (in),

The SCS Unit Hydrograph (UH) is a tool used to estimate the runoff hydrograph for a watershed in response to a unit of effective rainfall, typically 1 inch or 1 cm of rainfall uniformly distributed over a specified duration. It provides a way to predict how rainfall translates into runoff over time, which is essential for flood forecasting and hydrological modeling.

The SCS Unit Hydrograph formula is presented hereunder:

$$Qp = CP \times A \times QD/Tp$$

Where:

Qp = Peak of unit hydrograph (m^3/s)

QD = Depth of direct runoff (total excess rainfall), (mm)

A = Watershed area (km^2)

Tp = Time to peak of unit hydrograph (hours)

CP = 2.08 (483.4 in the English system).

Further, a study of unit hydrographs of many large and small rural watersheds indicates that the basin lag tp = 0.6Tc, where Tc; is the time of concentration of the watershed.

Time of rise Tp can be expressed in terms of lag time tp and the duration of effective rainfall tr:

$$Tp=\frac{tr}{2}+ tp$$

$$Tlag = 0.6\ tc$$

$$tr=tp/5.5$$

Where:
Tr = duration of effective rainfall (hours),
Tlag = lag time (hours),
Tc = time of concentration (hours),

Effective Rainfall

The process of evaporation and/or percolation to groundwater will abstract a considerable amount of the rainfall and the rest will contribute directly as a runoff, which is called effective rainfall. The total losses from any rainfall storm are generally divided into two parts:

- Initial losses (interception by plants, filling the small depressions over the ground surface, and covering the soil moisture deficit).
- Continuing losses (infiltration/percolation).

The most common procedure for estimating initial losses is to use the SCS
(US Soil Conservation Service) the method as mentioned earlier. This method estimates the initial losses based on a curve number, which depends on land use, soil type, hydrologic condition, and land development. A high curve number yields low losses and hence high effective rainfall and runoff. For selecting the curve number.

Based on above results the SCS tables give a curve number of values ranging between 74 and 79 for row crops (contoured & terraced) and pasture grassland for the average antecedent moisture condition (AMC class II). The SCS equation for estimating total losses in millimeters is developed in the following:

$$S = \frac{25400}{CN} - 254$$

S = Soil Retention, mm (in)
CN = Curve Number

The loss of initial abstraction (Ia), is the total loss of the rainfall occurring before the start of the runoff (i.e., before ponding). This value covers the interception, the filling of surface depressions, and the filling of soil moisture deficit and sometimes, in hot climates the evaporation may occur before the

runoff. In addition to this, each soil type might have a potential moisture retention (S'). Then, the total losses (SR) can be given by the summation of (Ia) and (S').

$$Ia = 0.2S$$

Where:

S= total losses (mm),

Ia= initial abstraction (mm).

The runoff curve number CN is a function of land use, antecedent soil moisture, and other factors affecting runoff and retention in a catchment, and its values are presented in **Table 11** and **Table 12** below.

Table 11: Runoff Curve Number Values

Land Use Description	Hydrology Soil Group (HSG)			
	A	B	C	D
Bare lands	77	86	91	94
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	-	80	87	93
Desert shrubs	63	77	85	88
Residential districts by average lot size:				
1/8 acre or less (town houses)	77	85	90	92
1/4 acre	61	75	83	87
1/3 acre	57	72	81	86
1/2 acre	54	70	80	85
1 acre	51	68	79	84
2 acres	49	65	77	82

Table 12: Soil Type Groupings

Soil Group	Characteristics
A	Soils in this category have a high infiltration rate even when thoroughly wetted and consist mainly of deep, well-to excessively-drained sands or gravels. (Low runoff potential)
B	Soils in this category have moderate infiltration rates when thoroughly wetted and consist of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures.
C	Soils in this category have slow infiltration rates when thoroughly wetted and consist mainly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures.
D	Soils in this category have a very slow infiltration rate when thoroughly wetted and consist mainly of clay soils with high swelling potential, soils with a permanently high-water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. (High runoff potential)

A curve number is a dimensionless number defined such that 0 ≤ CN ≤ 100. For impervious and water surface CN=100, for natural surface CN ≤ 100. The curve number related to AMC II is given, and the AMC I and AMC III curve numbers can be computed by using the following equations:

$$CN(I) = \frac{4.2CN(II)}{10 - 0.058\,CN(II)}$$

$$CN(III) = \frac{23CN(II)}{10 + 0.13CN(II)}$$

The SCS method contains equations for estimating losses throughout a storm. The cumulative losses

during the storm increase until they reach the estimated S total losses. This would only happen in a very severe event. Thereafter, all rainfall is effective.

A typical application of the Unit Hydrograph method includes the following basic steps:

- Determination of curve number that represent different land uses and soil type within the catchment area boundary.
- Calculation the lag time of the catchment area based on the catchment characteristics such as area, average basin slope (BS), maximum flow distance (MFD) and curve number.
- Using SCS Type II 24-hr rainfall distribution as a syntactic hyetograph for the arid and semi-arid regions and after estimate the initial abstraction (Ia) based on the CN value, the total and excess rainfall amounts are determined.
- Using the SCS unit hydrograph approach, the hydrograph of direct runoff for the excess rainfall over the catchment area can be developed based on the drainage area's characteristics, i.e., CN, T lag, etc.

Conclusion and Recommendations

Based on the results of the literature review and meteorological & morphological analysis for the Disi wells and its components, the following conclusion can be drawn:

1. The reviewed studies highlight that effective management of the Disi Aquifer's groundwater is essential for maintaining its long-term viability as a vital water source for Jordan.
2. The meteorological and morphological analysis conducted for the precise location of the new wells and its components indicate a flood risk at the wells site, potentially leading to flooding, soil erosion and sediment transport.
3. The morphological analysis reveals that both the proposed and existing wells are situated within areas where the delineated watersheds intersect and where the flow paths traverse the site.
4. Detailed characterization of the entire catchment, including its physical and hydrological attributes, was accomplished using advanced GIS-based analysis of a DEM through WMS modeling, GIS software, and Global Mapper tools and shall be utilized in future detailed studies.
5. The nearest rainfall stations that have updated daily rainfall data over the 30 years shall be considered in future studies.
6. A comprehensive hydrological study and hydraulic design are required for the location of the new wells and its components to estimate the maximum flood flow values at 50, 100-yr return periods alongside with an actual topographic survey along the Disi wells. This approach aims to determine the maximum peak flow and depth. Hence, propose suitable flood mitigation measures and erosion/scouring protection works.

5.2.7 Geology and Hydrogeology

This report offers an evaluation of the initial environmental conditions within the Project site and its immediate vicinity (Area of Influence) focusing on geology and hydrogeology.

Baseline Assessment and Methodology

The baseline assessment includes meticulous analysis of the existing data, which was sourced from government entities such as MWI, WAJ, and MEMR prior research endeavors, and various surveys. The primary objective in this phase was to rigorously assess the quality and relevance of the collected data ensuring its suitability for the ESIA.

Following this initial data examination, a detailed description of the Project area was developed. This entailed outlining the geographical boundaries and essential characteristics that define the region. These encompassed vital aspects such as topography, climate patterns, and regional hydrology, all of which are pivotal in understanding the environmental context.

Furthermore, the baseline assessment also investigated soil and geology characteristics for the area. This included an assessment of the different soil types present, the depth to bedrock, and the various geological formations within the area. Additionally, the assessment included the identification of potential geological hazards, shedding light on critical safety considerations.

Similarly, the investigation extended to groundwater features, encompassing aquifer types, water table depth, and groundwater quality. This information was culled from well data and monitoring points, contributing to our holistic understanding of the hydrogeological context. Lastly, groundwater quality was addressed by presenting data on relevant water quality parameters for groundwater. This resulted in a robust foundation of knowledge to inform a comprehensive study and provide recommendations.

Project Area Characteristics

The Project is situated in the Disi-Mudawarra area south of Jordan, near the border with Saudi Arabia. It is part of the larger Disi aquifer, a significant source of ancient, non-renewable fossil groundwater. This region has gained prominence due to its strategic water resources, especially in a country like Jordan, which faces chronic water scarcity. The area experiences an extremely dry, desert climate, with hot summers and mild winters. The elevation of the Disi-Mudawarra area in southern Jordan ranges from approximately 800 to 1,100 meters above sea level. The terrain is generally flat to gently undulating with some low-lying rocky formations and wadis (valleys), typical of the desert environment with minimal vegetation in this region. **Figure 19** below provides a graphical representation of the elevation variations across the project site. Historically, the area has been sparsely populated with limited economic activities.

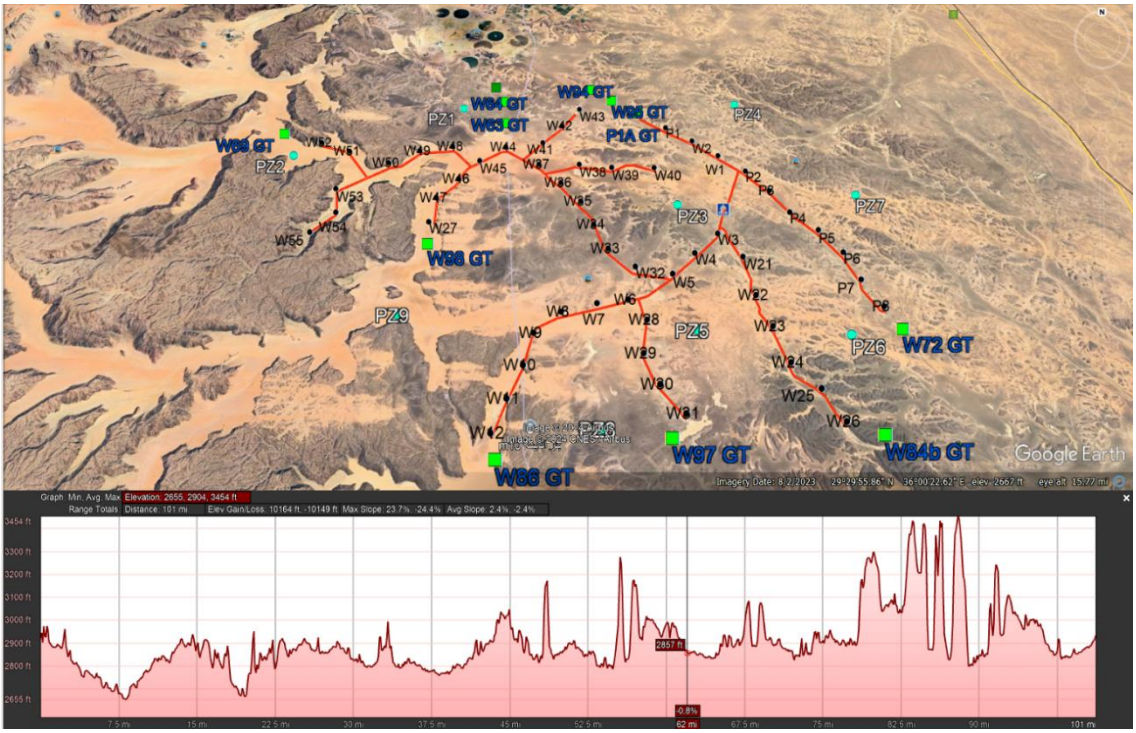


Figure 19: Elevation Profile of the Project Area (ESIA Team, 2024)

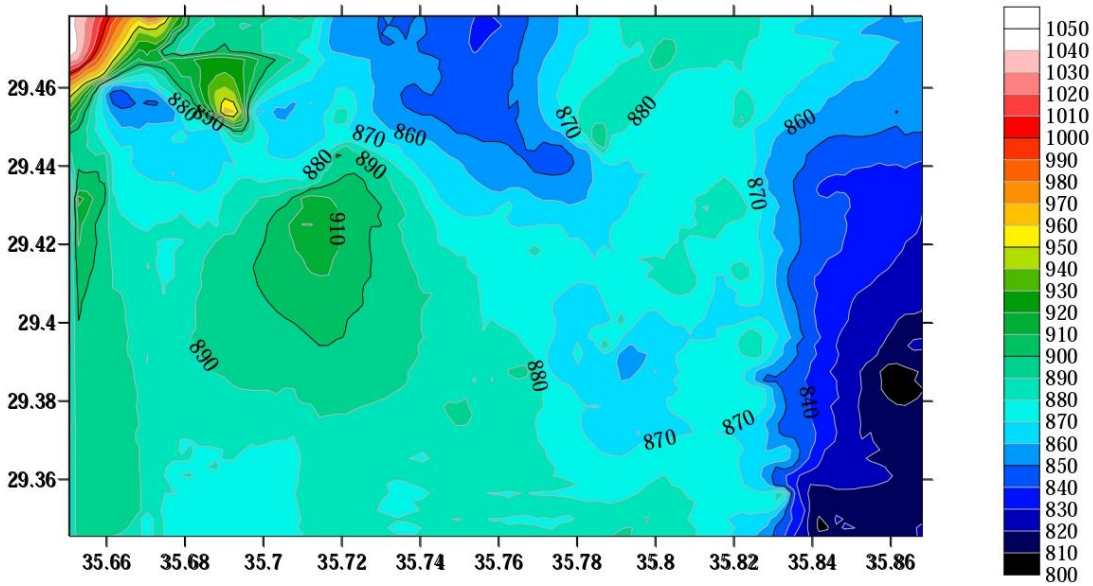


Figure 20: The Project Site Topography (ESIA Team, 2024)

5.2.7.1 Geology

The geological composition of the Project area is primarily characterized by sedimentary rock formations, mainly the Paleozoic and Lower Cretaceous systems. The project area primarily encompasses formations from the Khreim and Disi units of the Paleozoic group and the Kurnub unit of the Lower Cretaceous group.

The Khreim and Disi units are characterized by sedimentary rocks such as limestone, sandstone, shale, clay, dolomite, and gypsum. These formations contain water-bearing layers of limestone, dolomite, and sandstone, making them a significant source of water in regions like the Negev, north and south Wadi Araba, and the south Jordan Desert Basins. However, there are challenges such as high salinity in parts of the region, limited groundwater development due to drilling depths, high pumping lifts, and mineralization of groundwater. The upper part of these units largely functions as an aquiclude.

The Kurnub unit, part of the Lower Cretaceous group, consists of sandstone, dolomite, marl, sand, shale, clay, and sandy limestone. The upper part of this unit predominantly comprises shale and carbonates, forming an aquiclude, while the lower part mainly consists of water-bearing sandstone. High salinity is also noted in the vicinity of the Jordan Rift Valley.

The geological map of the Project area within Jordan is presented in **Figure 21** below.

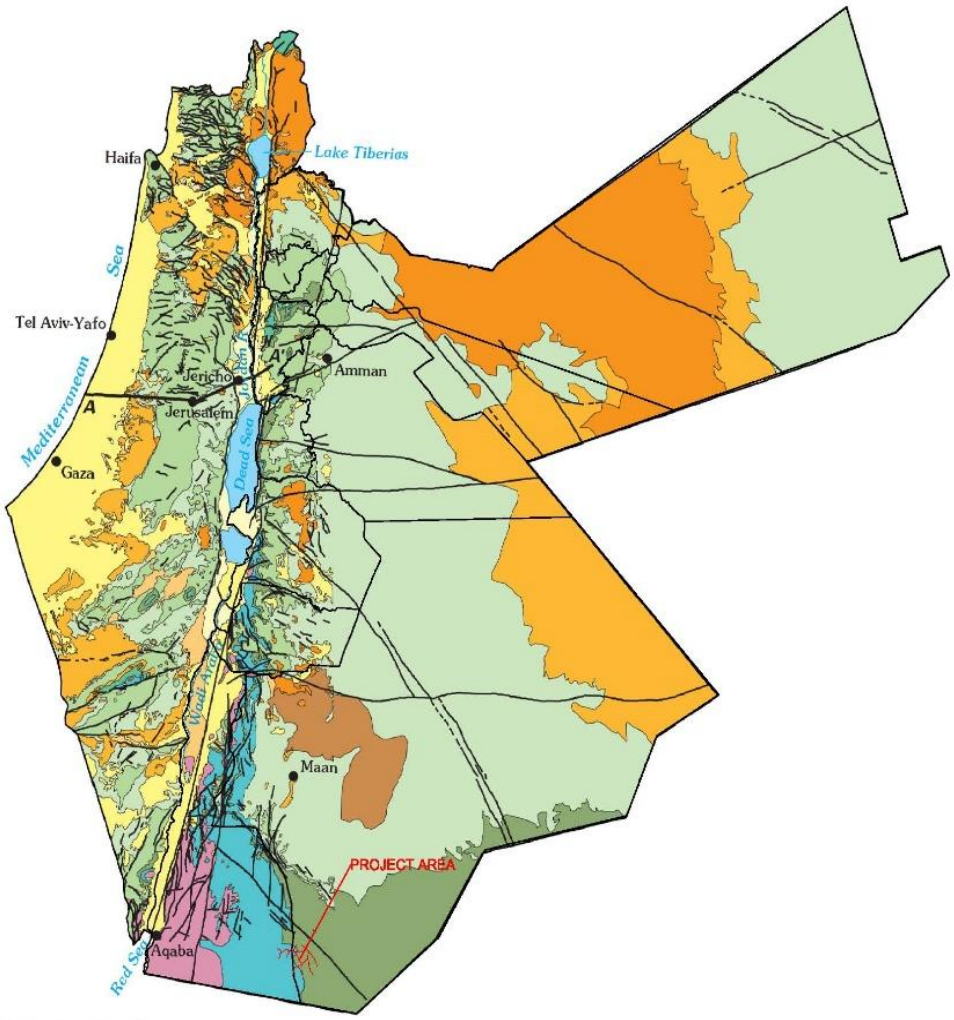


Figure 21: Geological Map of the Project Area, Source: USGS open report, overview of Middle East water resources, (1998)

Figure 22, shows the detailed legend of the geologic map explaining the rock units, their age, lithology and water bearing properties.

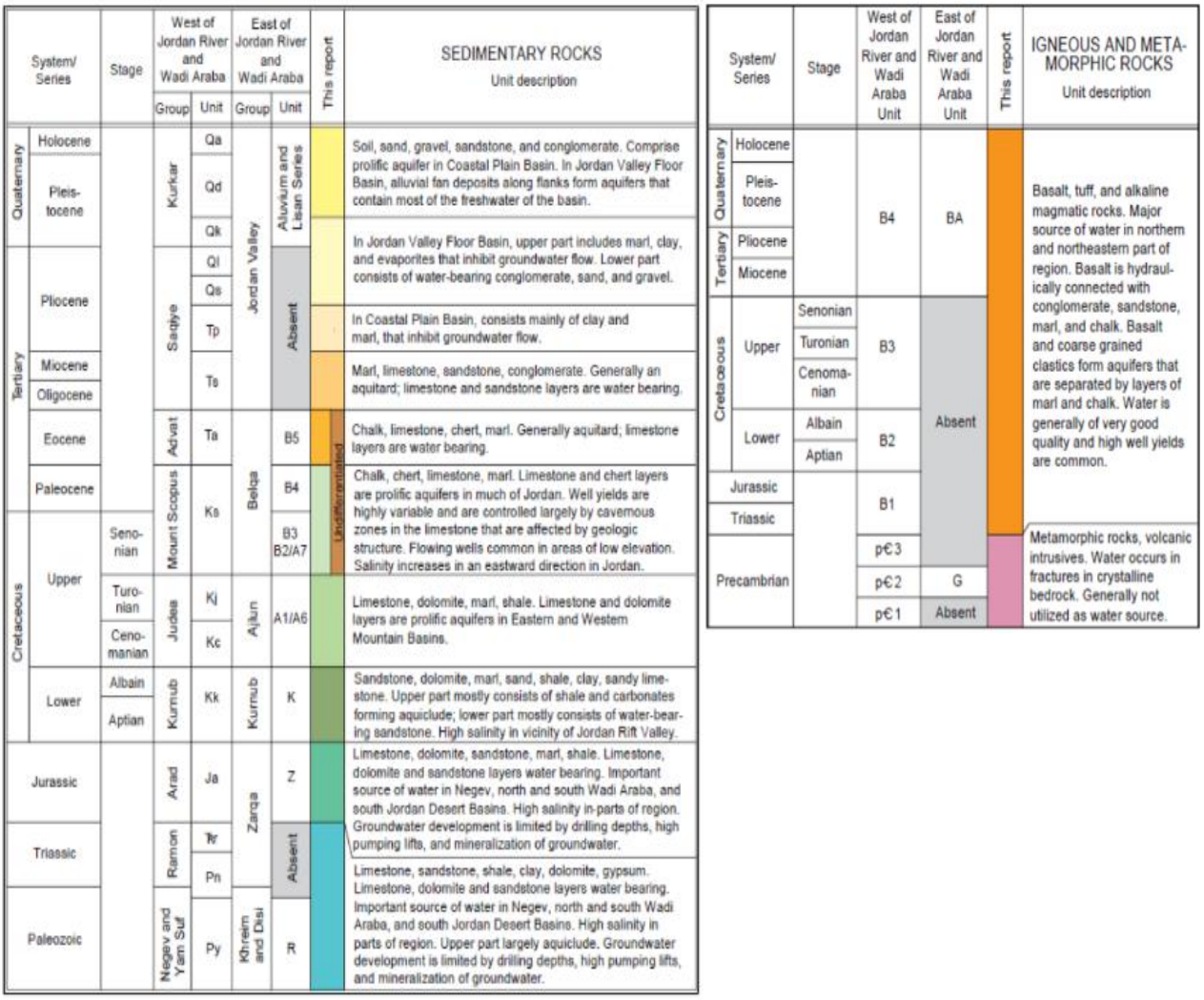
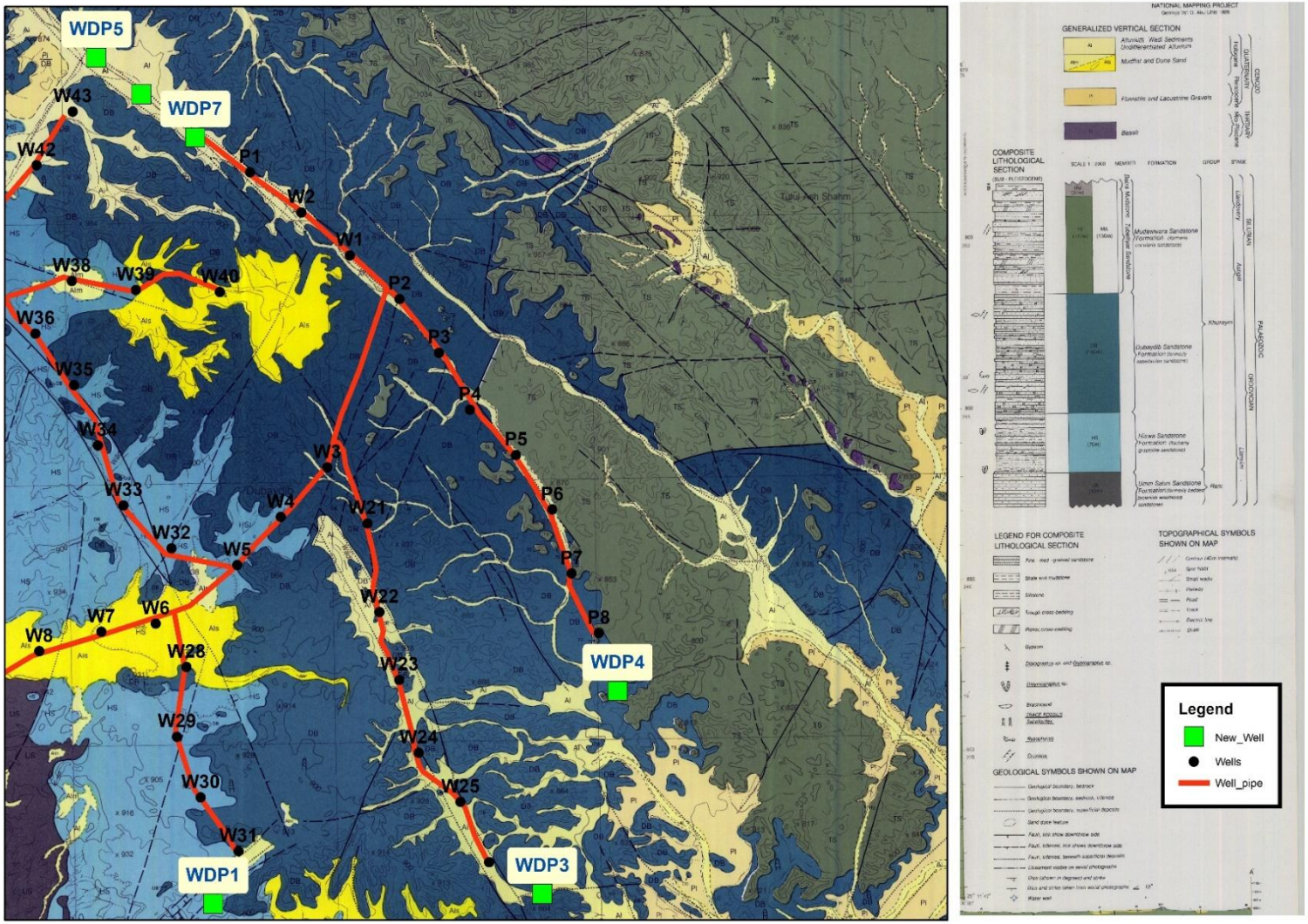


Figure 22: Generalized Geologic Units and Water-Bearing Properties, (Source: USGS open report, overview of Middle East water resources, (1998)

The Disi well field falls under two (2) geological area, the Jabal Ladghayn / Dubaydib area and Jabal Umm Sahm and Bir as Saladih area. The geology of the Jabal Ladghayn / Dubaydib area features bedrock primarily from the Ordovician Ram Group and the overlying Khreim Group. The Umm Sahm Sandstone Formation, the oldest outcropping unit, consists of hard, brown, medium-to coarse-grained quartzose sandstone with interbeds of fine-grained, micaceous sandstone and siltstone. This formation is topped by the Hiswa Sandstone Formation, marked by red-brown, yellowish weathered, finely laminated sandstone with ripple marks and fossils indicating a marine environment.

The overlying Dubaydib Sandstone Formation, up to 140 m thick, comprises fine-grained sandstone with extensive burrowing by marine organisms, and the Mudawwara Sandstone Formation, up to 250m thick, includes micaceous sandstone, siltstone, and mudstone with marine fossils. The area features Mio-Pliocene basalt plugs and prominent NW-SE trending faults, creating sinuous grabens and influencing the topography. Uranium, kaolin, and suitable gravels are notable resources, with the sandstone formations serving as local aquifers. **Figure 23** presents the geological map of the Jabal Ladghayn / Dubaydib area.



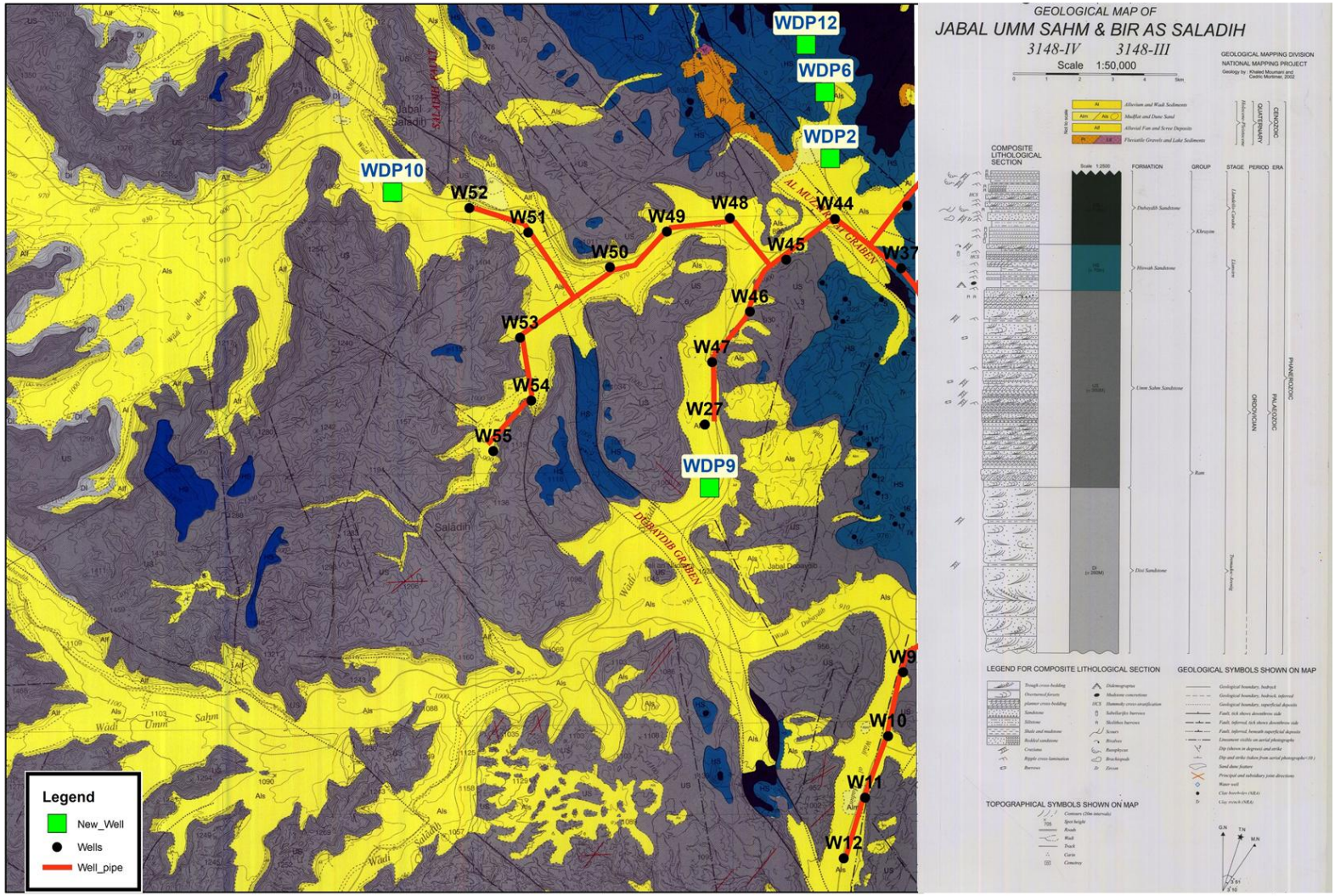
Source: Ministry of Energy and Mineral Resources

Figure 23: Geology of Dubaydib and Jabal Ladghayn Area

The Jabal Umm Sahm and Bir As Saladih area features significant superficial deposits from the Cenozoic, Quaternary, Holocene-Pleistocene periods. These include alluvial fans, scree deposits, mudflats, and dune sands. Alluvial fans and scree deposits dominate the landscape, comprising poorly sorted gravel, sand, and silt. Mudflats and dune sands, particularly in the axial areas, contain fine to medium-grained sandstone with cross-bedding, crucial for water extraction.

The region's structural geology, characterized by NNW-SSE, E-W, and N-S trending faults, influences the distribution and quality of these superficial deposits. The paleo valleys filled with these sediments are primary targets for drilling wells due to their water retention capabilities. The landscape, shaped by resistant sandstone ridges and softer siltstone beds, supports the accumulation of these deposits.

Figure 24 presents the geological map of the Jabal Umm Sahm and Bir As Saladih area.



Source: Ministry of Energy and Mineral Resources

Figure 24: Geology of Jabal Umm Sahm and Bir As Saladih Areas

Notably, the Project area falls within the Kurnub Group, Ram Group, and Khreim Group. The Kurnub Group which is exposed in the wadis and possesses high permeability. This formation serves as an aquifer layer but is also susceptible to contamination due to its permeability to pollutants. Permeability plays a crucial role in the transfer of pollutants in rock formations.
The Ram Group is predominantly composed of quartzitic sandstone, known for being highly resistant to weathering. This results in high permeability, especially in the well-sorted, coarse-grained sandstone layers. These properties make the Ram Group an important aquifer in some regions, providing efficient groundwater flow. The permeability may decrease in areas with cementation or finer-grained sections. Regarding the Khreim Group; is a mixed sequence of sandstone, siltstone, and mudstone. The permeability is variable, depending on the composition. Sandstone-dominated sections tend to have moderate to high permeability, while siltstone and mudstone interbeds significantly reduce it. Groundwater movement in this formation is generally restricted by these finer-grained materials.

The effect of permeability on pollutant's transfer can be summarized as follows:

- **Rate of Pollutant Movement**: Permeability is a measure of how easily fluids can flow through rock. Rocks with high permeability allow pollutants to move more rapidly through them, while rocks with low permeability impede the movement of pollutants. The higher the permeability, the faster pollutants can spread through the rock matrix.
- **Dispersion**: In rocks with high permeability, pollutants may disperse more widely because there are fewer obstacles to hinder their movement. This can lead to a broader contamination plume. In contrast, low- permeability rocks tend to confine pollutants to a smaller area since they restrict the flow of contaminants.
- **Retention and Sorption**: The permeability of rock also affects the ability of the material to retain and adsorb pollutants. Rocks with high permeability may have less capacity to retain pollutants within their pores because fluids can flow through more easily. In contrast, low-permeability rocks may provide more opportunities for pollutants to be retained and sorbed onto mineral surfaces.
- **Groundwater Contamination**: Permeable rocks can facilitate the rapid transport of pollutants into groundwater, potentially contaminating drinking water sources. In regions with highly permeable geological formations, pollutants can travel quickly and contaminate aquifers that supply water to communities.

Permeability plays a vital role in shaping the movement and behavior of pollutants within rock formations. It governs the speed at which contaminants traverse through rocks, the breadth of their dispersion, and the degree to which they can be captured or adsorbed. The effective management and mitigation of pollutant transfer in rocky environments necessitate a comprehensive grasp of the permeability attributes of the geological formations in question.

5.2.7.2 Hydrogeology

In Jordan, the significance of groundwater as a primary source of drinking water cannot be overstated, primarily due to the country's arid climate and the limited availability of freshwater resources. This arid climate, coupled with a scarcity of river systems, places Jordan in the throes of a severe shortage of surface water, compelling the nation to heavily depend on groundwater reservoirs to fulfill its drinking water requirements. Jordan boasts a complex network of aquifer systems, representing a vital repository of groundwater that serves as a lifeline for both urban and rural communities alike.

Nevertheless, the unabated extraction of groundwater has emerged as a pressing concern within Jordan's water management landscape. The unrelenting demand for water resources, particularly in urban areas, has precipitated the depletion of select aquifers. Consequently, there is a growing imperative to implement comprehensive measures aimed at the sustainable management and oversight of groundwater usage.

Groundwater Basin and Aquifers

Jordan's water scarcity challenges are significant, particularly with over-extraction from its groundwater resources. While the safe extraction of renewable groundwater is limited to 275 million cubic meters annually, over-pumping has exceeded this, leading to declines in groundwater levels across the country, with some basins nearing depletion. Hydrogeological studies by the German Institute for Geosciences and Natural Resources (BGR) highlight sharp declines in regions like Wadi al-Arab and the southern Karak and Tafilah basins, raising alarms about the sustainability of water resources.

As shown in **Figure 25** below; the Project area is located within Jordan Disi Ground Water Basin. The natural flow of groundwater predominantly moves from south to north. Based on the MWI report in 2022, The safe yield of the Disi Basin is 125 MCM annually, but current abstraction has reached 178.97 MCM, resulting in a deficit of approximately 53.97 MCM.

The Disi Basin is located in southern Jordan, 300 km south of Amman. It is one of the shared water basins between Jordan and Saudi Arabia. The exposed area of this basin in Jordanian territory is three thousand km^2 and about sixty-six km^2 in Saudi territory. The width of the exposed area ranges between (50-250) km.

As for the subsurface aspect, the Disi Basin covers the entire Jordanian territory. The depth to the surface of this groundwater reservoir in areas other than the exposed areas has reached about 1000 m, while the depth to the surface of the layer in the Azraq and Sirhan areas has reached more than 3000 m. The thickness of the water-bearing layer reaches an average of about 500 m, increasing towards the east and northeast, where the thickness of the layer reaches about 1500-2000 m.

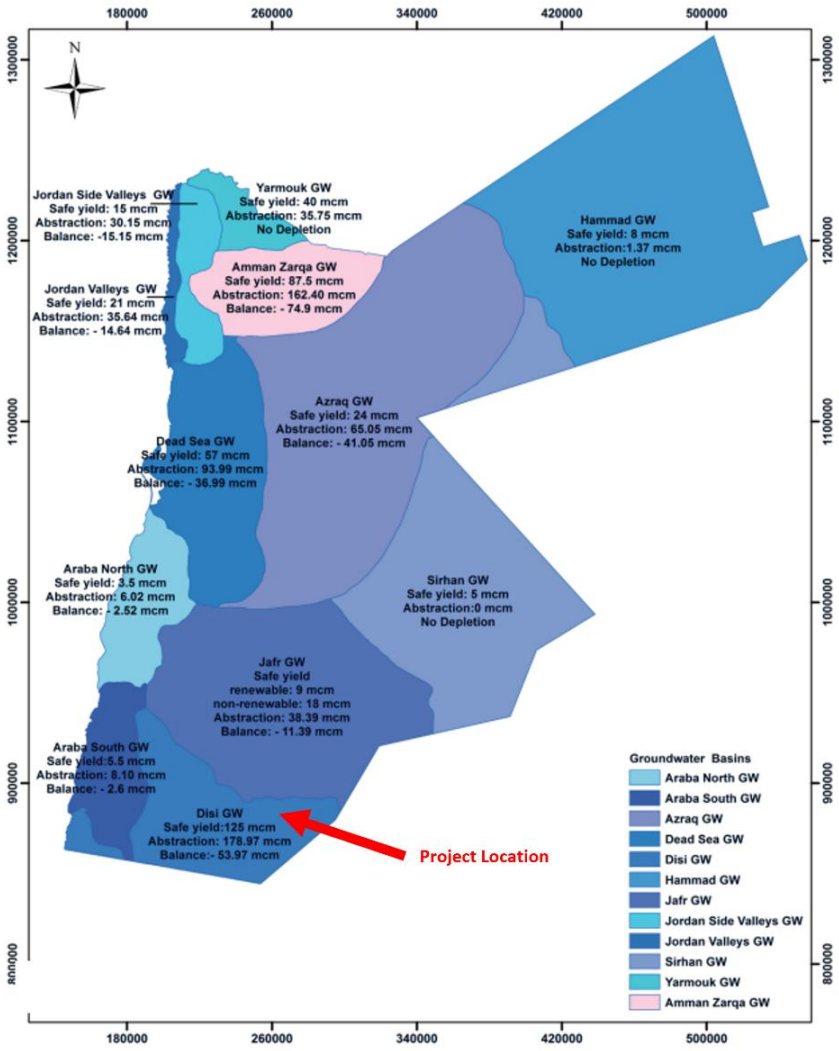


Figure 25: Jordan's Groundwater Basins Maps (MWI, 2022)[40]

As mentioned earlier based on the outcrop geology of the Disi Groundwater Basin, the rock units overlying the Precambrian basement complex are divided into two main groups: the Khreim Group (upper) and the Rum Group (lower)[41]. The Rum Group consists of several significant geological formations, including the Saleb, Burj, Umm Ishrin, Disi, and Umm Sahm formations. These formations make up the Rum aquifer system[42], which is the dominant freshwater aquifer system in southern Jordan. This aquifer is crucial for the region's water supply and is characterized by a high degree of permeability, making it a valuable source of groundwater.

The Khreim Group, which overlies the Rum Group, consists of the Shal Suwaan, Um Tarifa, Trabeel, Batra, and Alna formations, in order from bottom to top. This group acts primarily as a confining layer for the underlying Rum aquifer. Specifically, the Sahl Suwaan Formation within the Khreim Group serves as a key confining unit, while the rest of the formations function as a leaky aquitard. These layers allow limited

[40] https://www.mwi.gov.jo/ebv4.0/root_storage/ar/eb_list_page/jordan_water_sector_-_facts_and_figures_2022.pdf
[41] (PDF) The Rum-Saq Aquifer Resource – Risk Assessment for Long Term Resource Reliability (researchgate.net)
[42] https://pubs.usgs.gov/of/1985/0003/report.pdf

groundwater flow and contain relatively saline water, contrasting with the fresher water found in the Rum aquifer.

The nature of the aquifer system varies across the region. In areas where the Khreim Group does not deposit, the Rum aquifer system behaves as an unconfined aquifer, with no overlying layers restricting water movement. However, in areas where the Khreim Group is present, the aquifer becomes confined, meaning the overlying Khreim formations exert pressure on the groundwater stored in the Rum sandstone, affecting the flow and availability of water. This geological configuration underscores the importance of the Rum aquifer as a key freshwater resource while highlighting the role of the Khreim Group in controlling the flow and quality of water in the region[43].

The waters of the Disi Basin are hydrologically non-renewable waters with an average age of 10-30 thousand years. The Tabuk-Mudawara-Disi region extends from the Tabuk Plain in Saudi Arabia to the Wadi Rum Desert in Jordan, between the Disi, Mudawara, and Al-Jafer regions. This region is surrounded by protrusions of the groundwater layer that form mountains and steep slopes that rise to a height of about 800 m in the south to 1750 m near Jabal Rum in Jordan. The plains are covered with gravel that rests directly on the sandstone, while the terrain changes to the north in Wadi Rum to turn into wide sand-covered floors.

The depth to the water table in the Disi aquifer ranges from 100 meters to 1300 meters, while the bottom of the aquifer lies at depths between 200 m and 1400 m. The thickness of the saturated zone, which is the distance between the bottom of the aquifer and the top of the water level, ranges from 10 m to approximately 1100 m. Due to the depth of this sandstone aquifer, the porosity of the rock is lower than the typical porosity of sandstone. Additionally, fine cement materials between the porous sandstone further reduce the porosity of the saturated zone, bringing it to around 12%. This affects the estimated water volumes in the aquifer [44].

Because of the rock's retention capacity and the fact that not all water can be extracted from the sandstone bores, only about 60% of the total water in the rock is expected to be available for pumping. However, pumping these amounts could also lead to a deterioration in water quality, affecting the usable volume of water from the aquifer.

[43] https://www.researchgate.net/publication/281489794_The_Geology_of_Jabal_Umm_Sahm_and_Bir_As_Saladih_Area_Map_sheets_No_3148-IV_and_3148-III

[44] The Fate of Disi Aquifer as Stratigic Groundwater Reserve for Shared Countries (Jordan and Saudi Arabia) (scirp.org)

Groundwater Discharge Wells/ The Dubaydib Wellfield

The existing Disi-Amman System involves 55 production wells (46 abstraction wells and nine (9) standby wells) to abstract water from the fossil aquifer in southern Jordan. In addition, the existing system includes nine (9) piezometer wells and operational facilities including water reservoirs and pump stations conveying the water for a distance of approximately 325 km to supply 100 MCM per year of water to Amman. Recently the Disi project activated (4) four of the standby wells to be 50 abstraction wells and five (5) standby wells, and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM and since 2024, production has been increased to 115 MCM. Water is collected from each of the wells via a 'dendritic' collector network and delivered to a collector tank north of the well field by a main spinal collector.

Groundwater extraction from the Rum Group aquifer began as early as the late 1970s to provide irrigation for wheat farms in the Disi Valley. Modeling of the Rum Group aquifer to determine the potential for exploiting groundwater resources in the southern desert began at the same time, including mainly the work of Lloyd (1969), Howard Humphreys (1986), BRGM (1985) and BGR (1991). Overall, these modeling studies indicated that the Rum Group aquifer in the southern desert could be exploited at a rate of 200 million m^3/yr for at least 50 years.

During 1991-1995, the Ministry of Water and Irrigation and the Water Authority of Jordan (MWI/WAJ) commissioned a consortium led by Scott Wilson Kirkpatrick (SWK) to conduct extensive exploration in southern Jordan to further assess groundwater resource potential, identify relevant withdrawal areas, and assess appropriate withdrawal volumes. SWK identified three potential well fields with associated well sites and proposed several withdrawal scenarios, including 50 MCM/yr for Dubaydib, 25 MCM/yr for Wadi Haswa, and 25 MCM/yr for Baten al-Ghoul.

Following this project, SWK issued a detailed well field design report (1996) which laid the foundations for the current well field and well design. In 2001, Brown & Root North Africa (BRNA) reviewed previous well field proposals, and in this review, BRNA promoted the Dubaydib wellfield as the best location with a production of 120-150 MCM/yr, and proposed improvements in production well layout as well as design. After drilling and testing two exploration wells in the area (DPB1 and 2DPB), SWK re-evaluated the Dubaydib prospects positively (2002), and BRNA (2006) subsequently confirmed the well locations and well designs for the 100 MCM/yr Dubaydib wellfield. In 2009, the Ministry of Water and Irrigation/Water Authority issued tenders for the drilling of 55 production wells and nine (9) pressure gauge wells based on BRNA's final design. The drilling campaign extended during the period 2010-2013 and the wellfield has been put into production since then at a rate of 100 million cubic meters/year.

The groundwater model for the Dubaydib wellfield, which taps into the Ram Group aquifer system, has undergone progressive updates between 2022 and 2024 in order to evaluate the long-term impacts of current and planned abstraction levels. These updates have provided essential input for strategic water resource management in the Disi region, particularly as the aquifer is being mined with negligible recharge.

In 2023, attention shifted to identifying new production well sites to support an increase in abstraction up to 120 MCM/year. A total of 47 candidate sites were evaluated using a multi-criteria framework that

considered hydrogeological suitability, water quality, infrastructure connection costs, and border proximity constraints. A shortlist of 12 optimal well sites was generated, and the model was updated accordingly. Stakeholder workshops and field surveys conducted in mid-2023 validated the selected locations. Modeling results from this update indicated that expanding production would add approximately 5 to 10 meters of drawdown in certain parts of the wellfield on the long term by 2065. The long-term viability of new wells varied based on depth and geological setting, emphasizing the importance of careful design and operational planning.

By 2024, the model had been further refined using the latest groundwater level observations and production data collected up to mid-year. This latest update revisited five abstraction scenarios between 100 and 120 MCM/year, extending projections through 2065. The revised model closely matched observed trends in both monitoring and production wells. It confirmed that under both current abstraction levels (~100 MCM/year since 2014) and projected increases up to 120 MCM/year, the water table is expected to continue declining at an average rate of 1.2 to 1.5 meters per year.

Model simulations indicate that under the 100 MCM/year scenario, the piezometric depression could deepen by approximately 20 meters by 2038, while under the 120 MCM/year scenario, this could increase to 25 meters—representing an incremental difference of about 5 meters by 2038. By 2065, drawdowns of 50 to more than 60 meters are projected in many parts of the field. These effects are cumulative and not solely attributable to the project, as agricultural abstraction continues in parallel.

Areas of greatest concern include the agricultural zones of Al Mudawarra and Al Disi, where cumulative pumping stress from both project and non-project wells may amplify drawdowns.

Several production wells, including W01, W02, and P1, were projected to fall below pump intake levels by 2035, necessitating either reconfiguration or replacement. Under more intensive abstraction scenarios of 115 to 120 MCM/year, over ten wells could require intervention by 2050. In addition to operational risks, long-term impacts could include aquifer deconfinement, potential leakage from overlying strata, and reduced water quality particularly if pumping exceeds sustainable limits. It is also important to note that the model assumes consistent productivity from all wells and does not incorporate aging-related degradation, suggesting that actual performance might decline sooner than predicted. The Dubaydib wellfield groundwater model has been updated using the production data available up to March 2022 (hourly water levels in the nine (9) monitoring wells and 55 production wells, monthly abstraction flow rates). The groundwater model parameters (hydraulic conductivity, specific yield, specific storage coefficient for the aquifer properties, linear and quadratic head loss coefficient for the production wells) have been estimated using the Gauss-Marquardt-Levenberg algorithm implemented in the Parameter Estimation for Hydrogeological Processes (PEST-HP tool) [45].

Collectively, the results of the three modeling phases highlight the increasing long-term pressures on the Ram aquifer and underscore the importance of sustainable abstraction planning. While the model provides a robust basis for future decision-making, adaptive abstraction management strategies and periodic model updates will be essential to mitigate risks and ensure long-term water security in the Disi region.

[45] https://pesthomepage.org/software#:~:text=The%20latest%20version%20of%20PEST%20is%20named%20PEST_HP

Model history-matching has been carried out using a little less than 10 years of observations under pumping conditions. Model calibration has been improved since 2018, while the calibration method used provides opportunities to quantify the model uncertainty. The overall consistency of the model results and parameters with the observations and known properties of the Ram group aquifer indicates that the updated calibrated model is robust, reliable and suitable to use for predictive simulations.

Six (6) abstractions scenarios were investigated for the period 2022-2065, to assess the quantitative impacts of increasing groundwater abstractions within the wellfield (100 MCM/yr, 112 MCM/yr, 135 MCM/yr), including the implementation of new production wells north and south of the wellfield and/or conversion of existing irrigation wells in Al Disi area. The wells located in Al Disi (northwest of the Dubaydib wellfield) are tapping the same aquifer as the Dubaydib wellfield production wells (i.e. the Disi/Ram Group aquifer). The groundwater model assessment concludes that current withdrawals from all the discharge wells are depleting the groundwater resource (The model covers the southern part of Jordan and extends southwards into northwest Saudi Arabia[46]), with water levels expected to decline by 1 to 2 meters per year, leading to a cumulative drop of 30 to 40 meters by 2038 and by 60 to 80 meters by 2065 compared to 2022. Alternative abstraction scenarios suggest an additional drawdown of 2 to 20 meters by 2040, especially in areas with existing irrigation, such as Al Disi and Al Mudawwarah, with scenarios involving additional wells exacerbating this effect. While uncertainties in the model's predictions range from two (2) to four (4) meters by 2050, greater uncertainty (+/- 5 meters by 2040) arises from neighboring abstractions. Long-term effects may include a transition of parts of the aquifer from a confined to an unconfined state, potentially impacting groundwater quality and aquifer transmissivity, along with increased leakage from the overlying Khreim aquifer. The model effectively replicates water levels in production wells, supporting well rehabilitation efforts and highlighting unexpected well behaviors.

In conclusion, while the Ram group aquifer holds substantial reserves and the impacts of current groundwater withdrawals remain manageable in the short term, the long-term outlook is concerning. Continued depletion, particularly in irrigation areas, coupled with uncertainties in abstraction scenarios and neighboring withdrawals, necessitates sustainable groundwater governance.

The recommendations include continuing wellfield monitoring, enhancing regional aquifer monitoring, especially along the Jordan-Saudi border, developing a joint groundwater strategy with neighboring users, assessing the risks of drawdowns in irrigation areas, obtaining information on Saudi groundwater abstractions, and refining the model for improved predictive accuracy. **Figure 26** shows the forecast groundwater level in selected production well up to the year of 2065.

[46] BRGM,2024 (Simulations of abstraction scenarios for the Dubaydib wellfield Final report BRGM/RC-73853-FR)

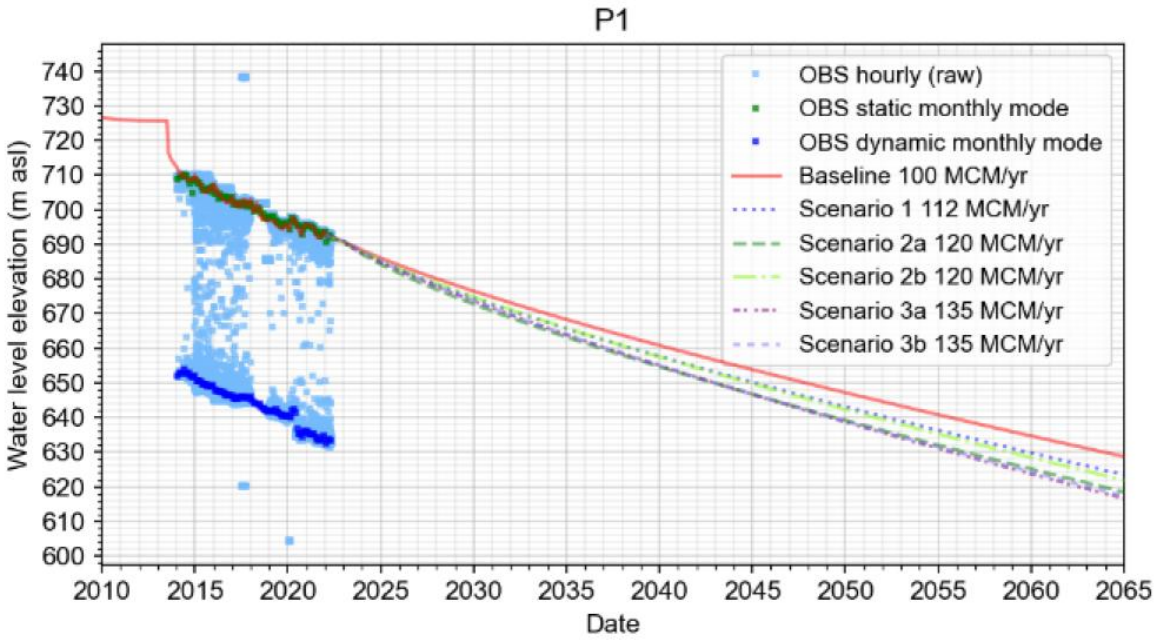


Figure 26: Forecast groundwater level in selected production wells

The Quality of Groundwater Discharge Wells

The project company and the O&M contractor commissioned the Royal Scientific Society (RSS) to assess the water quality in 55 wells located in the Disi-Mudawara basin. Over a four-year period (2021-2024), the RSS conducted comprehensive tests, analyzing the presence of inorganic chemical elements, substances that affect water taste, and various organic compounds. A total of 39 different organic and inorganic chemical compounds were evaluated, including Nitrate, Sulphate, Aluminium, Chloride, Copper, Sodium, Zinc, Manganese, Iron, Nitrite, Ammonium, Cadmium, Total Chromium, Mercury, Barium, Silver, Arsenic, Antimony, Boron, Selenium, Cyanide, Fluoride, Molybdenum, Lead, Nickel, DDT, Dieldrin, Aldrin, Heptachlor epoxide and Heptachlor, Lindane, Endrin, Benzene, Trichloroethylene (TCE), Tetrachloroethylene, Ethylbenzene, Toluene, Total Xylene, 2-4-5T, and 2,4-D. According to the Jordanian Standard (JS 286:2015) for drinking water, it was determined that most values fall below the maximum permissible limit, with a few slightly approaching the threshold. These findings strongly indicate the overall quality of the water. The detailed results are shown in Annex 7.

Potential Natural Radioactivity

Methodologies have been established by WAJ to calculate the Annual Effective Radiation Dose (AED) an individual may receive from consuming natural and industrial radionuclides via drinking water. These methodologies also determine the concentration of a specific radionuclide in drinking water that would exceed a given individual dose standard, as outlined by the World Health Organization (WHO 2011) and Jordan's drinking water quality standards.

In these calculations (**Table 13**), Jordanian Standards (JS 286/2015) specify using an adult drinking water consumption rate of 730 L/year, an individual dose standard of 0.5 mSv/year, which represents a guideline

level not to be exceeded for the total annual effective dose from all radionuclides combined. If multiple radionuclides are present, the total annual effective dose is calculated as the sum of the AED contributions from each radionuclide.

Based on previous studies of groundwater from the Ram Basin, the radionuclides that contribute the most to the radiation dose through direct consumption of Disi water at the wellhead are 228Ra and 226Ra. The concentration of lead-210 (210Pb) was below or equal to the detection limit (0.02 Bq/L) for most wells, indicating it does not contribute to the AED.

Table 13: Guidance Levels for Radionuclides Contributing to the Annual Equivalent Dose AED According to JS 286/2015

Radionuclide	Dose Coefficient (mSv/Bq) (DC)	Guidance level (Bq/liter) (GL)
Radium-226	$2.8X10^{-4}$	2.44
Radium-228	$6.9X10^{-4}$	0.99

WAJ has conducted several studies to monitor the radioactive quality of groundwater in the Disi aquifer. The purpose of the monitoring is to assess the radioactivity level of groundwater in the Disi wellfield (BH) and combined well field (CO). The data for the Disi wellfield during the 2021-2022 round (**Table 14**) shows that almost all the 55 wells exceed the screening values for gross Alpha and Beta activities specified in the Jordanian Standard for Drinking Water (JS 286/2015).

Results of Alpha, Beta, Ra226, Ra228 and Does Coefficient, of all operating boreholes (BH) (the 55 wells in the Disi well field) is shown the **Table 14** below.

Table 14: The Disi Wells Radioactivity Data for the 2021-2022

Well Name	Collection Date	Alpha (Bq/L)	Beta (Bq/l)	Ra226 (Bq/L)	Ra 228 (Bq/L)	Dose(mSv/y)	Result
ISO-P1	8/2/2022	3.41	3.38	0.67	1.7	0.99	*High*
ISO-P2	29/06/21	5.21	5.25	1.17	2.84	1.67	*High*
ISO-P3	9/3/2021	3.46	3.53	0.6	1.87	1.06	*High*
ISO-P4	9/3/2021	3.83	3.77	0.59	1.89	1.07	*High*
ISO-P5	9/3/2021	3.58	3.8	0.56	1.75	1.00	*High*
ISO-P6	29/06/21	4.29	4.39	0.67	1.95	1.12	*High*
ISO-P7	9/3/2021	3.71	3.94	0.77	1.91	1.12	*High*
ISO-P8	9/3/2021	3.94	4.12	0.94	2.45	1.43	*High*
ISO-W1	9/3/2021	3.67	3.12	0.93	1.81	1.10	*High*
ISO-W2	30/03/22	3.6	3.49	0.65	1.74	1.01	*High*
ISO-W3	9/3/2021	1.44	1.31	0.31	0.74	0.44	*Accepted*
ISO-W4	9/3/2021	2.78	2.3	0.41	1.06	0.62	*High*
ISO-W5	30/03/22	1.88	1.73	0.28	0.91	0.52	*High*
ISO-W6	30/03/22	2.11	1.71	0.28	1	0.56	*High*
ISO-W7	30/03/22	1.74	1.44	0.35	1.05	0.60	*High*
ISO-W8	30/03/22	3.7	4.19	0.49	2.14	1.18	*High*
ISO-W9	30/03/22	4.32	4.29	0.62	2.17	1.22	*High*
ISO-W10	30/03/22	3.3	3.92	0.62	2.17	1.22	*High*
ISO-W11	30/03/22	1.24	1.37	0.28	0.89	0.51	*High*
ISO-W12	15/06/22	3.46	2.18	<0.12	0.87	0.46	*Accepted*

Well Name	Collection Date	Alpha (Bq/L)	Beta (Bq/l)	Ra226 (Bq/L)	Ra 228 (Bq/L)	Dose(mSv/y)	Result
ISO-W21	29/06/21	1.47	0.85	0.7	1.48	0.89	*High*
ISO-W22	29/06-21	1.99	2.05	0.39	0.95	0.56	*High*
ISO-W23	29/06/21	3.18	3.26	1.71	2.94	1.83	*High*
ISO-W24	29/06/21	2.73	2.55	0.49	1.39	0.80	*High*
ISO-W25	29/06/21	3.54	3.32	0.54	1.38	0.81	*High*
ISO-W26	29/06/21	3.14	2.86	0.52	1.25	0.74	*High*
ISO-W27	14/9/2022	2.54	2.16	0.24	0.87	0.49	*Accepted*
ISO-W28	15/06/22	3.37	2.2	0.21	0.82	0.46	*Accepted*
ISO-W29	14/9/2022	3.87	2.85	0.23	0.98	0.54	*High*
ISO-W30	15/06/22	2.08	1.34	0.15	0.64	0.35	*Accepted*
ISO-W31	15/06/22	3.59	2.77	0.17	1.25	0.66	*High*
ISO-W32	15/09/21	0.59	0.85	0.26	0.35	0.23	Accepted
ISO-W33	15/09/21	0.51	0.68	0.21	0.28	0.18	Accepted
ISO-W34	8/2/2022	1.94	1.76	<0.12	0.68	0.37	Accepted
ISO-W35	15/09/21	0.49	0.75	0.18	0.26	0.17	Accepted
ISO-W36	15/09/21	1.76	1.99	0.18	0.8	0.44	Accepted
ISO-W37	8/2/2022	1.73	1.55	<0.12	0.64	0.35	Accepted
ISO-W38	15/09/21	3.29	3.16	0.39	1.43	0.80	High
ISO-W39	15/09/21	1.01	1.02	<0.12	0.36	0.21	Accepted
ISO-W40	15/09/21	2.5	2.52	0.3	1.11	0.62	High
ISO-W41	8/2/2022	3.08	2.8	0.28	1.23	0.68	High
ISO-W42	8/2/2022	2.18	2.23	0.19	0.96	0.52	High
ISO-W43	8/2/2022	3.76	3.03	0.53	1.49	0.86	High
ISO-W44	8/2/2022	1.31	1.1	<0.12	0.39	0.22	Accepted
ISO-W45	15/06/22	3.64	1.65	0.24	1.07	0.59	High
ISO-W46	15/06/22	1.75	1.25	<0.12	0.51	0.28	Accepted
ISO-W47	14/9/2022	3.33	2.78	0.26	1.16	0.64	High
ISO-W48	8/2/2022	3.01	2.86	0.33	1.12	0.63	High
ISO-W49	14/9/2022	2.74	2.84	0.4	1.24	0.71	High
ISO-W50	14/9/2022	2.48	2.63	0.35	1.12	0.64	High
ISO-W51	14/9/2022	1	0.95	<0.12	0.31	0.18	Accepted
ISO-W52	14/9/2022	1.72	1.93	0.35	0.93	0.54	High
ISO-W53	14/9/2022	2.88	2.66	0.38	1.14	0.65	High
ISO-W54	14/9/2022	2.78	2.95	0.54	1.26	0.75	High
ISO-W55	14/9/2022	2.64	3.15	0.69	1.39	0.84	High
Average		2.72	2.5	0.53	1.35	0.71	
Maximum		5.21	5.25	1.71	2.94	1.83	

Well Name	Collection Date	Alpha (Bq/L)	Beta (Bq/l)	Ra226 (Bq/L)	Ra 228 (Bq/L)	Dose(mSv/y)	Result
Minimum		0.49	0.68	0.18	0.26	0.17	

The results of the comparative work from 2014 until 2022 indicated that the results of the Annual Equivalent dose for each of 55 wells due to the natural radioactivity at the well head ranged from 0.68 mSv /y to 0.76 mSv /y and this shows that the largest difference in the dose factor during eight (8) years did not exceed than 0.08 mSv /y, which is not a significant deviation, because it represent not more than 11% of the average value. The minimum value of 0.68 mSv /y, was detected in 2019-2020 round, with the maximum value of 0.76 mSv /y was detected in 2016 round.

The slight variation can be explained by three main factors: the long monitoring period, which allows natural fluctuations to appear; the uncertainty inherent in radiological measurements; and the fact that the AED calculation is based on two separate inputs, the measured radionuclide concentrations and the dose conversion factors—both of which contribute to the overall variability.

The annual effective dose is adopted for comparison instead of alpha, beta, Ra226 or Ra228 individually because the AED is calculated by an equation that reflects the contribution of all other radionuclides, also, that the AED has a specified limit in all international standards. The majority of the AED in well and post-transfer is due to the contribution of 228Ra, which is a member of the thorium decay chain. Radium-226 was also noted but did not constitute the main component in terms of AED.

Private Wells within the Project Area

Within the Project Area and according to data collected from WAJ, it was found that the total number of private wells is 46, belonging to agricultural institutions and companies. **Figure 27** shows the distribution of these private wells.

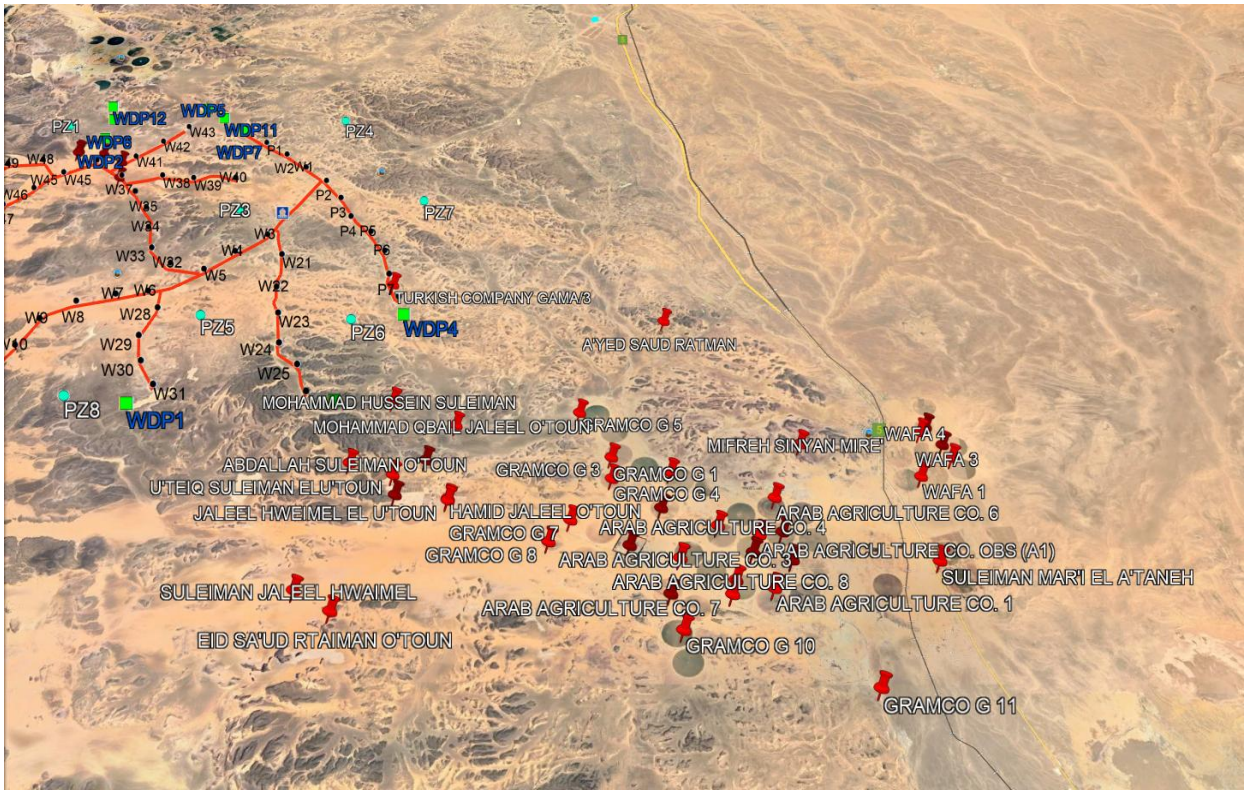


Figure 27: Distribution of the Private Wells within the Project Area

Table 15 highlights the abstraction of water for private irrigation wells in the Disi area. The wells are owned by both large agricultural companies and individual private owners. The total water abstraction in 2023 from these wells amounts to 8.628297 MCM.

One of the key observations is that Rum Agricultural Company is the largest water user in the region, operating 12 wells that collectively abstract 7.536856 MCM, accounting for approximately 87.3% of the total abstraction. Among these wells, ED1501 (S1) has the highest abstraction, withdrawing 1.46603 MCM, which constitutes 17% of the total water use. This indicates the company's significant reliance on groundwater resources for irrigation activities.

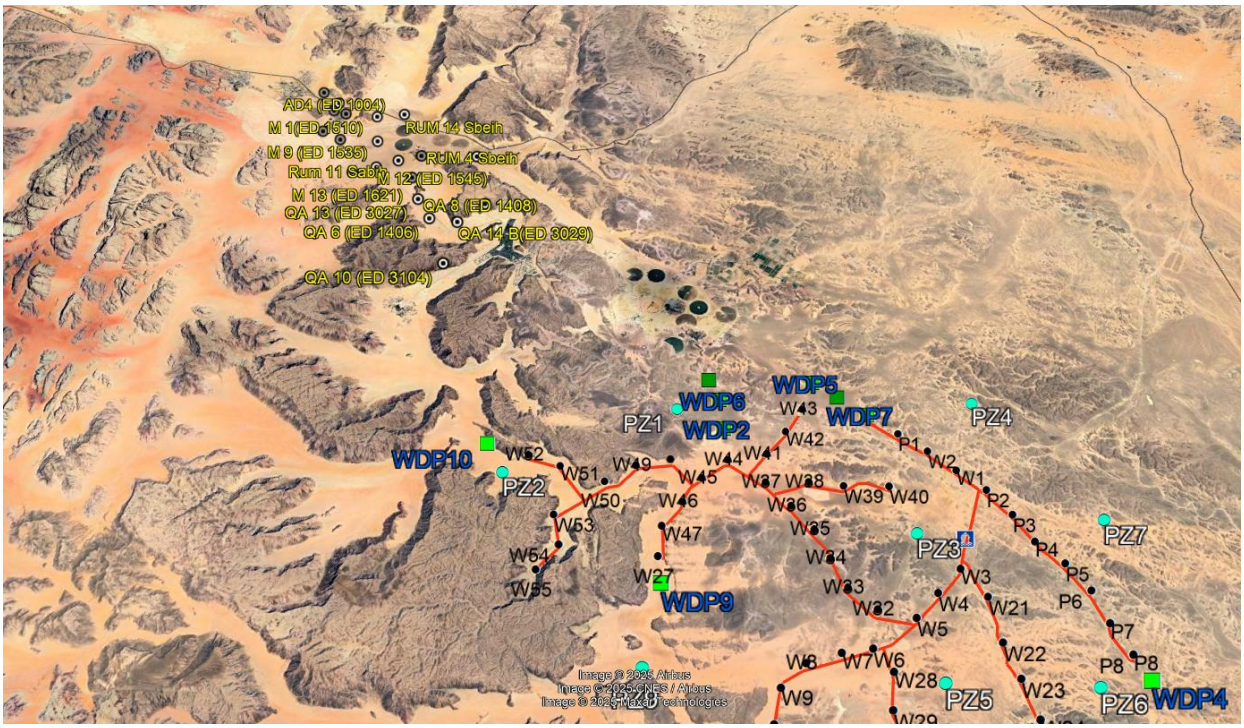
In contrast, other private owners contribute minimally to the total water abstraction. For instance, wells operated by Ali Al-Atoon and Aayed Al-Atoon collectively abstract only 0.12275 MCM, representing 1.4% of the total. This disparity highlights the dominance of Rum Agricultural Company in water use within the region.

Table 15: Abstraction from the Private Wells within the Project Area (MWI)

Well Code	Owner	Coordinates		Type of Use	Abstraction for 2023 (MCM)
ED1501	شركة رم الزراعية S1	884320	217520	Private irrigation	1.46603
ED1505	شركة رم الزراعية S5	881560	220000	Private irrigation	1.09335
ED1550	شركة رم الزراعية S11	882400	217500	Private irrigation	1.01344
K1032	شركة الضمان للاستثمار والصناعات الزراعية/ 9	861500	240400	Private irrigation	0.96562
ED1504	شركة رم الزراعية S4	881850	218650	Private irrigation	0.82902
ED1506	شركة رم الزراعية S6	881560	220640	Private irrigation	0.7895
ED1608	شركة رم الزراعية S24	884300	220050	Private irrigation	0.751369
ED1614	شركة رم الزراعية S20	884500	219900	Private irrigation	0.623156

Well Code	Owner	Coordinates		Type of Use	Abstraction for 2023 (MCM)
ED1607	شركة رم الزراعية S23	883350	223150	Private irrigation	0.468355
ED1613	شركة رم الزراعية S21	883600	221300	Private irrigation	0.266737
ED1502	شركة رم الزراعية S2	884180	218150	Private irrigation	0.14207
K3038	علي سليمان مرعي العطون	858296	235313	Private irrigation	0.1
ED1101	شركة رم الزراعية S10	883320	217220	Private irrigation	0.0969
K3043	عايد سعود رتيمان العطون	865538	242917	Private irrigation	0.02275
Total					**8.628297**

According to the data collected from Aqaba Water Company (AW), it was found that approximately 20 wells are owned by the company and extract water from the Disi Aquifer. The distribution of these wells is detailed in **Figure 28**, with the wells located approximately 10 kilometers apart.



Source: Aqaba Water Company

Figure 28: Distribution of Wells Owned by Aqaba Water Company

Table 16 provides data on 17 wells, including their Dynamic Water Level (DWL) and production rates (measured in cubic meters per hour). The Dynamic Water Level (DWL) for the wells ranges between 115 meters (AD3) and 150 meters (Rum13). Wells with shallower DWLs, such as AD3 (115m) and QA6 (117m), generally show higher production rates, which indicates better accessibility to water resources. On the other hand, deeper wells, such as Rum13 (150m), exhibit lower production rates (105 m^3/h), suggesting challenges in water extraction due to the greater depth. Notably, one well (QA9) lacks DWL data, which may require further investigation.

In terms of production rates, the highest-performing well is Rum1, producing 173 m^3/h, followed by QA9 (160 m^3/h) and QA6 (158 m^3/h). In contrast, the well with the lowest production rate is QA5, which

produces only 54 m^3/h, despite having a moderate DWL of 134 meters. This discrepancy may indicate issues such as reduced aquifer capacity or inefficiencies in the well's operation.

Table 16: The Production of Wells Owned by Aqaba Water Company

#	well Name	Dynamic Water Level	well production (m^3/h)
1	QA1	124	120
2	QA2	148.3	112
3	QA3	139	133
4	QA4	124	75
5	QA5	134	54
6	QA6	117	158
7	QA7	124	128
8	QA9	N.A	160
9	QA10	124	145
10	QA12	124	122
11	QA13	145	102
12	QA14-A	135	103
13	Rum1	141	173
14	Rum9	131	145
15	Rum12	145	118
16	Rum13	150	105
17	AD3	115	92

The Shared Basin between Jordan and Saudi Arabia (Saq-Rum)

Transboundary aquifers contain natural underground channels through which groundwater flows across international borders, as well as the extension of the aquifer itself into multiple countries. Activities in one country, such as over-extraction or severe pollution, can significantly affect groundwater resources in neighboring countries. Managing transboundary aquifers is often challenging due to a lack of institutional commitment and insufficient resources for gathering necessary information, particularly at the local level.

MWI has taken important steps toward fostering cooperation with neighboring countries through data coordination, harmonization, and exchange. These processes are fundamental to building mutual understanding, reaching agreements, and developing a shared conceptual model of the aquifer, an essential foundation for effective and sustainable transboundary water management.

In Jordan, the sandstone formations of the Rum Group are found both underground and in outcrops, except in the Wadi Araba region. In Saudi Arabia, the Saq sandstones cover a large area, stretching from the Qassim region to the northern border.

The Saq-Rum sandstone aquifer system spans a total area of approximately 560,000 km^2, with 82,000 km^2 located in Jordan and 478,000 km^2 in Saudi Arabia. The combined western part of the Saq-Rum basin system covers an area of about 308,000 km^2.

In Saudi Arabia, the Saq is located directly on the crystalline basement and gradually slopes north and northeast under less permeable formations. During the 1980s, the water level in the Saq was higher than the water level in the cave layer and the Saq was exploited in conjunction with the lower (Kahfa) and middle (Qewara) sandstones in the Tabuk region. The situation has since changed in this area, and the Saq

is now lower and to the east and south, the Saq is separated from the upper sandstone by the Hander clay. To the south of Tabuk city and up to Al-Ula city, small basalts are found above the Saq outcrop.

Jordan/Saudi Arabia Agreement for the Management of Groundwater in the Disi/Saq Basin

In 2015, Jordan and Saudi Arabia signed the "Agreement for the Management and Use of Groundwater in the Disi/Saq Basin" (Disi Agreement, 2015). This agreement includes, among other articles, the definition of a "management area," where groundwater withdrawals should be reserved for municipal purposes only, and a "no drilling area," where drilling for groundwater withdrawals should be prohibited. The following is a summary of the most important points:

- An agreement was signed between Jordan and Saudi Arabia in 2015;
- Determining the boundaries of the agreement / water basin;
- Disi in Jordan and Saq in Saudi Arabia;
- Administrative area and prohibited / protected area;
- Investment projects for groundwater may not be established in the protected area;
- Drilling in the administrative area must be in accordance with the agreed standards;
- Drilling in the protected area must be for monitoring purposes only;
- Protection from pollution;
- Use of groundwater for domestic purposes only;
- Joint Water Committee (to monitor the implementation of the agreement, and discuss any issue that may arise due to investments, pollution, and changes in water levels), experts may be invited;
- Exchange of monitoring data.

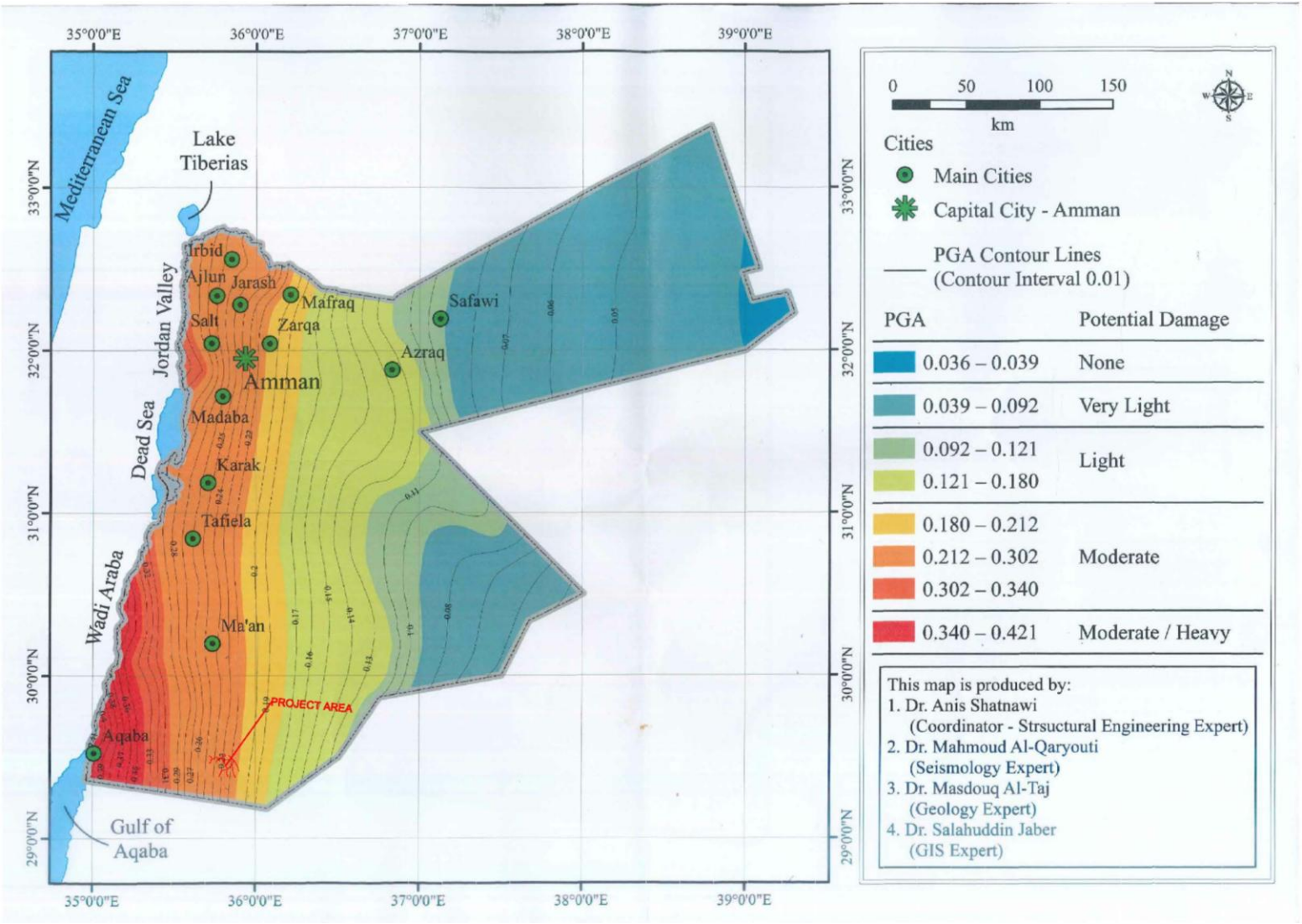
The agreement aims to achieve long-term sustainable management of this non-renewable transboundary groundwater resource between Jordan and the Kingdom of Saudi Arabia by integrating the following aspects:

- Monitoring and protection;
- Sustainability of the implementation and development of the agreement through the joint committee;
- Data exchange and dissemination;
- Social and economic aspects by limiting the use of this groundwater for domestic purposes only.

In conclusion, the long-term sustainability of groundwater resources is at risk, and without comprehensive monitoring, collaborative management among stakeholders, these resources could be further stressed, posing a significant challenge to future generations. Therefore, The MWI, in coordination with relevant stakeholders, should take a leading role in implementing a coordinated approach to water use, conservation, and policy enforcement to safeguard this vital resource.

5.2.7.3 Tectonic Setting

The project area lies within the area of a peak ground acceleration of 0.212 – 0.302 m/s^2. The Peak ground acceleration (PGA) is equal to the maximum ground acceleration that occurred during earthquake shaking at a location. PGA is equal to the amplitude of the largest absolute acceleration recorded on an accelerogram at a site during a particular earthquake.



Source: Ministry of Public Works and Housing, (2022)

Figure 29: The Seismic Distribution Hazard Map of Jordan

The United States Geological Survey developed an Instrumental Intensity scale, which maps peak ground acceleration and peak ground velocity on an intensity scale similar to the felt Mercalli scale. **Table 17** below represents the Mercalli scale.

Table 17: Mercalli Scale of PGA

Instrumental Intensity	Acceleration (m/s^2)	Velocity (cm/s)	Perceived shaking	Potential damage
I	< 0.0167	< 0.1	Not felt	None
II–III	0.0167 – 0.137	0.1 – 1.1	Weak	None
IV	0.137 – 0.382	1.1 – 3.4	Light	None
V	0.382 – 0.902	3.4 – 8.1	Moderate	Very light
VI	0.902 – 1.765	8.1 – 16	Strong	Light
VII	1.765 – 3.334	16 – 31	Very strong	Moderate
VIII	3.334 – 6.374	31 – 60	Severe	Moderate to heavy
IX	6.374 – 12.160	60 – 116	Violent	Heavy
X+	> 12.160	> 116	Extreme	Very heavy

Source: The United States Geological Survey, Mercalli Intensity Scale, Wald et al., (1999)

According to the Mercalli scale, the area experiencing a PGA of 0.212 – 0.302 m/s^2 falls under intensity IV. This level of shaking is generally perceived as light, posing no significant threat to infrastructure or buildings. However, it may be noticeable both indoors and outdoors during daylight hours. At night, it could awaken some individuals, causing disturbances to dishes, windows, and doors, with walls potentially emitting cracking sounds. The sensation might resemble that of a heavy truck striking a building.

Intensity	Shaking	Description/Damage
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest,especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Figure 30: Earthquake Intensity Scale, Modified Mercalli Intensity (MMI)

Source: The United States Geological Survey, Modified Mercalli Intensity Scale, (1931)

5.3 Biological Environment

5.3.1 Study Approach for Biological Environment

The study adopted a comprehensive approach to evaluate the biological environment by analyzing key ecological components in relation to their physical settings. This method allows for a holistic understanding of the potential environmental impacts the project may have. The following key biological elements were targeted and linked with the physical environment units of the project area:

- **Biogeographical Zones and Vegetation Types**: The study focused on identifying the specific biogeographical zones and vegetation types present within the project area. These zones are essential for understanding the environmental conditions, including soil type, climate, and natural plant communities, which in turn influence the distribution of flora and fauna.
- **Flora**: An assessment of plant species within the project area was conducted to identify the diversity, abundance, and conservation status of the vegetation. Special attention was paid to endemic, rare, or threatened plant species that could be impacted by project activities.
- **Fauna**: The study selected key wildlife groups to assess the status of fauna in the project area. Mammals, birds, and reptiles were chosen based on their national conservation status, ecological importance, and sensitivity to habitat disturbance. The focus was on species that are vulnerable to habitat changes or disturbances from human activities.
- **Sensitive Habitats**: The study identified and analyzed areas of significant biological importance within and around the project area, such as Protected Areas, Rangeland Reserves, and IBA. These habitats are crucial for the survival of certain species and require special consideration during project planning and execution.

- **Critical Habitat:** A Critical Habitat Assessment (CHA) was conducted to determine whether any areas within the project site meet the criteria for critical habitat as defined by IFC Performance Standard 6 (PS6) and EIB Environmental and Social Standard 4 (ESS4). This includes habitats of significant importance for endangered and endemic species, migratory birds, and unique or threatened ecosystems.

- **Ecosystem Services**: The study also assessed the range of ecosystem services provided by the local environment. The potential impacts of the project on these services were analyzed to ensure that ecosystem functions are maintained and not compromised by development activities.

5.3.2 Literature review

As part of the study, the team conducted an extensive literature review to gather all relevant data previously collected from the project site and its surrounding areas. This involved reviewing a wide range of sources, including:

- Previous Environmental Impact Assessments: These assessments provided baseline data on environmental conditions, species inventories, and potential environmental risks.
- Surveys and Biodiversity Assessments: If available, data from earlier surveys were incorporated to supplement the existing information and offer a more comprehensive view of the site's ecological characteristics.
- Additional Scientific Research: The team also consulted relevant scientific literature and databases to gather information on regional biodiversity trends, habitat types, and conservation priorities.

The desktop study focused on analyzing the available information and identifying knowledge gaps that needed to be addressed through further field visits. The key areas of focus during this review were:

- **Flora and Fauna Species**: The presence and distribution of plant and animal species in the project area were examined, paying particular attention to species of conservation concern, such as those that are threatened, endangered, or endemic to the region.
- **Habitat Types and Species Communities**: The study investigated the types of habitats present, such as desert ecosystems, wadis, and rangelands, and the characteristic species that define these habitats. This provided a broader understanding of the ecological dynamics and species interactions within the project area.

By combining the findings from the literature review with field assessments, the study aimed to provide a detailed and scientifically robust evaluation of the biological environment and the potential impacts of the project on biodi
ersity.

5.3.3 Field Work rapid assessment

The field visit for the rapid biodiversity assessment was conducted over two days, from the 6th to the 7th of August 2024. The assessment involved surveying the wells' locations and the access roads to twelve wells (W63, W69, W72, W84b, W86, W94, W97, W98, W95GT, W65GT, W64GT, and P1A). At each well site, flora and fauna species were observed and recorded within a 50-meter radius from the well location. To maximize wildlife observation opportunities, visits to each site were scheduled for early morning or late afternoon, as these times are optimal for detecting wildlife activity.

Data collection during the fieldwork was carefully organized. Handheld GPS devices were used to mark the exact coordinates of each point and to log the locations of any species of conservation importance. Observations were systematically documented on specially designed data sheets, ensuring accurate and efficient recording of data. This methodical approach enabled a precise assessment of biodiversity in the area while facilitating effective data management for subsequent analysis.

5.3.4 Baseline Conditions for Biological Environment

5.3.4.1 Biogeographic Zones

Jordan is categorized into four separate biogeographic regions: the Mediterranean, the Irano-Turanian, the Saharo-Arabian, and the Sudanian. The lines delineating the zones are purely suggestive, and many species can be observed in more than one region. (Al-Eisawi, 1996)

The project site is situated within two biogeographic zones: the Sudanian and Saharo-Arabian zones. Five wells (W84b, W86, W97, W98, and W69) are located in the Sudanian zone, sometimes referred to as the subtropical or Afrotropical region. This zone is confined to the warmest parts of Jordan, including areas such as Wadi Rum, Wadi Araba, and the region around the Dead Sea. Extending north toward Dair 'Alia, it is characterized by extremely hot summers, with temperatures ranging from 15 to 45°C, and relatively warm winters. Occasionally, temperatures may exceed these limits on certain days. This region is notable for its location in the lowest point on Earth, the Dead Sea, which lies around -400 meters below sea level. The region receives minimal rainfall, ranging between 50 and 100 millimeters annually, and the soil is predominantly saline, sandy, or Hammada, often found in sand dunes. The vegetation here consists of tropical species, including *Acacia spp.*, *Ziziphus spina-christi*, and other important shrubs and annual herbs. Over 300 plant species in this region are endemic to Jordan, adding significant ecological value to the area. (Al-Eisawi, 1996)

The Saharo-Arabian zone, where the remaining seven wells (W63, W72, W94, W95GT, W65DT, W64GT and P1A) are located, represents the vast desert or Badia region of Jordan. This region is characterized by extremely arid conditions, with very poor soils that are generally saline, sandy-loam, or Hammada in texture. The landscape is dominated by gravelly plains rather than sand dunes, which are typical of other deserts. Rainfall is scarce, averaging between 50 to 100 millimeters per year, and temperatures can soar above 40°C in summer and drop below freezing in winter. Vegetation in this zone is sparse and mainly restricted to wadis where moisture is available. Common plant species include *Artemisia herba-alba*, *Achillea fragrantissima*, *Phlomis spp.*, *Astragalus spp.*, and *Stipa spp.*, which are well-adapted to the harsh desert environment. (Al-Eisawi, 1996)

Dominant plants that can be referred to the Sudanian element include many trees shrubs and herbs, such as: (Al-Eisawi, 1996)

Haloxylon persicum*,* *Calitropos procera,*
Moringa peregirena, *Acacia raddiana,*
Ziziphus spina cristi, *Belanites aegyptiaca,*
Zygophylum dumosum, *Salvadora persica,*
Ochradenus baccatus *Cucumis prophetarum*.

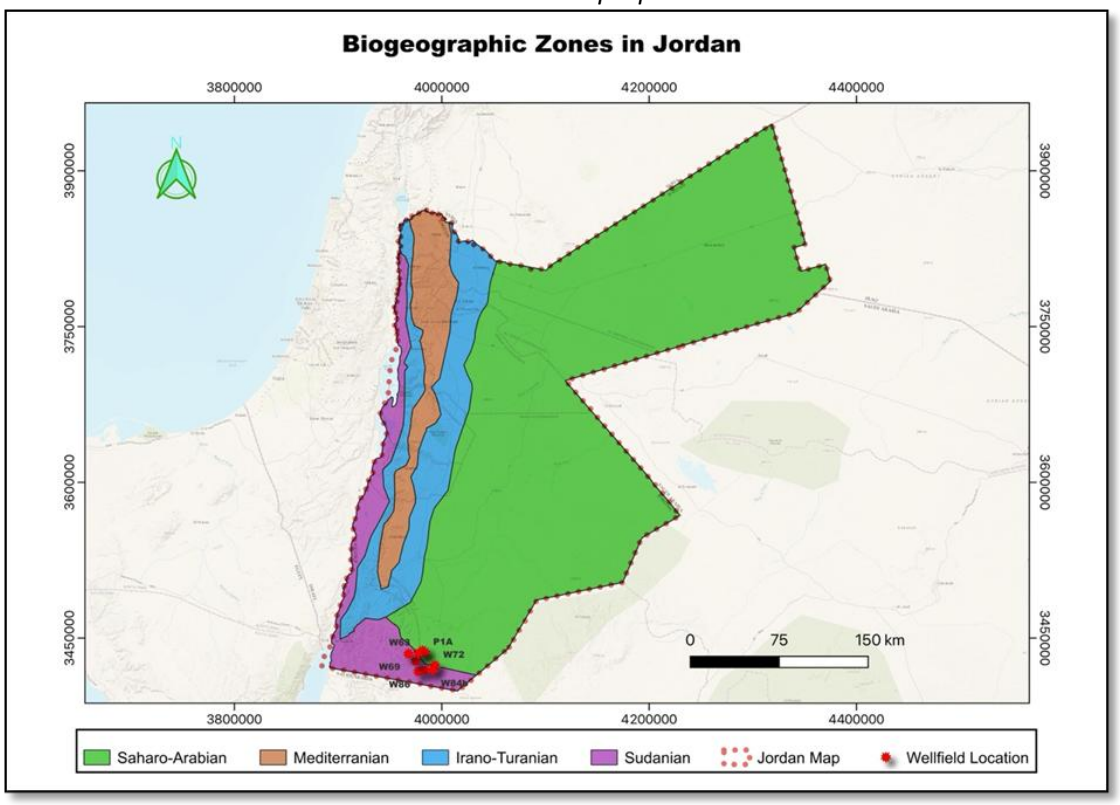


Figure 31: Biogeographic Zones of Jordan (Al-Eisawi, 1996)

5.3.4.2 Vegetation Types

There are three vegetation types present in the project area as shown on Map 3 these are:

Sand Dune Vegetation Type

This vegetation can only be found in the Sudanian Biogeographical Region, and the Wadi Rum Protected Area in Jordan is where the best examples of it can be seen. It is dominated by shrubs, which are known

as sand dunes fixatives. The most prominent species of these shrubs include *Haloxylon persicum, Retama raetam, Calligonum comosum, Neurada procumbens* and *Hammada scopiara*. (Al-Eisawi, 1996)

Acacia and Rocky Sudanian Vegetation Type

This vegetation type can only be found in the rocky regions of the area. Occasionally, it is seen in conjunction with the Sand Dune Vegetation Type in certain locations. These are the primary species that are representative of this type: *Acacia raddiana, Anabasis articulata, Caralluma spp., Fagonia spp., Gymnocarpos decndrum* and *Helianthemum lippii*. (Al-Eisawi, 1996)

Hammada Vegetation

The majority of the Saharo-Arabian region in Jordan is classified as Hammada, covering approximately 50% of the country's total area. Hammada is further divided into four main types based on soil composition and topography: run-off hammada, gravel hammada, pebble hammada, and sandy hammada (Al-Eisawi, 1996). Three types present in the project area:

- **Run-off Hammada**: Vegetation in run-off hammada is mainly confined to wadis and watershed areas, where water collects and supports denser plant life compared to the surrounding arid zones. The size of these areas can vary significantly, from a few meters to over a kilometer wide. For example, Wadi Bayer can exceed one kilometer in width, while Wadi Rajil and Wadi AL-Hazeem are typically much narrower. Vegetation varies by location; for example, along the Ma'an-Mudawarah road, common species include *Acacia tortilis*, *Acacia raddiana*, and *Tamarix spp.*

- **Gravel Hammada**: This is the largest and flattest part of Jordan's Eastern Desert, characterized by clayey loam soils covered in gravels. The vegetation consists mainly of low shrubs such as *Seidlitzia rosmarinus* and various annual herbs. Leading species include *Mesembryanthemum nodiflorum*, *Filago desertorum*, and *Gymnarrhena micrantha*.

- **Sandy Hammada**: This type is most common along Jordan's borders with Iraq and Saudi Arabia, and parts of it are found in the Ash-Shumari Reserve. The soil here is a mixture of gravel, pebbles, and sandy deposits originating from Saudi Arabia. In some areas, sand becomes dominant, leading to sand dune formations. Key species include *Seidlitzia rosmarinus*, *Atriplex spp.*, *Artemisia herba-alba*, and *Anabasis articulata*.

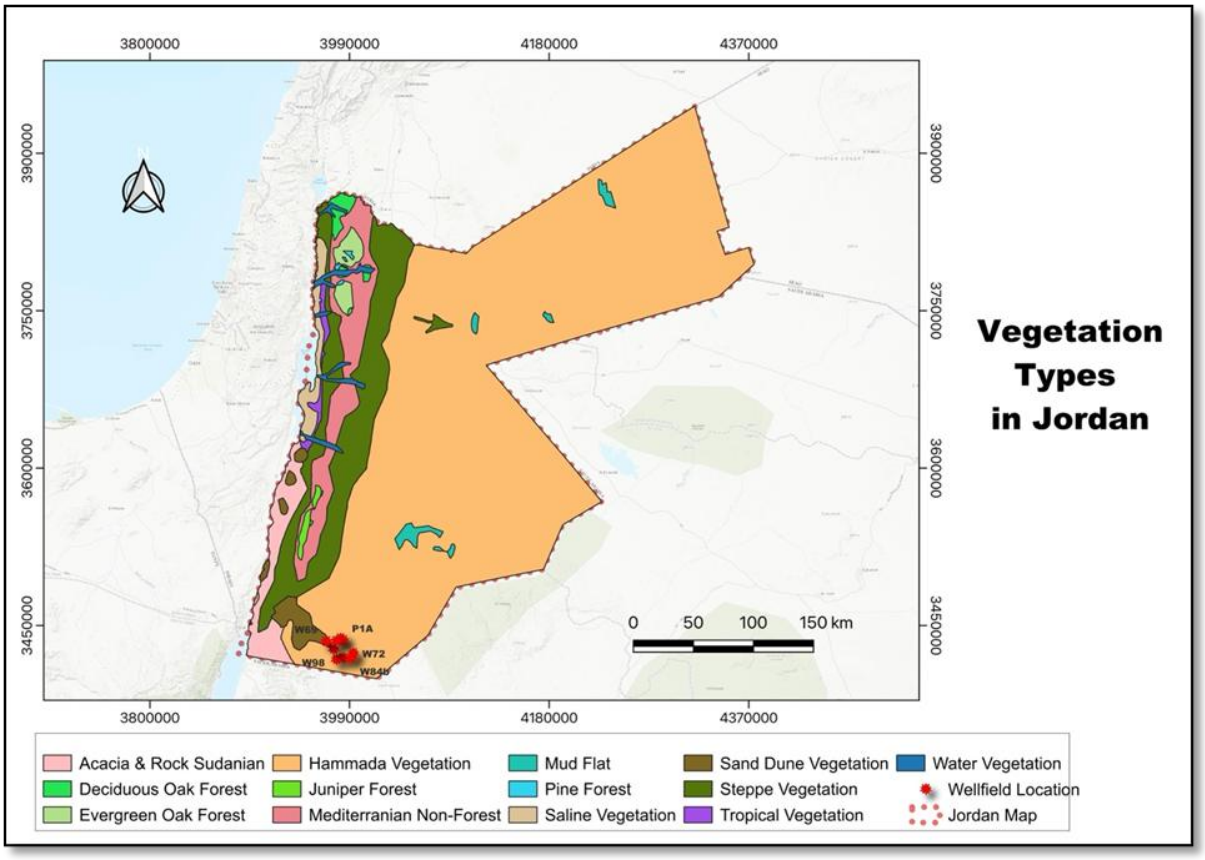


Figure 32: Vegetation Types in Jordan (Al-Eisawi, 1996)

Table 18 presents a selection of vegetation species that have been documented from the region that are of significant conservation importance.

Table 18: List of important plant species reported from the area (Taifour & El-Oqlah, 2014)

Family	Species	National Status
CARYOPHYLLACEAE	*Silene danaensis*	Rare, endemic South Jordan
CHENOPODIACEAE	*Haloxylon persicum*	Vulnerable
COMPOSITAE	*Anthemis melampodina*	Critically Endangered
	Anthemis scrobicularis	Critically Endangered
	Artemisia jordanica	Endangered
	Artemisia judaica	Vulnerable
	Onopordum jordanicolum	Rare, endemic
	Onopordum transjordanicum	Rare, endemic
	Verbesina encelioides	Critically Endangered
CUPRESSACEAE	*Juniperus phoenicea*	Endangered
LABIATAE	*Lavandula coronopifolia*	Near Threatened
	Micromeria graeca	Vulnerable
LEGUMINOSAE	*Acacia gerrardii*	Vulnerable
	Vachellia tortilis	Vulnerable
POLYGONACEAE	*Calligonum comosum*	Endangered
SCROPHULARIACEAE	*Scrophularia xylorrhiza*	Rare

The project area is part of a desert ecosystem, characterized by arid conditions and minimal vegetation. Due to the harsh environment, vegetation is typically confined to wadis, where water collects during sporadic rainfall events. However, the area has been significantly degraded by human activities, exacerbated by climate change and the scarcity of rain. Overgrazing, the expansion of vehicle tracks, and

other forms of land disturbance have contributed to the degradation of the ecosystem, limiting the natural regeneration of plant species.

Within the wadis near the well locations, *Acacia gerrardii* and *Retama raetam* were among the primary species observed, indicating the resilience of these plants in such dry conditions. Despite the presence of vegetation in these pockets, the majority of the land surrounding the wells remains barren, with almost no vegetation cover. The high level of human disturbance, including grazing and vehicle movement, has further hindered the potential for vegetation to thrive, leaving the landscape in a highly degraded state. Following is each well location description:

W94 and W95GT

The area surrounding Well W94 and W95GT is classified as Hammada, characterized by a barren, gravelly landscape with minimal to no vegetation directly at the site. However, close to the wells, a small wadi provides a more favorable microhabitat for plant life, where species such as *Seetzenia lanata*, *Acacia tortilis*, *Artemisia judaica*, *Pulicaria undulata*, *Citrullus colocynthis* and *Ochradenus baccatus* were observed. These species are typical of desert environments, thriving in areas where moisture can accumulate, and support limited but vital vegetation.

Figure 33: W94 Location

Despite the presence of these species in the nearby wadi, the overall area is highly disturbed by human activity. Heavy movement of vehicles has resulted in numerous tracks crisscrossing the landscape, contributing to significant land degradation. These disturbances further limit the potential for vegetation recovery and reduce the overall biodiversity at the site, leaving much of the surrounding area bare and unable to support a robust ecosystem.

P1A

The area around Well P1A is completely devoid of any flora species, with no vegetation observed at the site. It is classified as a Hammada landscape, characterized by barren, gravelly soil. The site shows clear signs of heavy disturbance, with numerous vehicle tracks crisscrossing the area, further contributing to the degradation of the already harsh environment. The lack of vegetation and the evident human impact make this location particularly susceptible to continued environmental degradation.

Figure 34: Acacia Tortilis

Figure 35: P1A sign of high disturbance

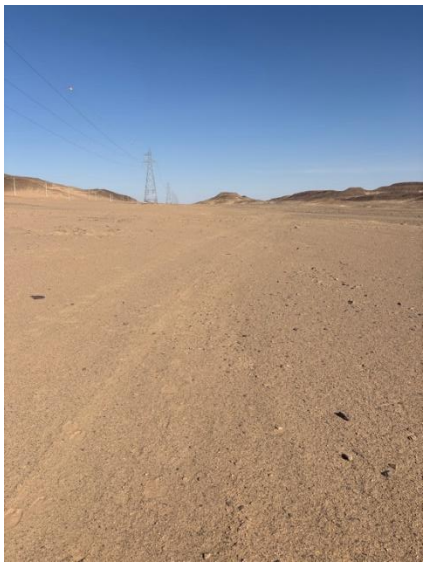


Figure 36: P1A sign of high disturbance

W72

The area surrounding Well W72 is a bare Hammada desert, with little to no vegetation directly at the site. However, a small seasonal water stream from the surrounding hills creates a more favorable environment for the growth of annual flora during brief periods of water availability. These seasonal streams support limited plant life, providing a temporary habitat for species that can take advantage of the short bursts of moisture. Despite the overall barren landscape, this small water stream plays a critical role in sustaining pockets of biodiversity in the otherwise harsh desert environment.

Figure 37: Annuals close to W72

W84b

The site surrounding Well W84b has some vegetation cover, with a few common species observed, including *Citrullus colocynthis*, *Asteriscus graveolens*, and *Artemisia judaica*. The area is classified as a

runoff Hammada, where water from occasional rainfall collects and supports vegetation growth. This type of landscape allows for slightly denser plant life compared to the barren Hammada, especially in areas where runoff channels or small wadis provide essential moisture. The presence of these species highlights the site's ability to sustain limited biodiversity in an otherwise arid environment.

Figure 38: W84b location

Figure 39: Vegetation at W84b

W86

The area surrounding Well W86 is dominated by sand dunes with no vegetation cover directly at the site. However, nearby, there is a wadi that supports a dense growth of *Retama raetam*. This wadi acts as an important habitat in the otherwise barren landscape, providing a refuge for plant life that can thrive in areas where water occasionally accumulates.

Figure 40: W86 location

Figure 41: Vegetation at W86

W97

The area surrounding Well W97 is a bare land located at the edge of a mud flat, where vegetation growth is extremely limited. The harsh conditions of the mud flat, with poor soil and minimal moisture retention, make it difficult for plant species to establish and thrive. As a result, the site is largely devoid of vegetation, reflecting the challenging environmental conditions typical of such areas in desert ecosystems.

W63

The area around Well W63 is a mud flat with no vegetation present.

W69

The area around Well W69 is characterized by sand dunes with scattered plant species.

W98

The area surrounding Well W98 consists of a combination of mud flats and sand dunes, with no vegetation cover observed at the site.

W64GT and W65GT

The wells W65GT and W64GT are located in a bare, rocky area that has been heavily disturbed by extensive vehicle tracks. The disturbance has significantly impacted the local environment, with only very limited vegetation present.

Figure 42: W97 location

Figure 43: W63 location

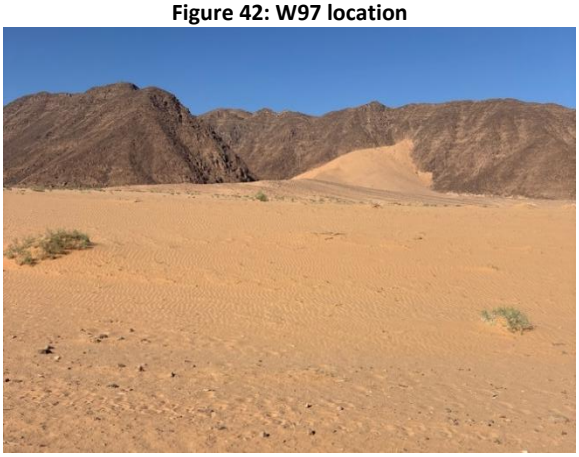


Figure 44: W69 location

Figure 45: W98 location

Access Roads

All wells in the project area are accessible via dirt roads that are commonly used by locals to reach the region. These access roads are generally devoid of vegetation, as they are situated far from water collection points such as wadis and small seasonal water streams. The lack of proximity to these moisture-

rich areas results in barren, dry conditions along the roads, further limiting the potential for any plant life to establish.

5.3.4.3 Fauna

Reptiles

Studies have identified a total of 35 reptile species in the project area and its vicinity, representing nine different families. These families include *Gekkonidae* (geckos), *Chamaeleonidae* (chameleons), *Agamidae* (agamas), *Lacertidae* (lizards), *Scincidae* (skinks), *Varanidae* (monitor lizards), *Leptotyphlopidae* (thread snakes), *Colubridae* (non-venomous snakes), and *Viperidae* (vipers). This diversity reflects the adaptability of reptile species to the arid desert environment, where they play an essential role in the local ecosystem.

Among these species, two are of special conservation concern according to the IUCN Red List. *Uromastyx aegyptia* (Egyptian spiny-tailed lizard) is classified as vulnerable, while *Coluber sinai* (Sinai racer) is listed as near threatened. Additionally, three species—*Chamaeleo chamaeleon* (common chameleon), *Ablepharus rueppellii* (Rüppell's snake-eyed skink), and *Lacerta cf. kulzeri*—are believed to be relicts from a former, more humid period in the area's history. These species inhabit limited and fragmented habitats, making their conservation particularly important. (Abu Baker, et al., 2004)

Table 19: List of species and their ecological importance (Disi, et al., 2001) (IUCN, 2024)

Family	Species	Common Name	IUCN Status
Gekkonidae	*Bunopus tuberculatus*	Baluch Ground Gecko	Least Concern
	Hemidactylus mindiae		Least Concern
	Pristurus rupestris	Rock Semaphore Gecko	Least Concern
	Ptyodactylus guttatus	Fan-footed Gecko	Least Concern
	Ptyodactylus hasselquistii		Least Concern
	Stenodactylus doriae	Dune Sand Gecko	Least Concern
	Stenodactylus sthenodactylus	Elegant Gecko	Least Concern
	Tropiocolotes nattereri	Natterers Gecko	Least Concern
Chamaeleonidae	*Chamaeleo chamaeleon*	Mediterranean Chameleon	Least Concern
Agamidae	*Laudakia stellio*	Starred Agama	Least Concern
	Phrynocephalus arabicus	Arabian Toad-headed Agama	Least Concern
	Pseudotrapelus sinaitus	Sinai Agama	Least Concern
	Uromastyx aegyptia	Egyptian Spiny–tailed Lizard	Vulnerable
Lacertidae	*Acanthodactylus boskianus*	Bosc's Fringe-toed Lizard	Least Concern
	Acanthodactylus opheodurus	Snake-tailed Fringe-toed	Least Concern
	Acanthodactylus schmidtii	Schmidt's Fringe-toed Lizard	Least Concern
	Lacerta cf. kulzeri		Rare
	Mesalina brevirostris		Least Concern
	Mesalina guttulata	Small-spotted Desert Racer	Least Concern
	Mesalina olivieri		Least Concern
Scincidae	*Ablepharus rueppellii*		Least Concern
	Chalcides ocellatus	Ocellated Skink	Least Concern
	Scincus scincus	Common Skink	Least Concern
Varanidae	*Varanus griseus*	Desert Monitor	Least Concern
Leptotyphlopidae	*Leptotyphlops macrorhynchus*	Hook-snouted Worm Snake	Least Concern
Colubridae	*Coluber elegantissimus*	Elegant Racer	Least Concern
	Coluber rhodorachis	Wadi Racer	Least Concern
	Coluber Sinai	Sinai Banded Racer	Near Threatened
	Eirenis coronella		Least Concern
	Lytorhynchus diadema	Crowned Leaf-nosed Snake	Least Concern

Family	Species	Common Name	IUCN Status
	Psammophis schokari	Forskal's Sand Snake	Least Concern
	Spalerosophis diadema	Diadem Snake	Least Concern
	Telescopus dhara	Arabian Cat Snake	Least Concern
Viperidae	*Cerastes gasperettii*	Arabian Horned Viper	Least Concern
	Echis coloratus	Hajar Saw-scaled Viper	Least Concern

Although the study area is known to host a rich diversity of reptiles, including 35 species across nine families, no reptiles were recorded during the field visit. This absence is likely due to the short duration of the study.

Mammals

In their native environments, a total of 26 different species of mammals were observed and documented from previous studies. These mammals were classified into the following categories: one ungulate, nine carnivores, eleven rodents, three bats, one insectivore, and one species of the family Hyraxidae. The conservation and ecological significance of a number of species is particularly noteworthy (**Table 20**).

Table 20: Conservation Important Species Reported from the Area

Common Name	Scientific Name	Global Status	National Status
Canidae			
Grey Wolf	*Canis lupus*	Least Concern	Endangered
Blanford's Fox	*Vulpes cana*	Vulnerable Mediterranean	Endangered
Felidae			
Caracal	*Caracal caracal*	Near threatened Mediterranean	Critically endangered
Sand Cat	*Felis margarita*	Near threatened Mediterranean	Critically endangered
Hyaenidae			
Hyena	*Hyaena hyaena*	Endangered	Near threatened
Rodentia			
Asian Dormouse	*Eliomys melanurus*	Least Concern	Near threatened
Hyraxidae			
Rock Hyrax	*Procavia capensis*	Least Concern	Endangered
Artiodactyla			
Dorcas Gazelle	*Gazella dorcas*	Vulnerable	Critically endangered
Nubian Ibex	*Capra ibex nubiana*	Vulnerable	Endangered

No mammal species were recorded during the survey. This absence of mammalian observations could indicate two possibilities, the presence of human activity within the area deterring wildlife, or the areas surveyed lacking sufficient habitat features to support a visible population of mammals.

Avifauna

A significant portion of the migration path that birds take between Africa, Asia, and Europe passes through Jordan. There are millions of birds that migrate over Jordan every year, and the majority of the avifauna that lives in Jordan also belongs to this migration. As a result of the large number of migratory birds that visit Jordan twice a year, the country has become an extremely important location for the avifauna of the entire world. According to BirdLife International, it is estimated that at least 500 million migratory birds belonging to more than 230 different species travel through Jordan twice a year and rest in IBAs located in the Middle East. There are 18 locations in Jordan that have been designated as Important Birds Areas. (Birdlife International, 2024).

An instrument for sensitivity mapping has been created by Birdlife International in order to evaluate the migratory soaring birds. For the purpose of determining the significance of the place for migrating soaring birds, this instrument was utilized. The soaring species that may be found on the site are listed in **Table 21** , along with their current conservation status. (Birdlife International , 2024)

Table 21: Important birds reported from the Area (Birdlife International , 2024)

Scientific Name	Common Name	Status
Aquila heliaca	Imperial Eagle	Vulnerable
Gypaetus barbatus	Bearded Vulture	Near Threatened
Neophrom percnopterus	Egyptian Vulture	Endangered
Falco concolor	Sooty Falcon	Vulnerable
Falco biarmicus	Lanner	Regionally Near Threatened
Falco cherrug	Saker Falcon	Endangered
Aquila Verreauxii	Verreaux's Eagle	Regionally Threatened
Circus cyaneus	Hen Harrier	Regionally Vulnerable

A total of 18 bird species were recorded during the survey, reflecting the avian diversity of the project area. Notably, two species observed have conservation status: The *Sooty Falcon* (*Falco concolor*), which is listed as Near Threatened, and the *Lesser Kestrel* (*Falco naumanni*), which is classified as Vulnerable according to the IUCN Red List. Both species are significant in terms of regional conservation efforts. The remaining bird species identified during the survey are considered common and resident to the area, indicating a stable avian population adapted to the local desert ecosystem.

Table 22: Bird Species Recorded during the field visit

Scientific Name	Common Name	Conservation Status
Aquila nipalensis	Steppe Eagle	Least Concern
Falco tinnunculus	Kestrel	Least Concern
Falco naumanni	Lesser Kestrel	Vulnerable
Falco concolor	Sooty Falcon	Near Threatened
Ammomanes cincturus	Bar-tailed Lark	Least Concern
Eremophila bilopha	Temminck's Horned Lark	Least Concern
Galerida cristata	Crested Lark	Least Concern
Calandrella rufescens	Lesser Short Toed Lark	Least Concern
Ammomanes deserti	Desert Lark	Least Concern
Corvus ruficollis	Brown Necked Raven	Least Concern
Oenanthe leucopyga	White Crowned Wheatear	Least Concern
Oenanthe isabellina	Isabelline Wheatear	Least Concern
Oenanthe deserti	Desert Wheatear	Least Concern
Hirundo rustica	Barn Swallow	Least Concern
Spilopelia senegalensis	Palm Dove	Least Concern
Columba livia	Rock Dove	Least Concern
Oena capensis	Namaqua Dove	Least Concern
Sylvia nana	Desert Warbler	Least Concern

5.3.4.4 Sensitive Habitats

Protected Areas

Jordan has established a total of 12 protected areas, covering approximately 5.3 % of the country's total land area. These protected areas, managed primarily by the RSCN, play a crucial role in conserving the country's unique biodiversity, safeguarding ecosystems, and providing refuge for endangered species. The RSCN continues to work toward expanding and managing these areas to ensure long-term ecological sustainability and balance with human development.

The closest protected area to the project site is the Rum Protected Area, located approximately 18 kilometers away (**Figure 46**). While the project site does not fall within the boundaries of this protected area, its proximity to Rum Protected Area is notable due to the ecological significance of the region. Rum Protected Area is a vital habitat for numerous species, including some that are of conservation concern. The distance from the project suggests that direct impacts on the protected area are unlikely, but indirect effects, such as disturbances to wildlife corridors or migration patterns, should be considered during the assessment process.

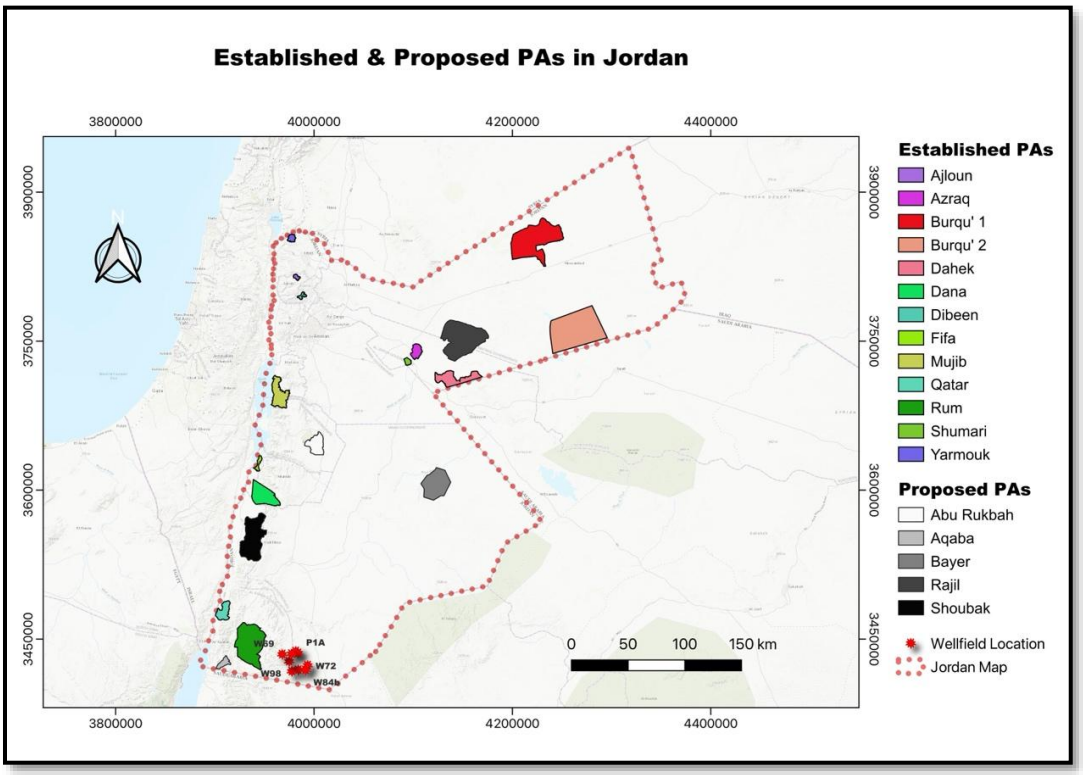


Figure 46: Protected Areas in Jordan (RSCN, 2024)

Important Bird Areas

The Rum IBA is a vital site for avian conservation in Jordan (**Figure 47**). Its diverse landscape, dominated by rugged mountains, vast sandy plains, and deep valleys, provides a variety of habitats that are crucial for both migratory and resident bird species. Serving as an important stopover for migratory birds, the Rum IBA plays a pivotal role in connecting Africa with Europe and Asia along important migratory routes. Among the notable species found here are the *Sooty Falcon* and the *Sinai Rose Finch*, both of which are of high conservation concern due to their specialized adaptations to the harsh desert environment. Additionally, the area's high cliffs offer essential nesting grounds for raptors such as the *Lappet-faced Vulture* and the *Egyptian Vulture*, which depend on the scarce water sources found in some valleys for their survival. This combination of unique habitats and important conservationspecies makes the Rum IBA an invaluable conservation site within Jordan. (Birdlife International, 2024)

As part of the project, two wells, W69 and W98, are situated within the boundaries of the Rum IBA, highlighting the need for careful consideration of potential impacts on the area's bird populations and habitats. These wells lie in a region of the IBA that is essential for both resident and migratory bird species. The remaining wells in the project are located close to the IBA's eastern borders, further underscoring the importance of implementing measures to minimize disturbances to the surrounding environment.

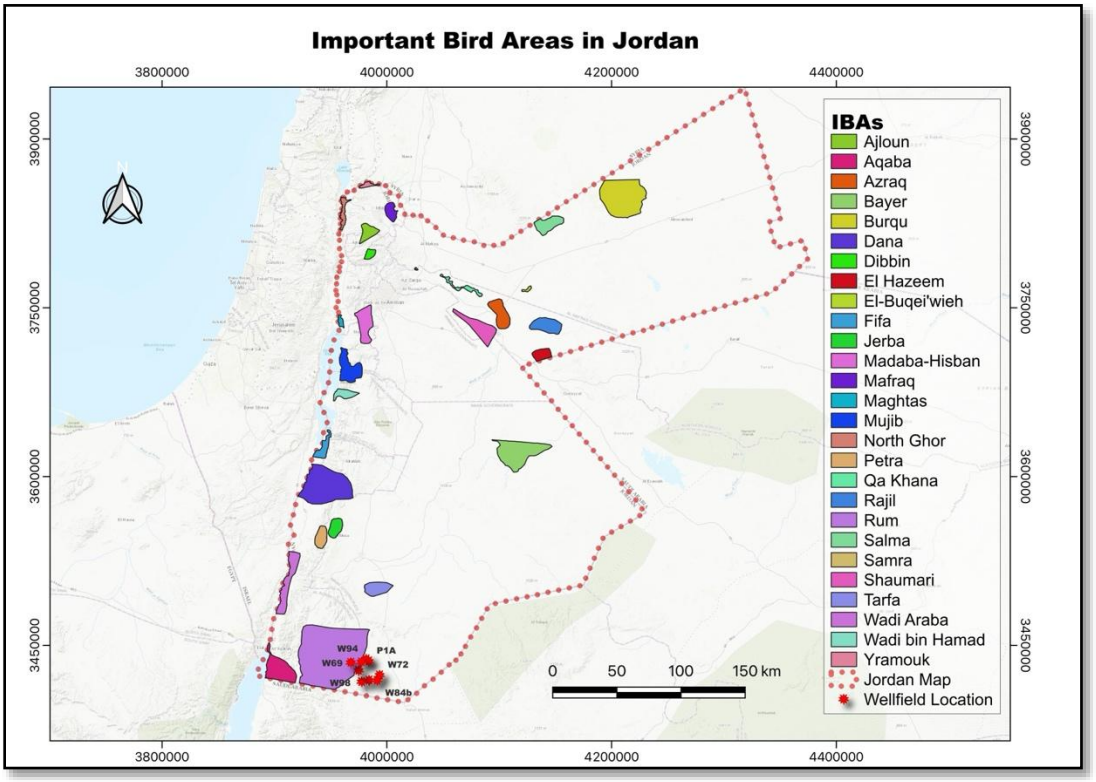


Figure 47: Important Bird Areas in Jordan (RSCN & Birdlife, 2000)

Rangeland Reserves

Jordan has established 20 rangeland reserves, which play a role in conserving the country's fragile desert ecosystems and supporting sustainable land use. These reserves are essential for maintaining the health and productivity of natural rangelands. Rangeland reserves provide grazing areas for livestock, helping to regulate grazing pressures on more vulnerable ecosystems while promoting sustainable land

management practices. They also act as habitats for a variety of wildlife species, particularly in arid and semi-arid regions, supporting biodiversity and mitigating the effects of land degradation caused by overgrazing, desertification, and climate change.
The project site is located approximately 15 kilometers from the nearest rangeland reserve, Al Mudawara. Al Mudawara Rangeland Reserve, like others in Jordan, plays a vital role in preserving the delicate balance of the desert ecosystem and ensuring that natural resources are used sustainably. Ensuring that the project does not disrupt these efforts is crucial to maintaining the ecological and economic benefits provided by rangeland reserves.

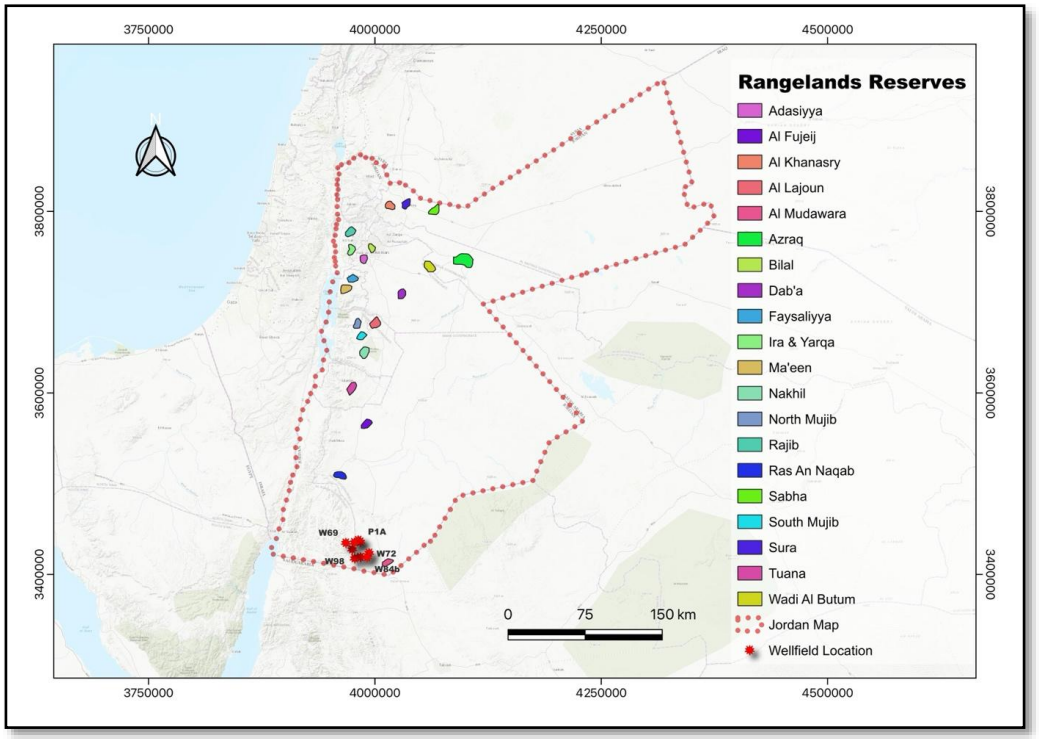


Figure 48: Rangelands Reserves in Jordan

Critical Habitat

The Critical Habitat (CH) screening has been developed to evaluate the potential presence of critical habitat within and around the footprint of the Disi Wellfield project area. The report is prepared in accordance with the International Finance Corporation's (IFC) Performance Standard 6 and the European Investment Bank (EIB) Environmental and Social Standard 4. These standards require projects financed by international institutions to assess and avoid adverse impacts on critical habitats and ensure the conservation of biodiversity. (Full CH Screening is illustrated in Annex 12).

The Disi Wellfield project involves the drilling of several groundwater wells and the construction of associated infrastructure, such as access roads and electricity transmission lines. While the project footprint is limited in size and many areas show signs of ecological degradation and sparse vegetation, its

proximity to sensitive ecological features, especially the Rum Important Bird Area (IBA), necessitates a thorough review of potential impacts on habitats and species of conservation concern.

Critical habitat, as per international standards, refers to areas with high biodiversity value that are essential for the survival of species or the functioning of ecosystems. This may include habitats supporting threatened or endemic species, important congregations, or ecosystems with unique ecological functions.

The methodology for this critical habitat screening followed the guidance of IFC Performance Standard 6 (PS6), as well as the complementary framework outlined by EIB Environmental and Social Standard 4. The process involved the following key steps:

Desktop Assessment and Field Survey

A comprehensive desktop review was conducted to gather information on biodiversity features relevant to the Disi Wellfield project area. The desktop review followed by a field visit was conducted over two days (6–7 August 2024) to ground-truth the desktop findings and document local flora and fauna.

Application of IFC PS6 Critical Habitat Criteria

Each of the five criteria for defining critical habitat under IFC PS6 was assessed systematically, using a combination of field data, literature sources, and spatial analysis. The criteria are

- Habitat of significant importance to critically endangered and/or endangered species (International Union for Conservation of Nature and Natural Resources (IUCN) Red List)
- Habitat of significant importance to endemic and/or restricted-range species
- Habitat supporting globally significant concentrations of migratory species and/or congregatory species
- Highly threatened and/or unique ecosystems
- Areas associated with key evolutionary processes

Species or ecosystems that triggered any of the above criteria were examined to determine the following:

- Whether their presence or use of the area is confirmed, likely, or unlikely.
- Whether the project footprint overlaps or is near important habitat features.
- Whether impacts are expected to be significant, residual, or irreversible.

Application of EIB E&S Standard 4: Biodiversity and Ecosystem

Critical habitat is the most sensitive of the high-value biodiversity features and is defined as comprising one of the following:

1. A highly threatened and/or unique ecosystem.

2. A habitat of priority and/or significant importance to critically endangered, endangered, or vulnerable species, as defined by the IUCN Red List of threatened species and in relevant national legislation.
3. A habitat of priority and/or significant importance to a population, range, or distribution of endemic or restricted-range species, or highly distinctive assemblages of species.
4. A habitat required for the survival of migratory species and/or congregatory species.
5. Biodiversity and/or an ecosystem of significant social, economic, or cultural importance to local communities and indigenous groups.
6. A habitat of key scientific value and/or associated with key evolutionary processes.

Risk Assessment

An expert evaluation was used to determine the potential likelihood of critical habitat triggers. In addition, consideration was given to the scale of project activities, the condition of the habitat, and existing disturbances. Where ambiguity existed, a **precautionary principle** was applied, recommending further investigation where necessary.

Conclusion of Screening

Based on the comprehensive assessment of the five Critical Habitat (CH) criteria under the IFC Performance Standard 6 and EIB Environmental and Social Standard 4, the following conclusions are drawn:

1. **Critically Endangered or Endangered Species: Not Triggered**

Although species of conservation concern have been recorded regionally, including *Uromastyx aegyptia* and *Falco naumanni*, the project site itself is highly degraded, and no significant populations were recorded.

2. **Restricted-range and Endemic Species: Not Triggered**

No endemic or restricted-range species were confirmed through literature review or the walkover survey, and none of the well locations support the required threshold of ≥10% of a global population.

3. **Migratory and Congregatory Species: Not Triggered**

Not formally triggered. While the eastern part of the project overlaps with the Rum IBA, and several migratory bird species of conservation concern (e.g., Sooty Falcon, Lesser Kestrel) were observed during the field visit, the scale of the project, the limited and disturbed footprint, and the absence of core nesting or roosting habitats reduce the likelihood of significant impact. According to IFC PS6 thresholds, the site does not appear to regularly support ≥1% of any migratory species' global population. Therefore, Criterion 3 is not formally triggered, although precautionary measures are still advised due to the ecological sensitivity of the area.

4. **Threatened Ecosystems: Not Triggered**

The site includes Saharo-Arabian and Sudanian habitats, but these are not listed as CR or EN in the IUCN Red List of Ecosystems, nor are they identified as high conservation priority by national planning frameworks.

5. **Key Evolutionary Processes: Not Triggered**

The site does not support recognized evolutionary processes such as major ecological gradients, refugia, centers of endemism, or unique species assemblages. No evidence of key ecological connectivity or evolutionary significance was identified through the literature or field visits. Consequently, Criterion 5 is not triggered.

6. **Ecosystems of Importance to Communities: Not Triggered**

Although rangelands are used locally, the project area is located in degraded and rarely used lands, and no biodiversity features of social, cultural, or economic significance to local communities were identified.

Ecosystem Services

The location of the project, which is situated within the arid desert ecosystems of Jordan, offers a wide range of ecosystem services that, despite their inconspicuous nature, significantly contribute to the preservation of environmental health and the provision of support for both human and wildlife populations. The regulation of water resources is one of the most important ecosystem services that the region provides because of its importance. Seasonal wadis and water collection points serve a crucial role in recharging groundwater, which is essential for supporting limited plant life, wildlife, and human activities. This is the case despite the fact that rainfall is scarce. In spite of the fact that they are only transitory, these water flow regions contribute to the preservation of soil moisture in specific locations, which in turn fosters the growth of vegetation that would otherwise be impossible in such a dry climate.
It is also important to note that the provision of habitat for biodiversity is an essential ecological service. wadis and tiny valleys support species such as Acacia gerrardii and Retama raetam, which in turn give shelter and food for a variety of desert fauna, including reptiles and migrating birds. Despite the fact that the area is generally devoid of vegetation, wadis and valleys help to sustain these species. Several species of conservation concern, including as the Sooty Falcon and the Sinai Rose Finch, rely on the project area as a stopping place during migration or as nesting grounds. These habitats are essential for the survival of these species, which are important for the conservation of environmental resources. Through the stabilization of soil, the provision of food for herbivores, and the support of the larger food web, the presence of diversified flora, despite its restricted presence, contributes to the overall sustainability of the ecological system.
Additionally, the project site offers regulating services, such as carbon sequestration and soil stabilization, which are important in mitigating the effects of desertification and climate change. The vegetation, although sparse, helps to prevent soil erosion by anchoring the sandy and gravelly soil, particularly in the wadis. In areas like the Saharo-Arabian and Sudanian zones, this natural soil stabilization is crucial for preventing further land degradation, which could worsen desertification and reduce the area's ability to support both human and ecological needs. Furthermore, the limited plant life in the region contributes to carbon sequestration, helping to mitigate the global impact of greenhouse gas emissions, although at a small scale.

For the local communities surrounding the project site, particularly those engaged in pastoralism, rangelands are an essential resource for their livelihoods. These lands provide important grazing areas for livestock, which is a primary source of income, food, and cultural identity for many nomadic and semi-nomadic communities in Jordan. The natural vegetation in the rangelands, such as *Acacia* and other drought-resistant species, offers forage for sheep, goats, and camels, helping to sustain local economies and preserve traditional ways of life. The well-being of these rangelands directly affects the economic stability of the local communities, as overgrazing or land degradation can lead to diminished forage availability.

5.4 Socio-Economic Conditions

5.4.1 Overview

Jordan faces a complex set of development challenges stemming from the chronic water scarcity. The situation is aggravated by climatic conditions, geography and, region's geopolitical environment including increasing demand due to high population growth, hosting several fluxes of refugees and economic development needs. Water scarcity poses a serious challenge that affects the wellbeing, security and economic future of all Jordanians.

Jordan is one of the most water-poor countries in the world for renewable freshwater with around 61 cubic meters per capita in 2021. Climate change and overuse of water resources have further reduced groundwater and surface water resources, while population has grown at a very high rate, placing Jordan among the world's top five countries in population growth historically. Jordan's health, prosperity, and food security require lasting water security[47].

In high-density municipalities, municipal capacity for service delivery, including waste collection and wastewater treatment, has been overstretched in response to increased demands which has been worsened by the inflow of Syrian refugees since 2011.

Furthermore, climate change adds to the stress experienced by the most vulnerable populations through the water scarcity, as well as land and air pollution, which are major issues that must be addressed in order to sustainably maintain the population.

This section gives an overview of the type and number of people who live and work within the vicinity of project site and the surroundings, the surrounding existing infrastructure and utilities.

5.4.2 Population and Demographics in the Vicinity of the Project Area

According to reports from the Department of Statistics, the population of Jordan in 2023 is estimated at 11,516,000 people, with a gender distribution of 47.5% females (5,419,000) and 52.5% males (6,097,000). The population is predominantly urban, with 90.3% residing in urban areas and 9.7% in rural areas.

[47] MWI, National Water Strategy 2023 - 2040

The wellfield area is situated in the southern region of Jordan, administratively spanning two governorates: Ma'an and Aqaba.

- Ma'an Governorate, the largest in Jordan by area, covers approximately 32,832 km², representing 37% of the country's total landmass. It is divided into four counties, seven districts, and seven municipalities and includes the Petra Development and Tourism Region Authority. A portion of the wellfield is located within the Jafr sub-district.
- Aqaba Governorate, positioned at Jordan's southernmost point along the Gulf of Aqaba, is divided into two districts: Aqaba Qasabah, which includes the major city, and Al-Quairah. The governorate also encompasses four sub-districts and five municipalities. The remaining part of the wellfield is located in the Disi sub-district within the Quairah District.

5.4.2.1 Population Data

The wellfield spans the Aqaba Governorate (including the Disi and Quairah municipalities) and the Jafer municipality in Ma'an Governorate, as depicted in the accompanying map. The map also identifies the closest localities to the wellfield, highlighted in blue.

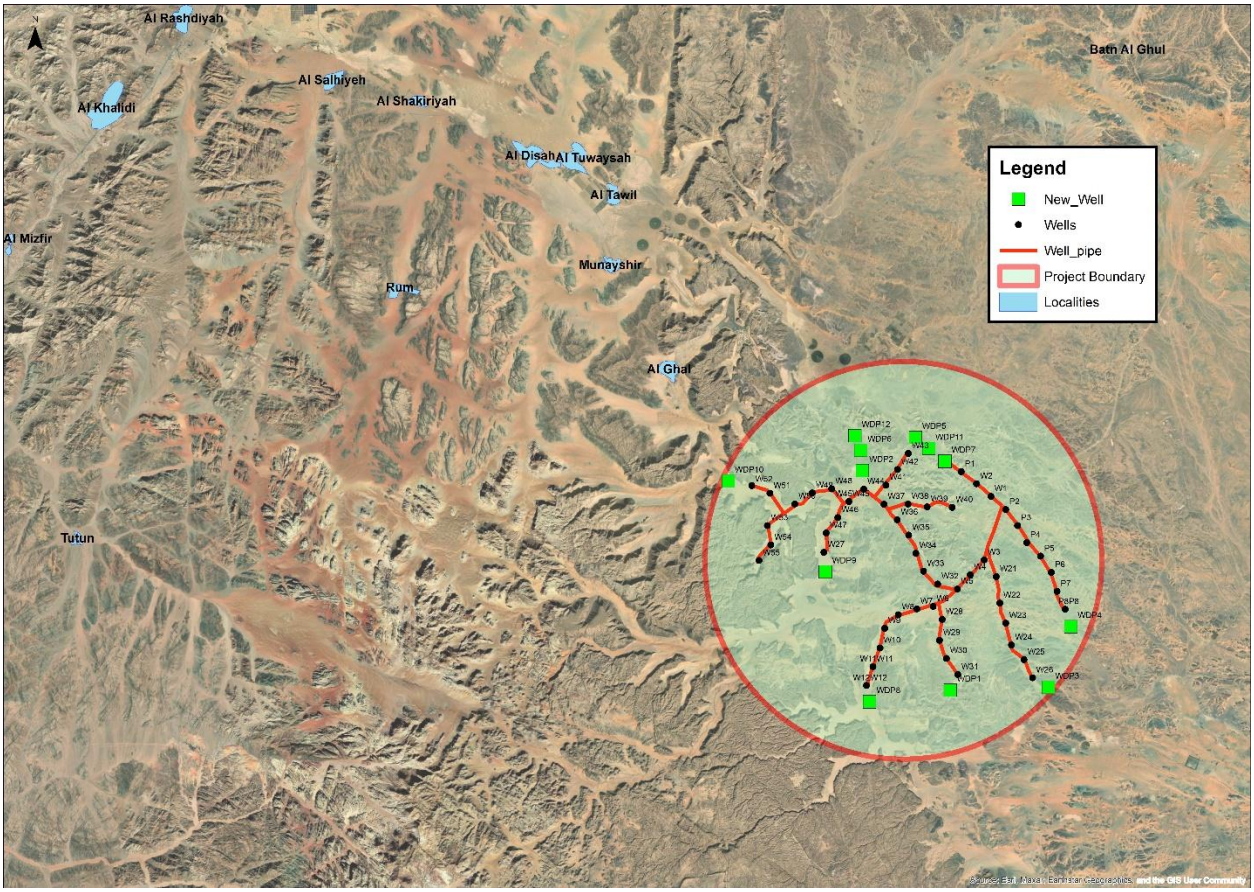


Figure 49: The project boundary with reference to the nearest localities

Table 23 details the total population of Aqaba Governorate and its administrative divisions as of the end of 2023.

Table 23: Population of Aqaba Governorate and its administrative divisions in the end of 2023

Division	Males	Females	Total
Aqaba Governorate	**99800**	**91300**	**191,100**
Iqlem Alaqaba	104,058	76,925	180,983
Qatar & Rahmah	923	911	1,834
Quairah	14,424	12,742	27,166
Disi	3,848	3,533	7,381
Krekrah & Finan	2,893	2,621	5,514
Wadi Araba	2,154	1,968	4,122

Source: DoS 2023

Table 24 provides the population of Disi and Quairah municipalities and their administrative divisions in the end of 2023.

Table 24: Population of Quairah Districts and its administrative divisions in the end of 2023

Municipality	Males	Females	Total
Disi Municipality			
Disi	1,888	1,565	3,453
Twaiseh	1,267	1299	2,566
Mnaishier	467	456	923
Ghal	226	213	439
Quairah Municipality			
Quairah	7,689	6,597	14286
Rashdyah	2,286	1,845	4,131
Rum	1,283	1,109	2,392
Hmaimieh Jadiedeh	1,317	1,295	2,612
Dabbet Hanoot	921	961	1,882
Shakriyyeh	187	186	373
Sallheiah	219	227	446
Asaleah	263	284	547
Hmaimieh	107	91	198
Um El-Beateen	358	255	613

Source: DoS 2023

Table 25 provides the total population of Ma'an Governorate and its administrative divisions as of the end of 2023.

Table 25: Population of Ma'an Governorate and its administrative divisions in the end of 2023

Division	Males	Females	Total
Ma'an Governorate	**60,800**	**55,400**	**116,200**
Iqlem Albatra	56,110	49,750	41030
Ma'an	26,930	23,360	50,290
Husanieh Aljadedah	10,920	10,000	20,920
Jafer	5,320	4,110	9,430
Iel Jadeda	9490	8780	18270
Alsharah	9140	8620	17760
Alashari	5,230	4,880	10,110
Shobak Aljadedah	11,760	11,530	23,290

Source: DoS 2023

Table 26 outlines the population of Jafer district and its administrative divisions in the end of 2023.

Table 26: Population of Jafr Sub-District and its administrative divisions in the end of 2023

Jafer Municipality	Males	Females	Total
Jafer	4,015	3,707	7,722
Modawwarah	439	396	835
Batn El-Ghool	5	2	7
Shadeiah	861	5	866

Source: DoS 2023

5.4.2.2 Refugees

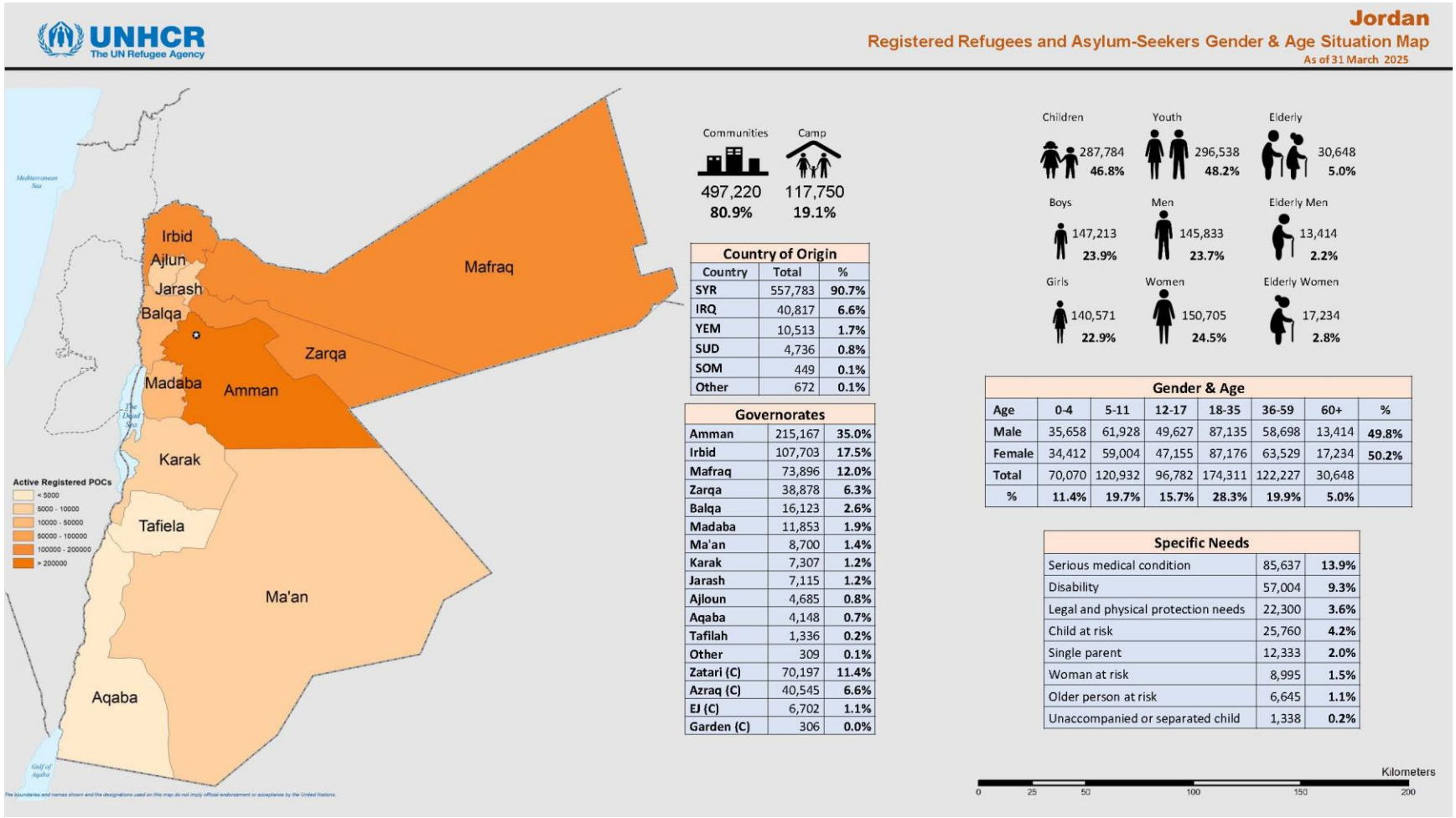
Jordan is among the countries most significantly impacted by the Syria crisis, hosting the world's second-highest number of refugees per capita. Refugees are registered with United Nations High Commissioner for Refugees (UNHCR), primarily from Syria, with substantial populations also coming from Iraq, Yemen, Sudan, and Somalia. Around 81 percent of these refugees reside in urban areas outside of refugee camps[48].

Jordan has been a commendable host nation, integrating refugees into essential national systems, such as healthcare and education. Additionally, Syrian refugees have been granted the right to work in specific sectors, enabling them to access livelihood opportunities.

According to UNHCR, Ma'an hosts 1.4% of the refugee population, while Aqaba has 0.7%. Despite these smaller percentages, the presence of refugees still impacts local demographics.

Figure 50 below illustrates the distribution of refugees across all governorates in Jordan.

[48] https://www.unhcr.org/countries/jordan



Source: UNHCR 2025

Figure 50: Geographic Distribution of Refugees Across Jordan's Governorates

5.4.3 Education

The Ministry of Education manages the various stages of education in Jordan, starting from kindergarten to the academic and vocational secondary education stage. There are other authorities that have their own schools, such as the United Nations Relief and Works Agency for Palestine Refugees (UNRWA) and the military sector. In addition to the role of the Ministry of Higher Education and Scientific Research in monitoring education in Jordanian universities and university colleges. The indicators for the education sector during the 2022/2023 academic year are:

- Average number of students per classroom unit: 24.4 students/classroom unit
- Average number of students per teacher: 15.6 students/teacher
- Percentage of female students: 49.3%
- Percentage of female teachers out of the total number of teachers: 69.6%
- Percentage of students in the primary and secondary levels out of the total population: 20%
- Percentage of charter schools out of the total number of schools: 33.0%

The total number of schools in Jordan in 2023 was 7,505 schools, including government schools owned by the Ministry of Education, private schools, schools affiliated with the UNRWA, and schools affiliated with the military sector. The total number of students enrolled in schools in various sectors for the year 2023 in Jordan reached 2,274,340.

The number of students in Ma'an Governorate for the year 2022/2023 was 46,619, enrolled in 236 schools, with a percentage of males reaching 50. % and females 50.0%. In contrast, the number of teachers in the same period was 4,247, including 1,472 males and 2,775 females, at a rate of 11 students per teacher.

Table 27 shows the distribution of the numbers of students, teachers, and schools within Ma'an Governorate, by gender.

Table 27: Distribution of educational components within Ma'an Governorate and by gender, 2023

Gender	Students	Schools	Teachers
Male	23,295	68	1,472
Female	23,324	11	2,775
Co-Edu	--------	157	--------
Total	46,619	236	4,247

Source: DoS 2023

The number of students in Aqaba Governorate for the year 2022/2023 was 54,477, enrolled in 157 schools, with a percentage of males reaching 51%, and females 49%. In contrast, the number of teachers in the same period was 3,803, including 1,263 males and 2,540 females, at a rate of 14 students per teacher.

Table 28 shows the distribution of the numbers of students, teachers, and schools within Aqaba Governorate by gender.

Table 28: Distribution of educational components within Aqaba Governorate and by gender, 2023

Gender	Students	Schools	Teachers
Male	27,630	40	1,263
Female	26,847	7	2,540
Co-Edu	--------	110	--------
Total	54,477	157	3,808

Source: DoS 2023

5.4.4 Health Care Services

Jordan's healthcare system is a mix of public and private services, generally providing good care, particularly in urban areas. However, the Syrian crisis has significantly strained the system. The influx of over 1.3 million Syrian refugees has increased demand for healthcare services, leading to overcrowded facilities, stretched resources, and challenges in maintaining the quality of care. The crisis has also put pressure on Jordan's economy, with additional healthcare costs and the need for international aid to support both refugees and the host community.

Basic indicators for the healthcare sector in Jordan for 2023:

Table 29: Basic indicators for the healthcare sector in Jordan for the year 2023

No. of Hospitals	119
No. of Beds	16182
Total Admissions per 1000 people	85
Average stay inside hospital	3.2 Days
Average Death Rate	%1.90

Source: Ministry of Health Annual Report 2023

Ma'an Governorate includes 2 hospitals with a bed capacity of 232 beds, with a rate of 12 beds per 10,000 population. These 2 hospitals are affiliated with the Ministry of Health. In addition, there are 87 health centers, distributed into 7 comprehensive health centers, 19 primary centers, 14 sub-centers, 27 maternity and childhood centers and 20 dental clinics.

Aqaba Governorate includes 4 hospitals with a bed capacity of 320 beds. These 4 hospitals are affiliated are 2 private and 2 governmental. In addition, there are 87 health centers, distributed into 4 comprehensive health centers, 9 primary centers, 11 sub-centers, 18 maternity and childhood centers and 13 dental clinics.

Table 30: Number of Hospitals and Beds by Governorate and Health Sectors, 2023

Governorate	Ministry of Health Hospitals		Private Hospitals		Governmental		Total	
	No of Hospital	No of Beds	No of Hospital	No of Beds	No of Hospital	No of Beds	No of Hospital	No of Beds
Ma`an	2	232	0	0	0	0	2	232
Aqaba	0	0	2	113	2	207	4	320

Source: Ministry of Health Annual Report 2023

5.4.5 Economic conditions

5.4.5.1 Overview

Jordan is classified by the World Bank as a lower-middle-income country. In 2022, the Kingdom experienced an inflation rate of 4.23% and a GDP growth rate of 2.5% at constant prices. The GDP per capita was approximately 2,981 Jordanian dinars, with the consumer price index reaching 106.79.

The gross domestic product in the first quarter of 2024 for the Hashemite Kingdom of Jordan was distributed among the following economic sectors:

Table 31: Economic Sectors and their contribution to the GDP at constant prices (First Quarter of 2024)

Sector	Contribution of sectors from GDP (%)
Agriculture	5.5
Quarrying industries	3.0
Manufacturing industries	17.3
Electricity and water	1.4
Construction	2.3

Sector	Contribution of sectors from GDP (%)
Wholesale, Retail Trade, Restaurants &Hotels	10.6
Transport, Storage & Communications	8.6
Finance, Insurance & Business services	19.7
Social & personal Services	8.1
Governmental services producers	13.5
Others	10.0
GDP	100%

Source: DoS 2024

Aqaba

Aqaba plays a crucial role as Jordan's only seaport and a major hub for logistics and trade. The ASEZA has transformed the city into a dynamic center for tourism, logistics, and industry by attracting significant domestic and international investments. The port of Aqaba, strategically located on the Red Sea, facilitates Jordan's international trade, making it a vital link for the country's economy.

Ma'an

Ma'an has emerged as a significant economic hub in Jordan, primarily driven by the Ma'an Development Area, which was established in 2007. The region is particularly known for its leadership in renewable energy, with extensive investments in solar power projects that have positioned Ma'an as a regional center for solar energy. In addition to energy, Ma'an hosts various industrial activities in the Roudah Industrial Area, including glass manufacturing and photovoltaic cell production. The development area also focuses on community development, creating job opportunities, supporting local businesses, and enhancing the region's infrastructure to boost economic growth and sustainability[49].

5.4.5.2 Employment and Unemployment

According to the report from the Department of General Statistics, Jordan's unemployment rate reached 21.4% during the first quarter of 2024. This reflects the ongoing challenges in the labor market, with a notable gender disparity. In the fourth quarter of 2023, the unemployment rate for males was 17.4%, while females faced a significantly higher rate of 34.7%.

The report also highlighted the growing unemployment rate among university graduates, with 25.8% of holders of a bachelor's degree or higher being unemployed. This marks an increase of 0.7 percentage points from the previous quarter. Additionally, 61.5% of the total unemployed individuals hold a secondary school certificate or higher, leaving 37.9% of unemployed individuals with educational qualifications below secondary school.

At the governorate level, Mafraq recorded the highest unemployment rate at 23.4%, while Jerash had the lowest at 18.4%. The data also reveals significant gender disparities in unemployment rates in the Ma'an and Aqaba governorates. In Ma'an, the overall unemployment rate for Jordanians is 1.9%, with

[49] Ma'an_Development_Area

males experiencing a higher rate of 2.2% compared to 1.3% for females. In Aqaba, the overall unemployment rate is slightly lower at 1.5%, with males at 2% and females at 0.7%.

Table 32 provides detailed unemployment rates for Jordanian and non-Jordanian residents for Ma'an and Aqaba governorates for the year 2024.

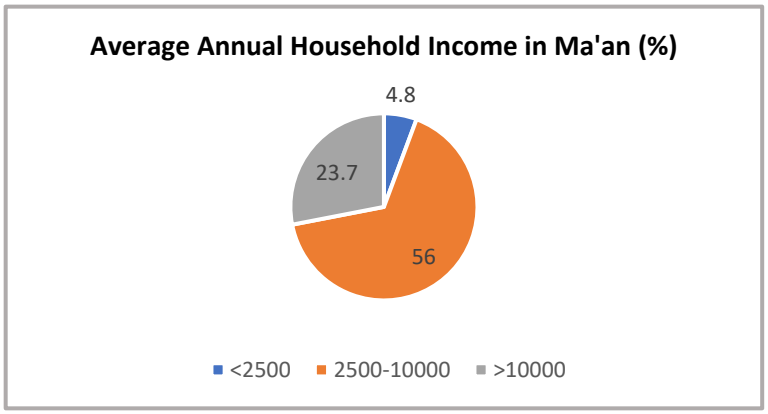
Table 32: Unemployment rate for Jordanian, non-Jordanian by governorate, gender, 2024

Governorate	Jordanian			Non-Jordanian		
	Total	Males	Females	Total	Males	Females
Ma`an	1.9	2.2	1.3	0.4	0.6	-
Aqaba	1.5	2	0.7	1.1	1.4	-

Source: DoS 2024

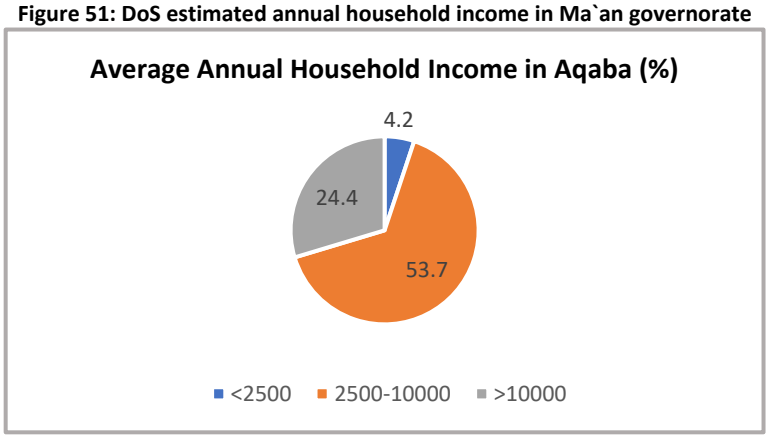
5.4.5.3 Household Income

According to the latest data from the Jordanian Department of Statistics, the average annual household income in Aqaba is approximately 10,400 Jordanian Dinars (JOD). This higher income level reflects Aqaba's role as a key economic hub, driven by significant tourism and industrial activities. In contrast, Ma'an, with its more rural setting and less diversified economy, has a lower average annual household income of around 8,600 JOD. These figures underscore the economic disparities between the two regions, with Aqaba benefiting from more developed infrastructure and greater economic opportunities compared to Ma'an.



Source: Household Expenditures & Income Survey 2017-2018, DoS

Figure 51: DoS estimated annual household income in Ma`an governorate

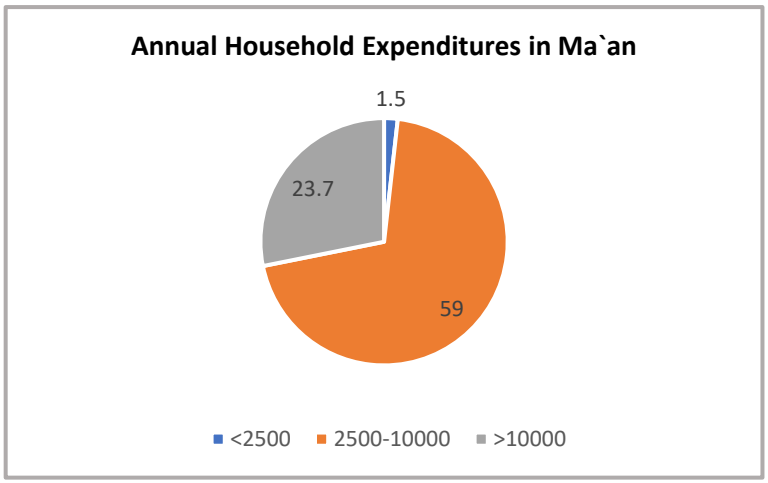


Source: Household Expenditures & Income Survey 2017-2018, DoS

Figure 52: DoS estimated annual household income in Aqaba governorate

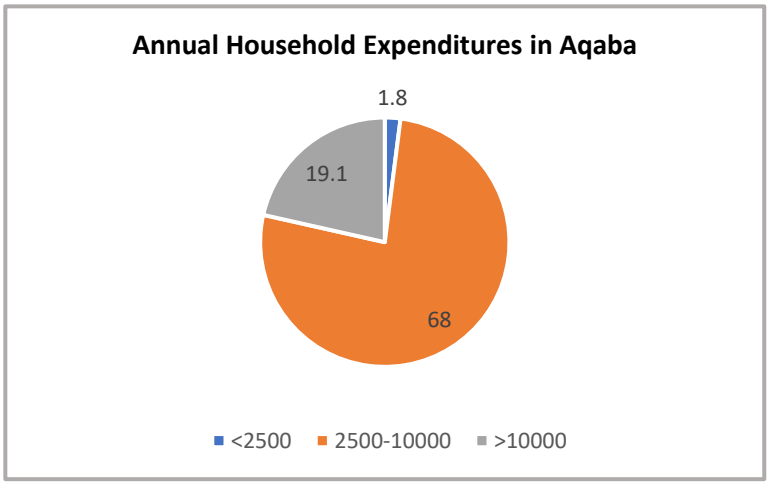
5.4.5.4 Household Expenditure

In Ma'an, the average annual household expenditure, which covers essential items such as food, housing, transportation, and healthcare, is approximately 6,500 Jordanian Dinars (JOD), according to the latest data. In contrast, households in Aqaba have a higher average annual expenditure of around 9,200 JOD.



Source: Household Expenditures & Income Survey 2017-2018, DoS

Figure 53: DoS estimated annual household expenditures in Ma`an



Source: Household Expenditures & Income Survey 2017-2018, DoS

Figure 54: DoS estimated annual household expenditures in Aqaba

5.4.5.5 Agricultural Activities

Aqaba

The Disi sub-district, near the wellfield project area, is known for its strong agricultural and tourism sectors, which form the backbone of the local economy. The arable land, which amounts to 57 thousand dunums, of which only a small portion of the total area has been utilized[50].

[50] Developmental Strategic Plan for the Disi Municipality for the Years 2019-2021

Table 33 presents the distribution of agricultural holdings in Aqaba, categorized by type of holding—crops, livestock, and a combination of both. It illustrates the total number and area of these holdings across the two districts.

Table 33: Number and Area of Agricultural Holdings by Type of Holding and District in Aqaba

District	Crops and Livestock		Livestock		Crops		Total	
	Area	No.	Area	No.	Area	No.	Area	No.
Aqaba Qasabah	1,140	69	83	699	10,166	211	11,389	979
Quairah	3,054	102	316	1,170	81,621	222	84,991	1,494

Source: DoS 2017
*Area: Dunum

Table 34 provides an overview of agricultural parcels in Aqaba, distinguishing between irrigated and non-irrigated crop parcels in the same districts. The table highlights the extent of land used for each type of farming method across both areas.

Table 34: Number & Area of Crops Agricultural Parcels of Non-Irrigated & Irrigated Parcels in Aqaba

District	Irrigated Parcels		Non-Irrigated Parcels		Total	
	Area	No.	Area	No.	Area	No.
Aqaba Qasabah	11,132	271	162	33	11,294	304
Quairah	79,950	281	4,709	50	84,659	331

Source: DoS 2017
*Area: Dunum

Ma'an

Table 35 presents the distribution of agricultural holdings in Ma'an, categorized by type of holding—crops, livestock, and a combination of both. It illustrates the total number and area of these holdings across the two districts.

Table 35: Number and Area of Agricultural Holdings by Type of Holding and District in Ma'an

District	Crops and Livestock		Livestock		Crops		Total	
	Area	No.	Area	No.	Area	No.	Area	No.
Ma'an Qasabah	33,670	259	248	1,163	125,021	875	158,939	2,297
Petra	3,202	69	103	874	6,238	246	9,543	1,189
Shobak	4,424	65	26	91	25,488	340	29,938	496
Huseiniya	23,745	80	34	185	12,322	159	36,101	424

Source: DoS 2017
*Area: Dunum

Table 36 provides an overview of agricultural parcels in Ma'an, distinguishing between irrigated and non-irrigated crop parcels in the same districts. The table highlights the extent of land used for each type of farming method across both areas.

Table 36: Number & Area of Crops Agricultural Holdings Parcels of Non-Irrigated & Irrigated Parcels in Ma'an

District	Irrigated Parcels		Non-Irrigated Parcels		Total	
	Area	No.	Area	No.	Area	No.
Ma'an Qasabah	100,036	682	58,608	505	158,644	1,187
Petra	3,348	218	6,084	116	9,431	334

District	Irrigated Parcels		Non-Irrigated Parcels		Total	
	Area	No.	Area	No.	Area	No.
Shobak	23,030	266	6,870	152	29,901	418
Huseiniya	7,021	114	29,020	132	36,041	246

Source: DoS 2017
*Area: Dunum

5.4.6 Indigenous Populations and Vulnerable Groups

5.4.6.1 Indigenous Populations

A rapid on-site assessment was conducted by the study team to identify any informal use of the wellfield area by local communities, including Bedouin groups. The assessment was complemented by feedback from the operator and the analysis of satellite imagery to ensure a comprehensive understanding of the area. The on-site evaluation focused on detecting signs of community presence, such as temporary structures, grazing activity, or other indications of use. The ESIA team found no evidence of structures, settlements, or significant community activity within the assessed area.

Feedback from the ESIA team field surveys and the operator indicated that Bedouin groups or other local communities pass through the area seasonally, particularly during the spring period for grazing purposes. However, these groups do not establish settlements or engage in long-term use of the land. The findings from the on-site assessment, operator feedback, and satellite imagery collectively confirm that while there is seasonal grazing activity, there is no informal or permanent community presence in the area.

5.4.6.2 Vulnerable Groups

Women

In Disi, females make up about 47.9% of the population (3,533 out of 7,381 individuals). In Jafer, females represent roughly 43.6% of the total population (4,110 out of 9,430 individuals). These figures are near the national average, where women make up 47.5% of Jordan's total population as of the end of 2023[51].

Low-Income Households

According to the Household Expenditure and Income Survey 2017, approximately 22% of households in Ma'an and 21.5% in Aqaba earn between JOD 2,500 and JOD 5,000 annually. Fewer than 6% of households in either governorate earn above JOD 15,000 per year[52]. Rural southern Jordan, including Ma'an and Aqaba, has high reliance on informal labor, agriculture, and seasonal tourism, which increases exposure to economic variations.

Refugees and Migrant Workers

Jordan has played a commendable role in hosting refugees by integrating them into national systems such as healthcare and education, and allowing access to work opportunities in designated sectors. Ma'an and Aqaba host relatively small proportions of the refugee population, 1.4% and 0.7% respectively[53].

[51] DoS, *Population Estimates at the End of 2023*
[52] DoS, *Household Expenditure and Income Survey 2017*
[53] UNHCR, 2025

While there are no formal refugee camps in Disi or Jafer, UNHCR reports indicate that refugees are dispersed across rural Jordan, including the southern governorates. Many Syrian refugees and migrant workers are engaged in agriculture and construction.

People with Disabilities

Nationally, about 11% of Jordanians live with a disability, with higher service access challenges reported in rural and remote areas such as Ma'an and Aqaba. These include limited access to inclusive education, public transportation, and employment opportunities[54].

5.4.7 Public services

5.4.7.1 Water Supply

Jordan faces severe water scarcity due to its arid climate, limited water resources, and growing population. The country relies heavily on groundwater and surface water sources, but these are rapidly depleting. With one of the lowest per capita water availability rates in the world, Jordan's water supply is critically strained, impacting agricultural, industrial, and domestic uses.

In 2022, Ma'an Governorate receives an annual water supply of 15.73 MCM, while Aqaba Governorate receives a larger supply of 22.72 MCM. These figures reflect the amount of water allocated to meet the domestic, industrial, and other needs within each governorate.

Table 37: Water Supply for Household & Municipal Purposes by Governorate 2022

Governorate	Water Supply (MCM)
Ma`an	15.73
Aqaba	22.72

Source: DoS 2022

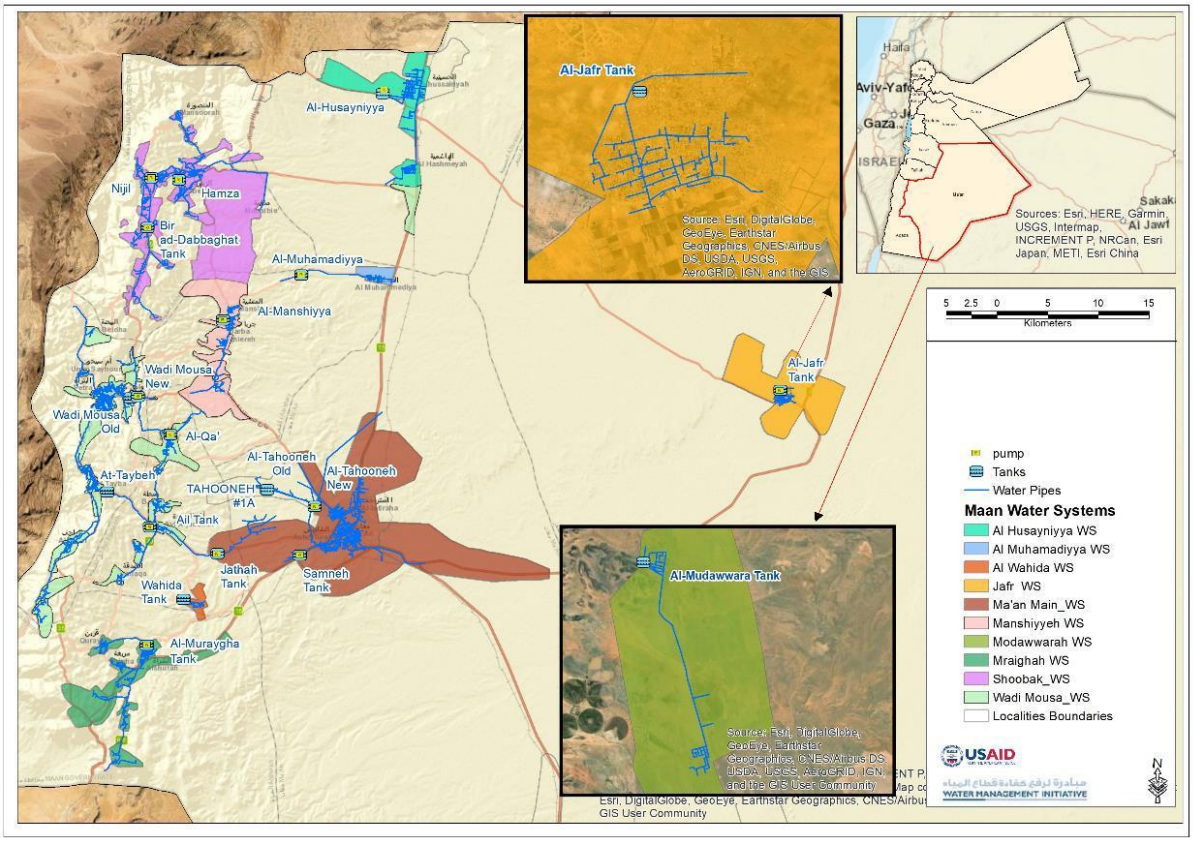
5.4.7.1.1 Ma'an's Water Supply System

Ma'an's water supply system is fed by several local wellfields, with major contributions from Al Tahooneh, Samneh, and Jitheh, which provide 17%, 14%, and 12% of the total supply, respectively. In 2018, the total production from these wells amounted to 15.67 MCM/year. The system operates through a combination of pumped and gravity supply, encompassing a vast network of 976,196 km, which includes 33 reservoirs and 17 pumping stations. The primary system spans 74.889 km, while the secondary system covers 261,728 km, with pipes primarily made of steel or ductile iron (DI).

The water supply network in Ma'an is divided into several key subsystems. The main Ma'an system includes reservoirs like Al Tahooneh and Samneh, which are fed by corresponding wellfields and supply water to various localities, including Sateh Maan and Mahatet Jerdaneh. The Wadi Mousa system relies on the Al Jitheh reservoir and supplies water to Wadi Mousa through a series of interconnected reservoirs. The Shobak system, with three reservoirs, serves multiple localities through wells and pumping stations. Additional systems, such as those in Al Wahida, Jafr, Al Mohammadiyyeh, and other areas, each cater to specific localities, ensuring the distribution of water throughout the governorate. Overall, the system has an existing capacity of 26,970 m^3, efficiently serving the water needs of the Ma'an governorate through a complex network of reservoirs, wells, and pipelines[55].

The figure below shows the existing water supply system:

[54] Higher Council for the Rights of Persons with Disabilities (HCD), Annual Report 2022
[55] National Water Infrastructure Master Plan, 2021



Source: National Water Infrastructure Master Plan, 2021

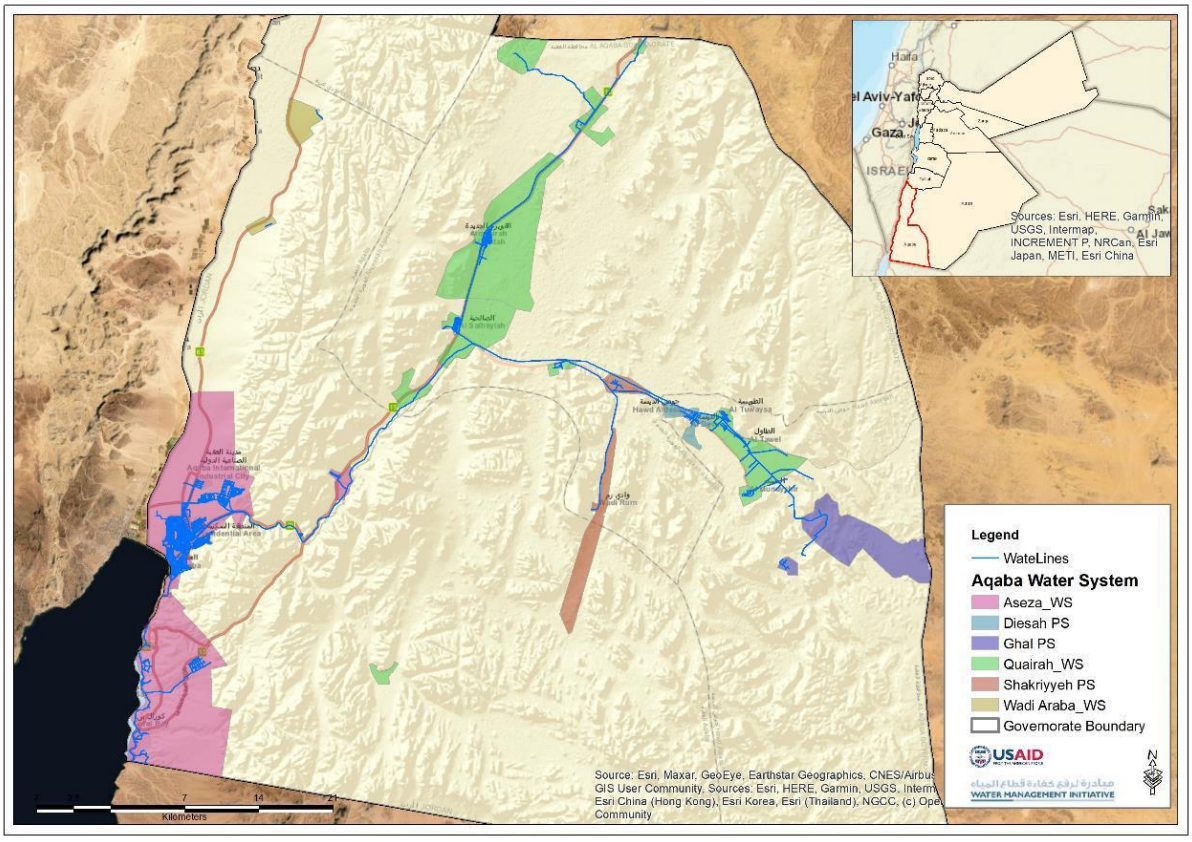
Figure 55: Ma'an's Existing Water Supply System

5.4.7.1.2 Aqaba's Water Supply System

Aqaba Governorate's water supply is sourced from several local wellfields, including Qa' a Disi, Mnaishier, Rahmeh, Qatar, Reisheh, Fienan, Shakriyyeh, and Um Mithla. In 2018, these wells collectively produced 19.08 MCM of water. The water supply system in Aqaba is a combination of pumped and gravity-fed systems, with a network spanning 913.3 kilometers. This includes 43 reservoirs and 21 pumping stations. The network is divided into primary, secondary, and tertiary systems, with lengths of 123 km, 38 km, and 752 km respectively. The system currently has a capacity of 8,000 cubic meters.

The ASEZA and Quairah water supply systems rely on a collection reservoir that is fed by the Abu-Dab'ah, Al-Qa'a, and Rum wellfields. This reservoir supplies water to Rashidia and Al-Etihad pumping stations via separate connections from an 800 mm pipeline. Additionally, it feeds the Mezfer and terminal reservoirs, which then supply the ASEZA system. The ASEZA system also receives water from the KEMAPCO desalination plant. In contrast, the Wadi Araba water supply system is composed of five scattered systems, each fed by its own local wells, including Qatar, Rahmeh, and Al-Reisheh pumping stations, as well as Fienan reservoir and Mathkoor Wellfield[55].

The figure below shows Aqaba's existing water supply system:



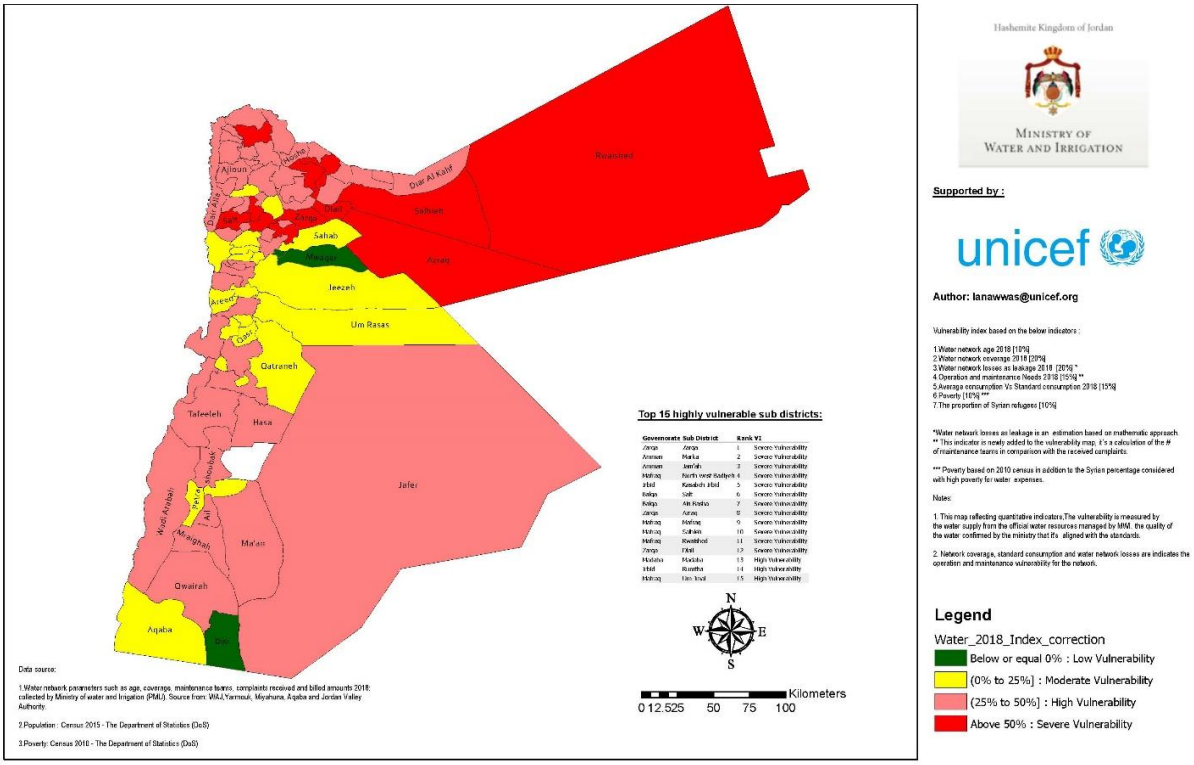
Source: National Water Infrastructure Master Plan, 2021

Figure 56: Aqaba's Existing Water Supply System

5.4.7.2 Water Vulnerability

Water vulnerability maps were updated in 2018 to assess sub-district-level risks, incorporating factors such as poverty, water demand, and infrastructure conditions. These revised maps identified 64 sub-districts across 43 districts in seven governorates as highly vulnerable. With the addition of operation and maintenance indicators, these maps have become crucial tools for prioritizing interventions in the most at-risk areas.

According to the water vulnerability map in **Figure 57** below, Disi is the only sub-district in Jordan classified as having low vulnerability. In contrast, Aqaba is ranked as a moderate vulnerability area, while both Ma'an and Jafer sub-districts are categorized as high vulnerability areas.



Source: Water supply vulnerability in Jordan, unicef 2018

Figure 57: Water Supply vulnerability Map (Jordan)

5.4.7.3 Sewer System

Approximately 35-40% of households in Ma'an are connected to the public wastewater network. The lower connection rate reflects the region's more rural nature and less developed infrastructure, however about 85-90% of households in Aqaba are connected to the public wastewater network. This higher rate is due to Aqaba's status as a major urban center and economic hub, with more developed infrastructure and services.

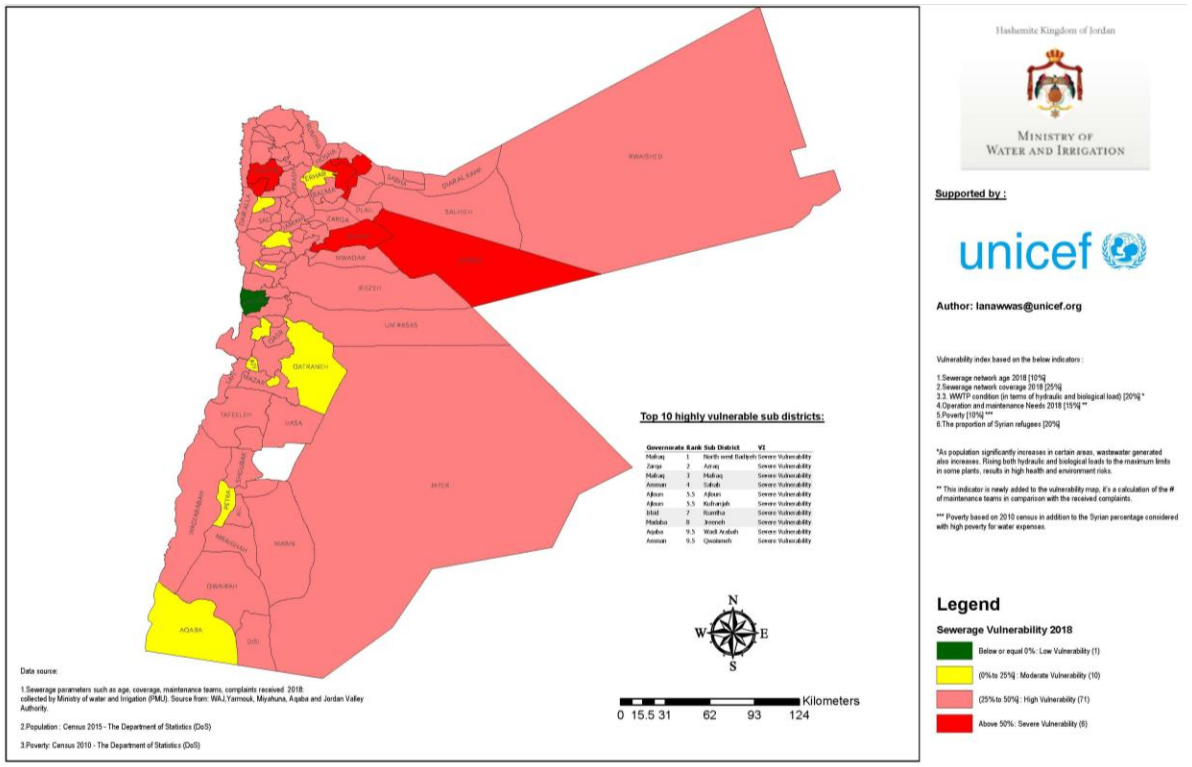
Table 38: Percentage of Distribution of Households according to Type of Sewerage System in Households (2018)

Governorate	Sewage Network	Cesspits	Other	None
Ma`an	34.7%	65.0%	0.0%	0.3%
Aqaba	87.5%	12.5%	0.1%	0.0%

Source: DoS 2018

Sewer Vulnerability

In 2018, sewerage vulnerability maps were updated to assess sub-district-level risks, incorporating factors such as infrastructure conditions, population pressures, and service needs. These updated maps identified 64 sub-districts across 43 districts in seven governorates as highly vulnerable. With the inclusion of operation and maintenance indicators, the maps have become vital tools for prioritizing interventions in the most at-risk areas. According to the sewerage vulnerability map, Disi is the only sub-district in Jordan classified as having low vulnerability. In contrast, Aqaba is ranked as a moderate vulnerability area, while both Ma'an and Jafer sub-districts are categorized as high vulnerability areas.



Source: Sewage vulnerability in Jordan, unicef 2018

Figure 58: Sewerage Vulnerability Map (Jordan)

5.4.7.4 Transportation

There are several facilities available for the transportation sector in Jordan and they are classified as follows:

- Air transportation: Jordan contains three airports, two international airports, namely Queen Alia International Airport in Amman and King Hussein International Airport in Aqaba, in addition to one civil airport, which is Amman Civil Airport.

- Maritime transport: The only port in Jordan is located in Aqaba Governorate, and most incoming and outgoing shipments pass through it, in addition to being used by travelers on ships and boats to and from the Kingdom.

- Land transportation: The road network in Jordan has developed in terms of design, construction and maintenance and is classified into three types of roads (main roads, secondary roads and rural roads (internal in villages and cities)) as shown in the following table for Jordan in general and Zarqa Governorate. In particular.

Table 39 provides an overview of the land transport roads in Jordan, specifically highlighting the road network in Ma'an and Aqaba Governorates for the year 2023:

Table 39: Land transport Roads (Km) in Jordan and in Ma'an Governorate during the year 2023

Type of Road	Ma'an	Aqaba
Main	571	321
Secondary	266	172
Rural	87	51
Total	924	544
Percentage from Kingdom's Total	10.9%	6.4%

Highway 5, the nearest main road to the project area (Disi wellfield), is a vital transportation route that starts at Safawi, from Iraq Highway in the north and ends at the Saudi Arabian border at Mudawwara in the south.

5.4.7.5 Solid Waste Management

In the Ma'an Governorate, the waste production rate is 0.5 kg/person, resulting in a total of 31,218 tons of municipal waste collected annually. This accounts for approximately 0.75 % of the total waste collected across the Kingdom. In contrast, the Aqaba Governorate has a lower waste production rate of 0.3 kg/person , with a total of 23,671 tons of municipal waste collected annually. This represents a about 0.57% of the total waste collected in the Kingdom. Together, these two governorates contribute a small fraction, around 1.31%, of the Kingdom's overall municipal waste.

The following table (**Table 40**) presents the per capita municipal waste collected by each governorate in Jordan:

Table 40: Solid Waste Generation Average collected from Municipalities by by Governorate in Jordan, 2022

Governorate	Waste Generation Average(kg/Person)	Population	Annual Collected Municipal Waste (Ton)
Ma'an	0.5	187,600	31,218.9
Aqaba	0.3	222,800	23,671

Source: DoS \ Environment Section[56]

5.4.8 Tourism

Aqaba, Jordan's coastal city on the Red Sea, is a prime destination known for its beaches, clear waters, and vibrant coral reefs, making it ideal for diving and snorkeling. The city also provides access to Wadi Rum, which is located approximately 14 km from the Disi wellfield. Wadi Rum is famous for its breathtaking desert landscapes and offers activities like desert safaris, camel rides, and stargazing.

Wadi Rum Protected Area is a unique site combining both natural and cultural elements, spanning 740,000 donums. Located in southern Jordan near the Saudi border, Wadi Rum is a desert with varied landscapes, including narrow canyons, natural arches, towering cliffs, sloping pathways, large rock formations, and several caves. The petroglyphs, rock carvings, and archaeological remains found here reflect 12,000 years of human settlement and interaction with the natural environment. With 25,000 rock carvings and 20,000 inscriptions, the site serves as a testament to the development of human thought and the early stages of alphabet creation. It also illustrates the region's agricultural, farming, and urban evolution.

Figure 59: Wadi Rum Protected Area

[56] https://dosweb.dos.gov.jo/environment/

Ma'an Governorate, home to the ancient city of Petra, one of the New Seven Wonders of the World, is rich in history and culture. Petra, carved into pink sandstone cliffs, is a UNESCO World Heritage site and a major tourist draw. The governorate also offers a glimpse into Jordan's Bedouin heritage, making it appealing to visitors interested in both history and adventure.

Table 41 provides an overview of the hotels located in the Aqaba and Ma'an governorates as of 2022:

Table 41: Hotels by Location, 2024

Governorate	Hotels	Rooms	Suites	Beds	Employees
Ma`an	3	53	0	112	12
Petra	84	3,731	116	6,634	1,623
Aqaba	101	6,560	534	12,247	2,692

Source: DoS, 2024

5.5 Archaeological and Cultural Heritage Resources

Jordan is well-known for its rich cultural heritage and archaeological treasures, which span thousands of years and reflect the legacy of numerous civilizations. Jordan's deserts, valleys, and mountains are dotted with historical sites, including Byzantine churches, Islamic castles, and prehistoric rock art in areas like Wadi Rum. These landmarks not only offer insight into the region's historical significance but also highlight the interplay between natural landscapes and human innovation. This deep historical and cultural context underscores the importance of preserving and integrating heritage considerations into development projects across the country.

Study Methodology

To establish the baseline archaeological and cultural heritage data for this project, the methodology was built upon the previous ESIA conducted in 2004 and its addendum 2008. This previous methodology included extensive field surveys and literature reviews to identify archaeological and cultural heritage resources within the project area, including graveyards or burial sites. It also defined the significance of these findings based on the possibility of direct or indirect impacts posed by the proposed project.

The methodology is outlined below:

- As part of the previous ESIA, field surveys were conducted by a team of three experts led by a Jordanian archaeologist to identify archaeological and cultural heritage resources and assess potential impacts. Observations formed the basis for mitigation and monitoring measures.
- The DoA recently conducted a field survey for the 12 proposed new wells to assess the archaeological and cultural heritage aspects of the project areas.
- Relevant references and databases, including the Jordan Antiquities Database and Information System (MEGA), were reviewed to identify and document any nearby archaeological and cultural heritage sites.

Study Findings

Overview

The MEGA database was reviewed to identify archaeological sites within the project area. **Figure 60** illustrates the locations of the identified archaeological sites in relation to the proposed new wells. The closest site is located more than 3 kilometers from the nearest proposed new well, minimizing the likelihood of direct impacts on cultural heritage sites.

Table 42 below provides details of the archaeological sites identified in the MEGA database:

Table 42: Archeological Sites Identified in MEGA Database

No.	Site Name	MEGA ID	JADIS No.
1	Umm Hawish	11613	2288002
2	Ghuzlan	10655	2188001
3	Quweirat Ghazi	11612	2288001
4	Al Abrar	59286	-

Source: MEGA Jordan

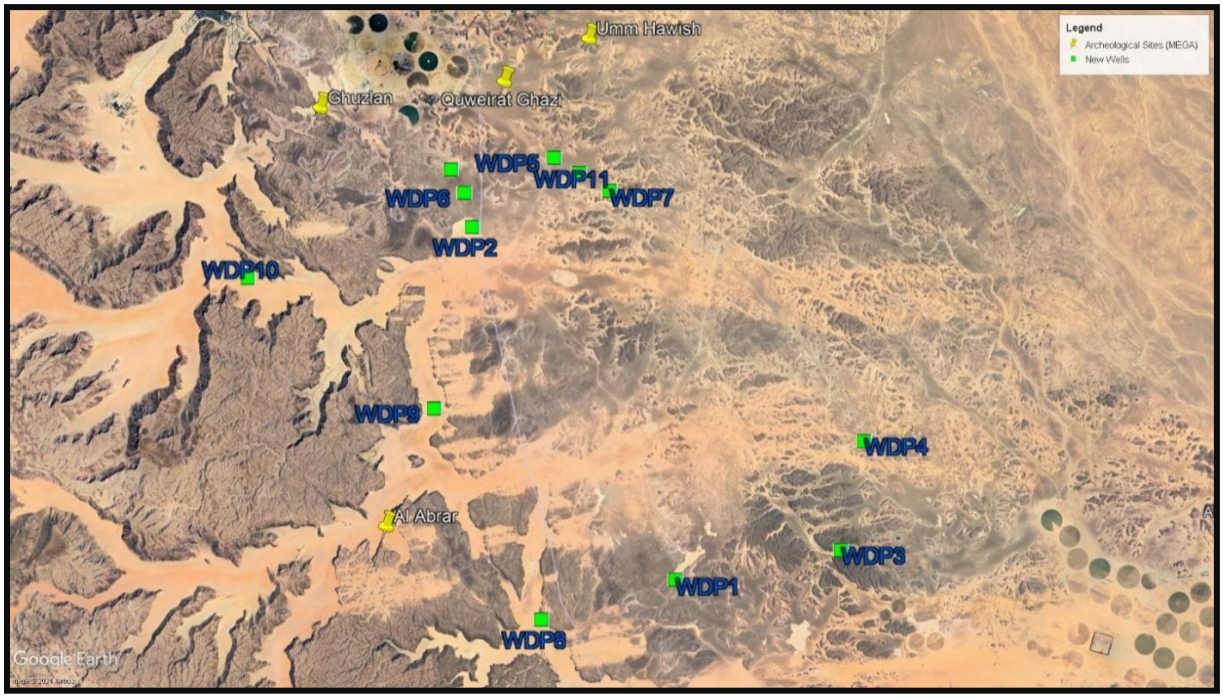


Figure 60: Nearest Archeological Sites According to MEGA

Inspection Results

Based on the findings of the previous ESIA, none of the identified archaeological sites are under direct or indirect threat from the proposed project activities. However, precautionary and management measures should be implemented to address the potential discovery of chance-found sites or any modifications to the project that might impact these sites.

Subsequently, a letter dated 25/11/2024 from the DoA, included in Annex 8, confirmed that a field inspection conducted by the DoA found no archaeological sites, features, or material remains within the proposed project zones. However, the letter emphasized that immediate notification to the Department of Antiquities is required if any artifacts or archaeological evidence are uncovered during construction activities.

6 STAKEHOLDER IDENTIFICATION AND ENGAGEMENT

Stakeholders are identified as any individual and/or group that could be affected by the proposed project activities and has interest in their outcome. According to this definition, the stakeholders may include property owners, business owners, central government and local officials, farmers, and non-government organizations.

Stakeholders should play a vital role in providing advice to the project management, therefore, in compliance with local ESIA regulations, and the lender's standards, stakeholder engagement activities will be ongoing process throughout the project construction and operation.

The stakeholder engagement activities to be carried out during this ESIA are as follows:

- Identification of project stakeholders and all parties affected or related to this project
- Conducting a scoping session and documenting its results in a scoping session report as part of the Final ToR.
    - Disclosure session will be conducted in line with the lenders requirements to present the ESIA findings and enclose additional comments within the final ESIA.
- Information disclosure: the team will disclose project details and accessible documentation (e.g., ESIA, ToR annexes) to ensure transparency on lenders and DIWACO and MWI websites to gather feedback, fulfilling lender's requirement for ongoing engagement.

6.1 Identification of Project Stakeholders

In order to define a communication process in line with lenders PSs, this section identifies stakeholder categories and affected parties and activities related to the project, these are presented in **Table 43** below.

Table 43: Identified Stakeholder Categories

Stakeholder Category	Stakeholders
Internal Stakeholders	
Employees	This includes relevant operator, contractor and subcontractor's female and male employees such as managers, engineers, technical staff, maintenance, secretaries, administrative personnel.
Workers	Temporary and permanent workers at project site.
Operators	The daily operation and maintenance of the wellfield which are overseen by the DAOM team.
Contractors / Sub-contractors	Contractors and sub-contractors working on this project.
External Stakeholders	
National Government	Ministry of Environment, Ministry of Energy and Mineral Resources, Ministry of Local Administration, Ministry of Health, Ministry of Labor, Ministry of Transport, Ministry of Public Works and Housing, Ministry of Agriculture, Ministry of Industry and Trade, Department of Antiquities, Jordan Institution for Standards and Metrology …etc.
Local Government	Municipalities such as Disi and Mudawara Municipalities
Local Community	Disi Project Advisory Committee (DPAC), Disi and Mudawara local community
Non-Governmental Organizations (NGOs) & Community Based Organizations (CBOs)	This category includes local CBOs, local woman organizations, local cooperation societies.

Stakeholder Category	Stakeholders
International Agencies	This includes international funding agencies that are funding projects in the area such as the EIB and IFC.

6.2 Stakeholder Engagement Plan

Stakeholder engagement will be carried out internally and externally. All anticipated stakeholders, communication methods and proposed media for each stakeholder are shown **Table 44.**

Table 44: Stakeholder Engagement Process

Stakeholder Category	Communication	Proposed Media
Internal Stakeholders		
Employees	Workshops, employee meetings/annual meetings, information sheets, etc.	MWI/WAJ and DIWACO/DAOM website (WAJ intranet), internal e-mails, internal newsletter.
Workers	Onsite advertisement, bulletin board	Brochures, leaflets
Operators	Meetings, workshops	E-mails, official letters
Contractors / Sub-contractors	Meetings	Emails, official invitation, information in contract
External Stakeholders		
National Government	Workshops, disclosure meetings, focus group discussions.	Official invitation letters, identify the venue location and time of meeting.
Local Government	Meetings	E-mails, official letters
Local Community	Disclosure meetings, focus groups, individual meetings Public consultation meetings (in case of grievance), this will be accomplished by DPAC	Newspaper, radio station, MWI website, brochures
NGOs & CBOs	Disclosure meetings, workshops this will be accomplished by DPAC	Notified through newspapers, radio stations, MWI website, or official letters
International Agencies	Disclosure meetings, workshops	Notified through official letters

A SEP has been established and is being implemented by the project operator, DAOM, to ensure effective and ongoing communication with identified stakeholders throughout the Operation and Maintenance (O&M) phase of the Project. This SEP outlines engagement procedures, grievance mechanisms, and the role of DPAC in addressing community and institutional concerns. The SEP is a living document and is regularly reviewed and updated based on stakeholder feedback, project developments, such as the addition of new wells—and emerging environmental or social issues. DAOM SEP is presented in Annex 13 In alignment of lenders requirements. In addition to DAOM's SEP, the project company has also developed its own SEP, which should be considered as part of the overall stakeholder engagement framework.

6.3 Information Disclosure and Stakeholder Engagement Activities

6.3.1 Summary of Previous Stakeholder Engagement Activities

6.3.1.1 Conducting a Scoping Session

The Ministry of Environment sent invitations to all relevant stakeholders to attend the scoping session a week prior to the session's date. The list of stakeholders that attended the scoping session is presented in the scoping session report which is provided within the ToR Annexes.

The main concerns and issues that were raised during the session can be summarized in the following bullets:

- The significance of taking into account the project's potential effects on farming operations close to the Disi wellfield was underscored by the participants. In addition to the possible effects of water over pumping operations (agricultural and regional water extraction) on the Disi aquifer overall.

- The importance of identifying any cultural or archaeological heritage before commencing construction was highlighted.

- Concerns were raised regarding the potential for collapses or earthquakes due to the water extraction from the Disi aquifer.

- The importance of having an on-site clinic and ambulance to ensure the health and safety of workers during both construction and operation phases.

- The importance of the social impact, which includes local community development and water availability to meet demand

- Project security and safety and the risk of theft and vandalism.

- The overall goal of the scoping session was to take into account any concerns expressed by stakeholders at various project phases. In order to ensure that the impacts are minimal and no negative effects arise during or after the project, the aforementioned issues were analysed and assessed, where appropriate.

6.3.1.2 Consultation with Local Community

As per the ESMP (2009)[57] for the "Disi-Mudawarra to Amman Water Conveyance System" project, a committee called the Disi Project Advisory Committee (DPAC) was proposed. According to the ESMP, the DPAC Environmental Committee serves as the review unit for overseeing the environmental performance of the Disi Project. Its members are primarily drawn from the MWI, along with representatives from other key stakeholders.

The DPAC Environmental Committee, chaired by an MWI representative, includes the Project Company's Environmental Manager and may involve a member from the MoEnv. Its main responsibilities are to annually review the ESMP's implementation, set environmental performance indicators, recommend necessary resources, and approve the Annual Environmental Report for submission to MWI.

Committee Composition

The proposed composition of the DPAC during different project phases is as follows:

- Construction Phase: Chaired by MWI, members include the Project Company, Engineering, Procurement, and Construction (EPC) Contractor, MoEnv, WAJ, RSCN, and community leaders from Amman, Wadi Rum, and Qatranah.

- Operational Phase: Chaired by MWI, members include the Project Operator, MoE, WAJ, RSCN, and the same community leaders.

[57] Disi-mudawarra to amman water conveyance system environmental & social management plan (ESMP) May 2009

Reactivation of the DPAC

On April 4, 2024, DIWACO submitted a formal letter (Ref: DISI-HQ-MWI/WAJ-17571-24) to the MWI, requesting the reactivation of the DPAC to establish mechanisms and channels to address the growing demands of the local community. This reactivation was necessitated by the increased local needs in recent months.

On March 6, 2024, DIWACO met with the local council of Mudawara, consisting of 10 members, where several requests were presented, including:

- Drilling a new water well to serve the southern village of Mudawara.
- Covering university tuition fees for selected local students.
- Providing and operating a bus service for the Mudawara area.
- Restoring homes for needy families.
- Offering assistance to low-income families and individuals with special needs.

In addition, on May 28, 2024, the Ministry of Local Administration – Al Mudawara Common Services Council sent a letter to DIWACO with the following requests, aligning with government policies that prioritize local community development:

- Provision of six air conditioning units for employee offices due to high temperatures in the area.
- Provision of six sets of administrative office furniture (desks, chairs, and tables).
- Provision of a hearse transport bus to address an urgent local need.

In response, DIWACO formally requested that MWI initiate the reactivation of DPAC. Consequently, MWI sent official correspondence to the Ministry of Local Administration (MoLA) and the MoEnv, requesting the nomination of representatives from each ministry. The DPAC will actively address local community needs and facilitate stakeholder engagement with the communities surrounding the Disi wellfield.

The DPAC will actively address local community demands and ensure that all stakeholders areengaged in a transparent and inclusive manner. By fostering open communication channels and maintaining transparency, the committee aims to build trust and cooperation with the local community, ensuring that their concerns are heard. This approach will help align the project’s objectives with the community's needs, promoting sustainable development.

6.3.1.3 Planned Stakeholder Engagement Activities

Table 45 presents a proposed programme for stakeholder engagement and the activities to be performed throughout the project to ensure that all stakeholders are informed of the project and are engaged and aware of their rights and the mechanism for voicing out their concerns.

Table 45: Planned Stakeholder Engagement Activities

Stakeholder Engagement Activity	Type of Information Disclosed / Method of Engagement	Potential Locations	Stakeholder Groups to be Consulted/Engaged
Prior to Construction			
Meetings with Employees	Inform them of the available grievance mechanism and how they can access it.	MWI/WAJ premises.	Employees and workers (temporary and permanent) at MWI Contractors / Sub-contractors DIWACO & Operator staff
Contractors/sub-contractors and temporary workers/operators	Agree of grievance management to be practiced during construction, inform all stakeholders, code of conduct for temporary workers, conduct relevant trainings.	contractor's premises	Contractors and temporary outsourced workers/operators
Consultation with relevant governmental institutions	Discussion of permits required and other monitoring requirements that will be needed for construction.	MWI/WAJ premises.	Relevant ministries and municipalities.
During Construction			
Public consultation meetings if necessary (depending on level of grievances), determined by DPAC	Ongoing during construction.	TBD	External Stakeholders
Operation Phase			
Public consultation meetings if necessary (depending on level of grievances), determined by DPAC	Ongoing during construction.	TBD	External Stakeholders
Meetings with Employees specially who are involved in operation and maintenance activities.	Create an open forum to ask direct questions to MWI management. Inform them of the available grievance mechanism and how they can access it.	MWI premises and/or operator premises.	Employees and workers (temporary and permanent) at MWI Operator Staff
Operator performance	Annual update and reporting on the ESMP.	Operator Reports	Internal stakeholders, and external stakeholders (local communities, suppliers).

Consideration of Indigenous Peoples

Based on site investigations and review of demographic data, no Indigenous Peoples —as defined by lenders requirements are present within the project's area of influence. The Dubaydib wellfield and surrounding areas are located on government land without permanent settlements, formal land use, or culturally distinct groups meeting the criteria of Indigenous Peoples.

While some Bedouin pastoralists may pass seasonally through the broader area during spring grazing periods, they do not maintain a long-term presence or claim land rights within the project footprint. As such, they are not considered project-affected Indigenous Peoples.

However, the project's Stakeholder Engagement Plan and grievance mechanism remain open and accessible to all potentially affected individuals or groups, including any transient or vulnerable populations, should future concerns arise.

6.3.1.4 Grievance Mechanism

DAOM has set up a process for receiving and handling internal and external grievances. The grievance redress process will be activated through DPAC, allowing stakeholders to raise concerns (e.g., via letters, meetings) and receive timely responses.

- Employees' Grievances are received and handled according to the process documented in the HR Policy.

- External grievances from local community and neighbors received are communicated to the project company, who will then communicate it directly to its client, the MWI. Dealing with external grievances follows the requirements of the Project Agreement and the O&M Agreement. The mechanism remains accessible to all potentially affected individuals, including transient or vulnerable groups such as seasonally present Bedouin shepherds.

- Grievances received from subcontractors are received by the concerned supervisor from DAOM and/or the Procurement department. The received grievance is discussed with the concerned parties to find the proper solution.

- All received grievances will be recorded in a dedicated register. **Annex 9** represents the internal and external grievance template used by the operator.

7 ENVIRONMENTAL AND SOCIO-ECONOMIC ASPECTS AND RECEPTORS

Environmental aspects are identified where project activities have the potential to interact with the surrounding environment. Similarly, socio-economic aspects arise when these activities may impact the social or economic conditions.

In order to identify environmental, health and socio-economic aspects for this project, project activities have been identified through:

- Project related studies including BRGM study.
- Consultation with project stakeholders during the scoping session.

The key input for the identification of receptors includes:

- Policy and legal framework.
- Environmental, health and safety and socio-economic baselines.

7.1 Identification of Environmental and Socio-Economic Receptors

Table 46 below provides a summary of the identified environmental and socio-economic receptors within and in the vicinity of the project area.

Table 46: Identified Environmental and Socio-economic Receptors

Aspects/ Receptors	Details
1-Physical Environment	
Air Quality	The air quality at and surrounding the proposed new wells.
Noise	Construction and reinstatement activities, particularly those involving transportation and execution.
Soil	The soils of the project area on which construction, reinstatement, operation, and decommissioning activities would occur.
Hydrogeology	The hydrogeology (groundwater) of the Disi aquifer.
Hydrology	Stormwater within the wellfield site.
Landscape / Visual Impact /Topography	The geomorphologic landforms and terrain at the proposed new wells site.
2-Biological Environment	
Flora	Plant species that may be present at the proposed new wells where construction and operational activities would take place.
Fauna (Reptiles, Birds, and Mammals)	Species of fauna that may be impacted by the proposed new wells operations in the area where construction and operational activities would take place.
3-Occupational Health and Safety	
Construction Team Operation Team	Employees working on the project site who may be exposed to occupational hazards such as noise or dust.
4-Socio-economic Environment	
Public Health & Safety	Project activities could potentially expose nearby communities to hazards, posing risks to public health and safety.
Workforce & Employment	There would be new job opportunities. Primarily through the construction and operation phases.
Utilities and infrastructure	The utilities (e.g., power supply, telecommunications) which would be provided for the proposed new wells.

Aspects/ Receptors	Details
Transport and Traffic	Access roads to the wells will be used for the transportation of equipment and materials during the construction phase of the new wells, as well as for the transport of personnel and supplies during the operation phase.
Archaeology / Cultural Property	Archaeological sites that have cultural significance within or in the vicinity of the proposed new wells sites.

7.2 Summary of Environmental and Socio-Economic Aspects

Table 47 presents the possible interaction between the environmental aspects and receptors relevant to this project which was developed based on the review of environmental and social aspects, project activities, potential environmental impacts, and the project's environmental receptors.

Table 47: Summary of Environmental and Socio-economic Aspects

Project Activity	Environmental Receptor / Potential Environmental Impact
Planned Project Activities	
Pre-Construction Phase	
Access Road	• Potential for dust and noise emissions. • Potential impact to flora and fauna.
Survey	• Potential for noise emissions. • Potential for soil and habitat disturbance. • Potential employment opportunities.
Site Investigation	• Potential for dust and noise emissions. • Potential for landscape and visual impact. • Potential impact to flora and fauna.
Construction Phase	
Drilling, Trenching, and Excavation Works	• Potential for dust and noise emissions. • Potential for spillage of fuel, oil or waste with consequent risk of soil contamination. • Landscape modification. • Potential for topsoil disturbance and erosion processes. • Visual/Aesthetic impacts. • Potential impact to flora, fauna, terrestrial habitats, and/or Important Bird Areas (if present) within the project area. • Potential occupational health and safety impacts. • Potential employment opportunities in construction work.
Solid waste (Spoil) Generation / Disposal	• Potential of visual impact. • Potential risk to flora and fauna if using unplanned disposal methods. • Potential occupational health risk.
Material and Chemical / Oil Storage	• Potential for soil quality degradation. • Potential of visual impact. • Potential for flora and fauna disturbance. • Potential impact to occupational health and safety.

Project Activity	Environmental Receptor / Potential Environmental Impact
Vehicle Operation	• Potential increases in exhaust emissions from vehicles. • Noise and vibrations when in the proximity of environmental and social receptors. • Potential for topsoil disturbance and erosion processes. • Potential impact to flora, fauna, and terrestrial habitats within the project area. • Potential impact to occupational health and safety.
Equipment Operation	• Potential increases in exhaust emissions from equipment. • Noise and vibrations when in the proximity of environmental and social receptors. • Potential for spillage of fuel, oil or waste and consequent risk to soil contamination. • Potential for topsoil disturbance and erosion processes. • Potential of visual impact. • Potential impact to flora, fauna, and terrestrial habitats within the project area. • Potential impact to occupational health and safety.
Access Roads	• Potential for dust and noise emissions during excavation. • Potential for topsoil disturbance. • Potential impact to flora, fauna, and terrestrial habitats within the project area. • Potential impact to occupational health and safety.
Reinstatement Phase	
Backfilling and Compaction	• Potential for dust emissions during backfilling. • Potential soil compaction leading to altered natural drainage patterns. • Potential disturbance to local flora, fauna, and terrestrial habitats. • Visual/aesthetic improvements due to site restoration. • Potential impact on occupational health and safety during the process.
Surface Grading and Smoothing	• Improvement in visual aesthetics by leveling disturbed areas. • Reduction in soil erosion potential through stabilized surfaces. • Potential short-term dust emissions during grading activities. • Potential minor disturbance to local fauna during surface works.
Waste Material Removal and Disposal	• Potential for dust and noise emissions during removal of remaining spoil or waste. • Risk to local flora and fauna if disposal is not done properly. • Potential visual impacts if waste is improperly managed. • Occupational health and safety risks during waste removal activities.
Vehicle Operation	• Potential increases in exhaust emissions from vehicles. • Noise and vibrations when in the proximity of environmental and social receptors. • Potential for topsoil disturbance and erosion processes. • Potential impact to flora, fauna, and terrestrial habitats within the project area. • Potential impact to occupational health and safety.
Operation Phase	
Operation of Wells	• Potential impact for noise. • Potential impact for GHG emissions. • Increase water extraction from Disi aquifer.

Project Activity	Environmental Receptor / Potential Environmental Impact
Pipeline Network Operation within the Wellfield	• Potential impact to flora, fauna, and terrestrial habitats within the project area. • Potential impact on soil stability
Power Lines	• Potential impact on fauna, especially bird collisions with overhead power lines. • Potential impact on visual aesthetics of the project area.
Potential Accidental Events (Unplanned)	
Construction Phase	
Spill of Chemicals or Liquid Fuels	• Potential air emissions. • Potential for disturbance of shallow groundwater. • Potential risk to occupational health. • Potential for flora and fauna disturbance.
Ignitions of Flammable Materials / Accidental Fires	• Potential for hazardous emissions. • Potential disturbance to flora and fauna. • Potential risk to workers. • Potential of damage to transport, machinery and general equipment.
Reinstatement Phase	
Accidental Spillage of Fuel or Oil	• Risk of contamination of soil and shallow groundwater. • Potential degradation of soil quality. • Impact on flora and fauna due to contamination. • Visual impacts caused by fuel/oil stains. • Occupational health and safety risks related to handling spills.
Accidental Equipment/ Machinery Damage or Failure	• Risk of spills or leaks from damaged equipment & machinery (e.g., fuel, oil). • Potential safety hazards for workers during equipment failure. • Increased noise and machinery emissions if repair or replacement is needed, affecting nearby receptors.
Operation Phase	
Well Pump Failure or Malfunction	• Potential risk to occupational health and employee safety. • Potential risk of soil erosion or localized flooding in the well area.
Spill of Hazardous Substances (e.g., lubricants, chemicals used for well maintenance)	• Potential contamination of soil. • Potential risk to occupational health. • Potential for flora and fauna disturbance.
Water Pipeline Rupture and Leakage	• Potential risk of increased water wastage, reducing the efficiency of the distribution network. • Potential risk of soil erosion.

7.3 Interaction of Identified Aspects and Receptors

A summary of potential interactions between environmental aspects and receptors relevant to the proposed project was identified based on an assessment of environmental aspects, project activities, and the project's environmental receptors. This will allow a preliminary assessment of the project's important environmental issues pertaining to physical, biological, occupational health and safety, and socioeconomic receptors, or 'key issues,' to be conducted. The interaction of aspects and receptors identified in the ESIA process are presented in **Table 48** for all planned and unplanned activities, and includes consideration of natural disasters.

Table 48: Environmental and Socio-Economic Aspect Matrix

Receptor		Physical						Biological			Occupational Health and Safety	Socio-economic			
		Air Quality	Noise	Soil	Groundwater	Hydrology	Landscape / Topography	Flora (habitats)	Birds	Reptiles & Mammals		Workforce & Employment	Utilities & Infrastructure	Transport & Traffic	Cultural & Archaeology Heritage
Planned Activities															
Pre-Construction	Access Road	✓	✓	✓		✓	✓	✓	✓	✓		✓		✓	✓
	Survey		✓	✓								✓		✓	
	Site Investigation	✓	✓												
Construction	Access Road	✓	✓	✓			✓	✓	✓	✓	✓	✓			
	Accommodation	✓	✓	✓				✓		✓	✓	✓	✓		
	Haulage	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	
	Site survey		✓									✓		✓	✓
	Site soil Investigation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
	Clearing and grading	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓
	Trenching & ditching	✓	✓	✓			✓	✓		✓	✓	✓	✓		✓
	Excavation & digging	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓		✓
	Earthworks	✓	✓	✓			✓	✓		✓	✓	✓			✓
	Mobilization/ demobilization of labor & equipment	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	
	Construction of Pump - Head, Electric Control Room	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

Receptor		Physical						Biological				Socio-economic			
		Air Quality	Noise	Soil	Groundwater	Hydrology	Landscape / Topography	Flora (habitats)	Birds	Reptiles & Mammals	Occupational Health and Safety	Workforce & Employment	Utilities & Infrastructure	Transport & Traffic	Cultural & Archaeology Heritage
	Waste generated from construction activities			✓		✓	✓	✓		✓	✓				
	Wastewater generated by site workers			✓	✓	✓	✓	✓		✓	✓		✓		
Reinstatement	Backfilling and Compaction	✓		✓			✓	✓		✓	✓	✓			
	Surface grading and smoothing	✓		✓			✓	✓		✓	✓	✓			
	Waste material removal and disposal	✓	✓				✓	✓		✓	✓				
	Vehicle operation	✓	✓	✓				✓	✓	✓	✓	✓			
Operation	Operation of Wells		✓		✓	✓		✓		✓		✓	✓		
	Pipeline Operation			✓		✓							✓		
	Power Line								✓				✓		
	Maintenance of Wells and Pipeline		✓								✓	✓		✓	
Decommissioning	Dismantling Equipment		✓	✓			✓	✓	✓	✓	✓	✓		✓	
	Demolition and Disposal of Building Infrastructure	✓	✓				✓	✓	✓	✓	✓	✓		✓	
	Fence Removal											✓		✓	
	Excavation & Backfilling	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Site Restoration	✓	✓	✓		✓	✓	✓	✓	✓		✓		✓	

Receptor		Physical						Biological			Occupational Health and Safety	Socio-economic			
		Air Quality	Noise	Soil	Groundwater	Hydrology	Landscape / Topography	Flora (habitats)	Birds	Reptiles & Mammals		Workforce & Employment	Utilities & Infrastructure	Transport & Traffic	Cultural & Archaeology Heritage
Unplanned Project Activities															
Construction	Spill of chemicals or liquid fuels			✓	✓	✓		✓	✓	✓	✓				
	Ignitions of flammable materials / accidental fires	✓					✓	✓	✓	✓	✓			✓	
Reinstatement	Accidental spillage of fuel or oil			✓			✓				✓				
	Accidental equipment damage or failure										✓	✓			
Operation	Well pump failure or malfunction				✓	✓							✓		
	Spill of Hazardous Substances (e.g., lubricants, chemicals used for well maintenance)			✓	✓	✓		✓		✓	✓				
	Water pipeline rupture and leakage			✓		✓							✓		
Natural Disasters															
Construction	Earthquake "Seismic Activities"		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
	Flooding			✓			✓	✓	✓	✓	✓		✓		

Receptor		Physical						Biological			Occupational Health and Safety	Socio-economic			
		Air Quality	Noise	Soil	Groundwater	Hydrology	Landscape / Topography	Flora (habitats)	Birds	Reptiles & Mammals		Workforce & Employment	Utilities & Infrastructure	Transport & Traffic	Cultural & Archaeology Heritage
Operation	Earthquake "Seismic Activities"		✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓
	Flooding			✓			✓	✓	✓	✓	✓		✓		

8 ANALYSIS OF PROPOSED PROJECT ALTERNATIVES

The analysis of project alternatives is one of the main tenets of environmental impact policy and procedures world-wide. A thorough, unbiased and transparent assessment of alternatives from an environmental, social, technical and economic standpoint is one of the most important contributions an ESIA can make to improve decision making.

Given the sensitivity of expanding water extraction at the Dubaydib wellfield, analyzing project alternatives is essential. The project aims to increase water supply to Amman, addressing urgent water scarcity. However, this expansion could impact the sustainability of the fossil aquifer. A thorough assessment of the "No Project" and "Project" scenarios will help balance the benefits of increased water supply with potential environmental and social consequences, ensuring informed and sustainable decision-making.

The analysis for this project contains two options/alternatives that are the “No Project” and the “Project” alternatives. By evaluating these alternatives prior to the start of project activities, the project’s environmental and social benefits can be maximized, and potential challenges can be identified and addressed.

Table 49 presents the symbols that denote the various levels of environmental impact to aid in the comparison of alternatives. Each symbol indicates an overall evaluation of the specified environmental component and social aspect.

Table 49: Evaluation Symbols for Levels of Environmental and Social Impact

Symbol	Description
X	Denotes potential for impact, which is not considered significant
S-	Denotes potential significant adverse impact
S+	Denotes potential significant beneficial impact
*****	Denotes no change to the existing situation

8.1 The “Project” Vs. the “No Project” Alternative

The “No Project” alternative considers the effects of not constructing the new wells. It is normally evaluated to assess the impacts if the project does not go ahead. This alternative is evaluated against the implementation of the construction of new wells in Dubaydib wellfield.

The key objective of the "Project" alternative is to enhance the water supply infrastructure to meet the growing demands of Amman, Jordan's capital, and its surrounding regions. The existing Disi-Mudawarra to Amman water conveyance system, which initially supplies 100 MCM of water annually, is no longer sufficient to address the increasing water needs, particularly during peak demand periods in the summer. To address this, the project proposes drilling additional new wells to maintain the three redundant wells, while pumping 120 MCM per year. This expansion is crucial for ensuring a consistent and reliable water supply to the greater Amman area, improving the overall quality of water, and enhancing public health conditions. Additionally, the project is aligned with the Government of Jordan's broader regional water management strategy, contributing to the long-term sustainability and resilience of the country's water resources.

The "No Project" alternative involves not proceeding with the expansion of drilling new wells in the Dubaydib wellfield. Under this scenario, the existing infrastructure would continue to operate at its current capacity, delivering 100 MCM of water annually from the Disi aquifer to Amman. However, without the addition of new wells and supporting infrastructure, the system would be unable to meet the increasing water demand projected for Amman and surrounding areas, especially during peak periods like the summer months. As a result, the "No Project" alternative could lead to continued or worsening water shortages,

In a “No Project” alternative scenario, several potential environmental impacts could arise:

- **Negative Impact on Public Health:** Water shortages could lead to inadequate access to clean drinking water, increasing the risk of waterborne diseases and other public health issues.
- **Increased Pressure on Alternative Water Sources:** Other water sources, which may be less sustainable or environmentally damaging, could be over-exploited to compensate for the shortfall in supply.
- **Potential Increase in Illegal Water Extraction:** With insufficient water supply, there could be an increase in unauthorized drilling and water extraction for the areas that are being supplied, leading to unregulated and environmentally harmful practices.

Given these considerations, the "Project" alternative presents several advantages over the "No Project" scenario:

- **Enhanced Water Security:** By increasing the water supply capacity from the Disi aquifer to 120 MCM per year, the project would ensure a more reliable and adequate water supply for Amman and surrounding regions, particularly during peak demand periods.
- **Improvement in Public Health:** With a stable and increased water supply, the project would improve access to clean drinking water, thereby reducing the risk of waterborne diseases and enhancing overall public health conditions.

Table 50 presents an overview of the evaluation of the proposed “Project” versus “No Project”. Going forward with the proposed project alternative is considered the best possible option as opposed to “No Project” since the proposed project will significantly enhance water security for Amman and

surrounding regions by increasing the water supply capacity to meet growing demand. It will also improve the quality of the water delivered, directly benefiting public health.

Table 50: Comparison of overall environmental and socio-economic impacts for the "project" Vs. "no project" alternative

Environmental Components	Project Options	
	Proposed Project	No-Project Alternative
Water Supply	S+	S-
Water Resources	S-	S-
Air Quality	X	*
GHG Emissions	S-	*
Noise Generation	X	*
Waste Generation / Disposal	X	*
Biodiversity and Ecosystem	X	*
Soil Erosion	S-	*
Public Health	S+	S-
Socio-Economic Impacts	S+	*
Traffic Disturbance	X	*
Land Use	*	*
Land Acquisition	*	*
Archaeology / Cultural Property	*	*
Energy Consumption	S-	*
Employment and Job Opportunity	S+	*

Notes:
X: Denotes potential for impact, which is not considered significant
S-: Denotes Potential Significant Adverse Impact
S+: Denotes Significant Beneficial Impact
***: Denotes no change to the existing situation**

8.2 Wells Locations Alternatives

8.2.1 Selection of Wells Overview

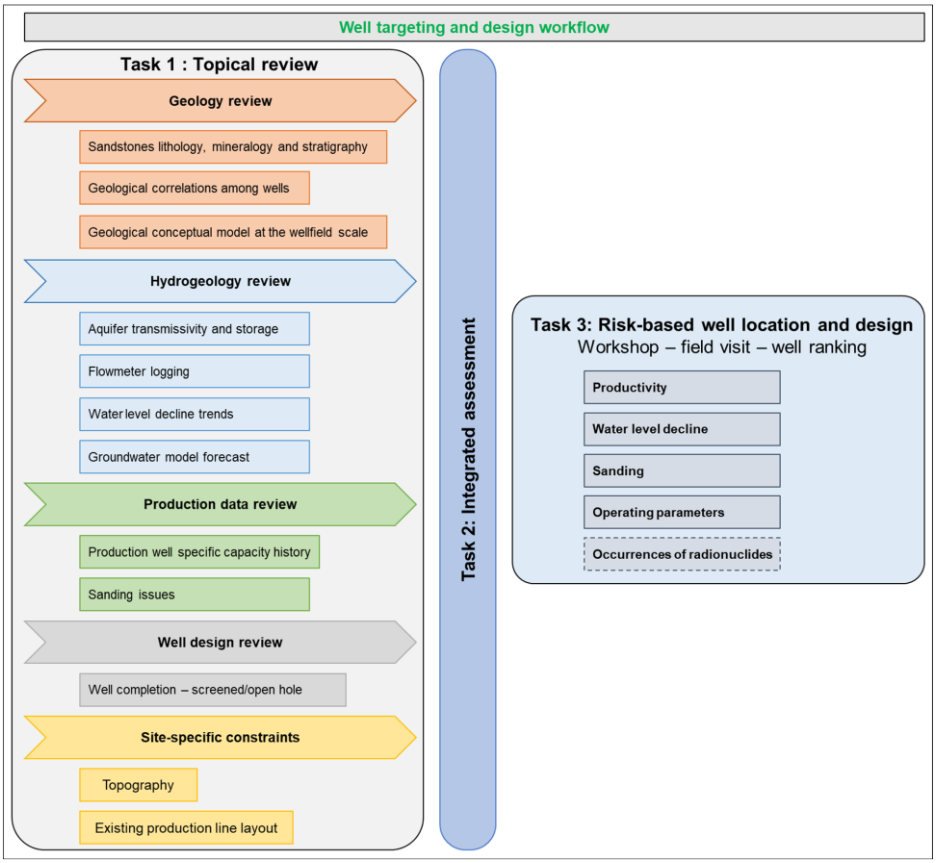
To determine the most suitable locations for new wells in the Dubaydib wellfield, the BRGM study employed a systematic approach to select the optimal sites for the new wells. The well targeting process entailed integrating the datasets of all geoscientific disciplines to build a robust conceptual model of the Dubaydib wellfield groundwater resources with the following objectives:

- Most productive sandstone horizons,
- Screen completion and sand pumping issues,
- Water level drawdowns,
- Site-specific constraints such as topography, and connection to the existing production lines.

The well locations were evaluated through a three-step process:

1. **Topical Review:** identifies key criteria and indicators from geoscientific data to determine optimal well locations. This step included the initial selection of 47 proposed well sites.

2. **Integrated Assessment:** ranking and grading system is then developed to evaluate the potential of each well location based on these criteria.
3. **Workshop – Field Visits:** criteria are weighted using expert input and stakeholder considerations, including factors like pipeline costs and CAPEX/OPEX strategy, to finalize well locations that balance risks, achieved through a collaborative workshop.



Source: BRGM, 2023

Figure 61: BRGM Geoscientific Well Targeting and Design Workflow

8.2.2 Step 1: Topical Review

The assessment of well location alternatives for the Dubaydib wellfield, involved a comprehensive review of geology, hydrogeology, well design, and site constraints. The geology review refined the stratigraphy of the Ram group aquifer, focusing on porosity, permeability, and radionuclide content. Hydrogeological data highlighted water level decline trends, with shallower water levels being preferred for well placement. Site constraints, including topography and regulatory requirements, were crucial in selecting accessible locations while adhering to the Jordan-Saudi Arabia agreement and considering infrastructure needs for well integration.

Forty-seven (47) new well locations have been planned, taking into account the topography and maintaining an average distance of 1,250 meters between wells. This spacing aligns with the existing wellfield layout, helping to minimize hydraulic interference in the aquifer and ensuring compatibility with the hydraulic surface network.

8.2.3 Step 2: Integrated Assessment and Well Ranking Criteria

8.2.3.1 Ranking

The analysis identified eleven well-siting criteria, grouped into five main risk categories, as shown in **Table 51**:

- **Groundwater Quantity**: Criteria 1, 2, 3, 4, and 6 relate to the well's expected productivity and water-level decline.
- **Groundwater Quality**: Criteria 5, 7, and 8 address the risk of radionuclide contamination, known within the Disi/Ram-group aquifer.
- **Well Completion**: Criteria 3, 7, and 9 concern the expected Electrical Submersible Pump (ESP) setting depth and the risk of borehole caving during drilling.
- **Pipeline Costs**: Criteria 11 approximates the engineering and costs to connect new wells to the supply system.
- **External Factor**: Criteria 10 considers a Jordan-Saudi Arabia agreement that restricts well locations.

8.2.3.2 Criteria Weights

A total rating of all the criteria is calculated for each well, as the weighted sum of each criteria. This weighted approach reflects the risk management approach and whether stakeholders are more or less comfortable with a given risk.

Table 51: Criteria Retained for Well Siting, Associated Risks and Rating Method

No.	Main criteria	Associated risks	Rating
1	Distance from outcrop	Wells closer to the Ram group outcrops (i.e., the aquifer boundary) have a reduced aquifer thickness, and potentially reduced longevity Proximity to the aquifer boundary limit leads to increased risk of well dewatering/reduced lifetime	Defined as a rank based on distance from the aquifer limits: 1 - closer to the aquifer boundary (0%) 7 - farthest from the aquifer boundary (100%)
2	Simulated water level (WL) decline trend as of 2022	Wells located in higher WL decline trend areas will have a reduced longevity	Proportional to the simulated WL decline trend as of 2022 (from GW model): lowest: -0.61 m/yr (100%) highest: -2.44 m/yr (0%)
3	Depth to WL	Wells located in areas where Ram group aquifer WL is deep may require deeper ESP setting depths, will have reduced longevity and reduced specific capacity	Proportional to the simulated WL depth of 2022 (from GW model): lowest: 50.2 m bgl (100%) highest: 159.4 m bgl (0%)
4	Aquifer confinement/storability	Wells located in confined parts of the aquifer will have an increased drawdown rate than for the unconfined parts	Class-based ranking If located in the unconfined part of the aquifer (100%) If not (0%) The confinement boundary location is based on the GW model
5	Depth to top Ram group	Wells located in areas where the top Ram group is too deep may require lowering the casing shoe to tap the productive sandstone (i.e., increased completion costs) Productive sandstone at the upper top of the Ram group may yield higher radionuclides-containing (RN) groundwater	Proportional to the simulated depth to the top Disi formation within the Ram group outcrops: 0 m bgl (100%) deepest: 244.5 m bgl (0%)
6	Depth to productive Umm Sahm sequence	Wells located in areas where the drilled formations are less likely to encounter the productive Umm Sahm sequence will result in less productive wells. If the top of this productive section is above 350 mbgl, it will be likely cased off and thus inaccessible	Proportional to the simulated depth to the top Umm Sahm formation: shallowest: 103 m bgl (0%) deepest: 372 m bgl (100%)
7	Depth to top Disi	Wells located in areas where the main productive section would be from the Disi	Proportional to the simulated depth to the top Disi formation

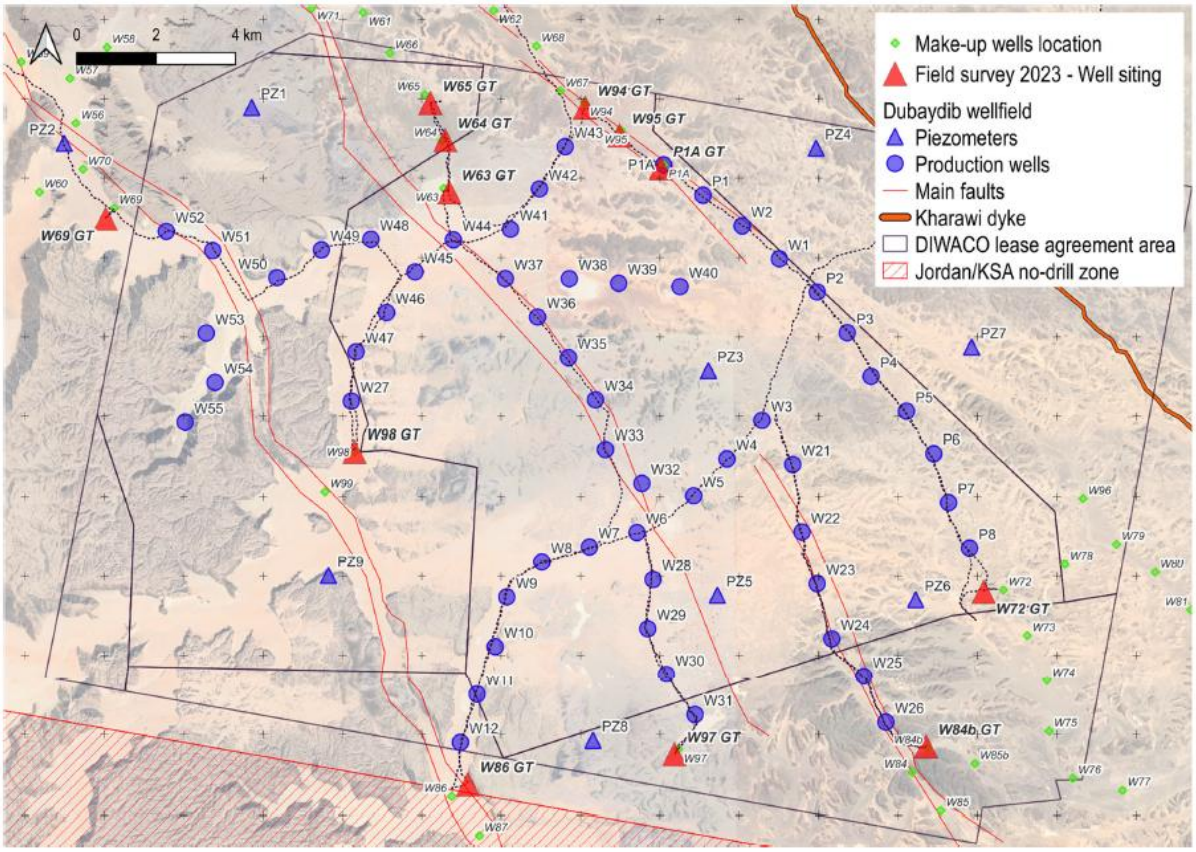
No.	Main criteria	Associated risks	Rating
		sandstone formation are susceptible to the following risks: - Disi sandstone appears to be more prone to caving at the top (more friable/crumblier than Umm Sahm formation) - Groundwater produced from Disi sandstone may yield higher RN water - Disi sandstone may be less productive than Umm Sahm formation	- shallowest: 263.9 m bgl (0%) - deepest: 550 m bgl (100%)
8	Located in a graben	Wells located in structural grabens may yield higher RN in groundwater	Class-based ranking - If located in a graben (0%) - If not (100%)
9	Caving occurrences	Sandstone sequences prone to caving have been identified in both the Umm Sahm and the Disi formations. It is likely that any new wells drilled within the Ram group sandstone will encounter caving to some extent and appropriate casing materials (i.e., screens) should be considered.	Class-based ranking - Drilled formation likely prone to caving (0%) - If not (100%)
10	Located in the Jordan/KSA no-drill zone	Wells located in the no-drill zone as defined by the 2015 Jordan-KSA agreement for the Management and Utilization of the Groundwater in the Disi-Saq aquifer may be prohibited	Class-based ranking - If located in the no-drill zone (0%) - If not (100%)
11	Distance from existing pipeline	Engineering costs associated with connection to the existing pipeline will be higher for wells located farther away from the existing supply system infrastructure.	Defined as a rank based on distance from the closest pipeline 1 - closer to the pipeline (100%) 7 - farthest from the pipeline (0%)

8.2.4 Step 3: Workshop – Field Visits

A workshop with key stakeholders and the field visit resulted in prioritizing well locations that minimize connection costs and avoid flood-prone areas. This consensus was followed by a field visit to assess 12 potential sites, ensuring they were suitable for drilling and accessible for equipment.

8.2.5 Final Wells Location

Figure 62 presents the final locations of the 12 selected wells, based on the comprehensive assessment process to determine the optimal well sites.



Source: BRGM, 2023

Figure 62: Map of the Final Potential Production Well Locations Siting (Red Triangle)

8.3 Wellfield Groundwater Extraction Scenarios

Several extraction scenarios were analyzed and studied to assess the impacts of groundwater extractions on additional drawdown.

The key findings of the study are summarized as follows:

- The additional drawdown resulting from extracting 120 MCM annually is projected to reach approximately 8 meters by 2038.
- To maintain redundancy across three existing wells, DIWACO will need to drill four additional wells by 2030 to ensure operational stability.
- Based on the model simulations and the new calibration, all production wells will remain operational with sufficient water levels above the pumps at the end of 2038, even in the 120 MCM/year scenario.

8.3.1 Well Requirements and Groundwater Drawdown Projections

Table 52 presents the number of wells required to sustain different groundwater extraction rates (MCM/year). It outlines the number of additional wells needed for various abstraction scenarios to maintain efficient production and redundancy.

Table 52: Number of Wells Needed for Different Abstraction Scenarios

Model Output for Number of Wells Needed to Extract (MCM/year)			
Date	100 MCM	112 MCM	120 MCM
Sep (2014)	42	48	52
Sep (2022)	45	50	54
Sep (2030)	48	52	56
Sep (2038)	51	54	58

Table 53 summarizes the projected drawdown under different abstraction scenarios over a 25-year period, providing an estimate of the groundwater level decline (in meters) by 2038 for each scenario.

Table 53: Groundwater Drawdown Scenarios By 2038

25 Years of operation (By 2038)	
Abstraction Scenario	Drawdown
MCM	Meter
100	Up To 38 m
112	Up To 42 m
115	Up To 44 m
120	Up To 46 m

8.3.2 Groundwater Level Elevation

Figure 63 illustrates groundwater level elevation over the years for different abstraction scenarios. The figure helps visualize the long-term impact of varying abstraction rates on water levels.

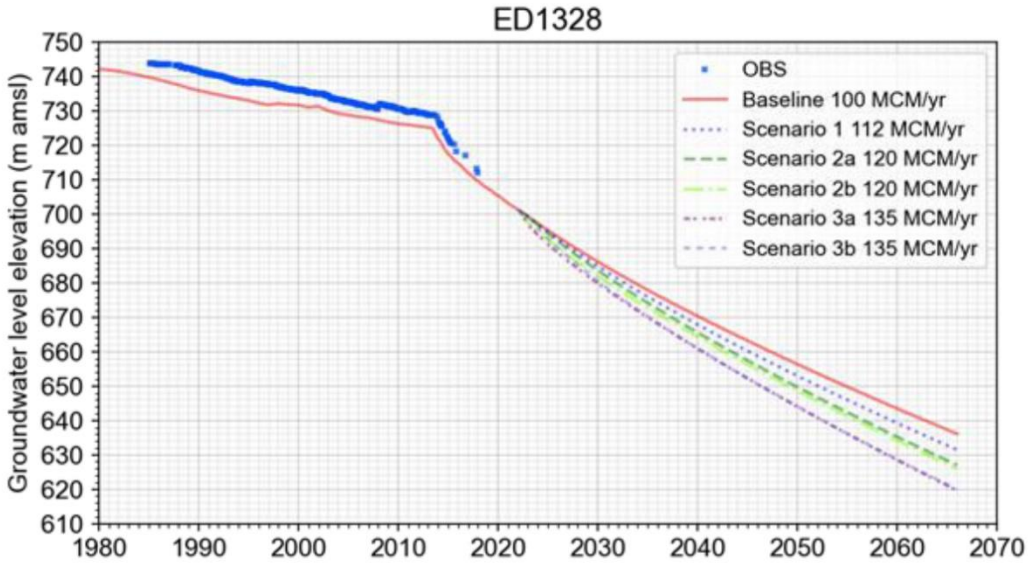


Figure 63: Groundwater Level Elevation Based on Different Scenarios

9 IMPACT ASSESSMENT

An impact assessment was undertaken following the full characterization of the environmental, social and health baseline, and identification of all project aspects. The scope of the assessment covers all project area and was undertaken in accordance with relevant MoEnv regulations and applicable local, national, IFC, and EIB standards and guidelines. In addition, this assessment has used the World Bank Group EHS Guidelines for Water and Sanitation (2007) as a reference to ensure that all identified impacts and mitigation measures reflect international best practices. However, for monitoring and compliance, national legislation and standards have been applied as the primary basis.

9.1 Approach and Methodology

Initially, project environmental, social and economic and health aspects were identified for the proposed activities. The activities were considered in terms of their potential to:

- Interact with the environment (physical, biological, socio-economic); and
- Breach the conditions of relevant national and international standards and guidelines or company policy.

The environmental, socio-economic and engineering information and data gathered, organized and reviewed during the baseline and aspect identification tasks were systematically developed to prepare matrices of key project activities and environmental, social, health, and economic receptors. This allowed for a preliminary assessment of the key environmental and socio-economic issues, or 'key issues' associated with the project to be completed.

When assessing impacts, the following were considered:

- Both positive and negative impacts
- Impacts occurring directly or indirectly from project activities
- Magnitude of impact
- Public health and safety risks
- Geographical extent of the effect
- Duration and frequency of the impact
- Sensitivities of the receiving environment over the entire project area
- Potential significance
- Residual impacts.

As part of the assessment, the potential cumulative effects were considered, taking into account other developments in the local area. In addition, the process has incorporated stakeholder engagement to ensure that the concerns and inputs of affected communities and other relevant parties are considered throughout the project lifecycle. Furthermore, the identified impacts, mitigation measures, and monitoring requirements are consolidated into a comprehensive Environmental and Social Management Plan (ESMP), which will guide implementation, compliance, and continuous improvement. Attention has been given to human rights and gender considerations, ensuring that the assessment and proposed measures promote equitable benefits and do not disproportionately affect vulnerable groups or indigenous people.

Once all of the project's environmental and socioeconomic impacts have been assessed, the significance of the impacts was ranked by considering the following elements:

- The consequence of identified events: the resulting effect (positive or negative) of an activity's interaction with legal, natural and/or socioeconomic environments; and
- Likelihood: the likelihood that an activity or event will occur.

Agreed criteria were defined for each level of consequence and each level of likelihood and the significance of the impact associated with each identified aspect is the product of the consequence and likelihood. It should be noted that the assessment has been conducted by considering the mitigation measures normally designed into / included in the project.

The following sections briefly describe the consequence, likelihood, and significance criteria.

9.1.1 Consequence

To assign a level of consequence to each environmental and social impact, criteria are defined for environmental and socio-economic consequence or severity. Legal issues are embedded in both criteria sets. The consequence categories and their ranking are presented in **Table 54**.

Table 54: Consequence Categories and Rankings

Consequence	Ranking	Description
Catastrophic	5	Massive effect – Persistent severe environmental damage or severe nuisance extending over a large area. In terms of commercial or recreational use or nature conservation, a major economic loss for the Company. Constant, high exceedance of statutory or prescribed limits, high profile community outrage.
Severe	4	Major effect – Severe environmental damage. The Company is required to take extensive measures to restore polluted or damaged environment to its original state. Extended breaches of statutory or prescribed limits, and serious community concerns and complaints.
Critical	3	Localized effect – Limited discharges of known toxicity, considerable community concern and/or complaints. Repeated breaches of statuary or prescribed limit. Affecting neighborhood. Spontaneous recovery of limited damage within one year.
Marginal	2	Minor effect – Contamination. Damage sufficiently large to damage the environment, some community concerns raised. Single exceedance of statutory or prescribed criterion. No permanent effect on the environment.
Negligible	1	Slight effect – Local environmental damage. Within the fence and within systems. Negligible financial severity.
None	0	No impact
Positive	+	Beneficial impact – enhances the environment

It should be noted that it is often difficult to compare impacts consistently across different natural and socio-economic environments. When evaluating the environmental and socio-economic aspects, emphasis was placed on specific cause and effect relationships.

Scientific evidence as well as predictions based on observation of previous similar activities can and have been used in the impact assessment process. Where it has not been possible to fully quantify the effect that an activity may have on the environment or a component of the environment, or where there is a lack of scientific knowledge, qualitative judgment has been used. Such judgments are based on a full understanding of the project activities, and the team's knowledge of the environment, social structure and general health aspects of the region in which the project's activities will occur.

9.1.2 Likelihood

To assign likelihood to each activity, five categories are defined and ranked. The criteria for likelihood are shown in **Table 55**.

Table 55: Likelihood Categories and Rankings

Category	Ranking	Definition
Certain	5	The activity will occur under normal operating conditions
Very Likely	4	The activity is very likely to occur under normal operational conditions
Likely	3	The activity is likely to occur at some time under normal operating conditions
Unlikely	2	The activity is unlikely to occur but may occur at some time under normal operating conditions
Very Unlikely	1	The activity is very unlikely to occur under normal operating conditions but may occur in exceptional circumstances

9.1.3 Significance

The significance of the impact is expressed as the product of the consequence and likelihood of occurrence of the activity, expressed as follows:

Significance = Consequence x Likelihood

Figure 64 Illustrates all possible product results for the five consequence and likelihood categories.

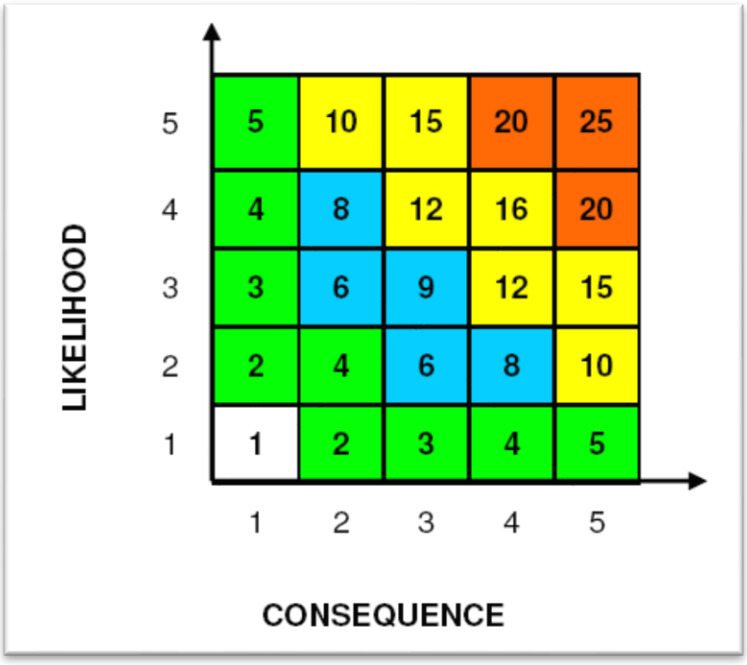


Figure 64: Product Results for Consequence & Likelihood Categories

Based on its consequence-likelihood score, each environmental aspect has been ranked into five categories by order of significance as illustrated in **Table 56**.

Table 56: Significance Categories

Ranking (Consequence X Likelihood)	Significance
>16	Critical
10-16	High
6-9	Medium
2-5	Low
<2	Negligible

9.1.4 Residual Impact

Residual impacts are impacts that remain after mitigation measures, including those incorporated into the project's base design and those developed to address specific impacts.

The residual impacts assessment identifies which project activities are likely to result in a semi-permanent to permanent change in the natural (i.e., physical, biological) and/or socio-economic environments. The significance of this change was also assessed.

9.2 Potential Environmental and Social Impact Assessment

Every identified aspect was assessed in terms of its potential to cause an impact on natural and/or socio-economic receptors and was subsequently ranked in terms of consequence and likelihood, thus enabling the determination of the overall significance of the impact. This section addresses the potential environmental and social impacts specific to this project.

The section is structured according to the main issues and effects resulting from the proposed project activities across the following project phases:

- Construction Phase which includes drilling the new groundwater wells, connection to the existing pipeline network and/or new network, and the service roads and electricity connection within the wellfield area.
- Reinstatement stage where all working areas or other areas used by the contractor shall be reinstated to a condition and in a manner, which is similar to and no worse than the original condition.
- Operation Phase for the different newly constructed facilities throughout the project.
- Decommissioning Phase of the project.

9.2.1 Physical Environment

9.2.1.1 Air Quality

Construction Phase

The main impacts associated with construction activities of new groundwater wells, connection to the existing pipeline network and/or new network, and service roads and electricity connection within the wellfield area would be:

Dust generation: resulting from earthworks such as leveling, grading, drilling and excavation works, and movement of vehicles along the roads, especially during windy conditions. The contractor shall

be committed to control dust from such operations through the proposed dust emission control procedures described in the ESMP included in this report. Considering the short duration of construction activities at a given location, it is not anticipated that dust levels will greatly impact the existing sensitive receptors within the adjoining area provided mitigation measures are implemented properly.

Exhaust emissions: Exhaust emissions of SO_2, NO_2, and PM_{10} would be attributed predominantly to the use of equipment for drilling the new groundwater wells and road vehicles such as the movement of trucks and vehicles during construction works. The nearest agricultural farm around 2 Km far from the nearest proposed well, all residential areas are far more than 5 km from the project boundary, thus there would be no potential nuisance impacts on the farm or any residential areas from the construction activities. These emissions will be localized to the project area. Therefore, any deterioration in the air quality at the project location is considered to be **Likely** (**3**) and **Marginal** (**2**) consequence with an overall **Medium** (**6**) Impact significance and is expected to be transient.

Green House Gas Emissions (GHG)

According to historical well records at the Dubaydib wellfield, the rig and camp generator would be the primary source of emissions during the construction period. The rig and camp generator would consume 45,545 liters of diesel annually / well. The emission factors to estimate the GHG are shown in Annex 10.

Diesel fuel produces 2.7 kg of CO_2 per liter (EIB Project Carbon FootprintMethodologies,2023) [58] , thus:

The total emissions = 122 tons of CO_2 / year/ well, Therefore, the GHG is considered to be **Likely (3)** and **Negligible (1)** consequence with an overall **Low** (**3**) Impact significance. It is considered a minimal contribution to Jordan's overall GHG emissions.

Operation Phase

Dust generation will be limited to the vehicular movement during the maintenance operations. In addition, indirect air emissions would be generated from energy consumption resulting from pumping operations. Based on the above, potential dust generation impact is considered **Unlikely** (**2**) with a **Marginal** (**2**) consequence, with an overall impact significance of **Low** (**4**).

Greenhouse Gas Emissions (GHG)

It is worth mentioning that the primary source of CO_2 emissions from well operations would be the indirect emissions from electricity use. These emissions will be estimated as follows:

The CO_2 emissions from electricity generated ($kgCO_2$/year) = Electricity consumption (kWh/year) × CO_2 emissions factor ($kgCO_2$/kWh).

- Electricity Consumption: Average well electricity consumption is: 121,971 kwh /year/well
- Emission Factor: The electricity grid emission factor for Jordan is considered to be 0.4585 $kgCO_2$/Kwh based on Jordan's Fourth National Communication Report (2022) [59] and (SBUR,2020) report[60].

[58] EIB Project Carbon Footprint Methodologies
[59] Jordan's Fourth National Communication Report,2022
https://www.moenv.gov.jo/ebv4.0/root_storage/en/eb_list_page/jordans_4th_national_communication_report.pdf
[60] Jordan's Second Biennial Update Report (SBUR) Under the United Nations Framework Convention on Climate Change,2020.

Expected CO_2 emissions	=55,923.63 kgCO_2/year / well ≈ 56 Ton /year/well

The total emissions of 56 tons of CO_2 per well and this is considered a minimal contribution to Jordan's overall GHGs emissions. Thus, the impact of the GHGs is considered to be **likely (3)** with **Negligible (1)** consequences at normal operation conditions with an overall **Low** (**3**) impact significance. On the other hand, the continuous groundwater extraction will deepen the piezometric depression in the wellfield as the water levels will decline which requires deeper wells, increasing costs for drilling, and pumping and accordingly increasing the associated GHG emissions. It is recommended to consider the use of renewable energy for future water pumping operations.

Decommissioning Phase

Similar to construction, the decommissioning phase is anticipated to generate dust and exhaust emissions. Decommissioning activities would involve site preparation, dismantling and disassembling of the components, clearance of the site, and reinstatement.

Similarly, to the construction phase, local degradation of air quality is expected on a limited and temporary level. As a result, the impact is considered **Likely** (**3**), with a **Marginal** (**2**) given the temporary nature of decommissioning, yielding an overall **Medium** (**6**) impact significance and it is expected to be transient.

9.2.1.2 Noise

Construction Phase

Construction and site preparation activities such as earth moving, site excavation, well-drilling, transportation of equipment and materials to and from the site through the surrounding road network, and installation of equipment, would contribute to noise impacts.

The noise levels of construction vehicles, equipment, and machinery are likely to exceed the noise allowable limits. However, noise exceedances from the construction vehicles, machinery, and equipment will be limited to the construction period and will be short-term. The construction of the new proposed wells will be conducted gradually. This may cause noise disturbances to the identified nearby sensitive receptors (ex: workforce, Flora, Fauna, and Sensitive Habitats). The recorded levels, though, are known to decrease with distance from the sources. The contractor will take into consideration all nearby sensitive receptors. The Construction activities will occur under normal operating conditions and are expected to have a localized effect with repeated breaches of statutory or prescribed limits mainly causing noise impacts within the vicinity of construction activities. Therefore, the increased noise levels on-site are limited to occupational noises that require occupational health and safety measures illustrated in the ESMP and shall comply with the occupational noise exposure limits.

https://unfccc.int/sites/default/files/resource/Jordan%E2%80%99s%20Second%20Biennial%20Update%20Report%20for%20web%2010-5.pdf

The activities will occur under normal operating conditions and are expected to have only localized and temporary effects within the project area, the impact likelihood is **Very Likely** (**4**) with a **Marginal** (**2**) consequence, thus the impact significance is **Medium** (**8**).

Operation Phase

The main source of noise during the operation phase would result from the operation of pumps as well as the movement of heavy machines during operation & maintenance activities. The sounds produced by the operation of pumps would only be audible from a nearby location and would not be anticipated to travel off-site recipients because sound decreases with increasing distance from the source. Therefore, the nearby sensitive receptors would be the operational and maintenance staff.

As a result, and assuming continuous maintenance to enhance the efficiency of the pumps and other noisy operations and considering all mitigation measures reported within the ESMP, the impact is **Unlikely** (**2**), with a **Marginal** (**2**) consequence, thus, the overall significance is **Low** (**4**).

Decommissioning Phase

The noise impact resulting from the decommissioning activities and removing the ancillary facilities would be similar to those anticipated from the construction activities. The workers at the site and within the proposed facilities of the well field will be the main receptors. Thus, the decommissioning activities would be localized, limited to occupational impacts, and have temporary effects within the project area, thus it requires occupational health and safety measures.

9.2.1.3 Soil

Negative impacts on soil during the construction and operation of the new wells may be related to:

- Soil creep, stability, topsoil loss and damage;
- Soil contamination;

Construction Phase

Soil creep and stability: The impact on soil creep and stability needs to be taken into account while construction is underway, particularly setting up of the construction site and camp, equipment replacement, earthworks, and temporary and permanent infrastructure arrangements as well as the surface water runoff. Excavation and construction operations related to well drilling may cause soil erosion and sedimentation if appropriate erosion control measures are not in place.

Soil contamination: It is anticipated that soil contamination will occur during the preparatory and construction phases as a result of mishandling of wastes causing direct contamination to soil which may penetrate to lower layers of soil depending on the spilled amount. Oil, chemicals and fuel spills or leaks from vehicles or other equipment used throughout the project area, in addition to inappropriate treatment of camp wastewater, or inadequate management of a removed soil layer during the construction phase.

To address these concerns, a soil management plan, spill response plan, and waste management plan must be developed and implemented. The soil management plan should include specific mitigation measures for preventing and managing soil creep and instability, while also addressing contamination risks through appropriate handling, storage, and disposal practices.

In addition, disposal of hazardous products including disposal of oils shall be according to legal requirements. Assuming that such plans shall be in place and implemented by the contractor taking into consideration the proper implementation of the proposed mitigation measure as illustrated in

the ESMP, it is anticipated that impacts to soil resulting from these activities will be **Likely**(**3**), with a **Marginal** (**2**) consequence, thus the impact significance is **Medium** (**6**).

Operation Phase

During the operation phase, no impacts on the stability of the soil or topsoil loss or damage are anticipated. However, soil contamination may result from leakage of fuel and lubricant storage and misconduct usage regulations, poorly managing municipal and other solid wastes (e.g., contaminated cloths used for equipment cleaning, dirty work gloves). The impact is also anticipated throughout the maintenance operations which necessitates the need for applying mitigation measures while carrying out maintenance activities. However, given the spill response procedures and good site practice that is expected to be in place as a result, the magnitude of the spill is expected to be minimal during operation. The proper existing /developed monitoring programs and implementation of spill response procedures, and proper storage and handling of any chemicals hazardous materials on site, will reduce the probability of the impact. Therefore, this impact is **Likely** (**3**), with a **Marginal** (**2**) consequence, yielding an overall **Medium** (**6**) impact significance.

Decommissioning Phase

During the decommissioning phase, the decommissioning activities are anticipated to have an impact of medium significance on the soil. This is due to possible accidental leakage of fuel, oil, or chemicals during dismantling activities. Therefore, proper environmental protection measures should be followed to prevent or control the occurrence of such incidences. The impact is **Likely** (**3**) to occur, with a **Marginal** (**2**) consequence, resulting in a **Medium** (**6**) impact significance.

9.2.2 Water Resources

9.2.2.1 Surface Water

All Phases

Based on the results of the literature review and meteorological & morphological analysis for the Dubaydib wells and its components, the meteorological and morphological analysis conducted for the precise location of the new wells and its components indicate a flood risk at the wells site, potentially leading to flooding, soil erosion and sediment transport. The morphological analysis reveals that both the proposed and existing wells are situated within areas where the delineated watersheds intersect and where the flow paths traverse the site. A comprehensive hydrological study and hydraulic design are required for the location of the new wells and its components to estimate the maximum flood flow values at 50, 100-yr. return periods and to determine the maximum peak flow and depth. Hence, propose suitable flood mitigation measures and erosion/scouring protection works.

Ongoing monitoring of hydrological conditions, flood risks, and erosion control measures should be part of the project's management plan. Regular inspections and maintenance will be crucial, especially after major storm events, to ensure the continued effectiveness of flood mitigation and erosion control systems.

The impact is **Likely** (**3**) to occur, with a **Marginal** (**2**) consequence, resulting in a **Medium** (**6**) impact significance.

9.2.2.2 Groundwater

Construction Phase

The conclusion can be drawn from the reviewed studies highlight that effective management of the Disi Aquifer's groundwater is essential for maintaining its long-term viability as a vital water source for Jordan.

Drilling can release contaminants into groundwater, affecting the quality of the water, if proper safeguards are not taken. This includes the potential contamination from lubricants and other chemicals (drilling fluids) used in the drilling process, as well as the risk of improper waste disposal by workers. Employing best practices for well drilling, including proper well design, construction, and maintenance, can help minimize environmental impacts and prevent groundwater contamination. The impact is considered **Likely** (**3**) with a **Critical** (**3**) consequence, yielding a **Medium** (**9**) impact significance.

Excavation and drilling activities might disrupt the natural flow patterns within the aquifer, potentially causing localized drawdowns or changes in groundwater flow. Employing best practices for well drilling, including proper well design and construction, can help minimize environmental impacts.

Operation Phase

Accidental spills from fuel, lubricants, and other chemicals used for maintenance and operation, and accidental chemical spills and leaks could negatively affect groundwater water quality. Proper implementation of the best practices and the proposed mitigation measure as illustrated in the ESMP is required.

According to the groundwater model for the Dubaydib wellfield, conducted in 2024, projections show that by 2038, continued groundwater extraction will deepen the piezometric depression in the wellfield by an additional 20 to 25 meters, compared to the current groundwater table. By 2065, the model predicts that the piezometric depression will expand further by over 50 meters in many parts, extending beyond the wellfield and impacting surrounding areas, including agricultural zones in Disi and Al Mudawarra, which also rely on the aquifer for irrigation. This could threaten agricultural productivity and the livelihoods dependent on these areas.

The reliance on non-renewable groundwater from the Disi aquifer is recognized by the Government of Jordan as unsustainable. In response, the government has planned alternative future water supplies, such as the Aqaba-Amman Water Desalination and Conveyance Project. However, these alternatives are not yet operational, and until they are implemented, the pressure on the Disi aquifer will continue to mount, potentially leading to environmental unsustainability and socioeconomic challenges in the region.

Long-term water level drawdown may cause parts of the aquifer to transition from a confined to an unconfined state, potentially impacting groundwater quality and the aquifer's quantitative response (e.g., decreasing transmissivity and specific capacity of production wells), while increased downward leakage from the overlying Khreim group aquifer system could further degrade groundwater quality. for all of the above, the impact is considered **Likely** (**3**) with a **Severe** (**4**) consequence, yielding a **High** (**12**) impact significance.

Land Subsidence:

Based on the available information, including the detailed geological and hydrogeological characterization of the Disi aquifer system and the latest BGR groundwater modeling study, the following conclusion regarding land subsidence risk is drawn:

The BGR report, which investigated various groundwater abstraction scenarios for the Disi aquifer, does not identify land subsidence as a potential risk. This indicates that, based on current modeling and available data, significant land subsidence has not been observed or projected as a primary concern within the scope and timeframe of that study. This finding is further supported by the geological characteristics of the Disi aquifer, which is predominantly composed of sandstone formations. such lithology is generally less susceptible to severe or rapid land subsidence compared to aquifers rich in highly compressible thick clay or silt layers (UN-ESCWA and BGR report (2013)[6] and MEMR).

However, despite these current assessments, it is crucial to acknowledge that the Disi aquifer is a non-renewable fossil water resource currently experiencing significant and ongoing groundwater level declines (projected to be over 50 meters by 2065). While sandstone is less compressible than clay, substantial and prolonged pore pressure reduction can still lead to compaction and ground deformation over time. Furthermore, specific dedicated land subsidence studies for the Disi aquifer are not currently available, meaning the absence of identified risk is largely based on inference from groundwater models rather than direct, long-term monitoring.

Therefore, while the current assessment suggests that land subsidence may not be a primary or immediate risk compared to other project impacts, the potential for slow-developing land subsidence cannot be entirely ruled out in the long term.

9.2.3 Biological Environment

According to the biodiversity study (Annex 11**)**, the project area is located in a desert ecosystem characterized by low vegetation cover and significant human disturbance from activities such as grazing and vehicle movement. These factors have degraded much of the local environment, reducing its ecological sensitivity. The potential impacts of the proposed project activities during the construction and operation phases have been evaluated, with a focus on flora, and fauna, sensitive habitats (protected area, important bird area, and rangeland reserves), and ecosystem services as illustrated in the section below:

Construction phase

Flora and Fauna

The construction activities of new groundwater wells, connection to the existing pipeline network and/or new network, and service roads and electricity connection within the wellfield area would have significant impacts on flora and fauna, primarily due to physical disturbances and habitat alterations. For instance, increased noise and human activity during the construction phase, including workers and machinery, could disturb local wildlife behavior, including feeding, breeding, and migration patterns, and could also contribute to further degradation of plant habitats, particularly in sensitive areas like wadis. In addition, improper waste disposal could accumulate in the area, leading to long-term pollution that affects both flora and fauna. Moreover, birds and other wildlife that perch on power lines or towers may be at risk of electrocution, particularly larger birds that may span across

conductive components. To ensure the protection of Flora and Fauna during construction, it is essential to create buffer zones around sensitive areas to minimize disturbance, develop and implement a comprehensive waste management plan, and ensure that hazardous waste is disposed of at approved facilities. In addition, guidelines for the protection of migratory birds from the danger of electric shock should also be implemented along with the proposed mitigation measure illustrated in the ESMP.

Sensitive habitat

For the construction phase, the biodiversity study revealed that the drilling activities and associated infrastructure development near or within the Rum IBA pose a significant disturbance to bird populations, particularly species of conservation concern such as the Sooty Falcon, Lesser Kestrel, and Sinai Rose Finch. Increased noise, vibrations, and human presence can disrupt key behaviors such as nesting, feeding, and migratory stopovers. Sensitive species may abandon their nesting sites or experience lower breeding success due to these disturbances, leading to long-term population declines. Also, migratory birds, which rely on the IBA as a critical stopover during their journeys, may be forced to alter their routes or stop at suboptimal locations, further impacting their survival. Additionally, large raptors, which are particularly sensitive to human activity, could face habitat abandonment, diminishing the ecological value of the IBA for bird conservation.

Moreover, birds and other wildlife that perch on power lines or towers may be at risk of electrocution, particularly larger birds that may span across conductive components within the vicinity of two wells situated within Rum IBA, W69 and W98. These wells lie in a region of the IBA that is essential for both resident and migratory bird species. Therefore, guidelines for the protection of migratory birds from the danger of electric shock should be implemented, along with the mitigation measures presented within the ESMP. The remaining wells in the project are located close to the IBA's eastern borders, further underscoring the importance of implementing measures to minimize disturbances to the surrounding environment.

On the other hand, Rum protected area is the closest protected area to the project site and it is located about 18 km away. The project site does not fall within the boundaries of this protected area, thus, direct impacts on the protected area are considered unlikely. On the other hand, the proximity of the project site to the Rum protected area is considered notable due to the ecological significance of the region, thus indirect effects, such as disturbances to wildlife corridors or migration patterns, should be considered and relevant mitigation measures should be implemented to minimize any potential adverse impacts. However, given the relatively limited size of the project activities and the possibility of implementing targeted mitigation measures, these impacts can be minimized or avoided altogether, preserving the ecological integrity of the IBA.

It is worth mentioning that the project site is located approximately 15 km from the nearest rangeland reserve, Al Mudawara. Therefore, direct impacts from construction activities on Al-Mudawara rangeland is considered unlikely. However, it is crucial to develop mitigation measures to ensure that the project activities do not disrupt such natural resources and maintain the ecological and economic benefits provided by rangeland reserves.

Ecosystem services

The project's activities, including drilling, road construction, and the installation of electricity transmission lines, are likely to affect several ecosystem services including water regulation, particularly in desert environments where water is scarce as well as soil stabilization.

Wadis and runoff areas play a crucial role in collecting and storing water during rare rain events, supporting vegetation and wildlife that depend on these moisture-rich zones. Drilling and road construction may disrupt natural water flow, reducing the ability of these areas to retain water, thus decreasing availability for plants and animals. Additionally, the compaction of soils and removal of vegetation can increase runoff and erosion, further reducing the water retention capacity of the land and threatening both flora and fauna that rely on these water sources.

On the other hand, in desert ecosystems, vegetation plays a vital role in preventing soil erosion by anchoring the soil with its roots. The removal of plants for drilling operations, road construction, and transmission lines can lead to soil erosion, particularly in sandy or loose soils. Without vegetation cover, the area is more vulnerable to wind and water erosion, which can degrade the land and lead to desertification. The loss of vegetation also reduces carbon sequestration, although it is minimal in desert ecosystems, contributing to the global challenge of climate change. Furthermore, the degradation of habitats may impair the area's ability to support biodiversity, disrupting the intricate balance of ecosystem services that sustain both wildlife and local communities. Therefore, is it significant to minimize soil disturbance and implement erosion control measures to avoid/minimize any potential impacts.

Thus, the overall impact during the construction of the proposed project is likely to be somewhat alleviated by the existing disturbances and the sparse vegetation, which limits the extent of habitat destruction and species displacement. Hence, careful consideration is required to ensure that remaining sensitive habitats, such as wadis, and species of conservation concern are protected from further degradation. Thus, the contractor shall follow the mitigation measures, presented in the ESMP, to minimize any potential impacts on the ecosystem and the identified species to the lowest possible extent.

As a result, and after considering all mitigation measures presented in the ESMP and based on the fact that the construction of the wells will be a gradual process, the overall impact consequence on the biological environment is anticipated to be **Critical (3)** with **Likely (3)** impact**,** yielding **Medium (6)** significance.

Operation Phase

Flora and Fauna

During the operation phase of the project, there are potential ongoing impacts on flora and fauna, that require careful management to minimize long-term environmental damage. For instance, the operation of wells, roads, and transmission lines may prevent the natural regeneration of vegetation in disturbed areas, particularly in desert ecosystems where recovery is already slow and may displace wildlife, especially if regular maintenance activities increase human presence in the area. Species that are sensitive to disturbances, such as birds and reptiles, may abandon habitats near the wells.

Also, regular maintenance activities could further compact the soil and limit plant regrowth. On one hand, human activities and the continued presence in the area may unintentionally promote the spread of invasive plant species, which can outcompete native flora and further degrade the ecosystem. On the other hand, this may provide easier access to remote areas, leading to an increased risk of illegal hunting or poaching, which could threaten vulnerable wildlife species in the area. Also,

wildlife corridors may be further impacted during the operation phase as infrastructure continues to act as a barrier to the movement of animals, especially for migratory birds and larger mammals that rely on large, connected habitats.

In addition, overhead power transmission lines remain a collision hazard for birds during the operation phase, especially for larger birds and migratory species. Electrocution risks also persist for birds that may perch on power lines or towers. Therefore, guidelines for the protection of migratory birds from the danger of electric shock should be implemented. Moreover, maintenance activities, vehicle movements, and noise associated with the operation of the project (mainly the operation of pumps) can disturb the local wildlife. Sensitive species may alter their foraging, nesting, or breeding behavior in response to the ongoing disturbance. Furthermore, infrastructure such as roads and transmission lines will continue to create edge effects, altering light, moisture, and temperature conditions that negatively affect native plant species near the infrastructure, making it difficult for them to thrive operation. The proposed mitigation measures presented in the ESMP must be effectively implemented to minimize the potential adverse impacts.

Sensitive habitat

The project poses ongoing risks to sensitive habitats, particularly in areas like Wadis and the Rum Important Bird Area. Habitat fragmentation remains a major concern, as the presence of infrastructure such as roads and transmission lines can disrupt wildlife corridors and reduce the connectivity of key habitats. This fragmentation limits the movement of migratory birds and other wildlife, leading to isolated populations and reduced biodiversity. In particular, species of conservation concern, like those that rely on the IBA, may experience reduced breeding success and altered migration patterns due to ongoing human disturbance and infrastructure presence. Hence, scheduling maintenance activities during periods of low wildlife activity, implementing noise mitigation measures such as mufflers and sound barriers, and restricting vehicle access to designated areas along with mitigation measures presented in the ESMP will minimize the potential adverse impacts.

Furthermore, increased human activity during the operation phase, including maintenance work and vehicle access, also introduces the risk of continued disturbance to wildlife and the potential spread of invasive species, which could further degrade these crucial habitats. Therefore, it is crucial to perform regular monitoring of invasive species and implement relevant control measures. It is important to note that given the relatively limited size of the project activities and the possibility of implementing targeted mitigation measures, these impacts can be minimized or avoided altogether, preserving the ecological integrity of the IBA.

Ecosystem services

The operation phase of the project is likely to have lasting effects on key ecosystem services in the region, particularly water regulation and soil stabilization. Soil stabilization, a vital service provided by desert vegetation, may be compromised by the continued disturbance of flora around operational infrastructure, increasing the risk of erosion and land degradation. Hence, using native plant species for revegetation and landscaping would minimize land degradation.

In addition, ecosystem services related to carbon sequestration, though minimal in desert environments, could also be impacted by the removal or degradation of vegetation over time. As native plants are slow to recover in arid conditions, any long-term damage to flora may further reduce the ecosystem's capacity to sequester carbon. The degradation of sensitive habitats may also diminish

their ability to provide essential services like habitat provision for wildlife, further disrupting the ecological balance and affecting the local communities surrounding the project site, particularly those depend on the rangelands as an essential source of their livelihood. These lands provide critical grazing areas for livestock, which is a primary source of income, food, and cultural identity for many nomadic and semi-nomadic communities in Jordan. The natural vegetation in the rangelands, such as Acacia and other drought-resistant species, offers forage for sheep, goats, and camels, helping to sustain local economies and preserve traditional ways of life. The well-being of these rangelands directly affects the economic stability of the local communities, as overgrazing or land degradation can lead to diminished forage availability.

The contractor shall maintain open pathways, provide alternative routes, and share the construction schedule earlier with the local community as described in the ESMP. Assuming the proper implementation of the proposed mitigation measure, it is anticipated that impacts to biodiversity resulting from the operation of the project will be **Likely (3),** with a **Critical (3)** consequence, thus the impact significance is **Medium (9).**

9.2.4 Socio-economics

9.2.4.1 Air Quality and Noise

Construction Phase

Dust and emissions from drilling equipment can affect air quality in the vicinity of the well site. There are several nuisance-generating activities such as earthworks such as leveling, grading, drilling works, and movement of vehicles along the roads. In addition to emissions, vibration and noise sources generated from machinery and equipment on site.

Since the proposed project is far from the nearest farm by 2 Km and from residential areas by more than 5 km as illustrated in **Figure 8**, Thus, there would be no potential nuisance impacts on the farm or the residential areas due to construction activities Thus, the impacts are mainly considered occupational impacts.

The impact likelihood is **Likely (3)** with a **Marginal (2)** consequence; thus, the impact significance is anticipated to be **Medium (6).**

9.2.4.2 Traffic

Construction Phase

Construction activities could contribute to limited short-term adverse impacts on traffic due to the transport of equipment and materials to and from the site through the surrounding road network. There are no residential areas within the wellfield boundaries. Thus, the impacts are mainly considered occupational impacts. The drivers and workers must comply with road safety measures to avoid possible accidents. In addition, the contractor shall ensure that all trucks and vehicles used for the project are operated by licensed operators as well as ensure adequate maintenance and inspection of vehicles.

Thus, the impact consequence is **Marginal (2)**, and the likelihood is **Unlikely (2)**, yielding an overall impact significance of **Low (6).**

9.2.4.3 Community, Health, Safety and Security

Construction Phase

The proposed project boundary is located more than 5 km away from the nearest residential area; thus, the identified project activities are not expected to cause any serious or long-term impacts on the local community. The potential for labor influx into the site, especially during construction, is not expected to negatively impact the surrounding environment as the construction of the wells will be a gradual process which will further reduce the impact consequence on the environment.

The potential impact on community, health, safety, and security is not expected for the construction phase. Therefore, the impact is considered **Unlikely (2)** with a **Marginal (2)** consequence, yielding a **Low (4)** impact significance. Even for the project operation phase, such an impact is not expected.

Operation Phase

The 100 MCM treated groundwater distributed to urban centers such as Amman is subject to MWI monitoring and blending practices that ensure compliance with national drinking water standards. With the planned increase in abstraction to 120 MCM/year, it is MWI's responsibility to review and, where necessary, adapt its blending strategy and water quality monitoring protocols to account for potential changes in water chemistry over time.

Therefore, assuming the proper implementation of the mitigation measures proposed in the ESMP, and continue the MWI regular monitoring and inspections to ensure compliance with regulations, the potential health impact during the operation phase is therefore classified as **likely (3)** with a **Critical (3)** consequence, resulting in an overall **Medium (9)** impact significance.

9.2.4.4 Indigenous and vulnerable groups

Construction Phase

There are no indigenous populations or vulnerable groups residing within the Dubaydib wellfield area. While Bedouin groups may seasonally pass through the area during the spring for grazing, no structures, long-term presence, or formal land use were identified within the project footprint.

Vulnerable populations, such as refugees, low-income households, women, and persons with disabilities, are located in other parts of Ma'an and Aqaba governorates and do not reside within or near the wellfield boundaries. Therefore, the construction activities are not expected to have any direct impacts on indigenous or vulnerable communities.

However, minor indirect risks may arise through labor-related activities, particularly in relation to migrant or informal workers. To address this, the contractor is expected to implement appropriate labor management procedures, including fair recruitment, and adequate working and living conditions.

Based on these factors, the potential impact is considered **Unlikely (2)** in likelihood and **Marginal (2)** in consequence, resulting in a **Low (4)** impact significance.

Operation Phase

During the operation phase, no impacts are anticipated on vulnerable groups or indigenous populations, as there is no informal, seasonal, or permanent community presence within the wellfield boundaries.

The operation of the new wells is not expected to pose any risk to indigenous people or vulnerable populations in the surrounding area.

Therefore, the impact is likelihood is **Very Unlikely (1)** in and has **Negligible (1)** consequence, resulting in a **Negligible (1)** impact significance.

9.2.4.5 Employment

Construction Phase

Positive benefits of the proposed project would arise from short-term job opportunities during construction. The construction phase (including drilling new groundwater, extending the wellfield collector pipeline network, extending the internal road network, and expansion of the overhead power line system) for each well is expected to last approximately 12 – 18 months and will involve around 100 workers, including engineers, specialists, suppliers as well as construction workers. It is important to note that the construction employment opportunities will be intermittent as the wells will be constructed gradually. Diwaco through the operation contracts shall ensure that the majority of the project's jobs are dedicated for the Jordanian workforce, prioritizing locals for these job opportunities, should their qualifications match the needed requirements.

While the majority of direct construction labor roles are expected to be filled by men due to the nature of the physical work and prevailing cultural norms, the project recognizes the importance of promoting inclusive job opportunities for women wherever possible. Efforts will be made to identify and support roles suitable for women—such as in administration, logistics, health and safety, or community engagement. In addition, income generated from local employment may also support broader household welfare, including benefits for women and children. The project is committed to gender-sensitive hiring practices and will encourage contractors to implement non-discriminatory recruitment and provide a safe and respectful work environment for all workers. The impact is assessed as positive (+); however, it would be for short-time bases during the construction period.

Operation Phase

Positive benefits of the proposed project would arise from very limited permeants job opportunities during the operation phase. Only two guards will be employed at each well. The employment process will be intermitted as the wells will be constructed gradually. In addition, there will be no additional operators are required. The impact is assessed as positive (+); with very limited opportunity.

9.2.4.6 Land use and resettlement

No change in land use is expected. In addition, no resettlement is required. Thus, the impact significance is Negligible.

9.2.4.7 Farmers and Agricultural Activities

Operation Phase:

The Dubaydib wellfield has been experiencing sustained groundwater depletion due to high abstraction rates since the initial project began operations in 2014.

Under the current permitted abstraction of 100 MCM/year, groundwater levels in the Disi wellfield are projected to drop by about 20 meters by 2038 and over 50 meters by 2065. This ongoing decline will affect nearby agricultural areas like Al Mudawarra and Disi, where farmers already rely on the same aquifer.

Increasing abstraction to 120 MCM/year would deepen the drawdown by about 5 meters more by 2038 and up to 10 meters more by 2065. it could increase stress on agricultural wells and bring forward the need for adaptation measures

In parallel, agricultural water use continues, with approximately 8.6 MCM abstracted from private irrigation wells within the Project Area in 2023, primarily by large agricultural companies and individual landowners in the Disi area. Additionally, 17 private agricultural wells are located within the Aqaba Governorate, although the exact volumes abstracted from these are currently unknown.

The baseline already reflects long-term stress on the aquifer from both project-related and non-project agricultural withdrawals. The proposed abstraction increase is expected to contribute to this stress, reducing groundwater levels further and posing long-term risks to agricultural viability particularly for farmers operating private wells that may become less productive or fall below pump intake thresholds over time.

Given the cumulative nature of groundwater abstraction in the area, including both the project and private agricultural users, the impact of continued and increased withdrawals is assessed as **Likely** (**3**) with a **Severe** (**4**) consequence, resulting in an overall impact significance of **High** (**12**).

This rating reflects the incremental and long-term impact of project expansion on an already declining aquifer system. It underscores the need for coordinated groundwater governance by **MWI** to manage competing demands from municipal supply and agriculture under conditions of escalating water scarcity.

9.2.4.8 Occupational Health, Safety and Security

Construction Phase

The construction activities include site preparation, infrastructure and utilities installation, and building structures. As a result, there would be potential impacts on workers' health and safety due to exposure to risks through construction activities that lead to accidents causing injuries or death.

The contractor will be committed to ensure all health and safety measures are in place to prevent accidents and/or reduce the consequences of nonconformance events – this is associated with the application of effective EHS policies by the contractor. The contractor shall ensure all potential risks during the construction phase are assessed and all prevention and mitigation measures are in place accordingly. The contractor shall ensure all workers during construction comply with safety procedures through training, awareness, and supervision. In addition to the adherence to the Occupational, Health, and Safety and Environmental procedures and emergency response procedures on site and issuing relevant procedures for different types of work.

Moreover, the contractor shall provide all appropriate resources (Personal Protective Equipment) onsite to ensure providing first aid for personnel in case of occurrence emergencies.

Given the health and safety systems and precautions that are expected to be applied by the contractor, the impact is considered to be **Likely** (**3**) with a **Critical** (**3**) consequence, yielding a **Medium** (**9**) impact significance.

Operation Phase

The operational and maintenance staff may be exposed to hazards related to working in confined spaces and a variety of hazardous chemical agents during maintenance works, these agents may cause acute poisoning, chemical accidents (e.g., skin burns, injury to the eyes, etc.) damage to the respiratory system, allergies, or chronic diseases. Other common hazards include electric shock, explosions, and entanglement in moving machinery.

Therefore, the project company and the O&M contractor shall ensure all risks from operation activities to be assessed and to establish specific work procedures for tasks, and develop Occupational, Health, Safety, and Environmental (HSE) procedures for the operation of the new proposed wells to prevent and reduce the incidence of health and safety risks and avoid non-conformance events.

It is worth mentioning that the operation of the existing well field has HSE plans and procedures that are expected to be updated (as appropriate) and applied to the new proposed wells as well as associated components taking into consideration the mitigation measures illustrated in the ESMP. Thus, given that these HSE plans and procedures are expected to be applied by the Project company and the O&M contractor, the potential impact is considered **Likely (3)** with a **Marginal (2)** consequence, yielding a **Medium (6)** impact significance.

In addition to health and environmental risks, two primary security threats are anticipated during project implementation: theft and vandalism. These may arise from potential encroachments or hostile actions by individuals from nearby local communities. Without appropriate preventive and control measures, such incidents could pose risks to worker safety and project property. Therefore, it is essential to develop and implement robust security protocols and site control measures to prevent and manage these threats throughout all phases of the project.

A variety of security control measures can be implemented including:

- Perimeter fencing
- Security lighting
- Guarding services: Security guards should be assigned to provide on-site security.

Security professionals can monitor the surroundings, react to emergencies and security violations, and serve as a visual warning to possible violators.

Any suspicious activity or individuals by employees should be reported to the site manager or security personnel. To prevent such actions/threats, regular coordination with local authorities is required. In this context, the social aspects of the proposed project including local community concerns and demand should be managed through the DISI Project Advisory Committee (DPAC).

9.2.5 Waste Management

Construction Phase

The waste generation impacts for the construction phase of the project include potential impacts from improper housekeeping practices such as improper management of waste streams, improper storage of construction material and hazardous material, illegal disposal of waste to land etc.

The expected hazardous and non-hazardous waste during the construction phase: inert waste generated in the process of excavation works; packaging and materials (paper, wood, plastic); ferrous and non-ferrous scrap metal and glass; drilling fluid wastes municipal solid waste and municipal wastewater. Hazardous waste includes chemicals and empty chemical containers, and waste oil from machinery lubricants.

As previously mentioned, the construction phase (including drilling new groundwater, extending the wellfield collector pipeline network, extending the internal road network, and expanding the overhead power line system) for each well is expected to last approximately 12 - 18 months and will include around 100 workers. Since the construction employment opportunities will be intermittent, as the wells will be constructed gradually. Thus, it is expected that around 30 workers on average will be present on-site on a daily basis. The amount of municipal solid waste generated by the workers is estimated by using a waste generation rate of 0.81 kg/cap/day. Thus, the minimum expected solid waste amount to be generated during the construction phase would be:

$$30*0.81 = 24.3 \text{ Kg/d}$$

Domestic waste will be stored in properly labeled, closed containers that will later be removed from the project area and disposed of at the closest landfill. Improper management of non-hazardous and hazardous waste generated during construction may lead to impacts on soil, water, and the visual environment, indirectly affect flora/fauna, in addition to the health and safety of workers for being exposed to such waste streams.

All waste generated at construction sites would be managed in accordance with the Contractor's Waste Management procedure. Domestic wastewater generated at the site (in case of existence of construction workers' camps) should be collected in storage tanks. These must be transported to the nearest approved municipal wastewater treatment facility.

Another source of contamination is the radioactive contaminated sedimentation resulted by the testing of the production wells, the company responsibility to upload this radioactive sedimentation that exceeds the Jordanian standards on trucks, and MWI shall arrange for its disposal to approved facility.

Following the implementation of the mitigation measures illustrated in the ESMP, the impact is **Likely (3)**, but the consequence would be **Marginal (2)** with appropriate management; yielding a **Medium (6)** impact significance.

In addition, drilling fluid wastes could be a source of contamination. Drilling fluids in the down-hole environment have the potential to invade freshwater aquifers near the wellbore and cause localized salinization or contamination. Thus, drilling fluid wastes must be properly handled, managed, and disposed of to guarantee that it does not constitute a serious threat to the environment.

The contractor shall select methods, equipment, and materials that will minimize any damage to the productive formation. The use of drilling mud will be restricted to non-biodegradable, non-toxic, synthetic polymer base, low solids mud and subjected to MWI/WAJ approval. In addition, the

employment of a skilled and experienced drilling fluid engineer is strongly recommended. Moreover, the contractor shall keep a record of the quantities of different drilling fluid additives, including but not limited to surfactants, and polymers used.

Specific drilling fluid general requirements by MWI/WAJ and mitigation measures shall be followed as presented in the relevant section in the ESMP. Following the implementation of these MWI/WAJ requirements and mitigation measures, the impact is **Likely (3)**, and the consequence would be **Critical (3)**; yielding a **Medium (9)** impact significance.

Operation Phase

The potential impact during operation includes the possibility of spills from oils, fuel, lubricants, and chemicals utilized in the maintenance activities in addition to the resultant unnecessary spare components. Proper management, storage, handling, and disposal of these materials are necessary to prevent negative impacts on both the environment and workers.

The impact is **Likely (3)**, the consequence would be **Marginal (2)** with appropriate management; the impact significance has been assessed as **Medium (6).**

Decommissioning Phase

Waste generated during decommissioning is the non-hazardous and inert wastes such as scrap metals, paper, wood, and plastic, given that the contractor will adhere to the set waste management procedures.

Similar to the construction phase, the potential generation of hazardous waste includes absorbent material, batteries, used pumps, tires, metal drums, empty chemical containers and / or unused chemicals, and waste oil from machinery lubricants.

To avoid the generation of hazardous wastes from dismantling the installations and disconnection of the wells components, it is recommended that these materials and components are evaluated to determine whether they are suitable to extend their life or return them the manufacturer for recycling or to be reused in other facilities depending on their efficiency and feasibility.

The impact of waste generation is considered **Likely (3),** with a consequence of **Marginal (2)** during to this short-term phase, given that specific waste management procedures would be implemented on-site, yielding an overall impact significance of **Medium (6).**

9.2.6 Labor Rights

Construction Phase:

Common activities during construction such as excavations, lifting, movement of heavy machinery, or handling chemicals, can introduce occupational health and safety risks to workers as mentioned under the health and safety impacts described above. Other risks are also associated with child labor and forced labor.

Effective systems in line with the IFC and EIB standards: Labor Rights and International Labor Organization (ILO) requirements and good site practices in terms of site services and facilities shall be designed and implemented to manage such potential risks. Such systems include a set of Human Resources policies that will comply with Jordanian Labor Law and required international guidelines (i.e., IFC, EIB, ILO). The contractor shall also take reasonable steps to develop a workers' grievance mechanism to be implemented during construction to receive and follow up on worker grievances.

The construction phase will be managed project company, to ensure that incidents such as labor violations or security threats do not occur. The contractor shall appoint competent personnel on-site to oversee all labor-related and occupational health and safety (OHS) activities, and to carry out regular audits and inspections. These obligations shall not be limited to the contractor's direct employees, but will also apply to third-party workers and supply chain actors (e.g., vendors and suppliers) engaged under the contract.

During construction, workers would likely be accommodated in the nearest accommodation facilities to the site, and labor camps with kitchen facilities and offices will most likely be present on site for daily use during working hours. However, there is a possibility of having worker accommodation facilities on site; if this is the case, the facilities shall be established in accordance with the specifications of the ILO standards.

On the other hand, the grievance mechanism provided by DIWACO and DAOM for project operation will be reviewed and updated accordingly (if required).

Given the comprehensive HR policy developed by DIWACO and DAOM, that includes detailed policies on wages, working hours, leave entitlements, termination procedures…etc. in addition to contracting with suppliers and sub-contractors that satisfy IFC and EIB standards will reduce the risks of labor rights throughout all project phases. As a result, the potential impact is considered **Likely (3)** with a **Marginal (2)** consequence – yielding an overall **Medium (6)** impact significance.

Operation Phase:

During the operation phase of the groundwater wells in the Disi area, activities such as the operation and maintenance of pumps, monitoring water levels and quality, and regular inspection of equipment may introduce occupational health and safety risks to workers. These risks could include exposure to noise, vibration, and potentially hazardous chemicals used in maintenance. Additionally, there may be risks associated with child labor and forced labor if not properly managed.

To mitigate these risks, effective systems aligned with IFC and EIB standards, as well as International Labor Organization (ILO) requirements, must be implemented. This includes the development of human resources policies compliant with Jordanian Labor Law and international guidelines, along with the establishment of a workers' grievance mechanism to address and resolve any worker complaints during operation.

The operation phase will be managed by the project company and the O&M contractor. Competent personnel will be assigned to oversee daily operations and ensure compliance with health and safety standards. Measures will also apply to all workers engaged by third parties and suppliers. Worker accommodations, if provided near or on-site, will adhere to ILO standards, ensuring proper facilities are available and it will meet or exceed ILO standards, including minimum space requirements per worker, access to clean water and sanitation facilities, and adequate security measures. Regular inspections will be conducted to ensure these standards are maintained.

The project operator, DAOM, has established a Human Resources and Labor Management Plan to ensure compliance with national labor laws, International Labor Organization (ILO) conventions, and lender requirements, The plan guarantees that all workers engaged in the project are protected under the fair wages and working hours, non-Discrimination and equal opportunity and prohibition of child & forced labor.

The grievance mechanism established for project operation by DIWACO and DAOM will be reviewed and updated as necessary to align with operational needs. Employee grievance template is in Annex 9.

By implementing these systems and ensuring contractors, suppliers, and subcontractors comply with IFC and EIB standards, the risks to labor rights and worker safety during the operational phase can be effectively minimized. Consequently, the potential impact is assessed as **Likely (3)** with a **Marginal (2)** consequence, resulting in an overall **Medium (6)** impact significance**.**

9.2.7 Climate Risk

Construction phase:

The potential climate change impacts during the construction phase include increased energy consumption for site preparation, transportation of materials, and other construction-related activities. Additionally, prolonged heat waves and higher ambient temperatures may pose health risks to workers, leading to heat stress and reduced labor productivity. Furthermore, the use of water for dust suppression and other activities may exacerbate local water scarcity issues. Proper implementation of energy-efficient practices, sustainable material use, and worker safety measures is necessary to mitigate these impacts.

The impact is **Likely (3),** the consequence would be **Marginal (2)** with appropriate management; the impact significance has been assessed as **Medium (6).**

The loss of vegetation due to soil disturbance and habitat degradation reduces carbon sequestration, even though this contribution may be minimal in desert ecosystems. This, however, adds to the global challenge of climate change. Additionally, habitat degradation may impair the area's ability to support biodiversity, disrupting the intricate balance of ecosystem services that sustain both wildlife and local communities.

The impact is **Likely (3)**, the consequence would be **Marginal (2)** with appropriate management; the impact significance has been assessed as **Medium (6).**

Operation Phase:

The energy demand for pumping, treating, and distributing water—particularly from deep, non-renewable aquifers such as the Disi—is expected to increase. Although the Disi aquifer itself is not directly affected by climate change due to its fossil nature and lack of recharge, climate-related reductions in surface water and renewable groundwater availability are likely to drive increased reliance on the Disi system. This shift in demand—especially for municipal and potentially agricultural use—will require higher abstraction volumes, resulting in greater energy consumption and increased indirect greenhouse gas (GHG) emissions, given the current reliance on fossil fuel-based energy sources.
Climate change is expected to indirectly intensify operational pressure on the Disi aquifer through:

- Reduced availability of renewable water sources elsewhere in the system.
- Increased dependence on the Disi aquifer to meet supply gaps for municipal and agricultural sectors.
- Elevated abstraction rates driven by climate-induced scarcity, increasing energy demand and associated GHG emissions.

The impact is **Likely (3)**, the consequence would be **Critical (3)** if not managed; the impact significance has been assessed as **Medium (9)**.

9.2.8 Archaeology and Cultural Resources

Construction & Decommissioning Phases

Construction Phase:

Based on the previously conducted ESIA study in 2004 and its addendum 2008, No archaeological and/or cultural heritage sites are foreseen within the proposed project area, across the well field. This was also confirmed by reviewing the MEGA database as well as conducting the archaeological survey by DoA as presented in their letter dated 25/11/2024 with No. 5210/1/9/5 (Annex 8). However, the contractor shall be responsible for notifying the DoA in case that antiquities are encountered in any area during construction in accordance with the specifications set in Article 15 of the Antiquities Law No. 21 (1988).

If any site was found during construction, and may potentially be damaged due to the project's construction activities, the DoA will assess the discovered remains and may carry out an emergency salvage excavation (i.e., archaeological excavation conducted during the construction phase, which should be conducted when an archaeological site is accidentally found (chance find procedure).

As a result, the potential impact is considered **Unlikely (2)** with a **Negligible (1)** consequence – yielding an overall **Low (2)** impact significance.

Operation Phase:

No impact on the archaeological and/or cultural heritage sites is expected. Thus, the impact significance is negligible.

9.2.9 Reinstatement Stage: Impact assessment

Site Survey Before Start Works:
Before the commencement of the works, the project company shall prepare written records, supported by relevant geolocated photos of the original conditions of all working areas and any other areas to be used during construction activities including access roads and tracks, laydown and welfare areas. Photographic records shall extend to at least 100m (in each direction) beyond the boundary of each road, worksite, welfare area, access track, pipeline or power line route. The working boundaries of such work areas shall be clearly marked, shown to the contractors, protected and actively monitored. Such records certified by MWI/WAJ will subsequently be used as a basis for standards of reinstatement and repair after the completion of construction activities (e.g.: well drilling works and wellfield infrastructure).

The main environmental aspects that should be considered during the reinstatement phase are landscape and generated waste management, soil, and wadi streams.

Cleaning and Reinstatement of Well Sites

All working areas or other areas used by the contractor shall be reinstated to a condition and in a manner, which is similar to and no worse than the original condition.

Landscape and generated wastes

On completion of all construction activities and before leaving the site, the contractor shall remove all equipment machinery, and remaining materials, as well as clean up all construction wastes and debris, other litter within at least the 100m boundary area identified above, and completely level/reinstate the whole area used, including pits and ditches.

The contractor shall also demobilize all living, office, store, servicing facilities, and workshops, as well as restore the area used for the contractor's camps and surrounding areas by cleaning it up and properly disposing of all generated wastes to the closest landfill.

As a result, and considering all mitigation measures reported within the ESMP, the impact is **likely** (**3**), with a **Marginal (2)** consequence, thus, the overall significance is **Medium (6).**

It is worth mentioning that on completion of clean-up and restoration of each well site and contractor's Campsite, MWI/WAJ accompanied by the project company shall perform a final site observation and inspection. If the site does not appear to be cleaned and leveled to MWI/WAJ's satisfaction and considering the previously mentioned site survey conducted prior to the start of construction activities, the project company shall collaborate with the contractor to execute additional site cleaning within a defined time frame, according to the directions of MWI/WAJ. If the project company fails to complete this task, MWI/WAJ may appoint a subcontractor to clean the site at the project company's expense.

9.2.10 Cumulative Impact

This section investigates the cumulative impacts that could result from incremental impacts of other known existing and/or planned developments in the area, based on currently available information.

The implementation of the project has environmental and social opportunities and positive impacts, to mainly include the following:

- The Project is in line with national strategies and plans and shall result in positive social opportunities on the strategic and national level, given the current challenges in Jordan’s water sectors.
- The project aims to increase the water supply from 100 MCM to 120 MCM per year, addressing the growing water demand in Amman, enhancing water security, and improving quality of life for residents.
- The Project strengthens the reliability of the Disi-Amman system, ensuring a steady water supply
- The construction stage would generate job opportunities for local skilled and unskilled laborers in the area.

Scope and Methodology

The scope of the cumulative assessment focuses on potential developments within the Disi-Mudawarra District that may interact with impacts (positive and negative) arising from the Project. The cumulative assessment has considered the effects of known planned projects.

For each of the impacts assessed, the ESIA investigates the cumulative impacts that could result from incremental impacts of other known existing and/or planned developments in the Project area, based on currently available information about such existing and/or planned developments.

The methodology for the identification and assessment of cumulative impacts has comprised the following steps:

- **Project identification**: Determine whether the other development projects in the Disi-Mudawarra area are in the planning system.
- **Impact and "interlinkages" assessment**: Undertake a cumulative assessment that determines whether the combined impact of the Project and the other development projects will have a significant effect on any of the resources or receptors identified in the ESIA.

Projects within Disi-Mudawarra Area

Despite undertaking as review of information on projects within the Project area, limited information is available for planned projects.

Discussions with the DIWACO and MWI/WAJ teams indicated that no large or mega projects are currently planned or under construction within the wellfield area. While the broader project surroundings may host other activities, no major developments were identified within the immediate footprint of the wellfield.

The existing agriculture activities in the vicinity of the Project and their associated impacts have been identified through site assessments/visits and consultations conducted by the ESIA Team.

However, after the review of the Ministry of Planning and International Cooperation (MoPIC) annual reports for the years 2023 and 2024, it was found that within the Project area there are three (3) main projects including; Desalination and water transport from Aqaba to Amman (National Water Conveyer), National Railway Network Project, and the Dubaydib wellfield and its associated infrastructure.

Identification and Assessment of Cumulative Impacts

Potential environmental and social impacts caused by a combination of planned projects and the Dubaydib wellfield Project and the results have been assessed and are described in **Table 57** below.

Table 57: Cumulative Impacts Assessment Matrix

Environmental Aspect	Disi Wellfiel&	Aqaba–Amman Desalination Project	National Railway Network Project	Cumulative Implications
Resource Extraction & Sustainability	Extracts nonrenewable "fossil" water from the Disi aquifer, reducing pressure on renewable upland aquifers.	Provides a renewable alternative through seawater desalination. reducing the need to overexploit groundwater	Does not extract water but requires land use changes.	Long-term groundwater sustainability concerns require integrated water resource management.
	Sustainability concerns as the aquifer is non-replenishable.	Supplies up to 300 MCM/year but is energy-intensive.	Supports efficient transport, reducing reliance on road freight.	Increased reliance on desalination and groundwater necessitates careful national water planning.
Water Quality	Supplies high-quality water, improving wastewater treatment efficiency. For a non-renewable groundwater source over abstraction leads	Uses reverse osmosis to produce potable water; reject brine requires proper disposal to maintain marine water quality. Effective contaminant removal and brine management critical to mitigating marine impacts.	Construction activities may generate sedimentation, runoff and contamination risks impacting local surface water and shallow groundwater sources. Not directly related to water quality but requires construction impact mitigation.	Potential interactions between water supply projects require coordinated management of MWI and related national institutions focused on sustainable groundwater use and quality concerns

Environmental Aspect	Disi Wellfiel&	Aqaba–Amman Desalination Project	National Railway Network Project	Cumulative Implications
	to aquifer depletion and quality decline			
Energy Demand & Emissions	High energy demand due to pumping over long distances and elevation differences.	Desalination is energy-intensive but includes renewable energy components.	Produces emissions during construction and operation but reduces reliance on road transport.	Combined energy demand from water conveyance, desalination, and rail transport may significantly contribute to national emissions.
	Without renewable offsets, contributes to cumulative GHG emissions.	Aims to limit operational emissions to 1.67 kg CO_2/m^3 by the planned integration of renewable energy.	Long-term shift from road to rail may reduce overall transportation emissions.	Integration of renewable energy into these projects can mitigate overall carbon footprint.
Brine/Discharge Impact	No brine produced, but extensive groundwater extraction may alter local hydrology.	Produces concentrated brine requiring effective dispersion to protect marine ecosystems.	No direct discharge, but construction waste must be managed.	impacts on hydrology and marine ecosystems necessitate MWI and national institutions integrated resource planning.
Habitat Fragmentation & Land Use	Infrastructure development affects desert and arid ecosystems.	Coastal and pipeline infrastructure may disturb marine and coastal habitats.	Rail alignments may fragment habitats and alter land use.	Large-scale infrastructure projects require coordinated land use and ecological impact mitigation strategies.
Noise, Dust, and Air Quality	Drilling and pipeline installation generate temporary noise and dust.	Construction and operations contribute to localized emissions, especially near sensitive coastal areas.	Construction and train operations produce noise and dust; mitigation measures are required during both phases, including dust suppression, noise barriers, and scheduling restrictions.	Combined construction and operational emissions necessitate regional air quality management strategies.
Socio-economic Benefits	Provides a reliable water source for Amman, improving public health and economic growth .	Enhances water security and economic growth.	Improves connectivity, reduces road congestion, and lowers transportation costs.	Strengthens national infrastructure resilience and economic development potential.
	Creates jobs during construction and operation.	Supports urban development.	Supports economic growth and trade efficiency.	Requires coordinated socio-economic planning to maximize benefits
Mitigation Measures	Continuous water quality monitoring and blending strategies.	brine management, continuous water quality monitoring,	Use of low-emission technologies and environmental safeguards.	Cross-sectoral environmental planning and adaptive management strategies are required.

Environmental Aspect	Disi Wellfiel&	Aqaba–Amman Desalination Project	National Railway Network Project	Cumulative Implications
Overall Cumulative Impact Considerations	Water-energy nexus challenges require integrated management with other supply projects.	Key component of national water security but interacts with energy and environmental policies. Water–energy nexus challenges require integrated management with other water supply projects,	Potential to reduce long-term emissions through transport modal shifts.	Requires national-scale coordination to balance water, energy, and infrastructure needs sustainably.

Air Quality, Noise, and Habitat Impacts

Construction and operational activities across the Aqaba-Amman desalination project and the National Railway Network will generate temporarily dust, noise, and localized air pollutant emissions. The cumulative effect of these emissions may extend the spatial footprint of air quality degradation and noise disturbance, affecting nearby communities and sensitive wildlife habitats. Habitat fragmentation and land use changes from pipeline corridors, coastal infrastructure, and railway alignments further emphasize the need for coordinated ecological impact assessments and mitigation strategies.

In contrast, the Disi wellfield has a comparatively lower impact on air quality, noise, and habitat disturbance due to its smaller-scale drilling activities and limited construction footprint. Nevertheless, regional air quality management, dust suppression, noise barriers, and scheduling restrictions remain essential across all projects to minimize cumulative impacts.

Socio-Economic Considerations

These infrastructure projects collectively offer socio-economic benefits, including improved water security, enhanced connectivity, job creation, and economic development. However, overlapping construction schedules and labor influxes may strain local services, housing, and water resources, particularly in water-scarce southern Jordan. Coordinated socio-economic planning is necessary to maximize positive outcomes while mitigating risks such as resource competition.

10 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The developer (MWI/WAJ) and DIWACO shall be committed to achieving and maintaining environmental standards, such that Jordanian environmental regulations and standards are met, and potential adverse environmental impacts resulting from the project activities are minimized as practicably as possible. This will be achieved through appropriate project planning and methods of project operation.

Implementation of environmental monitoring activities outlined in the periodic monitoring table will enable the assessment and modification, if required, of the new ESMP of the additional water project.

10.1 Objectives

This ESMP for the additional water project aims to ensure the application of the mitigation and monitoring measures needed to reduce and control the various potential environmental and social impacts associated with implementation of the new Disi wells and associated infrastructure.

The key objectives of the ESMP are summarized below:

- Minimize any adverse environmental, social, and health impacts resulting from the project activities.
- Conduct all project activities in accordance with relevant Jordanian Legislation and applicable EIB and IFC guidelines.
- Implement ongoing environmental and social monitoring program;
- Include environmental and social safeguards embedded in the ESMP to monitor the implementation of mitigation measures and propose relevant performance indicators.
- Periodically review the ESMP programs to allow for iterative improvement.
- Ensure that all stakeholder concerns are addressed.

10.2 Mitigation and Monitoring

This section presents more detailed mitigation measures and monitoring requirements that correspond to the impacts described in the previous section.

Mitigation measures aim to offset negative impacts that may result from the proposed additional water Project, and monitoring is the process of measuring the success of mitigation measures in order to assess their effectiveness. Reporting is the process of measuring actual performance or how well the mitigation measures have been implemented, including the format, timing, and responsibility for reporting on the monitoring results.

All Environmental and Social Safeguards (ESS), including those related to stakeholder engagement, labor and working conditions, resource efficiency, pollution prevention, biodiversity conservation, community health and safety, cultural heritage, and grievance mechanisms, are comprehensively addressed in the ESMP. The ESMP mitigation and monitoring measures for the construction and reinstatement phases are presented in **Table 58** and **Table 59**, respectively while the ESMP mitigation and monitoring measures for the operation phase are presented in **Table 60**. DIWACO shall employ specialized personnel to oversee and supervise the implementation of mitigation measures.

A column referencing the 2007 EHS Guidelines has been added to the ESMP tables to complement national regulatory requirements. This addition is intended to support clearer benchmarking, facilitate compliance assessment by lenders, and enhance alignment with international good practice.

All responses to lenders' environmental and social comments, and their corresponding ESIA section references, are consolidated in **Annex 15** "Response to Lenders' Environmental and Social Comments ", which forms an integral part of this ESIA.

Annex 16 "MWI Water Quality (Radioactivity Monitoring 2023–2024)" is included as part of this ESMP to provide source data supporting the water quality and blending commitments.

Table 58: Environmental and Social Management Plan during the Pre-Construction and Construction Phases

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
Physical Environment								
1	Air Quality and Dust	▪ Local degradation of air quality due to exhaust emissions of SO2, NO2, and PM10 ▪ Local degradation of air quality due to dust generation from construction/demolition activities such as leveling, grading, excavation works and well drilling, and movement of vehicles along the roads, especially during windy conditions.	▪ The Contractor shall perform regular maintenance on all equipment, vehicles, and machinery to prevent air emissions. ▪ The Contractor shall limit idling of engines when not in use. ▪ The Contractor shall make sure that any vehicle or equipment leaving the project area is cleaned of loose debris. Additionally, vehicles and equipment shall be covered to avoid dust generation. ▪ The Contractor shall use dust suppression measures on unpaved roads, excavations, stockpiles, and for transport of excavated material to reduce airborne particulate areas and/or sensitive receptors during windy conditions and when needed.	▪ Visual monitoring of source emissions from vehicles and equipment ▪ Visual monitoring of dust generated from construction activities, construction vehicle movement, stockpiles, storage of construction materials, etc.	▪ Daily	Contractor	▪ Regular vehicle maintenance records. ▪ No visible dust plumes originating from the construction site. ▪ No exhaust (heavy black or white smoke) from equipment and vehicles.	▪ **Ambient Air Quality**: - PM10: 50 µg/m³ (annual), 150 µg/m³ (24-hour) - NO_2: 40 µg/m³ (annual), 200 µg/m³ (1-hour) - SO_2: 50 µg/m³ (annual), 125 µg/m³ (24-hour) ▪ **Fugitive Dust:** Dust suppression (e.g., wetting unpaved roads) is recommended. Vehicle speeds should be limited to <20 km/h on unpaved surfaces.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			▪ The Contractor shall store cement, sand, or other fine-grained material in a manner to prevent wind erosion and dust. ▪ Construction vehicles shall comply with speed limits. Speed limits for heavy vehicles within the construction site shall be restricted to 20 km/hr. ▪ Vehicle and machinery movements during construction shall be restricted to designated routes at all times where practicable. ▪ No stockpiling of fine material is allowed within the construction sites. ▪ Spillage of materials on roads or pathways shall be cleaned up promptly in accordance with the spill prevention and response plan that shall be developed by the Contractor as part of the CESMP.					

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
2	Noise	▪ Noise pollution due to Construction and site preparation activities such as earth moving, site excavation, well-drilling, transportation of equipment and materials to and from the site through the surrounding road network, and installation of equipment.	▪ The contractor shall perform regular maintenance on all equipment, vehicles, and machinery to prevent noise emissions. ▪ The Contractor shall limit idling of engines when not in use to reduce its contribution to noise emissions. ▪ Contractor shall take reasonable measures, such as installing adequate noise prevention devices, (e.g., mufflers on noise-generating sources), to maintain noise levels within the national requirements at all construction sites. The Contractor has to ensure that all workers have access to protective measures and Personal Protective Equipment (PPE).	▪ Check the maintenance log sheet. ▪ Monitor the use and efficiency of the noise prevention devices used. ▪ Visual inspection	Monthly Daily Daily	Contractor	▪ Compliance with Instruction for Reduction and Prevention of Noise for 2003 ▪ Complete records of monitoring activities. ▪ No identified non-compliance with safety procedures. ▪ PPE used on site by workers.	▪ **Noise Level Guidelines** (residential receptor): - 55 dBA (daytime, 07:00–22:00) - 45 dBA (nighttime, 22:00–07:00) ▪ For industrial receptors: 70 dBA. Measured at the nearest property boundary. Construction should avoid night-time work where possible.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
3	Land and soil	▪ Potential impacts on the soil that is related to creep and stability. which are of particular concern for the proposed new roads, pipelines, boreholes, power networks, and construction camps ▪ Removal of soil due to construction activities, thus causing erosion. ▪ Contamination of soil due to improper waste management or accidental spillage/leakage of chemicals or oils stored on-site or used during construction or rupture of fuel storage tanks in the construction site.	▪ The Contractor shall adopt soil conservation methods during the project components construction to reduce the area of destruction during trenching/excavation works for the wellfield infrastructure. ▪ Develop and implement a soil management plan that should include specific mitigation measures for preventing and managing soil creep and instability. ▪ Develop and implement a waste management plan for addressing contamination risks through appropriate handling, storage, and disposal practices. ▪ Upon completion of construction activities (e.g.: well drilling works and wellfield infrastructure, the Contractor shall restore disturbed areas to their original condition.	▪ Visual inspection of disturbed areas in and around the construction site for erosion ▪ Inspection of soil management plan practices. ▪ Visual inspection of waste storage area, chemical storage area, and fuel storage area for spills and leaks. ▪ Visual inspection of vehicles, machinery, and equipment for leaks of oils, grease, etc. ▪ Inspection of waste management practices	Daily	Contractor	▪ Up-to-date and complete records as required by spill prevention and response procedures. ▪ Training records of personnel on spill prevention and response procedures. ▪ Environmental reports on the implementation of the soil management practices onsite. ▪ Environmental reports on the implementation of the waste management practices onsite.	▪ **Hazardous Materials Management:** - Secondary containment (110% of the largest container) - Impervious surfaces for chemical storage - Spill control plan and materials on site ▪ **Soil Erosion: Minimize area disturbed, re-vegetate exposed soils**

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			▪ Machineries and equipment shall be checked by the Contractor on daily basis to ensure that there is no leak of oil, fuel, greases or other liquids. If leaks are detected, machinery and equipment shall not be operated until repaired. ▪ Contractors shall use impervious drip trays under portable equipment such as mobile generators and pumps to contain any spills or leaks. The contractor shall carry out all re-fuelling in designated areas with impervious surfaces. The contractor shall ensure no spills of fuel. ▪ All chemicals shall be stored in dedicated areas in tightly closed containers and shall be protected from adverse weather conditions.					

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			▪ A spill prevention and response plan shall be prepared by the contractor as part of the CESMP in order to control any inadvertent leakage or spillage. Spill response measures shall be implemented (as necessary) to contain and clean up any contaminated soil. ▪ Ensure that general-purpose spill absorbent is available at the project site. ▪ Any spilled chemical shall be immediately collected and disposed of in accordance with the Spill Prevention and Response Plan.					
4	Water Resources	▪ Potential contamination of groundwater resources	▪ Use appropriate construction materials: The use of low-quality or non-durable materials during well construction can lead to corrosion, which compromises the integrity of the well structure. Corroded	▪ Adhere to local regulations for well drilling. ▪ Comply with construction standards, such as proper casing materials, wellhead seals, grouting, and	▪ Continuously during construction operations ▪ As needed	Contractor	▪ Compliance with the national regulations ▪ Monitoring and maintenance records	**Groundwater** ▪ **Water Quality Protection:** - Prevent fuel/chemical leaks - Proper well sealing and casing standards to avoid contamination

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
	4.1 groundwater		well casings or pipes may release harmful substances, including heavy metals or pollutants, into the groundwater.	construction practices ▪ Implement a routine maintenance plan for wells, including regular inspection, cleaning, and disinfection.				- Maintain safe distances between wells and contamination sources ▪
	4.2 Surface water	▪ Potential surface water runoff / potential flood risks at the wells site, potentially leading to flooding, soil erosion, and sediment transport.	▪ A comprehensive hydrological study and hydraulic design are required for the location of the new wells and its components to estimate the maximum flood flow values at 50, 100-yr return periods. ▪ A specialized hydrologic and hydraulic tool shall be utilized in future studies alongside an actual topographic survey along the Disi new wells. This approach aims to determine the	▪ Visual inspection. ▪ Ensure proper flood control measures are taken into the design and/or temporary drainage channels are built and that topsoil storage locations are away from potential surface runoff areas. ▪ Observation and inspection. ▪ Inspection of waste	Daily during rainy seasons at the construction site	Contractor	▪ Runoff from construction site	▪ Use sediment traps and erosion control structures. ▪ No direct discharge of contaminated water into surface water bodies. ▪ Temporary drainage systems and retention ponds as needed. ▪

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			maximum peak flow and depth. Hence, propose suitable flood mitigation measures and erosion/scouring protection works. ▪ Regular maintenance of all equipment and machinery used onsite. Maintenance activities and other activities that pose a risk for hazardous material spillage (such as refuelling) must take place at a suitable location (hard surface) with appropriate measures for trapping spilled material. The Contractor shall distribute a sufficient number of properly contained containers clearly marked as "Construction Waste" for the dumping and disposal of construction waste. ▪ The contractor shall direct contaminated wastewater from washing/maintenance as well as the domestic wastewater	management practices and check that the collected wastewater on-site is disposed of appropriately				

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			generated at the site to a storage tank. These must be transported to the nearest approved municipal wastewater treatment facility as illustrated below in the waste management aspects.					
Biological Environment								
5	Biodiversity 5.1 Flora	▪ Vegetation loss and degradation	▪ Implement strict controls on clearing and grading activities, and limit them to designated areas only. ▪ When possible, save and transplant native plants. ▪ If the first two mitigations are not sufficient ,re-vegetate disturbed areas with native species using appropriate seed mixes and planting techniques.	▪ Observation and inspection. ▪ Coordination with RSCN and the Ministry of Agriculture	▪ Continuously ▪ When needed	Contactor	▪ Contractor shall prepare and submit a monthly report to the supervisor engineer.	▪ **Habitat Alteration:** ▪ Avoid disturbance of natural habitats, especially critical habitats (IFC PS6).
		▪ Invasive species introduction	▪ Clean construction equipment and vehicles thoroughly before entering the site to prevent the introduction of invasive plant seeds.	▪ Visual monitoring of equipment and vehicle cleaning	▪ Continuously	Contactor	. ▪ Regular vehicle cleaning and maintenance records	▪ Clean equipment to prevent introduction ▪ Regular inspections and removal of invasives.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			▪ Regularly monitor the site for invasive species and implement control measures if necessary.				▪ No identified non-compliance to the mentioned measures	No specific numeric standard, but operational best practices recommended.
		▪ Increased Soil Erosion	▪ Implement erosion control measures. ▪ Minimize soil disturbance during construction.	▪ Visual inspection of disturbed areas in and around the construction site	▪ Continuously	Contactor	▪ Excavations are covered with soil after work is finished.	▪ Minimize clearing. ▪ Stabilize exposed areas with vegetation or cover. ▪ Sediment traps and silt fences.
		▪ Soil compaction	▪ Limit vehicle access to designated areas. ▪ Use low-ground pressure machinery when possible.	▪ Observation and inspection.	▪ Continuously	Contactor	▪ Excavations are covered with soil after work is finished	▪ Limit heavy equipment access. ▪ Use low ground pressure machinery. ▪ Restore compacted soils where possible.
		▪ Loss of Water Retention Capacity	▪ Design roads and structures to minimize disruption of natural drainage patterns. ▪ Install erosion control measures to prevent sedimentation in wadis and other water bodies.	▪ Observation and inspection.	▪ Continuously	Contactor	▪ No identified non-compliance to the mentioned measures	▪ Maintain natural drainage patterns. ▪ Use swales or retention ponds where necessary. ▪
		▪ Reduction in Biodiversity	▪ Avoid construction in sensitive areas.	▪ Observation and inspection.	▪ Continuously	Contactor	▪ No identified non-compliance to the mentioned measures	▪ Buffer zones of 50–100 m around critical habitats (when possible).

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			▪ Create buffer zones around sensitive areas to minimize disturbance.					▪ Construction outside breeding/migratory seasons.
		▪ Pollution	▪ Implement a Spill Prevention, Control, and Countermeasure (SPCC) Plan to manage potential spills of fuel and other hazardous materials. ▪ Properly dispose of all construction waste and debris at designated landfills. ▪ Train workers on proper handling and disposal of hazardous materials.	▪ Visual inspection of compliance with the SPCC and waste management plan. ▪ Visual monitoring of site cleanliness and waste storage& disposal	▪ Continuously	Contactor	▪ Up-to-date and complete records as required by spill prevention and response procedures. ▪ Training records of personnel on the importance of environmental protection. ▪ Current and complete records of regular waste collection and disposal. ▪ Compliance with applicable regulations as illustrated in the waste management ESMP Section.	▪ Implement spill prevention and response plans. ▪ - No discharge of hazardous materials into soil/water. See “Hazardous Materials” section of EHS General Guidelines.
		▪ Workers’ Illegal Activities	▪ Educate workers about the importance of environmental protection and the consequences of illegal activities.	▪ Observation and inspection.	▪ Continuously	Contactor	▪ Training records of personnel on the importance of environmental protection.	▪ Control site access. Environmental training for workers. ▪ Penalties for non-compliance.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			▪ Supervise workers during construction activities. ▪ Prohibit workers from establishing any temporary camps in non-designated areas for emplacements, set-down areas, meeting points, refueling points, and other activities. ▪ Prohibit driving outside or away from the designated working area. ▪ ▪ Implement penalties for violations.				▪ The contractor shall prepare and submit a monthly report to the supervisor engineer. ▪ Number of violations	
		▪ Improper Waste Disposal	▪ Implement a comprehensive waste management plan that includes recycling and reuse of materials where possible. ▪ Ensure that hazardous waste is disposed of at approved facilities.	▪ Visual inspection and conduct regular waste audits to ensure compliance with the waste management plan.	▪ Continuously	Contactor	▪ Proper handling and disposal of hazardous materials. ▪ Environmental reports on the implementation of the waste management practices onsite. ▪ Current and complete records of regular waste collection and disposal.	▪ Segregate hazardous/non-hazardous waste. ▪ Store in appropriate containers. ▪ Dispose only in authorized sites.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
							▪ Compliance with applicable regulations as illustrated in the waste management ESMP Section.	
		▪ Disturbance to Wildlife and Habitat from Human Presence	▪ Restrict construction activities during sensitive periods like breeding seasons. ▪ Implement noise and light mitigation measures to minimize disturbance to wildlife. ▪ Restrict vehicle access and movement to pre-designated tracks to minimize habitat degradation particularly in the vicinity of the IBA and ephemeral wadis.	▪ Observation and inspection. ▪ Monitor the use and efficiency of the utilized noise prevention devices.	▪ Continuously	Contactor	▪ Contractor shall prepare and submit a monthly report to the supervisor engineer. ▪ No identified non-compliance to the mentioned measures	▪ Reduce light pollution at night (shielded lights). ▪ Avoid loud activities during sensitive periods.
		▪ Edge Effects	▪ Restrict vehicle access and movement to pre-designated tracks to minimize edge effects, particularly in the	▪ Observation and inspection. ▪ Coordination with RSCN and the Ministry of Agriculture	▪ Continuously ▪ When needed	Contactor	▪ Contractor shall prepare and submit a monthly report to the supervisor engineer.	▪ Re-vegetate with native species to reduce fragmentation.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			vicinity of the IBA and ephemeral wadis. ▪ Prevent/Minimize the creation of new edges by limiting road width and footprint. ▪ If the creation of new edges can not be avoided, Re-vegetate road edges with native plants to create a buffer zone.					
	Biodiversity 5.2 Fauna	▪ Wildlife disturbance	▪ Restrict construction activities during sensitive periods like breeding and migration seasons. ▪ Implement buffer zones around active nesting or roosting sites (if any are discovered), especially in areas near cliffs or dense vegetation within the IBA. ▪ Implement noise and light mitigation measures to minimize disturbance to wildlife. ▪ Avoid nighttime lighting and reduce unnecessary noise	▪ Monitor the use and efficiency of the utilized noise prevention devices.	▪ Continuously	Contactor	▪ Contractor shall prepare and submit a monthly report to the supervisor engineer. ▪ No identified non-compliance to the mentioned measures	▪ Noise <55 dBA during sensitive periods, avoid nighttime construction. Use light mitigation.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			during construction, especially near W98 and W69, which fall within the IBA. Bright artificial lighting can disorient nocturnal species and attract or repel birds in unintended ways.					
		▪ Habitat loss	▪ Avoid construction in sensitive habitats. ▪ Minimize habitat fragmentation by clustering construction activities. ▪ Create wildlife corridors to connect fragmented habitats. ▪ Prohibit workers from establishing any temporary camps in non-designated areas for emplacements, set-down areas, meeting points, refueling points, and other activities. ▪ Prohibit driving outside or away from the designated working area.	▪ Observation and inspection. ▪ Coordination with RSCN and the Ministry of Agriculture	▪ Continuously ▪ When needed	Contactor	▪ Contractor shall prepare and submit a monthly report to the supervisor engineer. ▪ Number of animals killed and reports to relevant authorities. ▪ No identified non-compliance to the mentioned measures.	▪ Cluster activities to reduce fragmentation. ▪ Create buffer zones and corridors.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
		▪ Mortality risk (vehicle collisions)	▪ Implement speed limits and traffic calming measures in construction areas. ▪ Install wildlife crossing structures where necessary. ▪ Educate workers about wildlife awareness.	▪ Observation and inspection	▪ Continuously	Contactor	▪ No identified non-compliance to the mentioned measures ▪ Number of animals killed and reports to relevant authorities. ▪ Training records of personnel on the importance of environmental protection	Implement traffic calming, speed limits (20 km/h on site), and signage.
		▪ Bird collisions with power lines	▪ Design power lines with bird-friendly features like markers and diverters. ▪ Monitor bird activity and implement mitigation measures if necessary.	▪ Observation and inspection	▪ Continuously	▪ Designer ▪ Contactor	▪ Number of birds killed and reports to relevant authorities. ▪ No identified non-compliance to the mentioned measures	▪ Use bird diverters / marker balls on power lines. Refer to EHS Guidelines for Electric Power Transmission.
		▪ Electrocution	▪ Design power lines with bird-friendly features like insulated perches.	▪ ▪ Observation and inspection	▪ Continuously	▪ Designer ▪ Coordination with electricity company	▪ Number of animals killed and reports to relevant authorities.	▪ Design power poles with insulating materials and bird-safe designs (cross-arms separation, perch guards).

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			▪ Guidelines for protecting migratory birds from the danger of electric shock should also be implemented.				▪ No identified non-compliance to the instructions mentioned in the guideline	
		▪ Illegal hunting and poaching	▪ Prohibit illegal hunting or collection of fauna by workers. Include biodiversity protection protocols in worker induction and codes of conduct, with regular awareness briefings and enforcement mechanisms. ▪ Educate workers about the importance of wildlife conservation and the consequences of illegal hunting. ▪ Increase surveillance and enforcement in construction areas.	▪ Observation and inspection	▪ Continuously	Contactor	▪ Training records of personnel on the importance of environmental protection. ▪ No identified non-compliance to the mentioned measures.	▪ Awareness training, site patrols, enforce legal restrictions.
		▪ Disruption of migratory patterns	▪ Avoid construction in sensitive areas during migration seasons.	▪ Observation and inspection	▪ Continuously	Contactor	▪ Number of animals killed and reports to relevant authorities.	▪ Avoid peak migration periods. Limit light and noise. Monitor bird activity.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			▪ Implement lighting and noise mitigation measures to minimize disturbance to migrating birds.	▪ Monitor the use and efficiency of the utilized noise prevention devices.			▪ No identified non-compliance to the mentioned measures	
		▪ Pollution Impact on Fauna	▪ Implement strict erosion and sediment control measures to prevent pollution of waterways. ▪ Properly manage and dispose of hazardous materials to prevent contamination of soil and water.	▪ Observation and inspection	▪ Continuously	Contactor	▪ Proper handling and disposal of hazardous materials. ▪ Environmental reports on the implementation of the waste management practices onsite. ▪ Current and complete records of regular waste collection and disposal. ▪ Compliance with applicable regulations as illustrated in the waste management ESMP Section.	▪ Store hazardous materials in secure, contained areas with secondary containment (bunding capacity ≥ 110% of the largest container). ▪ Dispose of hazardous waste only in licensed facilities approved by competent authorities. ▪ Prevent discharge of contaminated runoff into natural water bodies.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
								▪ Maintain records of hazardous waste movement and disposal (including manifests).
		▪ Disruption of Breeding Cycles	▪ Avoid construction in sensitive habitats during breeding seasons. ▪ Implement noise and light mitigation measures to minimize disturbance to breeding wildlife.	▪ Observation and inspection ▪ Monitor the use and efficiency of the utilized noise prevention devices.	▪ Continuously	Contactor	▪ No identified non-compliance to the mentioned measures. ▪ Number of animals killed and reports to relevant authorities	▪ Avoid work in sensitive breeding habitats/seasons. Reduce noise/light exposure.
		▪ Introduction of Non-native Species	▪ Prohibit workers from introducing animals to the site ▪ Educate workers about the impact of non-native species on wildlife	▪ Observation and inspection	▪ Continuously	Contactor	▪ No identified non-compliance to the mentioned measures. ▪ Training records of personnel on the importance of environmental protection.	▪ Prohibit animals on site. Inspect equipment. Environmental training.
Socio-economics								

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
6	Employment	▪ Short-term job opportunities	▪ The contractor shall ensure that the majority of the project's jobs are dedicated for the Jordanian workforce, prioritizing local community for these job opportunities.	▪ Review the contractor's employment plan and ongoing records	Monthly	Contractor	▪ The employment plans and records contain local employee	▪ Prioritize local employment to maximize social benefit and community support. Contractors should implement transparent hiring practices and grievance mechanisms for workers.
7	Air Quality and Noise	▪ The proposed project is far from the nearest farm by 2 Km and from residential areas by more than 5 km. Thus, the impacts are mainly considered occupational impacts (as discussed below in the Occupational Health, Safety, and Security aspects).	▪ Refer to the Occupational Health, Safety, and Security aspects	---	---	---	---	▪ **Occupational Noise:** - Max 85 dBA for 8-hour exposure (OSHA/IFC) - Hearing protection above 85 dBA **Airborne Dust/Particles (workers):** Use respirators where dust > occupational exposure limits (OELs).
8	Indigenous People	▪ Disruption of traditional grazing routes and access to land during construction.	▪ The contractor shall maintain open pathways, provide alternative routes, and engage with the local community on construction schedules.	▪ Record and respond to any grievances or complaints from indigenous groups.	• Continuously	Contractor	▪ Complaints related to access. ▪ Evidence of maintained or alternative access.	No specific numeric standards under EHS 2007. However, stakeholder engagement and protection of indigenous peoples' rights must align with IFC Performance Standard 7 (PS7). Key requirements include:

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
								▪ Ensuring free, prior, and informed consultation with indigenous peoples when they are likely to be affected. ▪ Maintaining access to traditional land, natural resources, and grazing routes. ▪ Establishing a grievance redress mechanism for affected groups. ▪ Taking culturally appropriate mitigation measures in coordination with indigenous communities. ▪ Avoiding adverse impacts or, where unavoidable, ensuring fair compensation and benefit sharing.
Occupational Health, Safety and Security								

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
9	Occupational Health, Safety, and Security	▪ Occupational health and safety hazards from activities such as excavations and well drilling; working with heavy equipment; working under noisy and dusty conditions; working in confined spaces; lifting of heavy objects; and storage, handling, and use of hazardous substances and wastes. ▪ Potential impacts on workers and properties due to local community attacks including theft and vandalism on-site.	▪ The contractor shall provide all appropriate protective measures (Personal Protective Equipment (PPE)) on-site and ensure that all workers have access to such measures. ▪ The Contractor shall ensure providing first aid for workers in case of occurrence emergencies. ▪ The contractor shall ensure that all health and safety measures are in place to prevent accidents and/or reduce the consequences of nonconformance events. ▪ The contractor shall ensure all potential risks are assessed and shall develop and apply effective EHSpolicies. ▪ The contractor shall ensure all workers during construction comply with safety procedures through training, awareness, and supervision.	▪ Visual inspection of compliance with health, safety, and security procedures	Daily	Contractor	▪ Number of identified non-compliance of health, safety, and security procedures. ▪ Regular training records of personnel on H&S procedures on site. ▪ Injuries or accidents to workers on site are reported and investigated promptly and in compliance with the H&S procedures. ▪ H&S training provided. ▪ PPE used on site by workers. ▪ Review of grievance register	▪ **General:** - PPE for all workers - First aid available - Health and Safety Plan in place. ▪ **Exposure Limits:** - **Traffic Safety:** Speed limit 20 km/h onsite ▪ Fire Safety: Use NFPA or similar codes.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			▪ The Contractor shall nominate a qualified Health and Safety (H&S) Engineer dedicated to the site. The H&S Engineer and the Contractor shall be responsible for ensuring that a H&S plan is prepared and adhered to and shall coordinate with the sub-contractors for proper implementation during the execution of the works. ▪ Workers shall be briefed regularly on occupational health and safety regulations including receiving proper training. ▪ A grievance mechanism for workers has to be in place. ▪ The Contractor shall provide sufficient drinking water for workers as well as provide suitable locations for protection against the sun during breaks. ▪ Develop and implement of Traffic					

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			control measures, including road signs to warn of dangerous conditions. The Construction vehicles shall comply with speed limits. Speed limits for heavy vehicles within the construction site shall be restricted to 20 km/hr. The drivers and workers must comply with road safety measures to avoid possible accidents. ▪ The Contractor shall install fences, barriers, and dangerous warning/prohibition signs around the construction area in order to protect the workers. ▪ The Contractor shall develop and implement appropriate fire precautionary measures as per the H&S Plan in accordance with the requirements of the appropriate Local					

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			Standards for Construction. ▪ The contractor shall ensure that all trucks and vehicles used for the project are operated by licensed operators as well as ensure adequate maintenance and inspection of vehicles. ▪ The contractor shall develop appropriate precautions and security & control measures for preventing/managing theft and vandalism on-site including: -Perimeter fencing -Security lighting -Guarding services ▪ Any suspicious activity or individuals should be reported to the site manager or security personnel. ▪ Staff workers can learn how to prevent theft and vandalism as well as what to do in the event of an incident by receiving regular safety and security training.					

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			▪ Restricting access to authorized individuals. ▪ The contractors shall report all losses due to vandalism or theft to the local police department or security company ▪ The contractors shall minimize the time that materials are left on site before installing them.					
10	Labor rights	▪ Risk of poor conditions and absence of contracts for workers	▪ The Contractor shall ensure continuous compliance to all Labour obligations outlined in the local legislative framework, EIB and IFC Standards, and ILO requirements. ▪ The Contractor shall ensure the implementation of a just Human Resource Policy and related procedures and ensure it is communicated clearly to its workforce. ▪ The Contractor shall comply with and respect workers' rights as per local legislations and other relevant international	▪ Periodic audits, inspections, and/or spot checks of project locations or work sites ▪ Follow-up on workers' grievance mechanism	Continuously	Contractor	▪ Grievance mechanism is implemented, and grievance closure reports are prepared	▪ **Comply with ILO Core Conventions:** - No child/forced labor - Fair wages - Right to organize ▪ Equal opportunity

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			requirements to cover topics such as wages, compensation, benefits, workers' organization, clear grievance mechanisms, accommodation, etc. ▪ In case of having worker accommodation facilities on site; it shall be established in accordance with the specifications of the relevant standards. ▪ Competent persons shall be appointed by the contractor on site to oversee all activities and carry out relevant audits and inspections. Such practices shall be performed by the contractor staff, workers engaged by third parties, and the supply chain (vendors/suppliers) that the contractor deals with. ▪ The Contractor shall commit to non-discrimination employment procedures with equal					

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			opportunities and force and child labor.					
Waste Management								
11	Waste Management	▪ Improper housekeeping practices such as improper management of waste streams, improper storage of construction material and hazardous material, illegal disposal of waste to land which may lead to impacts on soil, and water, indirectly affecting flora/fauna, and health & safety of workers. ▪ Potential contamination from the radioactive contaminated sedimentation resulting by the testing of the production wells	▪ Domestic waste will be stored in properly in closed containers that will later be removed from the project area and disposed of at the closest landfill. ▪ All waste generated at construction sites would be managed in accordance with the Contractor's Waste Management procedure. Accordingly, the contractor shall develop and implement waste management procedure/plan. ▪ Chemical waste shall be stored in accordance with the provisions of Material Safety Data Sheets (MSDS). The Contractor shall keep MSDS onsite ▪ Domestic wastewater generated at the site (in case of the existence of construction workers'	▪ Visual monitoring of site cleanliness and waste storage	Daily	Contractor	▪ Compliance with waste management plan. ▪ Current and complete records of regular waste collection and disposal. ▪ Compliance with applicable regulations including: ▪ Waste Management Framework Law No. 16 of 2020. ▪ Regulation of hazardous materials and waste management No.68 for the year 2020 ▪ Regulation of Solid Waste Management No. 27 of 2005	▪ Hazardous waste stored with secondary containment ▪ Regular disposal at licensed facilities ▪ MSDS maintained ▪ Domestic wastewater stored, trucked offsite

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			camps) should be collected in storage tanks. These must be transported to the nearest approved municipal wastewater treatment facility. ▪ The project company is responsible for uploading the radioactive sedimentation that exceeds the Jordanian standards on trucks, and MWI shall arrange for its disposal to an approved facility. ▪ Keep records proving the safe disposal of all types of waste in approved landfills.				▪ Regulation of Environmental Information and Control System for Waste Management No. (85) of 2020. ▪ Instructions for hazardous waste management and handling for the year 2019 ▪ Instructions for Solid Waste Management of 2019. ▪ Compliance with Jordanian standards for radioactive sediments.	
11.1	10.1 Drilling fluid waste	▪ Potential localized contamination resulted from improper handling and disposal practices of the consumed drilling fluid	According to the drilling fluid general requirement by MWI/WAJ: ▪ The contractor shall select methods, Equipment, and Materials that will minimize any damage to the productive formation. ▪ The use of drilling mud shall be restricted to non-biodegradable, non-toxic, synthetic	▪ Observation and inspection. ▪ Unless otherwise specified in the approved works procedure, or required by MWI/WAJ, if drilling mud is used, the following parameters shall be measured and recorded throughout the	Daily	Contractor	▪ Compliance with MWI/WAJ approved works procedure ▪ Record of the quantities of different drilling fluid additives ▪ Daily Driller's Log ▪ Monitoring and maintenance records	▪ Use non-toxic, biodegradable drilling fluids. ▪ Designated lagoons for cuttings. ▪ Monitoring of mud properties (density, viscosity, pH, etc.). ▪ Avoid direct discharge to land or water. ▪

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			polymer base, low solids mud. The manufacturer's recommendation and specifications for preparing and maintaining such mud shall be followed. ▪ The contractor shall furnish MWI/WAJ with all necessary pamphlets with technical information concerning the polymer, polymer breaker, and all other additives and chemicals required. ▪ During drilling, the contractor shall continuously operate, 24 hours a day all solids control equipment of the drilling fluid system. The contractor has the obligation and bears full responsibility for the maintenance of all drilling fluid parameters within acceptable limits, according to good industry practice and MWI/WAJ's approval. ▪ The contractor shall keep a record of the	duration of drilling at one (1) hour intervals: ● Density ● API Marsh funnel viscosity ● Filtrate loss ● Sand content ● Filtrate cake ● Temperature ● pH			The employment of a skilled and experienced drilling fluid engineer	

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			quantities of different drilling fluid additives, including but not limited to surfactants, and polymers used ▪ The employment of a skilled and experienced drilling fluid engineer is strongly recommended. ▪ . ▪ The contractor shall use drilling fluid tanks which have a storage capacity of minimum 2 times the maximum borehole volume at total depth. Disposal of drilling mud waste and drill cuttings shall be to a purpose-built lagoon.					
Archaeology and Cultural Resources								
12	▪ Archaeology and Cultural Resources	▪ Discovering archaeological and/or cultural heritage sites within the proposed project during construction activities	▪ Based on the Archaeological section for the project. the following recommendations are proposed: ▪ Adherence to the project area allocated for the project and not exceed it; ▪ Implementation of chance find procedures as per the	Site inspection	Daily	Contractor/ Department of Antiquities	▪ No identified non-compliance to the mentioned measures ▪ Notification for the Department of Antiquities ▪ Employing chance find procedure	▪ Chance Find Procedure: Follow local law. ▪ Train workers on what to do if archaeological remains are found. ▪ Coordinate with Department of Antiquities (DoA).

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			Jordanian Antiquities Law. This is described as follows: ▪ Construction works shall be ceased if any historical/ culturally sensitive or archaeological sites / remains are chance found during construction activities. ▪ If any known sites were found during construction and may potentially be threatened by construction, the area with the newly discovered remains/sites shall be fenced and the DoA shall be notified immediately and invited for consultations and assessment of the finding and agreement must be reached with the DoA in order to minimize damages to the sites. It shall also be the Contractor's responsibility to notify the supervisor of the Cultural resources					

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			Management Office of the DoA are encountered in any area during construction and also specifications set in Article 15 of the Antiquities Law No. 21 (1988). ▪ The DoA will assess the discovered remains and may carry out an emergency salvage excavation (i.e. archaeological excavation conducted during the construction phase, which should be conducted only when an archaeological site is accidently found (chance found)). ▪ The available short time for salvage excavations cannot be considered an authorization to destroy the discovered remains or site. Each site must be given proper consideration and analysis before its destruction. ▪ Construction work shall be resumed					

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
			within the newly discovered area only after archaeological experts from DoA and official authorities are consulted and appropriate mitigation measures are implemented, however construction activities can continue at other parts of the site after coordination with DoA. ▪ .					
13	▪ Climate Risk	▪ Flooding events	▪ Following the CRVA in **Annex 6**.	Site inspection	During rainy season	Contractor	▪ Compliance with the CRVA plan	▪ No direct numeric standards under EHS Guidelines 2007 for climate risk. However, project design and operation must integrate climate resilience considerations in line with World Bank Group guidance on climate risk management, including:

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
								▪ Using World Bank Climate and Disaster Risk Screening Tools to identify and assess climate-related hazards (e.g., flooding, drought, extreme weather). ▪ Incorporating flood-resilient design measures such as proper drainage, topographic analysis, and infrastructure elevation where applicable. ▪ Ensuring stormwater management systems are designed to handle increased rainfall intensity and runoff under future climate scenarios.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	EHS 2007 Requirement
								▪ Enhancing infrastructure resilience through appropriate material selection and engineering standards suited for projected climate conditions. ▪ Monitoring and updating risk mitigation measures based on emerging climate data and extreme weather trends.

ESMP during the Reinstatement phase:

On completion of all construction activities and before leaving the site, all working areas or other areas used by the contractor shall be reinstated to a condition and in a manner, which is similar to and no worse than the original condition. Thus, the contractor shall consider the following main environmental aspects illustrated in **Table 59** below.

It is worth mentioning that before the commencement of the works, the project company shall prepare written records, supported by relevant photos of the original conditions of all working areas and any other areas to be used during construction activities. Such records certified by MWI/WAJ will subsequently be used as a basis for standards of reinstatement and repair after the completion of construction activities (e.g.: well drilling works and wellfield infrastructure).

Table 59: Environmental and Social Management Plan during Reinstatement Phases

No.	Environmental Attribute	Potential Impact	Management Action/ Mitigation measures	Monitoring Actions	Responsibility of Implementation	Performance Indicator	EHS 2007
	Reinstatement phase						
1	**Landscape and Waste Generation**	▪ Potential site contamination	▪ The contractor shall remove all equipment machinery, and remaining materials, as well as clean up all construction wastes and debris, and completely level/reinstate the whole area used, including pits and ditches. ▪ The contactor shall properly manage and dispose of all stored hazardous materials to an approved site by the MoEnv.	Visual monitoring of site cleanliness MWI/WAJ accompanied by the project company shall perform a final site observation and inspection	The Contactor	▪ MWI/WAJ site approval	▪ All hazardous and non-hazardous waste should be removed from the site and disposed of at licensed and approved facilities. ▪ Contractors should maintain records of waste types, quantities, and disposal methods.

No.	Environmental Attribute	Potential Impact	Management Action/ Mitigation measures	Monitoring Actions	Responsibility of Implementation	Performance Indicator	EHS 2007
	Reinstatement phase						
			▪ The contractor shall demobilize all living, office, store, servicing facilities, and workshops in addition to restoring the area used for the contractor's camps and surrounding areas by cleaning it up and properly disposing of all generated wastes to the closest landfill.				▪ Waste storage areas should be cleaned and decommissioned properly. ▪ General EHS Guidelines – Section 1.6 (Contaminated Land): - Affected sites must be assessed for residual contamination, and corrective action taken as necessary. - All temporary infrastructure (e.g., contractor camps, pits) should be fully removed and the land reinstated to its original or agreed-upon condition. ▪ Demobilization Best Practices:

No.	Environmental Attribute	Potential Impact	Management Action/ Mitigation measures	Monitoring Actions	Responsibility of Implementation	Performance Indicator	EHS 2007
	Reinstatement phase						
							- Complete demobilization of equipment, materials, and temporary facilities. ▪ Implementation of final site inspection and closure checklist with the supervising authority.

Table 60: Environmental and Social Management Plan during Operation Phase

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	ESH 2007 Requirements
Physical Environment								
1	Air Quality and Dust	▪ Potential dust generation is limited to vehicular movement during the maintenance operations ▪ Indirect air emissions would be generated from energy consumption resulting from the operation of pumps.	▪ Continuous maintenance to enhance pump efficiency ▪ Real-time energy monitoring to optimize resource use and minimize operational emissions .	▪ Site Observation	▪ Continuously	▪ The Project Company and the O &M Contractor	▪ The cut-off emissions ▪ Complete records of monitoring activities. ▪ Monitoring and maintenance records	▪ PM10: ≤ 50 µg/m³ (24-hour mean) ▪ SO_2: ≤ 20 µg/m³ (24-hour mean) ▪ NO_2: ≤ 200 µg/m³ (1-hour mean) ▪ Use high-efficiency pumps ▪ Integrate renewable energy ▪ Apply dust suppression (e.g., water spraying)
2	Noise	▪ The main source of noise during the operation phase would result from the operation of pumps as well as the movement of heavy machines during operation & maintenance activities.	▪ Continuous maintenance to enhance pump efficiency. ▪ Provide workers with protective hearing equipment. ▪ A grievance mechanism for workers has to be in place.	▪ Site inspection. ▪ Check the availability and proper use of Personal Protective Equipment (PPE). ▪ Review the record of employee complaints.	▪ Continuously	▪ The Project Company and the O &M Contractor	▪ Number of employee complaints in relation to the project. ▪ PPE used on site by workers.	▪ Limit to 70 dB(A) daytime, 55 dB(A) nighttime (environmental) ▪ Occupational limit: 85 dB(A) (use PPE if exceeded) ▪ Use mufflers and barriers ▪ Regular maintenance of equipment ▪
3	Soil	▪ Potential impacts on soil are limited to soil contamination that may result from leakage of fuel and lubricant storage and misconduct usage regulations, poorly managing municipal and other solid wastes throughout the maintenance operations	▪ A soil management plan and spill response procedure/plan must be developed. ▪ Proper storage and handling of any chemicals and hazardous materials on site. ▪ Disposal of hazardous products including disposal of oils shall be according to legal requirements	▪ Check spillage incidents report. ▪ Inspection of waste management practices ▪ Site inspection	▪ Continuously	▪ The Project Company and the O &M Contractor	▪ Up-to-date and complete records as required by spill prevention and response procedures. ▪ Environmental reports on the implementation of the waste management practices onsite.	▪ Develop and implement a Spill Prevention and Response Plan ▪ Store hazardous materials on sealed, contained surfaces ▪ Train staff in spill management Waste disposal at licensed facilities only.

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	ESH 2007 Requirements
4	4.1 Surface Water	Potential surface water runoff / potential flood risks at the wells site, potentially leading to flooding and soil erosion.	▪ Visual inspection. ▪ Maintain the adopted flood control measures	▪ Visual inspection. ▪ Ensure proper flood control measures are taken into the design.	▪ Daily during rainy seasons ▪ When needed	▪ The Project Company and the O &M Contractor	▪ Runoff within the site	▪ Design for 10- to 25-year storm event runoff control ▪ Provide site drainage systems ▪ Avoid direct discharge to natural water bodies
	4.2 Groundwater	▪ Groundwater decline	▪ Implement groundwater level monitoring	▪ Measure groundwater levels using piezometers in key locations. ▪ Regularly inspect aquifer recharge rates and conduct hydrogeological assessments. ▪ Track seasonal fluctuations in groundwater levels to identify trends.	▪ Continuous (real-time meters)	▪ The Project Company and the O &M Contractor	▪ Percentage reduction in unauthorized groundwater abstraction.	▪ Install piezometers and monitor levels ▪ Establish sustainable abstraction limits based on hydrogeological assessments ▪ Prevent unauthorized abstraction
		▪ Land Subsidence	▪ Implement sustainable groundwater extraction limits based on hydrogeological studies to avoid over-extraction ▪ Regularly assess aquifer levels	▪ Conduct continuous groundwater level monitoring using piezometers installed in key locations. ▪ Monitor groundwater extraction volumes from operational wells to ensure compliance with approved limits.	▪ Annually	▪ The Project Company and the O &M Contractor	▪ Percentage of operational wells in compliance with extraction volume limits. ▪ Percentage of monitoring locations equipped with functioning piezometers	
Biological Environment								
5	Biodiversity 5.1 Flora	▪ Continued Vegetation Disturbance	▪ Implement a long-term monitoring and maintenance plan for vegetation in disturbed areas. ▪ Minimize soil disturbance during maintenance activities. ▪ Use native plant species for revegetation and landscaping as a result of O&M activities.	▪ Observation and inspection. ▪ Coordination with RSCN	▪ Annually ▪ When needed	▪ The Project Company and the O &M Contractor ▪ The coordination with RSCN shall be through DPAC as needed.	▪ Complete records of monitoring activities. ▪ Monitoring and maintenance records	▪ Use native species for revegetation ▪ Inspect quarterly for invasive species ▪ Avoid clearing during sensitive periods ▪ Minimize land disturbance during maintenance

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	ESH 2007 Requirements
		▪ Invasive Species Spread	▪ Continue regular monitoring for invasive species and implement control measures promptly. ▪ Educate operation and maintenance staff about invasive species identification and control.	▪ Observation and inspection	▪ Annually	▪ The Project Company and the O &M Contractor	▪ Complete records of monitoring activities. ▪ Training records	
		▪ Edge Effects from Infrastructure	▪ Plant native vegetation along infrastructure edges to create buffer zones and reduce edge effects as a result of O&M activities. ▪ Monitor vegetation health along edges and implement corrective measures as a result of O&M activities, if necessary	▪ Observation and inspection. ▪ Coordination with RSCN	▪ Annually ▪ When needed	▪ The Project Company and the O &M Contractor ▪ The coordination with RSCN shall be through DPAC as needed.	▪ Complete records of monitoring activities.	
	Biodiversity 5.2 Fauna	▪ Habitat Displacement	▪ Implement measures to minimize human presence and to minimize disturbance in sensitive areas as a result of O&M activity. ▪ Create artificial habitats or nesting structures to compensate for habitat loss as a result of the O&M activities.	▪ Conduct regular wildlife monitoring to assess impacts on habitat use. ▪ Observation and inspection. ▪ Coordination with RSCN	▪ Annually ▪ When needed	▪ The Project Company and the O &M Contractor ▪ The coordination with RSCN shall be through DPAC as needed.	▪ Complete records of monitoring activities.	▪ Avoid night-time activities in sensitive zones ▪ Install bird diverters on power lines ▪ Limit access and train staff ▪ Conduct quarterly inspections and collaborate with RSCN
		▪ Collision and Electrocution Risks for Birds	▪ Implement regular maintenance and inspection of power lines to prevent electrocution hazards	▪ Observation and inspection ▪ Coordination with the electricity company to conduct regular maintenance and inspection of power line.	▪ Annually	▪ The Project Company &and the O &M Contractor /Electricity Company	▪ Complete records of monitoring activities. ▪ Monitoring and maintenance records	
		▪ Noise and Human Activity Disturbance	▪ Regular Inspection for the adopted noise mitigation measures/ prevention devices. ▪ Schedule maintenance activities during periods of low wildlife activity.	▪ Observation and inspection ▪ Monitor the use and efficiency of the adopted noise prevention devices.	▪ Annually	▪ The Project Company and the O &M Contractor	▪ Complete records of monitoring activities. ▪ Monitoring and maintenance records	

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	ESH 2007 Requirements
			▪ Restrict vehicle access to designated areas.					
		▪ Increased Access to Illegal environmental Activities	▪ Increase surveillance and enforcement in remote areas. ▪ Implement awareness sessions for the operation and maintenance staff about the importance of wildlife conservation and the consequences of illegal activities.	▪ Observation and inspection	▪ Annually	▪ The Project Company and the O &M Contractor	▪ Complete records of monitoring activities. ▪ Training records	
		▪ Alteration of Migration and Movement Patterns	▪ Maintain wildlife corridors to facilitate movement. ▪ Monitor wildlife movement patterns and adjust management practices if necessary.	▪ Observation and inspection	▪ Annually	▪ The Project Company and the O &M Contractor	▪ Complete records of monitoring activities.	
Socioeconomic								
6.1	Employment	▪ Minimal permanent job opportunities	▪ Locals should be prioritized for these limited job opportunities.	▪ Review the employment plan and ongoing records	▪ On Demand	▪ The project Company and the O &M Contractor	▪ The employment plans and records contain local employee	▪ Prioritize local hiring ▪ Maintain transparent employment records
6.2	Groundwater decline	▪ Declining water levels and potential impacts on water quality may disrupt agricultural activities, particularly in regions dependent on groundwater for irrigation. This could negatively affect livelihoods and food security. ▪ As water levels decline, deeper wells may be required, increasing costs for drilling, pumping, and maintaining water supply infrastructure.	▪ Implement groundwater monitoring	▪ Conduct monthly monitoring of groundwater levels in production and observation wells to track depletion rates. ▪ Install piezometers for continuous water level logging. ▪ Periodically test aquifer transmissivity and storability to evaluate changes in aquifer properties due to drawdown.	▪ Quarterly	▪ The Project Company and the O &M Contractor	▪ % of observation wells equipped with functioning piezometers. ▪ Frequency and completeness of aquifer transmissivity and storability testing.	▪ Monitor groundwater depletion and impacts quarterly ▪ Support sustainable water use planning ▪ Coordinate with local water users if required

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	ESH 2007 Requirements
6.3	Indigenous people	▪ Possible restriction of seasonal grazing access due to operational activities and infrastructure.	▪ Ensure that access routes for seasonal grazing remain open. ▪ Prevent unauthorized access to operational areas for safety.	▪ Document and address grievances raised by indigenous groups	▪ Quarterly	▪ The project Company and the O &M Contractor	▪ Grievances from indigenous communities	▪ Maintain regular dialogue with affected communities ▪ Document grievances and responses
Health, Safety and Security								
7.1	Occupational Health, Safety and Security	▪ The operational and maintenance staff may be exposed to hazards related to working in confined spaces and a variety of hazardous chemical agents during maintenance works. In addition, exposure to other hazards including electric shock, explosions, and entanglement in moving machinery. ▪ Potential impacts on workers and properties due to local community attacks including theft and vandalism on-site.	▪ The project company shall ensure all risks from operation activities are assessed, specific work procedures for tasks established, and Occupational, Health, Safety, and Environmental (HSE) procedures are developed for the operation of the new proposed wells to prevent and reduce the incidence of health and safety risks and avoid non-conformance events. ▪ The project company shall develop appropriate precautions and security & control measures for preventing/managing theft and vandalism on-site including: -Perimeter fencing -Security lighting -Guarding services (ex: employing skilled security personnel) ▪ Access to the new well sites should be restricted to authorized individuals. ▪ Operation and Maintenance staff shall be briefed regularly on occupational health and safety regulations including receiving proper training.	▪ Visual inspection of compliance with health, safety, and security procedures	▪ Continuously	▪ The project Company and the O &M Contractor	▪ No identified non-compliance of health, safety, and security procedures. ▪ Regular training records of operation and maintenance staff on H&S procedures on site. ▪ Up-to-date and complete records of PPEs and records of any incidences and appropriate responses	▪ Provide PPE and HSE training ▪ Implement site access controls, emergency response plans, and fencing ▪ Daily toolbox meetings and quarterly drills

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	ESH 2007 Requirements
			▪ Ensure that an emergency plan and a rescue plan are in place and ready to be implemented if needed ▪ Inspection PPEs for operation and maintenance workers					
8	Waste Management	▪ Potential Impacts of spills from oils, fuel, lubricants, and chemicals utilized in the maintenance activities.	▪ Proper management, storage, handling, and disposal of these materials are necessary to prevent negative impacts on both the environment and workers. ▪ The hazardous materials/products must be labeled with proper identification of their hazardous properties. ▪ Hazardous wastes generated must be disposed of off-site at an approved waste facility. ▪ The damaged equipment (eg. pumps) shall be replaced and disposed of in coordination with the MWI to prevent the potential radioactive contamination	▪ Visual monitoring of site cleanliness and proper storage and handling of waste. ▪ Records on the procedures followed to dispose of all damaged equipment.	▪ Continuously	▪ The project company and the O &M Contractor	▪ Compliance with waste management plan. ▪ Current and complete records of regular waste pickup and disposal. Complete records of damaged equipment and procedures. ▪ Compliance with applicable regulations	▪ Label and store hazardous materials per MSDS ▪ Collect and dispose of hazardous waste at licensed facilities ▪ Maintain waste records and inspect storage areas regularly
9	Labor Rights	▪ Risk of poor conditions and absence of contracts for workers	▪ Ensuring continuous compliance with all Labor obligations outlined in the local legislative framework, EIB and IFC Standards, and ILO requirements. ▪ Ensuring the implementation of a just Human Resource Policy and related procedures and ensure it is communicated clearly to its workforce.	▪ Periodic audits, inspections, and/or spot checks of project locations or work sites. ▪ Follow-up on workers' grievance mechanism.	▪ Continuously	▪ The project company and the O &M Contractor	▪ Grievance mechanism is implemented, and grievance closure reports are prepared	▪ Ensure compliance with ILO core standards ▪ Implement grievance mechanisms and HR policies ▪ Conduct periodic audits and worker interviews

#	Environmental Attribute	Potential Impact	Mitigation measures	Monitoring Actions	Frequency	Responsibility of Implementation	Performance Indicator	ESH 2007 Requirements
			▪ The Contractor shall comply with and respect workers' rights as per local legislations and other relevant international requirements to cover topics such as wages, compensation, benefits, workers' organization, clear grievance mechanisms, accommodation, etc.					
10	Climate Risk	▪ Climate Risk & Vulnerability Management	▪ Maintain the adopted early warning systems to monitor operational disruptions ▪ Train personnel and stakeholders on climate change adaptation and resilience-building practices. ▪ Following the CRVA in **Annex 6.**	▪ Site Inspection and observation	▪ Continuously during operation	▪ The project company and the O &M Contractor	▪ Compliance with the CRVA plan	▪ Apply climate-resilient design standards ▪ Install early warning systems ▪ Enhance vegetation buffers ▪ Train staff on climate adaptation ▪ Follow CRVA action plan.

10.3 Periodic Monitoring

Table 62 illustrates the periodic monitoring during the operation phase for the project company, while **Table 63** illustrates the MWI periodic monitoring during the construction and operation phase.

Table 61: Periodic Monitoring during the operation phase for the project company

Aspect	Potential Impact	Monitoring Requirements	Standard	Frequency	Responsibility
Water Resources Water Resources	Groundwater Pollution	▪ Monitor the groundwater quality in compliance with JS 286/2015 for the new wells. ▪ Monitor the following parameters: **In Organic Parameters:** o Colour, Taste, Odour, Turbidity Ammonium, Aluminium, Manganese, Iron, Copper, Zinc, Sodium, Chloride, Sulphates, Hydroxide, TDS, Total Harness, and Chemical detergents. o Arsenic, Lead, Cyanide, Cadmium, Chrome, Barium, Selenium, Boron, Mercury, Silver, Nickel, Antimony, Fluoride.	Comply with JS 286/2015	Once every 3 months for the first year and annually thereafter Once every 6 months for the first year and annually thereafter	The Project Company
	Groundwater Level decline	▪ Regular groundwater level Monitoring		Annually	The Project Company
Noise	Nuisance to the workers	▪ Monitor noise levels in compliance with noise prevention and control instructions year 2003	Comply with Instructions of noise prevention and control instructions year 2003	Spot noise measurements on Semi-annual basis for the new wells	The Project Company

Table 62: Periodic Monitoring during the construction and operation phase for the MWI

Aspect	Potential Impact	Monitoring Requirements	Standard	Frequency	Responsibility
During Construction					
Waste Management	Potential localized contamination resulted from improper handling and disposal practices of the consumed drilling fluid	▪ The following parameters shall be measured and recorded: ● Density ● API Marsh funnel viscosity ● Filtrate loss ● Sand content ● Filtrate cake ● Temperature ● pH	-	Throughout the duration of drilling at one (1) hour intervals	MWI
During Operation					
Water Resources	Groundwater Pollution	**<u>Radioactivity Parameters:</u>** ○ Total Alpha and Total Beta activities. ○ Activities for Radionuclides (Ra-226 AND Ra-228)	Comply with JS 286/2015	Quarterly for the first year. and Every 2 years thereafter	MWI*

***: Natural Radioactivity Monitoring:**

Monitoring of natural radioactivity in groundwater is not within the direct scope of the project operator. As per the obligations outlined in the original Disi Project ESMP2[61], this responsibility lies with the MWI. This assignment is reflected in the periodic monitoring table of this ESIA to ensure continuity with existing regulatory frameworks and previous project commitments.

[61] Disi-mudawarra to Amman water conveyance system environmental & social management plan part 2 (ESMP 2) August 2017

10.4 Decommissioning

The new Dubaydib wells represent a strategic, long-term investment aimed at enhancing Amman's water supply and advancing national water security goals. These wells will be designed according to best practices, aligning with all relevant national and international codes and legislation.

The post-design life for the wells is expected to involve the following two options:

- **Rehabilitation, Upgrading, and Modernization of the wells:** This may include casing integrity, potential corrosion, or contamination risks, and well infrastructure to improve efficiency and output. Consequently, impacts from decommissioning would not be anticipated in the near future unless retrofitting and upgrades were deemed feasible.
- **Decommissioning:** In the event that there is a need to dismantle the wells and terminate their operations, a full decommissioning process would be initiated to safely end their use.

The main mitigation and monitoring measures to minimize or reduce the environmental and social impacts during decommissioning are anticipated to be similar to those identified for the construction phase. However, it is recommended that before any decommissioning activities take place, a disposal plan for the wells shall be prepared by the responsible entity undertaking decommissioning activities.

Decommissioning, including backfilling and sealing the well, should be carried out under the supervision of MWI/WAJ in accordance with the Regulation of Groundwater Monitoring No. 85 of 2002. The disposal plan shall consider the following options at a minimum and compare the feasibility and applicability of each:

- Recycling the well components where suitable;
- Reuse in other technologies;
- Screening and testing of well components for potential radioactivity, as referenced in the ESMP. This includes conducting radiological surveys on well casings, pipes, and any extracted geological materials to determine radiation levels. If elevated radioactivity is detected, specialized containment and disposal measures must be implemented in line with national radiation protection standards and the International Atomic Energy Agency (IAEA) guidelines.
- Disposal of any hazardous components and/or other materials that cannot be reused at existing hazardous waste facilities in Jordan through coordination with the Ministry of Environment.

To ensure compliance and effectiveness of the mitigation measures, the following monitoring actions will be implemented:

- Regular environmental audits and inspections conducted by qualified personnel.
- Documentation and reporting of waste management practices, including waste manifests and disposal certificates.
- Verification of waste disposal through certified facilities, with records maintained for regulatory review

- Monitoring of groundwater quality post-decommissioning to detect any potential contamination and ensure the long-term safety of the aquifer.
- Radiological monitoring of dismantled materials and the surrounding environment to confirm the absence of residual radioactive contamination.

Therefore, to avoid repetition, please refer to **Table 58** for detailed mitigation measures that overlap with decommissioning.

11 OVERVIEW OF ESMS AND AUDITING PROTOCOL

11.1 Environmental and Social Management System (ESMS) Framework

After the identification and assessment of environmental and social risks/impacts generated by the project (throughout the ESIA stage), the project developer and DIWACO will be obliged to manage such risks during the project lifecycle (i.e., Construction, operation and closure/decommissioning).

The main tool to manage such risks is through developing an ESMS that is commensurate to the level of risks/impacts identified.

The ESMS documentation shall be in place prior to construction and may include plans relevant to the project's identified risks and impacts - mainly related to the following:

- Requirements for environmental and social management;
- Requirements for management of labor rights;
- Requirements on emergency preparedness and response;
- Requirements for the climate risk vulnerability assessment;
- Requirements for other relevant plans.

11.2 Monitoring and Reporting

After the preparation of the relevant ESMS plans and procedures, the project developer will be required to establish procedures to monitor and measure the effectiveness of the management program during project implementation, as well as compliance with any related legal and/or contractual obligations and regulatory requirements.

Reports must be issued (when required) and include information and indicators in accordance with national environmental and social reporting requirements.

11.3 Auditing

Environmental and social audits will assess a project's performance against its project specific ESMS should the need arise.

The audit may be required during project implementation to review the current operational performance of the DIWACO and DAOM existing operations. The audit might be conducted during the construction phase and the operation phase, usually by an independent third-party consulting company / Environmental and Social Management Experts.

Key issues that are recommended to be covered under the Environmental and Social Audit may include, but are not be limited to:

A review of the DIWACO and DAOM's existing and approved ESMS policies and practices;

- Organizational capacity and resources;
- Human Resources and employment policies (e.g., child labor, forced labor, non-discrimination, and equal opportunity, workers' organizations, project developer or the operator management, retrenchment, and employment);

- Occupational health and safety (e.g., national requirements, key health and safety issues, control and major accident hazards, current health and safety monitoring program, summary of regulatory compliance status, and emergency response practices and procedures);
- Pollution prevention measures available at the Dubaydib wellfield and regulatory compliance with national requirements and EIB and IFC requirements including applicable Best Available Techniques.
- Community health, safety, and security as it relates to the project developer's existing operations;
- Management of potentially hazardous works;
- Waste management procedures on-site during all project phases;
- Noise generation during construction and operation;
- Identification of potential environmental liabilities (e.g., potential contamination as a consequence of project operations);
- Overview of the supply chain (e.g., suppliers, contractors, sub-contractors of main materials and resources) and identification of relevant environmental, social, labor, and/or reputation issues;
- Public interaction, including responsiveness to public comments, complaints, and questions. The audit should also identify the main stakeholder groups and current stakeholder engagement activities. A check on grievance mechanisms and records and frequency of response shall be conducted;
- Updates to the ESMP accordingly.

The successful implementation of the ESMS will require performing awareness programs/workshops for employees and other stakeholders to ensure that they are aware of the main objectives and purpose of the ESMS and its benefit to the project.

References

- BRGM. (2023, June). *Additional production well targeting and well design for the Dubaydib wellfield – Jordan: Final Report*. Orléans, France: Bureau de Recherches Géologiques et Minières (BRGM).
- Abdulla, F. (2020). *21st Century Climate Change Projections of Precipitation and Temperature in Jordan.*
- International Finance Corporation (IFC). (2012). *Performance standards on environmental and social sustainability*.
- European Investment Bank (EIB). (2022). *The EIB Statement of Environmental and Social Standards*. Published February 2, 2022.
- World Bank Group. (2007). *Environmental, health, and safety (EHS) general guidelines*.
- International Finance Corporation (IFC). (2007). *Environmental, health, and safety (EHS) guidelines for water and sanitation*.
- World Bank. *Climate Change Knowledge Portal*.
- Ministry of Environment. (2014). *Jordan's Third National Communication on Climate Change.* Fanack Water. (2022, June 2). *Jordan: Water resources and challenges*.
- Ministry of Environment. (2021). *The National Climate Change Adaptation Plan of Jordan 2021*
- Ministry of Water and Irrigation. (2021). *Energy Efficiency and Renewable Energy Policy for the Water Sector 2020–2030*.
- Ministry of Environment. (2020). *Jordan's Second Biennial Update Report (SBUR) under the United Nations Framework Convention on Climate Change*.
- Ministry of Environment. (2022). *Facilitative Sharing of Views: Jordan*.
- United Nations Development Programme (UNEP). (2022). *Jordan's 2022–2050 National Climate Change Policy.*
- United Nations Environment Programme (UNEP). *Nationally Determined Contributions (NDC) Action Area: Jordan*.
- Global Facility for Disaster Reduction and Recovery. (2024). *ThinkHazard! Report: Aqaba, Jordan – Extreme Heat*.
- Global Facility for Disaster Reduction and Recovery. (2024). *ThinkHazard! Report: Aqaba, Jordan – Water Scarcity.*
- Ministry of Environment. (2023). *Jordan's Fourth National Communication on Climate Change*.
- World Bank. (2020). *Transformative Climate Finance: A new approach for climate finance to achieve low-carbon resilient development in developing countries.*
- World Bank. (2020). *Water in the Balance: The Economic Impacts of Climate Change and Water Scarcity in the Middle East – Technical Report.*

- Ministry of Agriculture (MoA). (2006). *Jordan soils and land management*.
- Ministry of Water and Irrigation. (2023). *National Water Strategy 2023–2040*.
- Al-Mashagbah, A. F. (2023). *Water Resources in Jordan: A Review of Current Challenges and Future Opportunities*. *Water*, 15(21), 3729.
- Hadadin, N. A., Qaqish, M., Akawwi, E., & Bdour, A. (2009). *Water shortage in Jordan—Sustainable solutions*. *Desalination*, 250(1), 197–202.
- United States Geological Survey (USGS). (1931). *Modified Mercalli Intensity Scale*. Washington, DC: United States Geological Survey.
- Ministry of Water and Irrigation. (2022). *Jordan Water Sector – Facts and Figures 2022*.
- Puri, S., & Al-Karasneh, G. (2008). *The Rum-Saq Aquifer Resource – Risk Assessment for Long Term Resource Reliability*.
- Johnson, P. R., & Williams, P. L. (1985). *Geology of the Precambrian Rocks of the Jabal Habashi Quadrangle, Sheet 26F, Kingdom of Saudi Arabia*. U.S. Geological Survey Open-File Report 85-3.
- Ministry of Water and Irrigation (MWI). (2023). *National Water Strategy 2023–2040*.
- Ma'an Development Area (MDA). (2023, February 14)
- Disi Municipality. (2019). *Developmental Strategic Plan for the Disi Municipality for the Years 2019–2021*.
- Ministry of Water and Irrigation (MWI). (2021). *National Water Infrastructure Master Plan*.
- Al-Lahham, O., El-Khairy, W., & Daraa, M. (2020). *Treated wastewater reuse for irrigation: Pros and cons*.
- U.S. Environmental Protection Agency. (2024). *GHG Emission Factors Hub 2024*.
- Environmental and Social Impact Assessment of Disi-Mudawara to Amman Water Conveyance System,2004.
- Disi-mudawarra to amman water conveyance system environmental & social management plan (ESMP) May 2009.
- Disi-mudawarra to Amman water conveyance system environmental & social management plan part 2 (ESMP 2) August 2017

Annexes

Annex 1: Official Letter of Reactivation of the Disi Project Advisory Committee (DPAC)

Diwaco
Disi Water Company

Date : 27 May 2024
Ref. : DISI-HQ-MWI/WAJ-17623-24

Ministry of Water and Irrigation
Water Authority of Jordan
Att.: Eng. Ahmad Al-Awamleh
DISI Project Manager / WAJ

Subject: **Reactivation of the Disi Project Advisory Committee (DPAC)**

Reference:
1. MWI/WAJ letter No. 7.2.14085 dated 8/12/2014
2. PC letter No. DISI-HQ-MWI/WAJ-11987-14 dated 17/12/2014
3. MWI/WAJ letter No. 7.2.13862 dated 11/11/2015
4. PC letter No. DISI-HQ-MWI/WAJ-12965-15 dated 15/11/2015
5. PC letter No. DISI-HQ-MWI/WAJ-13158-16 dated 20/01/2016
6. MWI/WAJ letter No. 7.2.9156 dated 10/8/2016
7. MWI/WAJ letter No. 7.2.11974 dated 15/10/2017
8. PC letter No. DISI-HQ-MWI/WAJ-14271-17 dated 06/11/2017
9. PC letter No. DISI-HQ-MWI/WAJ-17571-24 dated 04/04/2024
10. MWI/WAJ letter No. MWIWAJ-BOT-24-545 dated 26/05/2024

Dear Eng. Ahmad,

Reference to the aforementioned subject and its referenced letters, kindly be informed that:

- **Mr. Khalil Al Wazir** - DIWACO Technical Manager is the nominated person to represent DIWACO in the DPAC committee.
- **Mr. Mustafa Al Mazanah** – DAOM Security Manager and Conveyance Line Engineer is the nominated person to represent DAOM in the DPAC committee.

The Project Company would kindly request MWI/WAJ to arrange a (DPAC) meeting as soon as possible.

Yours Faithfully,

Mohiddin Abu Lughod
Deputy GM/ CFO

Ahmet Burak Kadıoğlu
General Manager

CC: Director of Programme Management Directorate

Annex 2: EDCO Power Supply Confirmation Letter for Wellfield Expansion

شركة توزيع الكهرباء المساهمة العامة
Electricity Distribution Company

الرقم : ٤٠٠٦ / ١ / ٤ / ٨ Ref : _____

التاريخ : ١٨ / ٤ / ٢٠٢٢ Date : _____

السادة شركة الديسي عمان للتشغيل والصيانة

الموضوع: تحسين كميات الضخ لمشروع جر مياه الديسي

إشارة إلى الموضوع أعلاه، وإلى كتابكم رقم (بلا) تاريخ 2022/03/20، بخصوص تزويدكم بالقدرة الكلية للمحطات الكهربائية المغذية لمجموعة آبار ومضخات مشروع مياه الديسي، ومقدرة هذه المحطات على استيعاب الأحمال الجديدة ضمن منطقة آبار الديسي وعلى مرحلتين كما تم توضيحه في كتابكم، يرجى إعلامكم بما يلي:

- تتغذى أحمال مشروع مياه الديسي بشكل رئيسي من محطة الديسي الرئيسية الجديدة (33/132 ك.ف) التابعة لشركة الكهرباء الوطنية وبقدرة (2×63 م.ف.أ)، حيث تتغذى الأحمال الكهربائية لمحطات آبار الديسي بفولتية 33 ك.ف من خلال أربعة مغذيات (33 ك.ف) حلقية، أما فيما يخص محطات الضخ فتتم تغذيتها عن طريق محطة ضخ الديسي (11/33 ك.ف) بقدرة (2×25 م.ف.أ) والتي تتغذى من محطة الديسي الرئيسية بمغذيات (33 ك.ف) عدد (2) .
- بلغ الحمل الأقصى لمحطة الديسي الرئيسية (33/132) ك.ف خلال أشهر عام 2021 (36 م.ف.أ)، منها (7.5 م.ف.أ) فقط أحمال شركة التوزيع والباقي هو أحمال مشروع ضخ الديسي.

وبناءً على طلبكم فقد تم دراسة مايلي:

- تشغيل محطة الضخ الخامسة بحيث تصبح المضخات العاملة بشكل مستمر خمس مضخات بدلًا من أربع مضخات، وبالتالي يصبح حمل محطة ضخ الديسي (11/33) ك.ف (17.4 م.ف.أ) تقريبًا وبنسبة تحميل (68%).
- زيادة عدد الآبار العاملة إلى (65) بئر، بحيث تصبح القدرة الإجمالية لجميع الآبار (19.5 م.ف.أ).

وعليه تصبح القدرة الإجمالية لمشروع ضخ مياة الديسي (37 م.ف.أ)، مما يبين وجود الإمكانية الفنية لتغذية الأحمال الكهربائية الجديدة لمشروع ضخ مياه الديسي كم هو موضح في كتابكم.

وأقبلوا الاحترام،،،

المدير العام

م. ريـم حمـدان

FQp18-02

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DAOM-HQ-EDCO-0248-22
Electricity Distribution Company
The Managing Director of EDCO

Amman March 20th, 2022

Subject: DISI Project Enhancement Capacity

For the attention of The Managing Director of Electricity Distribution Company,

Dear Sir,

Kindly be informed that the DISI Water Company is studying the possibility of increasing the pumping quantities of the DISI-Amman Water Pumping Project. The Project capacity enhancement will be implemented through two phases as follows:

1) Increasing the number of the conveyance pumps that are working simultaneously within the DISI-Mudawara Pumping Station and the number of operating wells within the wellfield area. Through this phase, five conveyance pumps will run continuously with an approximate power consumption of 17 MW/h. At this stage of operation, 55 production wells will run continuously with an approximate power consumption of 300 kW/h per well,

2) The second phase includes the continuous operation of five pumps in the Disi-Mudawara pumping station with an expected power consumption of 17 MW/h. At this stage of operation, an additional 10 wells will come into operation (total of 65 wells will run simultaneously) with an approximate power consumption of 300 kW/h per well.

Based on the abovementioned, we kindly ask you to provide us with the total capacity of the electrical substation responsible for the electrical supply of the production wells and the Disi-Mudawara Pumping Station. We would like EDCO to confirm the stations' ability to cover the expected total load of the DISI-Mudawara Pumping Station and the expected total load within the wellfield area for the two phases indicated above.

Thanking you in advance for your direct attention in this matter, and your continuous cooperation seeking the development and strength of the relationship between the two parties.

Best Regards,

Mustafa Tunç Erk
Executive Director

Cc: Disi Water Company (DIWACO)
Ministry of Water and Irrigation (MWI)

DISI AMMAN OPERATION AND MAINTENANCE
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الموضوع: تحسين كميات الضخ - مشروع جر مياه الديسي

السيد مدير عام شركة توزيع الكهرباء الاردنية المحترم،

تحيه طيبة وبعد،

في البداية نود ان نشكركم على التعاون المستمر من اجل التطوير الدائم وتعزيز العلاقات بين الطرفين.

يرجى العلم بان شركة مياه الديسي تقوم بدراسة إمكانية زيادة كميات الضخ لمشروع جر مياه الديسي المدورة - عمان ضمن مرحلتين من خلال زيادة عدد المضخات العاملة اللحظية ضمن محطة ضخ الديسي – المدورة وعدد الآبار العاملة ضمن منطقة آبار الديسي المدورة كما يلي:

١) تتضمن المرحلة الأولى تشغيل خمس مضخات بشكل مستمر بقدرة تقريبية تصل الى (١٧ ميغا واط / ساعة) ضمن محطة ضخ الديسي المدورة بالإضافة الى زيادة عدد الآبار العاملة الى (٥٥) بقدرة تقريبية تصل الى (٣٠٠ كيلو واط/ ساعة) للبئر الواحد.

٢) وتشمل المرحلة الثانية الاستمرار بتشغيل خمس مضخات ضمن محطة ضخ الديسي - المدورة بشكل مستمر وتشغيل عشر آبار اضافيه جديدة بقدرة تقريبية تصل الى (٣٠٠ كيلو واط / ساعة) للبئر الواحد بحيث يكون العدد الإجمالي للآبار العامله خمسة ووستون بئر (٦٥).

بناءا على ما تقدم نرجو تزويدنا بالقدرة الكلية للمحطات الكهربائية المسؤولة عن التزويد الكهربائي لمجموعة آبار مشروع الديسي ومحطة ضخ الديسي-المدورة بالإضافة للتأكيد على قدرة المحطات على استيعاب الحمل الكلي المتوقع لمحطة ضخ الديسي-المدورة والحمل الكلي المتوقع ضمن منطقة الآبار للمرحلتين والمشار الية أعلاه.

مع اطيب التمنيات.

المدير التنفيذي
مصطفى تونش ارك

Annex 3: Final ToR and Scoping Session Report

Environmental & Social Impact Assessment (ESIA) for Drilling New Wells and Associated Infrastructure Works – DUBAYDIB Well Field / Disi

Final Terms of Reference (ToR)

January 2025

Document Title: Final Terms of Reference (ToR) Report

Project: ESIA for Drilling New Wells and Associated Infrastructure Works – DUBAYDIB Well Field / Disi

Code: AW146.00

Client: DIWACO

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Weam Mahdawi	All Sections	

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01	12/01/2024	Final Terms of Reference	WD	WD	GJ

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List of Abbreviations

amsl	Above Mean Sea Level
DIWACO	Disi Water Company
DAOM	DISI Amman Operation & Maintenance
DoA	Department of Antiquities
DP	Drilled Priority
ESIA	Environmental and Social Impact Assessment
EIB	European Investment Bank
ESSs	Environmental and Social Standards
ESMP	Environmental and Social Management Plan
EHS	Environmental, Health, and Safety
EPSG	European Petroleum Survey Group
GOJ	The Government of Jordan
GIF	Global Infrastructure Fund
IFC	International Finance Corporation
ILO	International Labor Organization
JSMO	Jordan Institution for Standards and Metrology
MoEnv	Ministry of Environment
MCM	Million Cubic Meters
MWI	Ministry of Water and Irrigation
MoPIC	Ministry of Planning and International Cooperation
MoH	Ministry of Health
MoL	Ministry of Labor
MoLA	Ministry of Local Administration
MoTA	Ministry of Tourism and Antiquities
NGO	Non-Governmental Organization
US DFC	United States International Development Finance Corporation
RSCN	Royal Society for the Conservation of Nature
ToR	Term of References
TNB	Tenaga Nasional Berhad
WAJ	Water Authority of Jordan
WGS84	World Geodetic System 1984

1 INTRODUCTION

1.1 Overview of the Project

The Disi Mudawarra to Amman water conveyance system is supplying potable water to the Greater Amman Area from the Disi aquifer in the south of Jordan. Water is abstracted from the 'fossil' aquifer and carried approximately 325km to Amman via a pipeline. The system is conveying an annual flow of 100 million cubic meters (MCM); 40MCM to a new tank in Abu Alanda and 60MCM to an existing tank in Dabuk.

Five emergency turnouts from the conveyance pipeline are suggested to supply demand centers along the conveyance route (Ma'an, Tafila, Karak, and Madaba city and Madaba bridge pump station), following the construction of the infrastructure, these turnouts can only be used temporarily and in an emergency situation when the demand center in question cannot be supplied with enough water supply from the current source.

The project is considered as part of the Government of Jordan's (GOJ's) larger regional framework of water management and development of new resources. The project started operation in 2014 and it comprises of 55 production wells (46 operational and 9 standbys). Recently the Disi project activated 4 of the standby wells to be 50 abstraction wells and 5 standby wells, and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM and since 2024, production has been increased to 115 MCM. Water is collected from each of the wells via a 'dendritic' collector network and delivered to a collector tank north of the well field by a main spinal collector.

An Environmental and Social Impact Assessment (ESIA) for the project was completed in 2004 by Consolidated Consultants Group. In 2007 Dar Al-Handasah Consultants were assigned by GAMA Enerji A.S. to conduct a review of project ESIA to determine:

- If the changes to the project design since 2004 were sufficient to invalidate all or part of the ESIA
- If there were any changes to the national framework since 2004 that would necessitate revision of all or part of the ESIA.

As a result of the ESIA review, an Addendum to the ESIA was submitted and approved in 2008 by the MWI and Ministry of Environment (MoEnv).

Recently, Disi Water Company (DIWACO) plans to increase the annual output of the wellfield to 120 MCM/year, which will require the construction of additional production wells. Twelve (12) new well locations have been identified and confirmed within the Dubaydib wellfield.

These locations result from the most appropriate trade-off between geoscientific criteria and stakeholders' requirements. Out of the 12 proposed well locations, two require clearance from the MWI due to their positions outside the current Land Lease Agreement, with one situated at the border of a designated 'no-drill' zone. DIWACO is not planning to utilize the two uncleared locations until the other 10 wells are either fully operational or abandoned. DIWACO will start soon working with the consultant for the network design to use several locations out of 12 proposed. Ultimate plan of DIWACO is to drill wells for holding redundancy at the level of 3-4 wells at any point in time. The following section represents the project's main components:

- Drilling new groundwater wells.

- Constructing the relevant infrastructure to collect and transfer water to the existing wellfield collector tank.
- Establish the internal road network to connect the new wells with the existing parts of the project in the Mudawarra area.
- Expansion of the overhead power line system to connect the new wells.

Thus, in compliance with the Jordanian Environmental Classification and Licensing Regulation Number (No.) 69 for the year 2020 and its amendment, MWI/WAJ has submitted letter No.12306/2/7 on 22/6/2023 to MoEnv requesting the classification and the requirements to implement the additional project activities (the new wells). The MoEnv confirmed its need for ESIA prior to the drilling of new wells and classified the project as Category 1, requiring a comprehensive ESIA. The MoEnv classification letter No.6116/7/4 dated August 31st, 2023, is attached in **Appendix 1.**

As part of the project scope, AJi for Water and Environment has been requested to conduct a comprehensive ESIA for the new project phase. Accordingly, this project's Final Term of Reference (ToR) is prepared as an initial requirement of the Ministry of Environment and the lenders (European Investment bank (EIB), United States International Development Finance Corporation (US DFC) and Proparco (France)), and Lenders' Independent Engineer environmental approvals.

1.2 Objective of this Report

The Jordanian Environmental Protection Law has introduced a system of an environmental "pre-emptive" assessment of all economic and developmental projects to be established in Jordan. This process is known as the Environmental and Social Impact Assessment (ESIA) where any development or economic project should carry out a detailed assessment of the potential environmental impacts arising from the implementation of the project, and how to address these impacts through remedial action at the technical, legislative, and public level. According to the Environmental Protection Law, the ESIA study should be done before the project is initiated and submitted to the MoEnv for review and approval. The Environmental Classification and Licensing Regulation No. 69 of the year 2020 and its amendments, classify projects into four categories according to their expected environmental impacts:

- **Class 1:** Projects of high risk that require a comprehensive environmental impact assessment.
- **Class 2:** Projects of medium risk and potential damage that require an initial environmental impact assessment.
- **Class 3:** Projects of low risk that require environmental approval.
- **Class 4:** Projects of low risk that don't need to apply for environmental approval or any other permits.

In accordance with MoEnv's requirements, the ESIA assignment will consist of the following phases:

- Prepare project description and submit it to the MoEnv for the project classification.
- Prepare a preliminary ToR.
- Conduct and document scoping session with stakeholders.
- Submit final ToR following input from MoEnv along with a scoping statement. (This Report)
- Perform ESIA study and prepare ESIA report – including the Environmental and Social Management Plan (ESMP).
- Finalize and submit the ESIA study following input from stakeholders.

The ESIA approval is required to obtain the proper license and to start implementation of the proposed new wells while adhering to the environmental and social mitigation and management plan specified and approved in the study. Any deviation from those guidelines would lead to the project to violation of laws and regulations.
This final ToR is prepared to provide the necessary information to the parties, institutions, and individuals related to the project and to document the consultative work for the ESIA study of the project. This final ToR outlines the requirements of conducting a comprehensive ESIA and requirements for environmental approvals in accordance with the Jordanian Environmental Classification and Licensing Regulation No. 69 of the year 2020 and its amendment No.97 issued by the Jordanian MoEnv.

The ESIA study will be conducted by AJi Water & Environment based on MoEnv's decision on the final ToR which is now submitted after conducting the scoping session and documenting its outcomes. The study will be conducted in accordance with the national Jordanian requirements and in line with the International Finance Corporation (IFC) and lenders requirements and guidelines.

1.3 Project Description and Background

1.3.1 General Overview & Project's Justification

The Disi Water Company (DIWACO) is contracted to MWI/WAJ, and subcontracted the operation of the Dubaydib wellfield to Disi Amman Operation and Maintenance (DAOM). The principal objective of this project is to facilitate the resolution of the water supply problem experienced at Amman, the capital city of Jordan, and the surrounding area. Thus, increasing the supplied water to Amman and accordingly improving public health conditions.

As per the existing project agreement terms, DIWACO is required to deliver up to 100 MCM of water per year to Abu Alanda and Dabuk in Amman from the Dubaydib well field.

However, MWI asked DIWACO to raise the water delivery quantities to 120 MCM for the longer term (2025 onwards) due to the high demand, particularly in the summer. After conducting an infrastructure evaluation, DIWACO verified that the project could accommodate the addition of new wells to meet the quantity need of 120 MCM/year.

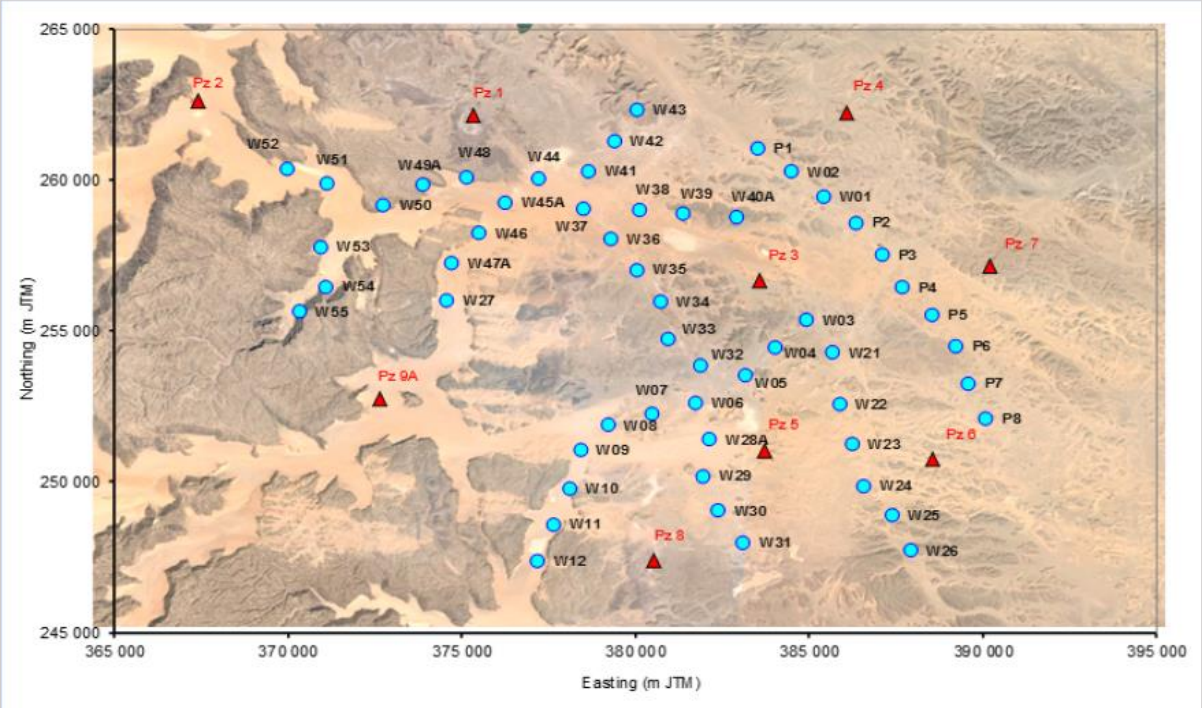
To reliably meet the increased water quantity requested by MWI/WAJ (up to a total of 120 MCM/yr) , DIWACO is planning to conduct additional activities described in the following subsection. These additional activities are herein referred to as "The Proposed wells "which will be covered in the ESIA.

1.3.2 Project Description

1.3.2.1 Existing Disi–Amman Project

The existing Disi-Amman System involves 55 production wells (46 abstraction wells and 9 standby wells) to abstract water from the fossil aquifer in southern Jordan. (Wells map is presented in **Figure 1**). In addition, the project includes 9 piezometer wells and operational facilities including water tanks and pump stations conveying the water for a distance of approximately 325 km to supply 100 MCM per year of water to Amman. The water is received at two tanks, at Dabuk and Abu Alanda in western and eastern Amman respectively. Recently the Disi project activated 4 of the standby wells to be 50

abstraction wells and 5 standby wells, and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM.
Disi is a fossil aquifer extending from the southern edge of the Dead Sea in Jordan to Tabuk in northwest Saudi Arabia. Significant exploitation of the Jordanian part of the aquifer started in 1980.

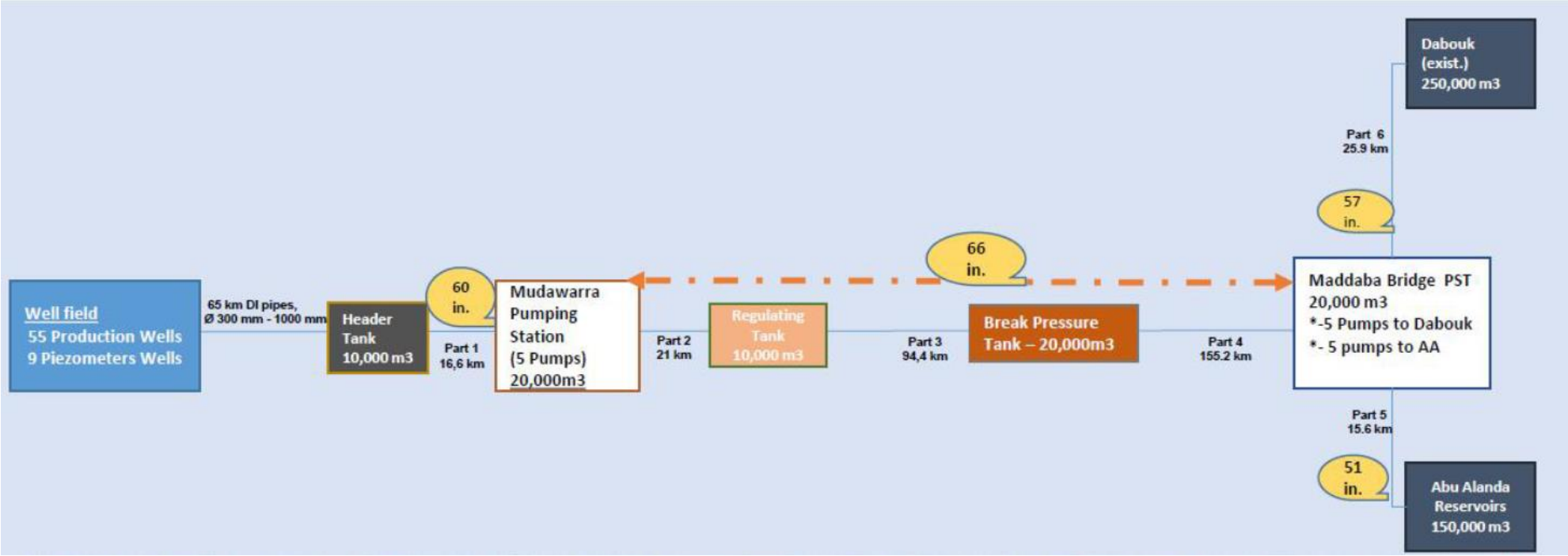


Source: DIWACO

Figure 1: Well-field Map

The Major existing components of the Disi-Amman Project include the following:

- Well field consisting of 46 abstraction wells and 9 standby wells. (Recently the Disi project activated 4 of the standby wells to be 50 abstraction wells and 5 standby wells), and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM.
- Well field collection network
- Main pipeline
- Break pressure and regulating tanks
- Two Pumping stations
- Tanks (Abu Alanda and Dabouk tanks)
- Associated ancillary buildings
- Power supply and communications infrastructure
- Access and Service Roads



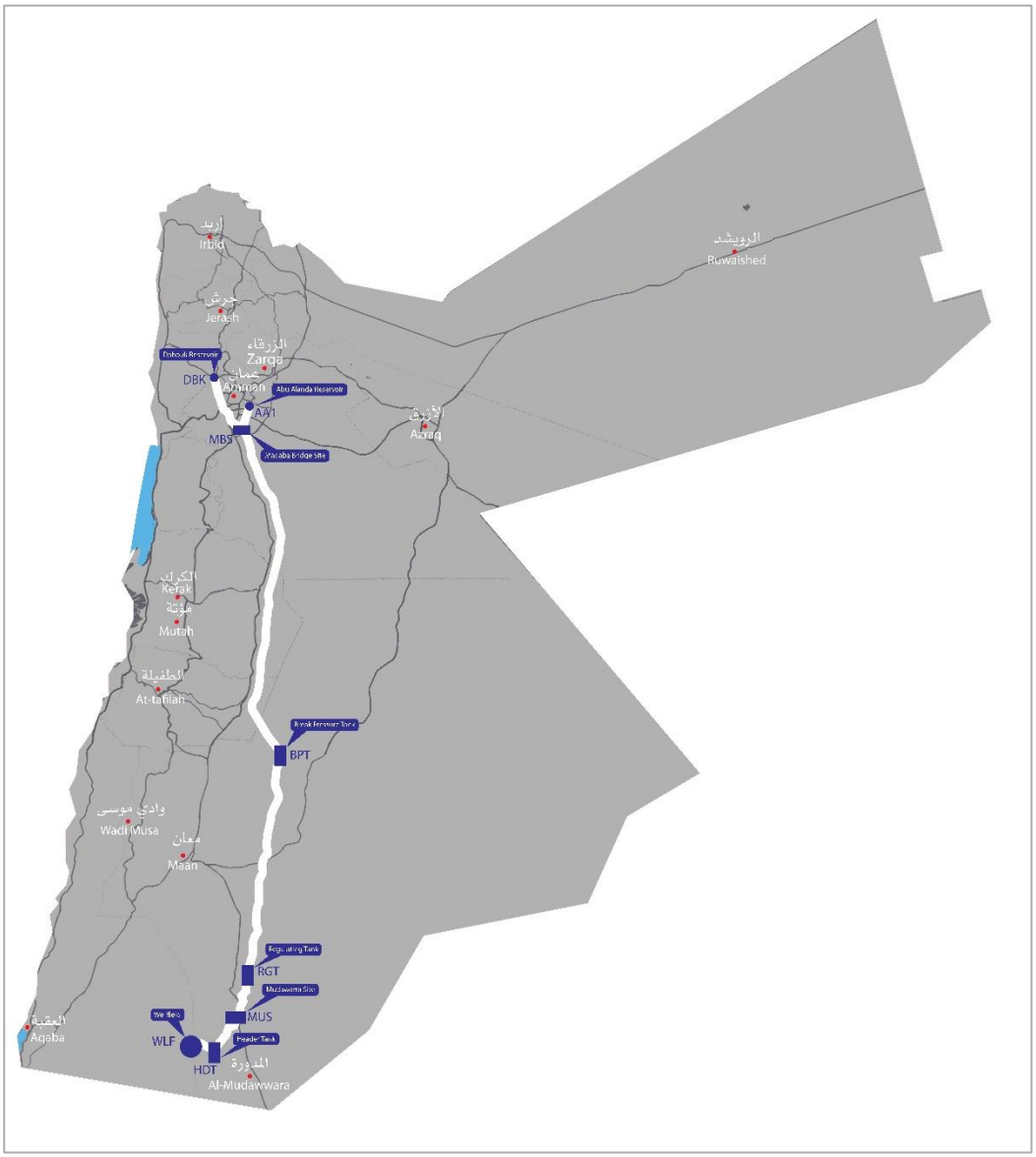
Source: DIWACO

Figure 2: Layout for the major components of the Disi–Amman Project

The Existing Project Location

The project area is the area between the Disi wellfields and Greater Amman and passes through Governorates of Greater Amman, Madaba, Karak, Tafileh, Ma'an, and Aqaba.

Figure 3 shows the constructed alignment of the conveyor to Amman.



Source: DIWACO

Figure 3: Constructed alignment of the Disi-Mudawarra to Amman water conveyance system

1.3.2.2 The Proposed wells

The Dubaydib wellfield, has been producing about 97 to 100 MCM/year. It comprises 55 production wells (initially started with 46 wells in operation and 9 standby wells, recently the Disi project activated 4 of the standby wells to be 50 abstraction wells and 5 standby wells), and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM in 2023 and since 2024, production increased to 115 MCM). The wells have a total depth ranging from 394 to 600 m.

The production target for each new production well has an average of 70 L/s, with a maximum of 80 L/s, with the aim of increasing the current wellfield production up to about 120 MCM/year. Thus, new

additional production wells are required. The identification of the most suitable location and design for these wells have been identified based on the Bureau de Recherches Géologiques et Minières (BRGM) report, published in 2023 [1]

Project components:

The proposed project includes the following activities which will be covered in the ESIA:

- Drilling new groundwater wells (will involve drilling of the well shafts, installation of well casing, screens and pump head).
- Drilling activities are tentatively scheduled to commence in October 2025, and continue through July 2026 for the completion of the first three additional wells (Contingent upon financial security conditions, the approval of study results by all relevant parties, and the GoJ approval of the ESIA). Additional wells will be drilled as required to ensure the continuous availability of three redundant wells at all times. Constructing the relevant infrastructure including wellheads, compounds, pipelines and electricity networks to collect and transfer water to the existing collection tank.
- Extend the internal road network to connect the new wells with the existing parts of the project.
- Expansion of the overhead power line system to connect the new wells.

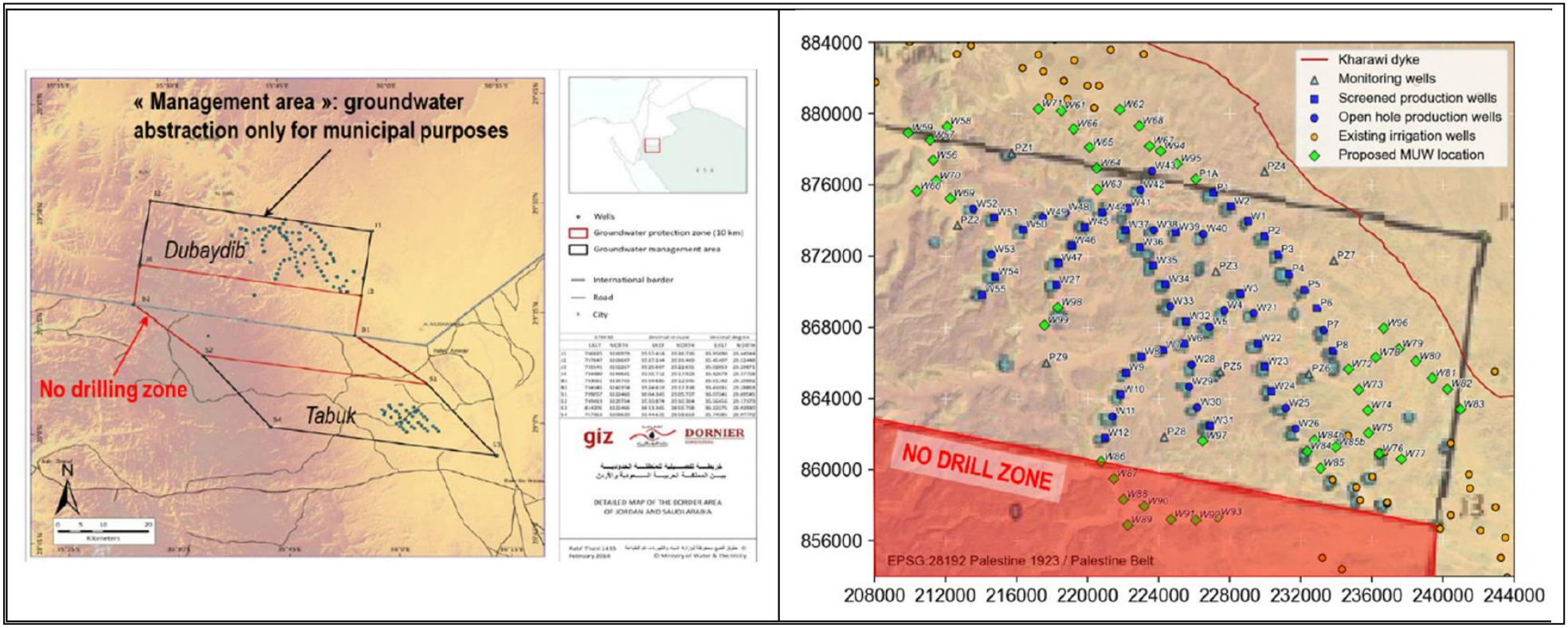
Jordan/KSA agreement for managing of the Disi/Saq groundwater

In 2015, Jordan and Saudi Arabia signed an "Agreement for the Management and Utilization of the Groundwater in the Disi-Saq aquifer" (Disi Agreement, 2015). Amongst several articles, this agreement includes the definition of a "Management area", where groundwater abstractions should be dedicated for municipal purposes only, and a "No drill zone" area, where drilling for groundwater abstractions should be prohibited.

The no-drill zone (**Figure 4**) encompasses the south-western area of the Dubaydib wellfield, thus preventing to consider any new production wells in this area.

Appendix 2 illustrates the agreement between the Government of Jordan and the government of Saudi Arabia in order to manage and investing groundwater in the Al-Saq layer Disi. **Appendix 3** illustrates the agreement map while **Appendix 4** and **Appendix 5**, present the official signed approval of Jordan and Saudi Arabia for this agreement. respectively.

[1] Additional production well targeting and well design for the Dubaydib wellfield -Jordan, BRGM Final Report, June 2023



Source: BRGM Final Report 2023 [1]

Figure 4: "No drill zone" defined in the 2015 Jordan-KSA agreement and close-up view of the Dubaydib wellfield

Criteria and Selection of Wells Locations

The identification of the most suitable location of the new wells has been studied and identified in 2023 by BRGM[2] based on the topography and a mean distance between wells of 1,250 m as illustrated in the following three stages.

First Stage:

In the first phase, all available geoscientific data from the Dubaydib wellfield have been reviewed to build a robust conceptual model of the groundwater tank. The information included well reports, geological and geophysical logs, production data to date, groundwater levels in production and observation wells, historical consultancy reports, and site-specific constraints. Following this analysis, eleven (11) criteria of relevance for well-siting have been retained, corresponding to five (5) main risks including groundwater quantity, groundwater quality, well completion, pipeline costs, and external factor related to a specific agreement between Jordan and Saudi Arabia, which prohibits drilling in the southern edge of the wellfield). Each new well location was given a rating with respect to each criteria.

Second Stage:

In the second stage, a total rating of all the criteria was calculated for each well, as the weighted sum of each criteria. This weighted approach indicates a risk management perspective and whether stakeholders are more or less comfortable with a specific risk.

Third Stage:

In the third stage, a collective workshop was held in Amman with the Dubaydib wellfield's main stakeholders. Twelve locations were decided upon, to be further assessed in the field. Locations were confirmed and/or appropriately adjusted during the field visit (June 2023).

Proposed Wells Locations

The new well locations have been identified and confirmed within the Dubaydib wellfield. These locations result in the most appropriate trade-off between geoscientific criteria and requirements of the stakeholders. **Table 1** presents the coordinates of the new wells and the drilling priority which proposes drilling the first nine wells, while **Figure 5** illustrates the wells' locations.

[2] Additional production well targeting and well design for the Dubaydib wellfield -Jordan, BRGM Final Report, June 2023

Table 1: Locations of The New Wells and Recommended Drilled Priority (DP)

Recommended DP	Original Wells Name	Wells Name	GPS Elevation (m amsl)*	Coordinates in decimal World Geodetic System 1984 (WGS84) system (European Petroleum Survey Group (EPSG) 4326)	
				X	Y
1	W97 GT	$W_{DP\ 1}$	892.13	29.339564	35.790387
2	W63 GT	$W_{DP\ 2}$	861.82	29.467421	35.732639
3	W84b GT	$W_{DP\ 3}$	808.59	29.340959	35.855645
4	W72 GT	$W_{DP\ 4}$	816.83	29.376162	35.870822
5	W94 GT	$W_{DP\ 5}$	848.43	29.486488	35.768032
6	W64 GT	$W_{DP\ 6}$	864.83	29.479227	35.73164
7	P1A GT	$W_{DP\ 7}$	867.24	29.472573	35.787571
8	W86 GT	$W_{DP\ 8}$	905.22	29.333002	35.736758
9	W98 GT	$W_{DP\ 9}$	930.99	29.408731	35.707753
10	W69 GT	W_{DP10}	867.29	29.46167	35.643365
11	W95 GT	W_{DP11}	854.62	29.48011	35.776918
12	W65 GT	W_{DP12}	869.07	29.487706	35.727821

Source: BRGM Final Report 2023 [1]

*asml: Above mean sea level

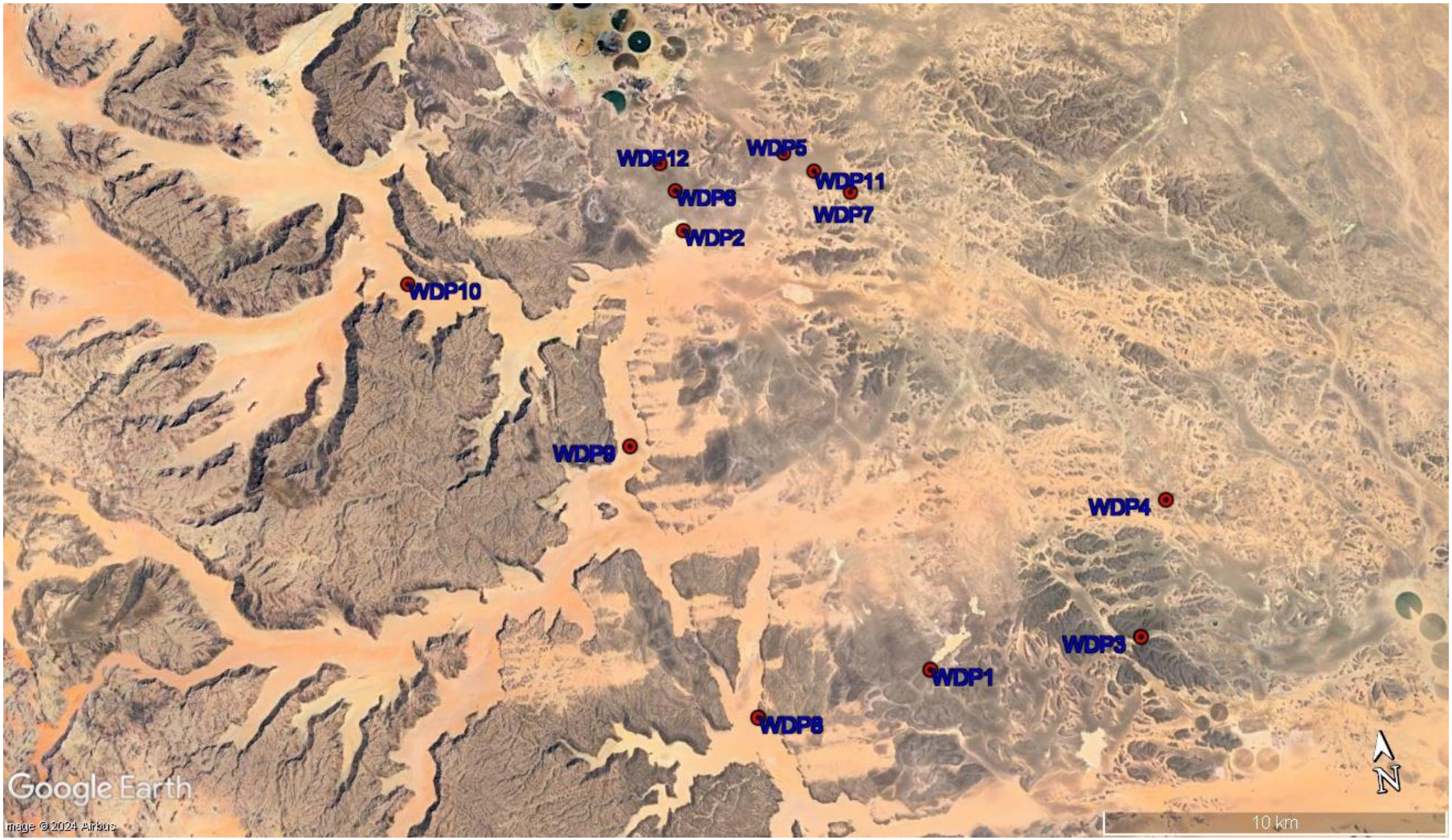


Figure 5: Map of the new drilling well's locations

Construction of the new wells will involve drilling of the well shafts, installation of well casing, screens and pump head with all necessary valves, pipes and instruments). In addition to wellhead components (including mechanical works, electrical and control rooms, transformers, lifting equipment and fence). Associated service road and electricity company connection are also included.

Appendix 6 illustrates the wellhead general layout plan.

Project's Area of Influence

The Project is situated in the Disi-Mudawarra area south of Jordan, near the border with Saudi Arabia. It is part of the larger Disi aquifer, a significant source of ancient, non-renewable fossil groundwater. This region has gained prominence due to its strategic water resources, especially in a country like Jordan, which faces chronic water scarcity. The area experiences an extremely dry, desert climate, with hot summers and mild winters. The waters of the Disi Basin are hydrologically non-renewable waters with an average age of 10-30 thousand years. The Tabuk-Mudawara-Disi region extends from the Tabuk Plain in Saudi Arabia to the Wadi Rum Desert in Jordan, between the Disi, Mudawara and Al-Jafer regions.

Figure 5 below illustrates the wellfield boundary, along with 1 km and 5 km buffer zones. The map indicates that the nearest communities are located more than 5 km from the project boundary. Additionally, it shows two farms situated within the 1 to 5 km buffer zone, and the Rum Protected Area is approximately 14 km away from the wellfield boundary.

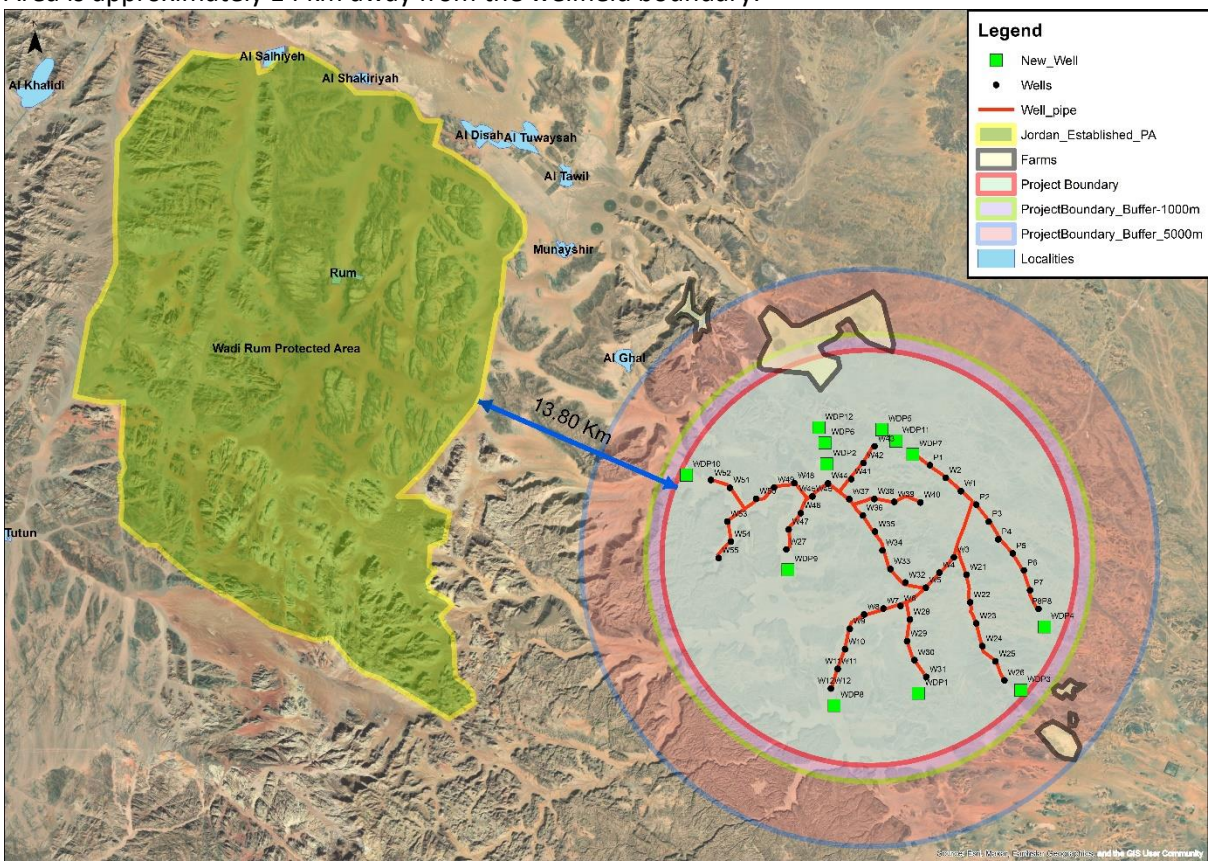


Figure 6: Map of the Project's Area of Influence

Key Stakeholders Relevant to the Study:

- **Owner**: Government of Jordan (GoJ) represented by the MWI/WAJ,
- **Other governmental stakeholders**: relevant ministries.
- **DIWACO**: Disi water company, the owner of the project facilities during the concession period of 25 years since the commercial operation date January 27th, 2014 under the BOT contract signed with MWI/WAJ.
- **Technical Expertise**: Owner's Engineer (OE) will be appointed by DIWACO and will seek technical advice from external experts.
- **Lender (Investor):** EIB, US DFC and Proparco.
- **Environmental and Social Impact Assessment Study Consultant:** AJi Water and Environmental will prepare the comprehensive ESIA.
- **Beneficiaries**: Amman City which will utilize the Disi water for domestic needs, the cities along the Disi conveyor rout will be provided with emergency turn out.
- **The Operator:** DISI Amman Operation and Maintenance (DAOM) is responsible for operating and maintaining the entire Disi Conveyance System starting from the well field in the south of Jordan all the way up to the Greater Amman Area.

The ESIA will cover the following phases:

- The construction phase which includes drilling the new groundwater wells, connection to the existing pipeline network and/or new network, electricity network, and the service roads within the wellfield area.
- The operation phase for the different newly constructed facilities throughout the project.
- The decommissioning phase of the project.

2 LEGAL AND REGULATORY FRAMEWORK

This section provides an overview of the national legal and regulatory considerations applicable to the proposed project, including relevant international conventions and treaties of which Jordan is a party of or a signatory. Also, IFC and lenders requirements will be considered in addition to these national requirements.

2.1 National Laws and Guidelines

2.1.1 Laws

- Environment Protection Law No. 6 of 2017
- Protection of Cultural Heritage and Sites Law No. 5 of 2005
- Roads Law No. 24 of 1986 and its amendments
- Transportation Law No. 89 of 2003 and its amendments
- Waste Management Framework Law No. 16 of 2020
- Local Administration Law No. 22 of 2021
- Water Authority Law No. 62 of 2001 and its amendments (Law No. 22 of 2014)
- Agricultural Law No. 13 of 2015 and its amendments
- Public Health Law No. 47 of 2008 and its amendments (Law No. 11 of 2017)
- Renewable Energy and Energy Efficiency Law No. 13 for 2012 and its amendment Law No. 33, of 2014, and Law No. 12 of 2024 amending the Renewable Energy and Energy Efficiency Law
- Traffic Law No. 49 of 2008 and its amendments of 2020
- Labor Law No. 8 of 1996 and its amendments of 2019
- Civil Defense Law No. (90) of 2003; read with Law No. (18) of 1999
- Cultural Heritage & Antiquities Law No. (21) of 1988 and its Amendment Law No. (55) of 2008
- Professional Licensing Law No. 28 of 1999 and its amendments
- Monitoring and Control of Economic Activities Law No. 33 of 2017
- Industry and Trade Law No. 18 of 1998
- Temporary General Electricity Law No.64 of 2002 and its amendments
- Management of Natural Resources Law No. 19 of 2018
- Industry & handicraft law No. 16 of 1953
- Municipalities Law, No. 14 of 2017
- Anti-human trafficking Law No. (9) of 2009
- Land Transport Regulatory Authority Law (2011)

2.1.2 Regulations

- Regulation of the Environmental Classification and Licensing No. 69 of 2020 and its amendments.
- Regulation of the Joint Services Councils No. 113 of 2016
- Regulation of the Protection of the Environment from Pollution in Emergency Situations No. 26 of 2005
- Regulation of Soil Protection No. 25 of 2005
- Regulation of Natural Reserves and National Parks No. 29 of 2005
- Regulation of Air Protection No. 28 of 2005
- Regulation of Groundwater Monitoring No. 64 of 2002, read in conjunction with regulation No. 85 of 2002.
- Regulation of Hazardous Materials and Waste Management[3] No. 68 of 2020
- Regulation of Solid Waste Management No. 27 of 2005
- Regulation of Land Use Planning No. 6 of 2007
- Regulation of Hazard Prevention, Charges, and Waste Collection Fees within Municipalities Areas No. 68 of 2016
- Regulation of Protection and Safety from Industrial Tools and Machines and Worksites No. 43 of 1998[4]
- Regulation for the Establishment of Occupational Health and Safety Committees and Supervisors in Institutions No. 33 of 2023[5].
- Regulation for Occupational Safety & Health and Prevention of Occupational Hazards in Institutions No. (31) of 2023[6]
- Bird Protection and Hunting Regulation No. (13) of 1973 and all amendments
- Regulation for the licensing and permitting of excavation and infrastructure network projects No. 112 of 2007
- Regulation of Environmental Protection No. 37 of 2018.
- Regulation of 2013 on the instructions of the use, import, and export of ozone depleting substances.
- Regulation of Harmful and Hazardous Substances Management No. 24 of 2005

[3] issued in accordance with Articles 6 and 7 of Environmental Protection Law No. 6 of 2017

[4] Issued by the virtue of the provisions of Paragraph (c) of Article (85) of the Labor Law No. 8 of 1996 and its amendments

[5] Issued in accordance with Paragraph (a)Article (85) of the Jordanian Labor Law No. 8 of 1996 and its amendments

[6] Issued in accordance with Paragraph (b)Article (85) of the Jordanian Labor Law No. 8 of 1996 and its amendments

- Regulation No. (85) of 2020.of Environmental Information and Control System for Waste Management
- Regulation of Climate Change No.79 of 2019 issued pursuant to Article 30 of the Environmental Protection Law No.6 of 2017.

2.1.3 Instructions

- Instruction for the Limitation and Control of Noise of 2003
- Instructions for the Management and Handling of Hazardous Waste of 2019
- Spent Mineral Oils Management and Handling Instructions of 2014 and its amendments Instruction No. 1 of 2013 for the preventing of occupational hazards related to health hazards resulting from labor housing units onsite, issued in accordance with article (49) of the Public Health Law No. 47of 2008
- Instructions for the General Health Conditions for Industries of 2019
- Instructions for Solid Waste Management of 2019
- Instruction for Controlling the Use of Substances that Deplete the Ozone Layer for the year 2003, issued in accordance with the Protection of the Environment Law No. 1 / 2003, Articles 9 through15
- Instructions for birds and wildlife protection and organizing their hunting and trafficking of 2021.
- Instructions for Disposal of Industrial and Commercial wastewater into the sewage network of 2017
- Instructions for the Selection of locations for Development Activities for 2007 issued in accordance with paragraph (d) of Article (4) of the Environmental Protection Law no. 52 of 2006.
- Instructions on the Prevention of Health Nuisances related to Health Hazards resulting from Housing Units of Labor Groups No. (1) of 2013
- Instructions of Protection of Workers from Workplace Hazards of 1998
- Instructions for the Protection of Water Resources for the Year 2011 and its Amendments for the Year 2019.

2.1.4 Guidelines and Policies

- Guidelines for the protection of migratory birds from the danger of electric shock
- Policy of the National Climate Change of the Hashemite Kingdom of Jordan (2022-2050).

2.1.5 Standards

- Standard for Ambient Air Quality No. 1140/2006
- Standards for the Maximum Allowable Limits of Air Pollutants Emitted from Stationary Sources No. JS 1189/2011
- Standards for Lighting — Lighting levels in work environment No. JS 524/1987
- Standards for Motor Vehicles — Emission - Diesel Engines No. JS 1054/1998
- Standards for Reclaimed Domestic Wastewater No. JS 893/2021

- Standards for Drinking Water No. JS 286/2015
- Standards for Storage – General precautionary requirements for storage of hazardous materials No. JS 431/1985
- Standards for Motor Emissions No. JS 1052/1998
- Standards for Motor Vehicles (Noise Levels) No. JS 1059/1998
- Standard for heat levels allowed to be exposed to in the work environment No. JS 525/1987
- Ergonomics of the thermal environment - Analytical determination and interpretation of heat stress using calculation of the predicted heat strain No. JS 2310 / 2021.
- Ergonomics of the thermal environment — Analytical determination and interpretation of heat stress using calculation of the predicted heat strain (ISO 7933/2004)

2.1.6 International Treaties and Conventions of Which Jordan is a Party/Signatory

- Basel Convention of Transboundary Movements of Hazardous Wastes and Their Disposal — 1989. Designed to reduce the movement of hazardous waste between countries and specifically to prevent the transfer of hazardous waste from developed to undeveloped countries. Jordan signed on this convention in 1989, but it went into effect in 1992.
- Convention on Biological Diversity — 1992. The convention was dedicated to promote sustainable development. It recognizes that biological diversity is about more than plants, animals, and microorganisms and their ecosystems — it is also about people and their need for food security, medicine, fresh air, water, shelter, and a clean and healthy environment in which to live. Jordan signed this convention in 1992 and it became a party in 1994.
- Convention on the Conservation of Migratory Species of Wild Animals, Bonn Convention — 2000. The convention is aimed at protecting migratory species, their habitats, and migration routes.
- The United Nation Framework Convention on Climate Change — 1994. It is an international environmental treaty that aims to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.
- United Nations Convention to Combat Desertification — 1994. The convention aims to combat desertification and mitigate the effects of drought through national action programs that incorporate long-term strategies supported by international cooperation and partnership arrangements.
- Convention Concerning the Protection of the World Cultural and Natural Heritage (December 17, 1975);
- Convention on Wetlands of International Importance especially as Waterfowl Habitat (May 10, 1977);
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (March 14, 1979);
- Protocol to amend the Convention on Wetlands of International Importance, especially as Waterfowl Habitat (RAMSAR Convention) (October 1, 1986);
- Amendment to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (art. XI) (April 13, 1987);

- Protocol on Substances that Deplete the Ozone Layer (August 30, 1989);
- Convention for the Protection of the Ozone Layer (August 31, 1989);
- Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer (September 28, 1995);
- International Plant Protection Convention (April 24, 1970);
- International Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (December 26, 1996);
- International Labor Organization (ILO) Conventions, Jordan has ratified 26 ILO Conventions, which will clearly be presented in the Labor Management Plan (LMP) as a part of the ESIA preparation.

2.1.7 Lender's Requirement

In addition to the national requirements, the ESIA study will be conducted in line with:

- The Performance Standards (PSs) of IFC's Sustainability Framework (2012)[7]: The IFC of the World Bank Group has established its Performance Standards on Environmental and Social Sustainability (2012) building on the World Bank Environmental and Social Policies. IFC's Sustainability Framework is represented by the following eight PSs that the client [8] is to meet throughout the life of an investment by IFC:
  - Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
  - Performance Standard 2: Labor and Working Conditions
  - Performance Standard 3: Resource Efficiency and Pollution Prevention
  - Performance Standard 4: Community Health, Safety, and Security
  - Performance Standard 5: Land Acquisition and Involuntary Resettlement
  - Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
  - Performance Standard 7: Indigenous Peoples
  - Performance Standard 8: Cultural Heritage

- The EIB Statement of Environmental and Social Standards of February 2, 2022[9]. The EIB Group Environmental and Social Sustainability Framework is an overarching policy framework that allows EIB to focus on sustainable and inclusive development, committing to a just and fair transition and supporting the transition to economies and communities that are climate and disaster resilient, low carbon, environmentally sound, and more resource-efficient.

  It consists of an Environmental and Social Policy and a revised set of EIB Environmental and Social Standards (ESSs) which describe the requirements that all EIB-financed projects must meet. The standards are grouped in the following 11 thematic areas:

  - Standard 1: Environmental and Social Impacts and Risks
  - Standard 2: Stakeholder Engagement

[7] Performance Standards of IFC's Sustainability Framework (2012)
[8] Refers to the party responsible for implementing and operating the project that is being financed, or the recipient of the financing, depending on the project structure and type of financing
[9] The EIB Statement of Environmental and Social Standards of February 2, 2022

- Standard 3: Resource Efficiency and Pollution Prevention
- Standard 4: Biodiversity and Ecosystems
- Standard 5: Climate Change
- Standard 6: Involuntary resettlement with relevance to this project, ESS 6 is irrelevant
- Standard 7: Vulnerable Groups, Indigenous Peoples and Gender
- Standard 8: Labor Rights
- Standard 9: Health, Safety, and Security
- Standard 10: Cultural Heritage
- Standard 11: Intermediated Finance With relevance to this project, ESS 11 is irrelevant

- The applicable World Bank Group Environmental, Health, and Safety (EHS) guidelines are General EHS Guidelines dated April 30, 2007 [10].
- The EHS Guidelines for Water and Sanitation dated December 10, 2007[11]

[10] The applicable World Bank Group Environmental, Health, and Safety (EHS) guidelines
[11] https://www.ifc.org/content/dam/ifc/doc/2000/2007-water-and-sanitation-ehs-guidelines-en.pdf

3 CONSULTATIVE WORK APPROACH AND METHODOLOGY

3.1 Stakeholders Engagement & Identification

Stakeholders should play a vital role in providing advice to the project management in compliance with local ESIA regulations, IFC, and lenders requirements and guidelines. Stakeholder engagement will be an ongoing process by DIWACO, DAOM, and MWI/WAJ through the reactivation of the Disi Project Advisory Committee (DPAC) to review the local community requests. and ensure transparency with all stakeholders that may be affected by the proposed project or have an influence on the project.

In addition, the AJi team will be engaged with the stakeholder activities during this ESIA as follows:

- Identifying the project stakeholders and all parties affected or related to this project
- Conducting a scoping session and documenting its results in a scoping session report as part of this final ToR.
- Conducting a disclosure session to present the ESIA study findings.

The Environmental Classification and Licensing Regulation No. 69 for the Year 2020 and its amendments No.97 requires that consultation session(s) be conducted with all project's related stakeholders to identify valued environmental and social components that need to be addressed in the ESIA study. The ESIA will assess the significance of the anticipated impacts of the proposed project (activities) on each identified component. The scoping process aims to achieve the following:

- Ensure that inputs of stakeholders as well as experts in the field are not overlooked and are affirmed.
- Ensure coordination with related governmental bodies in compliance with the ESIA procedures.
- Identify stakeholders' concerns and assess these concerns significance. These include concerns raised by related governmental organizations, nongovernmental organizations, civil society organizations, and the identified people affected by the project.
- reviewing the grievance mechanism for both the community and the project labor provided by DIWACO. The grievance mechanism provides the public with a tool enabling alternative and pre-emptive resolution of disputes between them and the project management. This mechanism will lead to a good administration by contributing to the identification of possible improvements to the implementation of the project.
- The stakeholder engagement process will identify the related parties and stakeholders influencing and/or influenced by the project and detail how the project management will communicate, inform, and discuss the substantive issues with all interested and affected parties.

An initial list of stakeholders is identified based on the project location, nature, and its potential social and environmental impacts. Governmental stakeholders include Ministries, Directorates, municipalities, and other agencies, while non-governmental stakeholders include non-governmental organizations (NGOs), businesses, residents, and academic institutions.

Table 2 provides a list of key national and local stakeholders along with their influence on the project.

Table 2: Initial List of Stakeholders

Stakeholder	Stakeholder Details	Description
The Client	Ministry of Water and Irrigation (MWI)/Water Authority of Jordan (WAJ)	The client of this project as it is considered as the official body is responsible for the overall monitoring of the water sector, water supply and wastewater systems, and related projects, planning and management, and the formulation of national water strategies and policies.
	Disi Water Company (Diwaco)	Disi Water Company (Diwaco) is a Jordanian project company owned by Gama Enerji. DIWACO is the owner of the project facilities during the concession period of 25 years since the commercial operation date January 27th, 2014 under the BOT contract signed with MWI/WAJ.
Shareholders	GAMA Energy Water Investment • GAMA Enerji A.Ş: o GAMA Holding (50.5%) o Tenaga Nasional Berhad (TNB) (30%) o International Finance Corporation (IFC) (14.5%) o IFC Global Infrastructure Fund Holding (GIF) (5%)	• GAMA Energy Water Investment Build-Operate-Transfer concession agreement based on 25-year guarantee of purchase. • TNB is the largest electrical infrastructure services company in Malaysia. The main activities of TNB include the entire electric production and supply value chain which consists of "Production", "Transmission" and "Distribution". • IFC improves the lives of people in developing countries by investing in private sector growth. • GIF invests capital in new or developing projects in the energy, transportation, public utilities, telecom and urban infrastructure sectors.
Government	Ministry of Environment (MoEnv)	National body responsible for the protection of the environment through the development of legislation and ensuring it is enforced.

Stakeholder	Stakeholder Details	Description
	Ministry of Planning and International Cooperation (MoPIC)	MoPIC endeavors to promote a culture of excellence, good governance, sustainable development, and improvement in accordance with best practices, and activate its role and its desired goal in development, planning, and international cooperation, so as the interest of the country and the citizen.
	Ministry of Health (MoH)	MoH is the competent authority accountable for the protection of public health in the country. It is also responsible for monitoring the drinking water to ensure its safety and adequacy for human consumption.
	Ministry of Labor (MoL)	MoL is the main entity responsible for labor issues and affairs, regulating the labor market, supervising labor unions, providing vocational training and enhancing labor education, employment of Jordanians and non-Jordanians, etc.
	Ministry of Local Administration (MoLA)	Land uses in Jordan are designated by MoLA, which in turn identifies the projects and activities that are allowed at each location. For this project, this mainly includes issues related to designated land use of the Project site.
	Ministry of Tourism and Antiquities (MoTA) / Department of Antiquities (DoA)	MoTA and DoA are mainly responsible for tourism development and protection of antiquities in Jordan. Their interest in this project is primarily the potential for impacts related to archaeology and cultural heritage at the project area.
	Ministry of Energy and Mineral Resources (MEMR)	The official body is entrusted with administering and organizing the energy sector in a way that achieves the national objectives.

Stakeholder	Stakeholder Details	Description
	Jordan Institution for Standards and Metrology (JSMO)	It plays a proactive role in protecting the interests, health, and safety of citizens and the environment and enhancing the competitiveness of Jordanian products in national, regional, and international markets. JSMO prepares, approves, revises, amends, and monitors the implementation of standards and technical regulations covering all services and products (with the exception of pharmaceutical products, medicines, veterinary medicines, serums, and vaccines). JSMO fulfills its mandate to build, implement, and update systems compatible with international practices, in the fields of standardization, metrology, conformity assessment, market surveillance, accreditation, information, and related areas by providing an internal supportive working environment and developing all needed human, knowledge, material, technological, and financial resources.
	Ministry of Industry and Trade	It contributes to building and enhancing a national, competitive, global, and diverse economy in partnership with the private sector to raise citizens' standard of living where it enhances investment and business environment, so it becomes more competitive through the development of economic policies and legislations in order to ensure protection for both consumers and business sectors.
	Disi Basin Municipality	One of the southern municipalities affiliated with the Aqaba Governorate. It provides public services to all the villages of the basin.

Stakeholder		Stakeholder Details	Description
The lenders (Investors)	Providing a Loan for the implementation of the proposed project	European Investment Bank (EIB)	The European Investment Bank (EIB) is the lending arm of the European Union.
		United States International Development Finance Corporation (US DFC).	It is America's development finance institution.
		Proparco	It is the private sector financing arm of Agence Française de Développement Group (AFD Group.
The Operator		Disi Amman Operation & Maintenance (DAOM)	For this Project, it is the Project Operator who is responsible for operating and maintaining the entire Disi Conveyance System starting from the well field in the south of Jordan all the way up to the Greater Amman Area.
Service Providers		Civil Defense, Traffic Department, and Electricity Providers (EDCO)	Service and utility providers within the Project Area
Non-Governmental Organizations (NGOs)		The Royal Society for the Conservation of Nature (RSCN)	The RSCN is responsible for protecting the biodiversity and natural resources in Jordan. This environmental NGO sets up protected areas to safeguard wildlife and birds. As part of this Project, RSCN's role involved issues related to the proposed Project area being in environmental reserves and important bird areas (If any) as well as the potential impacts of the Project on biodiversity.
Local Community nearby Dubaydib well field		Local Community within the vicinity of the Dubaydib well field	
DISI Project Advisory Committee (DPAC)		The social aspects of the DISI project are managed through the DPAC. It comprises the review unit for the Disi project's environmental performance.	
Gama HQ Head Quarters (Ankara, Turkey)		Technical expertise, support, and knowledge sharing	
Dar Al Handasah & AJi Water & Environment (AJi)		Dar Al Handasah is the consultant who is responsible of designing the new network for the wells and AJi for design review.	
Bureau de Recherches Géologiques et Minières (BRGM)		BRGM, France's leading earth science public institution, (Additional production well targeting and well design for the Dubaydib wellfield)	

4 TERMS OF REFERENCE FOR THE ESIA STUDY

Prior to the commencement of the Environmental and Social Impact Assessment (ESIA) scoping session, a preliminary Terms of Reference (ToR) document was submitted to the Ministry of Environment (MoEnv). The preliminary ToR provided the MoEnv with a project description, a proposed approach to completing the required ESIA study, including provisions of impact assessment criteria and methods for establishing mitigation measures to control (eliminate and/or minimize) those impacts identified as significant, and a list of identified project-related key issues. The Preliminary ToR document was submitted to MoEnv before the scoping session in order to facilitate the scoping process.

The following presents the preliminary ToR which was presented at the scoping session for stakeholders' and participants' review and comments. The updated version was produced after the scoping session to address the comments and inquiries gathered from the scoping session participants, and will accordingly be submitted to DIWACO, and lenders for their review and approvals and then to MoEnv for the final approval.

The significance of the expected impacts will be determined based on stakeholder feedback, current prevailing conditions, and technical and preliminary expert analysis of each impact. The significance and assessment of impacts will be discussed in the ESIA study.

The ESIA will address impacts that have been identified to be of high to medium importance according to professional judgment.

4.1 Comprehensive ESIA Study Methodology

The expected workflow for preparing the ESIA study is detailed in the following sections, while **Table 3** presents the timeline of the study.

Table 3: ESIA Study Timeline

No.	ESIA Major Task	Expected Date
1	Assessment of Environmental and Social Baseline Conditions.	January 2025
2	Identification of Environmental and Social Impacts. As part of the assessment, potential cumulative impacts will also be considered.	January 2025
3	Development of Environmental and Social Management Plan (ESMP)	March 2025
4	Submission of Draft ESIA	March 2025

4.2 Environmental and Social Baseline

The consultant will assemble, evaluate, and present baseline data on the relevant environmental, social, and economic characteristics of the project study area.

The baseline will be prepared according to the methodology in **Table 4**.

Table 4: Methodology for Baseline Study

No.	Environmental/ Social Component	Baseline measurements that will be conducted during ESIA
1	**Air Quality and Dust**	● No baseline air quality measurements are anticipated for the project site due to the predicted transitory air emissions during the construction phase, the absence of any nearby residences or the local community, and the very low expected air emissions throughout the operating period.

No.	Environmental/ Social Component	Baseline measurements that will be conducted during ESIA
		● The air quality baseline description will be completed based on secondary information only.
2	**Noise**	● Noise measurements will be conducted at the project site in accordance with noise measurement methodologies aligned with good international practices, taking into account occupational health and safety as well as biodiversity considerations. Noise measurements will be carried out over a 24-hour period at four proposed locations, as indicated on the map in **Appendix 7**.The survey will include current conditions at locations distant from existing wells, as well as areas near operational wells.
3	**Land and Soil**	● Literature review and review of previous studies, in addition to rapid visual field assessment.
4	**Water Resources**	● Literature review and review of previous studies including the BRGM study in addition to rapid visual field assessment. ● Review DIWACO, DAOM and MWI/WAJ recent groundwater testing for all the parameters (2021-2024), in addition to review the radioactivity report (2021-2022). No further testing is suggested. The parameters are: Colour, Taste, Odour, Turbidity, Ammonium, Aluminum, Manganese, Iron, Copper, Zinc, Sodium, Chloride, Sulphate, Hydroxide, TDS, Total hardness, Chemical detergents, Arsenic, Lead, Cyanide, Cadmium, Chrome, Barium, Selenium, Boron, Mercury, Silver, Nickel, Antimony, Fluoride. Radionuclides: - Alpha Radionuclides excluding Radon. - Beta Radionuclides excluding Tritium and Carbon 14.
5	**Solid Waste**	● Previous studies, such as previous ESIA conducted in 2004 and its addendum.
6	**Hazardous Waste**	● Previous studies, such as previous ESIA conducted in 2004 and its addendum.
7	**Drilling liquid waste**	● Literature review and review of previous studies, in addition to DIWACO expertise.
8	**Aesthetics**	● Field rapid diagnosis / assessment.
9	**Socioeconomic Issues**	● Data review and collection from (i) DoS, https://dosweb.dos.gov.jo/ar ; (ii) MoPIC, https://www.mop.gov.jo/Default/Ar ; (iii) Ministry of Education (MoEdu), https://moe.gov.jo ; and (iv) MoI, https://moi.gov.jo/Default/Ar. ● Investigate the official land use of the Project area as well as the actual customary land use (informal land use) if differs from the planned. ● Analyze data to map and profile the socio-economic conditions of the project area, using on-site assessments, operator's feedback,

No.	Environmental/ Social Component	Baseline measurements that will be conducted during ESIA
		and satellite imagery to identify informal community activities such as temporary structures. ● Display the outcomes and findings using illustrative maps, tables, and photos as applicable.
10	**Public Health and Safety**	● Literature review. ● Scoping and disclosure sessions. ● DPAC outcomes.
11	**Occupational Health and Safety**	● Review of the well field existing safety procedures and documents.
12	**Land Use**	● Department of Lands and Survey documents.
13	**Climate Risk & Vulnerability Assessment**	● Literature review and review of previous studies. In addition to assess the sensitivity of project component(s) and Labor to climate/weather conditions such as temperature, rainfall or flooding in order to improve preparedness for climate variability through the incorporation of resilient designs for all infrastructure works, and ensure adaptations measures for the labor on site for the assessed climate risks.
14	**Biodiversity**	● Literature review and review of previous studies, in addition to rapid ecological assessment of the project implementation site. The methodology for the biodiversity study is detailed in **Appendix 8**.
15	**Archeology and Cultural Heritage**	● Literature review and review of previous ESIA for the well field. ● Based on data obtained from the Department of Antiquities.

In case of any monitoring tests and measurements, they will be conducted by accredited laboratories using methods in accordance with the related requirements.

4.3 Methodology of Impact Identification and Assessment

After reviewing the project's proposed design and approach, the consultant will identify potential risks and impacts expected during the construction, operation, and decommissioning phases. Identified impacts will be further assessed during ESIA preparation. Mitigation and monitoring measures will be designed to mitigate these risks and impacts.

This section presents the methodology to be implemented by the ESIA consultant to identify expected impacts. Upon identifying the impacts, consideration will be given to the outcomes from the stakeholder's consultation, results of previous ESIAs for similar projects, as well as expert judgment and experience in this field.

The consultant will assess the affected elements and will determine the magnitude of the potential impacts on them after reviewing the project's design, conducting a site visit, collecting online data, conducting a scoping session, and using the experience gained from similar previous projects.

The significance of the expected impacts on the identified valuable environmental and social components will be assessed.

To enable the determination of the overall significance of the impact, each identified impact interaction will be ranked in terms of consequence and likelihood. Impact significance is expressed as the product of the consequence and likelihood of occurrence of the activity.

Consequence

To assign a level of consequence to each potential environmental and social impact, criteria are defined for environmental and socio-economic consequences. The consequence categories and their rankings are presented in **Table 5** below. "Catastrophic" represents the most severe consequence.

Table 5: Consequence Categories & Rankings

Consequence	Ranking	Description
Catastrophic	5	Massive effect: Persistent severe environmental damage or severe nuisance extending over a large area. In terms of commercial or recreational use or nature conservation, a major economic loss for the contractor/operator. Constant, high exceedance of statutory or prescribed limits.
Severe	4	Major effect: Severe environmental damage. The contractor/operator is required to take extensive measures to restore polluted or damaged environment to its original state. Extended breaches of statutory or prescribed limits.
Critical	3	Localized effect: Limited discharges of known toxicity. Repeated breaches of statuary or prescribed limit that affect the surrounding neighborhood. Spontaneous recovery of limited damage within one year.
Marginal	2	Minor effect: Contamination. Damage sufficiently large to attack the environment. Single exceedance of statutory or prescribed criterion. Single complaint. No permanent effect on the environment.
Negligible	1	Slight effect: Local environmental damage. Within the fence and within systems. Negligible financial severity.
None	0	No impact
Positive	+	Beneficial impact – enhances the environment.

Likelihood

To assign likelihood to each activity, five categories are defined and ranked. Level five, "certain", represents the highest likelihood that the activity will occur. The likelihood categories and their rankings are presented in **Table 6** below.

Table 6: Likelihood Categories and Rankings

Category	Ranking	Definition
Certain	5	The activity will occur under normal construction and operation conditions.

Category	Ranking	Definition
Very Likely	4	The activity is very likely to occur under normal construction and operation conditions.
Likely	3	The activity is likely to occur at some time under normal construction and operation conditions.
Unlikely	2	The activity is unlikely to but may occur at some time under normal construction and operation conditions.
Very Unlikely	1	The activity is very unlikely to occur under normal construction and operation conditions but may occur in exceptional circumstances.

Significance

As described above, the significance of the impact is expressed as the product of the consequence and likelihood of occurrence of the activity, expressed as follows:

Significance = Consequence x Likelihood

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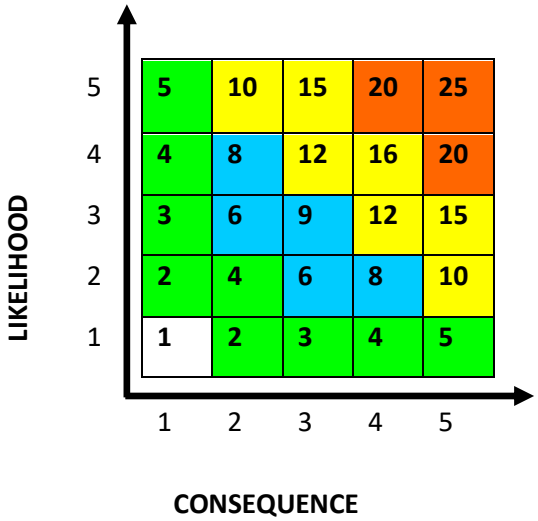


Figure 7: Product Results for Consequence & Likelihood Categories

Based on its consequence-likelihood score, each environmental aspect can be ranked into five categories or orders of significance as illustrated in **Table 7.**

Table 7: Significance Categories

Ranking (Consequence X Likelihood)	Significance
>16	Critical
10-16	High
6-9	Medium
2-5	Low
<2	Negligible

To assist in determining and calculating the significance of an impact, impact assessment matrices will be developed based on an aspect identification exercise.

4.4 Potential Environmental and Social Impacts during the Construction and Reinstatement Phase

Table 8 presents the expected potential construction phase and impacts that will be consulted on with the identified stakeholders and the impact's significance would be revised based on the outcomes of the scoping process, which will be further studied and mitigated during the ESIA study.

Table 8: List of the Potential Environmental and Social Impacts during Construction Phase

No.	Environmental / Social Component	Potential Impact(s)
1	**Reinstatement**	● Cleaning and reinstatement of well sites following construction completion.
2	**Air Quality and Dust**	● Exhaust emissions and dust generation from construction activities may cause local degradation of air quality.
3	**Noise**	● Increased noise because of construction activities (e.g., construction works, excavation), the use of heavy machinery, and vehicle and equipment operation.
4	**Land and Soil**	● The nature of construction activities (land clearing, excavations, etc.) could disturb the soil. ● Improper housekeeping practices during construction including the improper disposal of solid waste as well as hazardous materials and wastes could contaminate and pollute soil. ● Soil erosion as a result of land preparation and well drilling. ● Contamination of soil because of accidental spillage/leakage of chemicals or oils stored on-site or used during construction.
5	**Water Resources**	● Drilling operations can introduce contaminants into groundwater if not properly managed. This includes the potential contamination from lubricants and other chemicals used in the drilling process, as well as the risk of improper waste disposal such as oil and fuel by workers.
6	**Solid Waste**	● Improper management of the waste generated from the workers at the site, affecting the soil, water, and occupational health and safety.

No.	Environmental / Social Component	Potential Impact(s)
7	**Liquid Waste**	● Potential absence of appropriate liquid waste management system from construction workers housing would increase the possibility of occurrence of negative impacts on the surrounding environment mainly soil and public health and pollute the groundwater aquifers. ● Potential impacts from drilling fluids will be managed in accordance with MWI/WAJ instructions.
8	**Hazardous Waste**	● Potential absence of appropriate management system of hazardous waste, such as fuels, oils and lubricants, would increase the possibility of occurrence of negative impacts on the surrounding environment and public health.
9	**Biodiversity**	● Possible habitat loss/destruction due to physical damage from clearance activities and vehicular transport during construction.
10	**Employment**	● Temporary workforce employment.
11	**Infrastructure and Public Services**	● Disruption or disturbance to road networks and services provided within the site.
12	**Public Health and Safety**	● Impact on public health and safety because of dust generation and noise generation. ● Movement of heavy machinery on-site for excavation work, could pose health risks to local community. ● Entering the well field site by unauthorized people and/or vehicles.
13	**Occupational Health and Safety**	● Work-related injury risk for construction workers as result of the construction activities.
14	**Land Acquisition**	● No land acquisition is required.
15	**Land use**	● No significant change in land use.
16	**Archaeology and Cultural Heritage**	● Possible damage to cultural or heritage sites (chance find) during construction activities; contractor to follow chance find procedure
17	**Aesthetic**	● Visual intrusion and aesthetic interference due to potential generation of waste as well as presence of construction machinery in the project area.
18	**Climate Risks**	● Heat waves or heavy precipitation and flood risk during the construction phase.
19	**Additional impacts**	● Any other identified impacts by the stakeholder engagement and the ESIA process.

4.5 Potential Environmental and Social Impacts during the Operation Phase

Table 9 presents the potential operation phase risks and impacts that will be discussed further with the stakeholders and that will be assessed and mitigated during the ESIA study.

Table 9: List of the potential Environmental and Social Impacts during Operation Phase

No.	Environmental / Social Component	Potential Impact(s)
1	**Air Quality and Dust**	• Energy consumption from pumping and thus the emission of combustion gases into the air; however, power will be supplied from the EDCO grids. • Dust generation from vehicular movement.
2	**Noise**	• Noise is expected to result mainly from operation of the pumps.
3	**Land and Soil**	• Excessive groundwater extraction lowers the pressure within aquifers, causing the surrounding unconsolidated or semi-consolidated sediments to compact. This compaction can result in ground-level sinking, known as land subsidence. In some cases, excessive groundwater depletion leads to permanent aquifer compaction., • The use of heavy machinery during the operation and maintenance of wells and pumps can cause soil compaction. • Accidental spills or leaks can contaminate the soil, affecting its quality and potentially impacting groundwater if contaminants infiltrate through the soil.
4	**Water Resources**	• Continuous pumping from the wellfield will lead to a decrease in the groundwater table. Therefore, affecting the availability and quality of water of the wellfield and the neighboring communities' wells as well. • A declining water table can lead to increased pumping costs as wells need to be drilled deeper to access water. • Operational risks, accidents, and failures of wells. • Accidental spills from fuel, lubricants, and other chemicals used for maintenance and operation, and accidental chemical spills and leaks could negatively affect groundwater water quality.
5	**Radioactivity**	• Natural radioactivity of water abstracted.
6	**Solid Waste**	• Improper management of the waste generated from the workers at the site, affecting the soil, groundwater, and occupational health and safety.
7	**Liquid Waste**	• Improper management of the waste generated from the workers at the site, affecting the soil, groundwater, and occupational health and safety.
8	**Hazardous Waste**	• Potential absence of appropriate management system of hazardous waste, such as fuels, oils and lubricants, would increase the possibility of occurrence of negative impacts on the surrounding environment and public health.
9	**Biodiversity**	• Improper conduct or poor housekeeping practices by workers (e.g., hunting of animals, discharge of hazardous waste to land) would impact biodiversity.
10	**Employment**	• Limited permanent employment opportunities are expected to be generated by the project for local communities.
11	**Infrastructure and Public Services**	• The water supply system will be enhanced, providing additional water volume to meet the increased demand in Amman.

No.	Environmental / Social Component	Potential Impact(s)
12	**Public Health and Safety**	• The project could positively impact public health by ensuring sufficient supply of clean water, subject to appropriate water quality standards (JS 286/2015).
13	**Occupational Health and Safety**	• Potential for worker exposure to risk of accidents, injuries, and health impacts related to moving mechanical equipment, maintenance activities, and operational failures of pumping and conveyance system.
14	**Archaeology and Cultural Heritage**	• Impacts on archaeology and cultural heritage are not anticipated during operation and maintenance because any required maintenance or repair would not require excavating undisturbed ground or major earthworks that could potentially disturb archaeological assets.
15	**Aesthetic**	• No significant impact is anticipated during the operation phase.
16	**Climate Risks**	• To be minimized through the well's designs during the design phase.
17	**Additional impacts**	• Other identified impacts during the ESIA process and the stakeholder engagement plan.

Decommissioning activities are anticipated to be similar to construction; therefore, the potential impacts are anticipated to be relatively similar.

4.6 Development of the Environmental and Social Management Plan (ESMP)

The consultant will develop an ESMP for all phases of the project (construction, operation and decommissioning), including:

- Mitigation measures to avoid, minimize, or limit potentially adverse impacts and to maximize positive effects where applicable. Wherever a negative impact is inevitable, rehabilitation, restoration, or compensation should be considered.
- Institutional structures required to implement the mitigation measures, along with addressing a clear responsible party for each activity and to whom they report functionally and legally.
- Monitoring program to verify compliance with the recommended mitigation measures.

This ESMP aims at ensuring the application of the mitigation and monitoring measures needed to reduce and control the various environmental and social impacts associated with the implementation of the proposed project, the social and human rights for different stakeholders' categories will be imbedded within the mitigation measures, and a social responsibility measure will be added to the ESMP (if applicable).

4.7 Development of the Environmental and Social Monitoring Plan

The consultant will develop a monitoring plan for all phases of the project, which will include the following:

- Parameters to be monitored
- Location of monitoring
- Measurement method and equipment to be used
- Frequency of measurement
- Monitoring responsibility

5 OVERALL SCOPE OF THE ESIA

5.1 ESIA Compliance and Key Components Overview

The study will be conducted in compliance with local legislation, specifically the Environmental Impact Assessment (EIA) regulations, as well as international guidelines and requirements for Environmental and Social Impact Assessment (ESIA) in accordance with IFC and lenders standards.

The ESIA will be supported by the following major components:

1. **Scoping Process:** A scoping session was conducted on the 20th of August 2024 to ensure that the input of stakeholders, as well as experts in the field, is not overlooked and affirmed, which will guide the development of the ESIA. The session was conducted according to Environmental Classification and Licensing Regulation No. 69 of 2020 and its amendments No.97. Full coordination with the related governmental bodies will be assured according to the enforced ESIA procedures. Then, the result of the scoping session was documented in this final ToR in **Appendix 9**, which will be submitted to the client, lenders, lender's engineers and MoEnv for final review and approval.
2. **Draft ESIA:** Analysis of activities, environmental and socioeconomic components, impacts, and mitigation will be carried out, and an ESMP will be developed. To ensure proper implementation of the mitigation measures, the ESMP will also include monitoring measures.
3. **A disclosure session** will be conducted following the production of the revised version of the Draft ESIA and after the review of the draft report by DIWACO. In this session, the consultant will present the ESIA findings related to stakeholders and interested groups to ensure the input of stakeholders, as well as experts in the field, is not overlooked and is affirmed.
4. **Non-Technical Report:** A non-technical report will be prepared and delivered for public disclosure to ensure the findings are accessible to the public and to promote transparency.
5. **Revised ESIA:** A final ESIA will be prepared to include any comments and inquiries instructed by the disclosure session, MWI/WAJ and MoEnv, thus integrating the consultant's response to these comments. The revised report will be submitted to DIWACO, and lenders in English for review and final approval. The translated Arabic version will be submitted to MoEnv for final approval.

5.2 Proposed ESIA Reporting

The ESIA report will include, at a minimum:

Table 10: ESIA Report Outline

No.	Section	Sub Section
0	**Executive Summary**	Summary (in English and Arabic) of the project, main findings and Recommendations.
1	**Introduction**	Overview and purpose of the project and scope of the ESIA.
2	**Project Description**	A clear and concise description of different activities over the life of the project. The description should be sufficient to allow the risks and impacts to be identified, described and evaluated.
3	**Project Alternatives**	This section reviews the site selection process, explaining how various alternatives were considered and assessed based on environmental, social, and technical criteria.
4	**Legislative and Institutional Framework**	Details of the applicable national and international legislation, regulations and standards with potential implications to the project.
5	**Environmental and Social Baseline Description**	Assessment of the baseline conditions against which the impacts of the project can be assessed.
6	**Impact Assessment & Cumulative Impact**	This section evaluates the project's impacts, detailing the methodology used. It lists, describes, and quantifies both positive and negative effects on the environment and socio-economic context. It also considers potential cumulative impacts and unplanned but predictable activities enabled by the project
7	**Stakeholder Identification and Engagement**	Summary of the stakeholder engagement process which will identify affected parties and detail how the project will communicate, inform, and discuss the substantive issues with all interested and affected parties.
8	**Analysis of Project Alternatives**	A comparison of the “Project” Vs. “No Project” Alternatives and their potential impacts.
9	**Environmental and Social Management Plan (ESMP)**	Details of specific activities to be carried out during different phases of the project and project activities to ensure the identified mitigation measures are implemented.
10	**ESIA Conclusions**	A summary of the key environmental and social impacts identified, along with the proposed mitigation measures. It shall confirm the project’s ability to proceed responsibly, with ongoing monitoring and compliance with the ESMP.
11	**References**	A listing of all the references used in the ESIA study. Including the CRVA document.

6 STUDY TEAM

The study team for this project comprises the personnel from AJi Infrastructure & Environment, who possess significant expertise in the field. **Table 11** provides descriptions outlining the qualifications of the Key Project Staff:

Table 11: EIA Study Team (AJi Infrastructure & Environment)

No.	Name	Position	Qualifications
1	**Wafa Daibes**	Team Leader / Social Expert	B.Sc. in Civil Engineering, with over 30 years of expertise that includes comprehensive involvement in project stages, with a specific focus on conducting Environmental & Social Impact Assessments (ESIAs), stakeholder engagement, and Occupational Health & Safety Assessments.
2	**Anwar El Halah**	Biodiversity Expert	B.Sc. in Rangeland & Forestry, with over 23 years of specialized experience in biodiversity conservation and surveying across Jordan's ecosystems. Extensive collaboration with international financing institutions on infrastructure projects. Specialized in biodiversity assessments, mitigation strategies, and promoting sustainable practices. Proficient in aligning project goals with conservation priorities, ensuring regulatory compliance and ecological preservation.
3	**Ghada Jaber**	Process/ Mechanical Engineer	M.Sc. in Environmental Engineering, with over 22 years of experience, she has successfully managed projects in Jordan and Iraq, showcasing proficiency in environmental initiatives, including water and wastewater treatment. Eng. Ghada's commitment to sustainability is evident through her leadership in developing eco-friendly solutions adhering to high standards.
4	**Mais Makkawi**	Project Coordinator	B.Sc. in Industrial Engineering, with over 11 years of experience, specializing in internationally funded climate projects in the MENA region, she seamlessly combines business growth with a strong commitment to environmental initiatives. Eng. Mais played a vital role in the World Bank's Climate Investment Mobilization Plan, demonstrating her expertise in project prioritization and environmental assessment.
5	**Ghada Halaweh**	Environmental Engineer	M.Sc. in Environmental and Renewable Engineering with 6 years of relevant experience. Her work consistently reflects a commitment to sustainable solutions, demonstrating proficiency in integrating environmental considerations into various projects and initiatives, particularly in conducting ESIA for major infrastructure projects in Jordan.
6	**Mohammed Jurf**	Environmental Engineer	B.Sc. in Civil Engineering, with over 2 years of relevant experience, he specializes in conducting ESIA and coordinating major infrastructure projects, including water supply, wastewater, and road developments. His

No.	Name	Position	Qualifications
			work demonstrates a strong commitment to environmental sustainability.
7	**Weam Mahdawi**	Senior Environmental Engineer	M.Sc. in Water Resources and Environmental Engineering with over 9 years of experience in environmental impact assessment studies, particularly for wastewater treatment plants. Led environmental impact assessment studies for major projects such as the South Amman Wastewater Treatment Plant and the Fuheis and Mahes Plant, ensuring environmental compliance and community protection.
8	**Lara Louzi**	Hydrology Engineer	B.Sc. in Civil Engineering, specializing in hydrology, she excels in conducting hydrological studies and flood assessments. Her expertise encompasses evaluating water resources, analyzing flood risks, and implementing sustainable water management practices.
9	**Khalid Al Majali**	Water Resources Expert	M.Sc. in Civil Engineering, with over 35 years of experience, he specializes in the study and management of water resources for major projects. His expertise encompasses the evaluation of water resources, assessment of water quality, and identification of potential impacts on water systems, including groundwater resources.

APPENDICES

Appendix 1: Project Classification

وزارة البيئة

الرقم ٤/١/٦٣٦
التاريخ
الموافق ٢٠٢٣/٨/٢١

معالي وزير المياه و الري/سلطة المياه

تحية طيبة وبعد ،،

إشارة الى كتابكم رقم 12306/2/7 تاريخ 2023/6/22 بخصوص حفر الابار التسعة الجديدة بمنطقة حقل ابار مشروع جر مياه الديسي.

يرجى التكرم بالعلم بأن المشروع أعلاه يتطلب إعداد دراسة تقييم أثر بيئي شاملة و ذلك استناداً لأحكام نظام التصنيف و الترخيص رقم 69 لسنة 2020.

وتفضلوا بقبول فائق الإحترام ،،،

وزارة المياه والري - سلطة المياه
الديوان المركزي
٣٠ آب ٢٠٢٣
الرقم المتسلسل: ٧٢٦٧
رقم الملف:

وزير البيئة
الدكتور معاوية خالد الردايدة

د.محمد الخشاشنة
الأمين العام

Appendix 2: The agreement between the Government of Jordan and the government of Saudi Arabia in order to manage and invest groundwater in the Al-Saq layer Disi

A Royal Decree was issued approving Cabinet Decision No. 9619 dated 13/5/2015 containing Approval of an agreement between the Government of the Hashemite Kingdom of Jordan and the Government of the Kingdom of Saudi Arabia for the Management and investment of groundwater in the Al-Saq layer / Al-Disi, which was signed in the city of Riyadh on 30/04/2015 as the following:

The Government of the Kingdom of Saudi Arabia is represented by the Ministry of Water and Electricity, and the Government of the Hashemite Kingdom of Jordan is Represented by the Ministry of Water and Irrigation, (hereinafter referred to as the two parties), and based on the bonds of brotherhood that link between the two peoples and the two brotherly countries and the distinguished relations that exist between them, and in confirmation of the sincere cooperation between them, And since there is a common water basin layer between them, known in the Kingdom of Saudi Arabia as the AL-Saq layer, and in the Hashemite Kingdom of Jordan, in the Disi layer, and to match the two countries' desire to apply the utmost wisdom in the management and investment of limited renewable groundwater in this layer for the benefit of both.

The parties agreed on the following:

Article (1)

For the purposes of this Agreement, the following words and phrases shall have the meanings set forth therewith:

Saudi Arabia: Government of the Kingdom of Saudi Arabia - Ministry of Water and Electricity.

Jordan: Government of the Hashemite Kingdom of Jordan - Ministry of Water and Irrigation.

The Al-Saq layer: it is the part of the water-bearing geological formation from the main Al-Saq layer and extending from the boundary Jordan until the end of the wells field of the central Tabuk water project in the Kingdom of Saudi Arabia.

Disi Layer: It is the part of the water-bearing geological formation of the main Disi layer extending from

The Saudi border until the end of the wells field of the Disi water transfer project in the Dubaydib area in the Hashemite Kingdom of Jordan.

Disi Water Transfer Project: A project to transfer water from the Disi layer in the Dubaydib area to the city of Amman and other counties.

Tabuk Central Water Project: Water transfer project from Al-Saq layer to Tabuk and other cities and villages.

Joint Technical Committee: The committee shown in Article (Third) of this Agreement.

Pollution: Any pollution of surface or ground water, whether chemical, bacterial, or other, directly or indirectly.

International Border Line: It is the international border line between the Kingdom of Saudi Arabia and the Hashemite Kingdom of Jordan, according to the agreement signed between the two countries in Amman on Monday, August 9, 1965.

Administration area: It is the area bounded by the coordinates of points (B1, B2, J1, J2) in Jordan and the area bounded by the coordinates of the points (B1, B2, S3, S4) in Saudi Arabia, and it's part of the Disi layer in Jordan and the Al-Sag layer in Saudi Arabia, and shown in the attached plan (the map of the agreement for the management and investment of groundwater in the Al-Saq layer / Al-Disi).

The Protected Area (Restricted): It is part of the management area bounded by the coordinates of points (B1, B2, J3, J4) located in Jordan and the area bounded by the coordinates of points (B1, B2, S1, S2) in Saudi Arabia, which are shown in the attached plan (the map of the agreement for the management and investment of groundwater in the Al-Saq layer / Al-Disi).

Article (2)

The two parties agreed on the necessity of efficient management, investment and sustainability of the water of the Al-Saq layer / Al-Disi, through the following:

1. Elimination of all activities in the protected (Restricted) area that depend on the extraction of groundwater within a period of five years from the date of signing this Agreement.

2. Keep the protected (Restricted) area between the two brotherly countries free from all activities that depend on extracting groundwater from it.

3. Drilling monitoring wells for groundwater in the protected (Restricted) area to extract information related to the quality and levels of groundwater, provided that drilling operations are preceded by coordination through the Joint Technical Committee.

4. The drilling of water wells in the administration area shall be in accordance with the technical specifications approved in the two countries, and horizontal or diagonal drilling in water wells is prohibited to avoid any pollution.

5. Preserving the groundwater in the administration area between the two countries from any pollution and not allowing the injection of any pollutant, whatever its type or quantity.

6. Limit the use of groundwater extracted from the administration area to be only used locally by the two countries.

Article (3)

1. A joint Saudi Jordanian technical committee will be formed, consisting of five members from each side, to be chaired by the side Saudi Undersecretary of the Ministry of Water and Electricity for Water Affairs, and headed on the Jordanian side by the Secretary-General of the Ministry of Water and Irrigation.

2. The Committee has the right to be guided by experts, consultants and to employ assistants, technicians and employees from the nationals of the two countries or others as needed to do limited work.

3. The Joint Technical Committee holds its meetings periodically every (six) months; Or whenever needed.

4. The Joint Technical Committee undertakes the following:

A. Supervising the implementation of the provisions of this Agreement.

B. Monitoring of groundwater in terms of withdrawal quantity, water levels and quality.

C. Collecting and exchanging data, information and studies, analyzing them, and presenting the results to the competent authorities in Saudi Arabia and Jordan, and this information and data shall be owned by both parties, and the Joint Technical Committee may not provide it to a third party Only with the written consent of both parties.

Article (4)

1. This agreement is approved in accordance with the provisions and legislation in force for both parties, and it becomes effective from the date of its signing according to the official procedures in both countries.

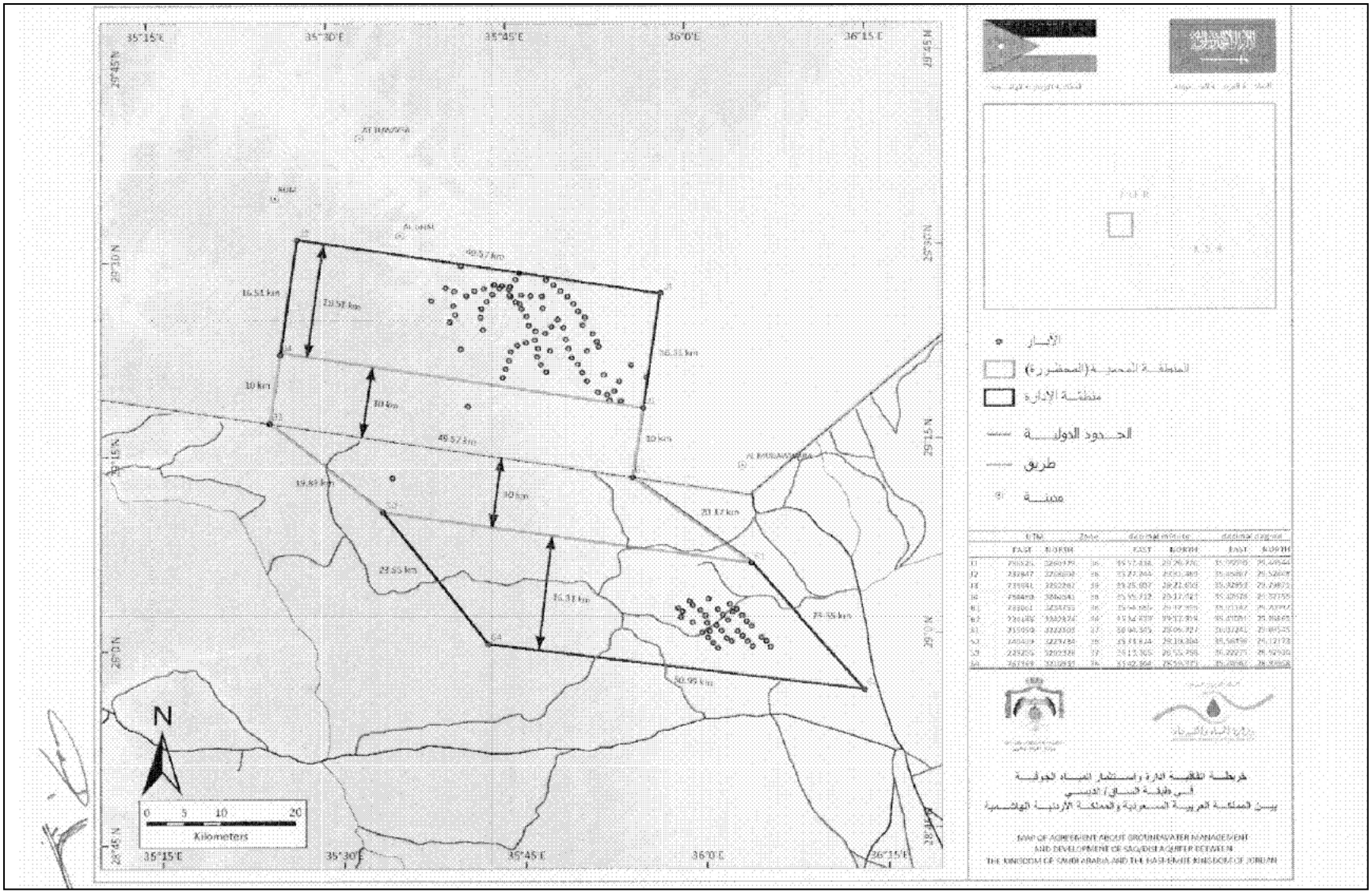
2. The chart attached to this Agreement is considered an integral part of it, and the provisions of this Agreement shall apply to the part specified therein.

3. This Agreement shall be revised every twenty-five years.

4. When there is a need to amend any of the provisions of this agreement for the benefit of the two countries, the Joint Technical Committee shall study that and submit it to the competent authorities to complete the official procedures in both countries for approval.

5. This agreement was made in the city of Riyadh on the 30th of April 2015, in two original copies in the Arabic language, and they are equally authentic, and a copy was given to each party.

Appendix 3: Agreement Map


35°15'E
35°30'E
35°45'E
36°0'E
36°15'E
29°45'N
29°30'N
29°15'N
29°0'N
28°45'N
N
0 5 10 20
Kilometers
الآبـــار
المنطقـــة المحميـــة (المحضورة)
منطقـــة الإدارة
الحـــدود الدوليـــة
طريق
مبنـــى
خريطـــة اتفاقيـــة الادارة واستثمار المياه الجوفيـــة
في حوضـــ الســـاق / الديســـي
بيـــن المملكـــة العربيـــة الســـعودية والمملكـــة الأردنيـــة الهاشـــمية
MAP OF AGREEMENT ABOUT GROUNDWATER MANAGEMENT
AND DEVELOPMENT OF SAQ/DISI AQUIFER BETWEEN
THE KINGDOM OF SAUDI ARABIA AND THE HASHEMITE KINGDOM OF JORDAN

Appendix 4: Letters of Saudi Arabia Approval for the Agreement

The Hashemite Kingdom Of Jordan
Ministry Of Water & Irrigation
Minister's Office

لائحة وقائع

المملكة الأردنية الهاشمية
وزارة المياه والري
مكتب الوزير

Minister's Office : إشارتنا :

Date: التاريخ : ٢٠-٤-٢٠١٦

Incoming Ref No : رقم الكتاب الوارد :

Date: التاريخ: ١٧-٤-٢٠١٦

من : وزارة البيئة

الموضوع: Subject: موافقة الجهات المعنية على اتفاقية ادارة واستثمار المياه الجوفية المشتركة

الرقم	التاريخ	إلى	المشروحات والتوقيع / Action
	١٧/٤	عطوفة امين عام وزارة المياه	للاطلاع
		عطوفة امين عام سلطة وادي الاردن بالوكالة	
			مكتب وزير المياه والري موفق
	١٧/٤	رئيس سلطة المياه	للتنسيب مع الشكر والتقدير
		رئيس سلطة المياه	موفق

ROYAL EMBASSY OF SAUDI ARABIA
AMMAN

سفارة المملكة العربية السعودية
عمان

تهدي سفارة المملكة العربية السعودية في عمّان اطيب تحياتها إلى مقام وزارة الخارجية وشؤون المغتربين بالمملكة الأردنية الهاشمية الشقيقة .

تفيدها بصدور الموافقة على إتفاقية بين المملكة العربية السعودية والمملكة الأردنية الهاشمية من أجل إدارة إستثمار المياه الجوفية في (طبقة الساق/ الديسي) والمصادق عليها بتاريخ ١٤٣٧/٦/٢٧ هـ الموافق ٢٠١٦/٤/٥ م .

تأمل التفضل بالإطلاع واتخاذ ما تراه مناسباً حيال أبلاغ الجهة المعنية بذلك .

وتنتهز السفارة هذه المناسبة لتعرب لمقامها عن فائق تقديرها واحترامها .

AMMAN
ROYAL EMBASSY OF SAUDI ARABIA

المملكة الأردنية الهاشمية
وزارة الخارجية وشؤون المغتربين - الديوان العام
17 APR 2016

الرقم : ٦٢٢٢ التاريخ : ١٤٣٧/٧/٢٦ هـ الموافق : ٢٠١٦/٤/١٣ م المرفقات : بدون

Appendix 5: Letters of Jordan Approval for the Agreement

رئاسة الوزراء

الرقم ٥٧ / ١/١١ / ٢٥٦٠٦
التاريخ ٢٠ / شعبان / ١٤٣٦
الموافق ٢٠١٥/٠٦/٠٧

معالي وزير المياه والـــري

أشـــــير لكتـــــابكم رقـــــم وم ر/١٦٠٨/٣٧/٥/١ تـــــاريخ ٢٠١٥/٥/٥.

صدرت الإرادة الملكية السامية بالموافقة على قرار مجلس الوزراء رقم (٩٦١٩) تاريخ ٢٠١٥/٥/١٣ ، المتضمن الموافقة على اتفاقية بين حكومة المملكة الأردنية الهاشمية وحكومة المملكة العربية السعودية من أجل إدارة واستثمار المياه الجوفية في طبقة الساق / الديسي التي تم التوقيع عليها في مدينة الرياض بتاريخ ٢٠١٥/٤/٣٠ بصيغتها المرفقة بكتابكم المشار إليه أعلاه.

واقبلوا فائق الاحتـــرام.

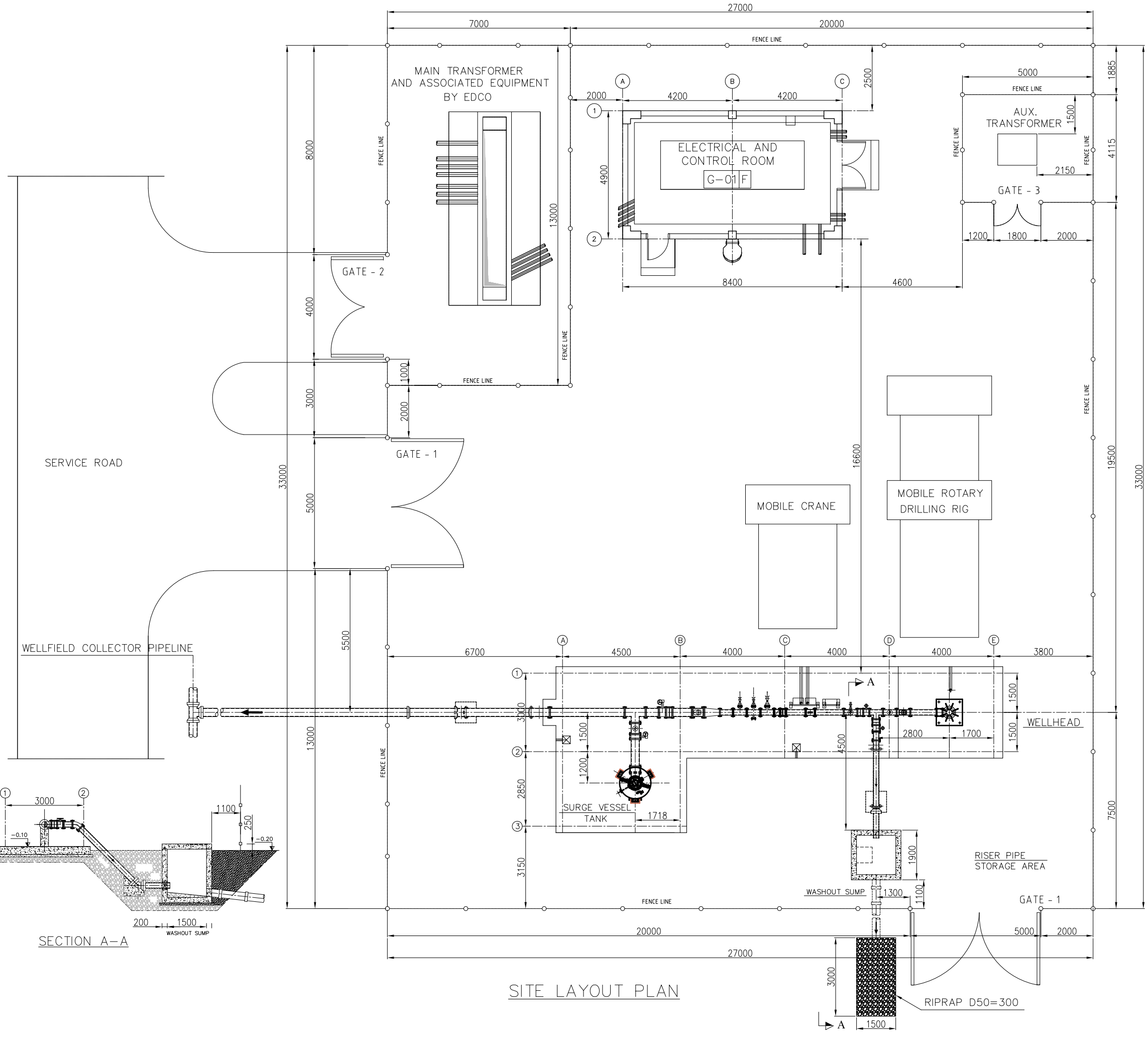
المملكة الأردنية الهاشمية
وزارة المياه والري - سلطة المياه
الديوان المركزي
الرقم المتسلسل ١٨٠٧٣
رقم الملف

/ رئيـــس الـــوزراء

نسخة / إلى معالي نائب رئيس الـــــوزراء
ووزير الخارجية وشؤون المغتربيـن
نسخة / إلى عطوفة أمين سر مجلس الوزراء
قرار رقم (٩٦١٩).
نسخة / إلى مدير الجريدة الرسميـــــــة

و ٦/٤

Appendix 6: Wellhead General Layout Plan



THE HASHEMITE KINGDOM
OF JORDAN
MINISTRY OF WATER AND
IRRIGATION

DISI-MUDAWARRA TO AMMAN
WATER CONVEYANCE SYSTEM PROJECT

Diwaco
Disi Water Company

GAMA
GAMA GÜÇ SİSTEMLERİ MÜHENDİSLİK VE TAAHHÜT A.Ş.

SURGE VESSELS

WELL NUMBER	SURGE VESSEL CAPACITY (m^3)
W12	8
W23	6
W26	6
P8	6

AS BUILT
MARCH 2014

GAMA GUC SISTEMLERI	
Approved by: S.K	Date: 13/03/14

No	Description	Date	Checked	Approved

REVISIONS

Drawing Title:
WELLHEAD
GENERAL LAYOUT PLAN

Designer:
GAMA POWER SYSTEMS INC.
GAMA GÜÇ SİSTEMLERİ A.S.

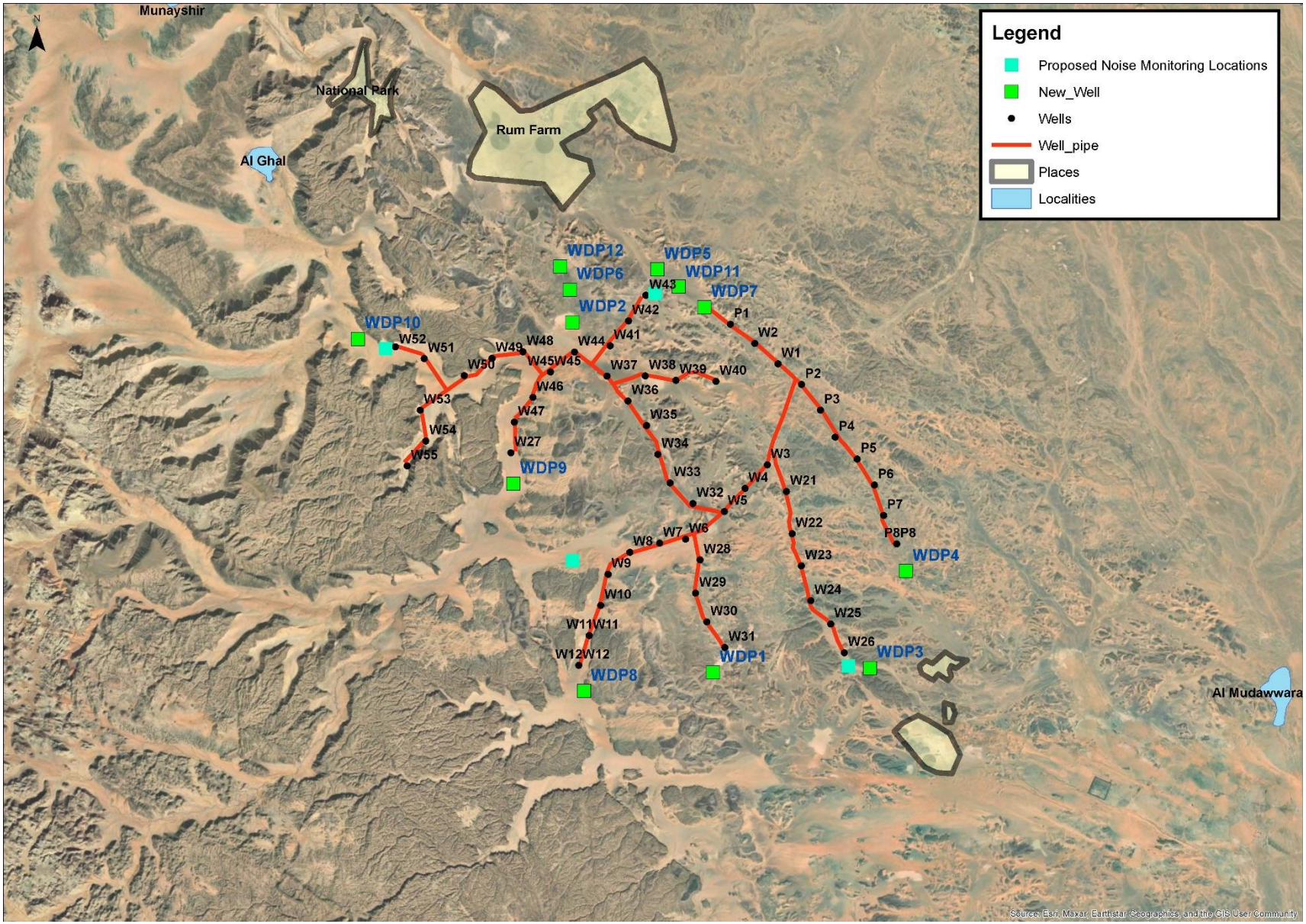
Drawn by:	Designed by:	Checked by:	Approved by:
H.D	S.V	S.F	S.K

Scale: 1/50	Size: A0	Date: MARCH 2014

DRAWING NO	REV
JO8086-WLF-WLH-AB-ENV-GN-001 DET-201	A

GAMA POWER SYSTEM INC. AutoCAD & AutoPlant

Appendix 7: Proposed Locations for Noise Monitoring


Munayshir
National Park
Rum Farm
Al Ghal
Al Mudawwara
Legend
Proposed Noise Monitoring Locations
New_Well
Wells
Well_pipe
Places
Localities
WDP1
WDP2
WDP3
WDP4
WDP5
WDP6
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P8
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Appendix 8: Biodiversity Study Methodology

Approach/Methodology for the Biodiversity Study

1) Overview

The biodiversity survey will adopt a comprehensive approach to assess the biological environment by evaluating key ecological components in relation to their physical settings and shall be in compliance with IFC PS6. This methodology will aim to provide a holistic understanding of the potential environmental impacts a project may have on the local ecosystem.

The key steps involved in the approach will be as follows:

- **Biogeographical Zones and Vegetation Types:** The survey will begin by identifying the biogeographical zones and vegetation types within the area of interest. These zones will be critical for understanding the environmental conditions, such as soil type, climate, and natural plant communities, which influence the distribution of flora and fauna.
- **Flora Assessment:** A detailed examination of plant species will be conducted to evaluate the diversity, abundance, and conservation status of the vegetation. Special attention will be given to species that are endemic, rare, or threatened, as they may be more vulnerable to potential project impacts.
- **Fauna Assessment:** Key wildlife groups, including mammals, birds, and reptiles, will be selected for study based on their ecological importance, national conservation status, and sensitivity to habitat disturbance. The focus will be on species that could be affected by habitat changes or human activities.
- **Sensitive Habitats:** Areas of significant biological importance, such as protected areas, reserves, and key wildlife habitats, will be identified and assessed. These habitats will be vital for the survival of various species and will require careful consideration during project planning to ensure minimal disruption.
- **Ecosystem Services:** The study will evaluate the range of ecosystem services provided by the local environment. Potential impacts of the project on these services will be analyzed to ensure that ecosystem functions are preserved and not compromised by development activities.

2) Literature Review

As part of the study, a thorough review of existing literature will be undertaken to gather all relevant data from previous surveys, environmental impact assessments, and scientific research. This will help establish baseline conditions for the project area and highlight any existing knowledge gaps. Key areas of focus will include:

- **Flora and Fauna Species:** Reviewing the presence and distribution of plant and animal species, with particular attention to species of conservation concern, such as threatened or endangered species.
- **Habitat Types and Species Communities:** Investigating the types of habitats present and the species communities that define these habitats, will provide insight into ecological interactions and dynamics.

3) Fieldwork and Rapid Biodiversity Assessment

Fieldwork will be conducted to complement the findings from the literature review and gather on-the-ground data. Rapid biodiversity assessments will typically be scheduled over several days to survey key locations within the project area. At each site, observations of flora and fauna species will be recorded using standardized methods, such as:

- **GPS Mapping:** Handheld GPS devices will be used to record the coordinates of important species and habitats to ensure precise data collection.
- **Systematic Observation:** A structured approach to recording observations of species, habitat characteristics, and any signs of ecological disturbance will be followed to maintain accuracy and consistency in the data collection process.

This systematic approach will allow for a detailed evaluation of biodiversity, ensuring that any potential environmental impacts of the project are carefully considered and mitigated where necessary.

Appendix 9: Scoping Session Report

Environmental & Social Impact Assessment (ESIA) for Drilling New Make-up Wells and Associated Infrastructure Works – DUBAYDIB Well Field / Disi

Scoping Session Report

August 2024

Document Title: Scoping Session Report

Project: ESIA for Drilling New Make-up Wells and Associated Infrastructure Works – DUBAYDIB Well Field / Disi

Code AW146

Client: DIWACO

Main Contributors	Aspect/Section	Notes
Wafa Daibes	Check & Review	
Ghada Jaber	Check & Review	
Mohammed Al Jurf	All Sections	
Ghada Halaweh	Check & Review	

Project Code: AW146.00		Document No:		Controlled Copy No: 1	
Revision No	**Date**	**Description/Amendment**	**Checked**	**Reviewed**	**Authorized for Issue**
01	26/08/2024	Scoping Session Report	WD	WD	GJ

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Appendix 5: Questionnaire Filled by Each Working Group

List of Abbreviations

DIWACO	Disi Water Company
DAOM	Disi Amman Operation & Maintenance
ESIA	Environmental and Social Impact Assessment
MoEnv	Ministry of Environment
MWI	Ministry of Water and Irrigation
RSCN	Royal Society for the Conservation of Nature
ToR	Term of References
WAJ	Jordan Water Authority

1 Scoping Methodology

1.1 Invitations and Logistical Arrangements

Prior to the commencement of the Environmental and Social Impact Assessment (ESIA) scoping session, a preliminary Terms of Reference (ToR) document was prepared by the AJi team and submitted to the Ministry of Environment (MoEnv). The preliminary ToR provided the MoEnv with a project description, a proposed approach to completing the required ESIA study, including provisions of impact assessment criteria and methods for establishing mitigation measures to control (eliminate and/or minimize) those impacts identified as significant, and a list of identified project-related key issues. The Preliminary ToR document was submitted to MoEnv before the scoping session in order to facilitate the scoping process.

AJi team coordinated with the MoEnv to hold the scoping session on August 20th, 2024. The MoEnv prepared and sent the official invitations to relevant stakeholders including representatives from various ministries and governmental institutions, academia, relevant municipalities (Disi and local community), the Royal Society for the Conservation of Nature (RSCN), and all related stakeholders.

The location, date, and time of the session were as follows:

Location: Hilton Hotel-Amman

Date: Tuesday, August 20th 2024

Time: 10:00 am – 01:00 pm

1.2 Scoping Session Components

The Scoping Session consisted of the following:

Opening Statement:

- Eng. Fawaz Al-Karasneh Director of the Licensing Directorate at the Ministry of Environment.

ESIA Presentation:

- The first part of the presentation was provided by Eng. Wafa Daibes (AJi - Project Team Leader). Wafa presented an introduction and an overview about the scoping session and its objectives.
- Eng. Ghada Jaber (AJi - Process Design) and Eng. Mohammed Jurf (AJi - Environmental Engineer) led the second part of the presentation. Ghada provided a comprehensive overview of the project, including its description, technical components, area of influence, and objectives. Mohammed followed by discussing the findings of the site visit and presenting the assessment of project alternatives.
- The third part of the presentation was presented by Eng. Ghada Halaweh. Ghada presented the project's ESIA approach, legal framework and environmental/social potential impacts.

The detailed presentation is included in **Appendix 1.**

The following is a general outline of the presentation:

Part 1: Scoping Session Overview

- ESIA approach.
- Scoping session objectives and main stakeholders to the project.

Part 2: Technical presentation

- Project Description
- Project Current and Projected Components
- Project Area of Influence
- Project phases
- Wells General Layout
- Site Visit Findings
- Project alternatives including with or without project, and new makeup wells site alternatives.
- Questions and answers

Part 3: Environmental impact assessment

- Objectives.
- Legal framework
- ESIA Methodology
- Expected impacts
- Questions and answers

The stakeholders participated in discussions and a feedback period where they voiced their areas of concern. Detailed comments, discussions, and issues raised are included in section 2 below. Responses were subsequently given by:

- Eng. Khalil Al Wazir, Technical Manager, Dissi Water Company (DIWACO).
- Eng. Mohammad Abu Hamdeh, Operation & Maintenance Manager, Disi Amman Operation & Maintenance (DAOM).
- Eng. Mustafa Al Mazneh, Operator, (DAOM)
- Eng. Wafa Daibes, ESIA Team Leader, AJi.

Figure 1 below presents some pictures from the scoping session.

Appendix 2 includes additional photos from the scoping session.

ESIA Project Presentation

Working Groups

Figure 1: Pictures from the Scoping Session

2 Main Issues of Concern

2.1 Overview

The scoping session was attended by stakeholders from a number of organizations including, but not limited to: Ministry of Environment, Ministry of Local Administration, Ministry of Interior, Ministry of Energy and Mineral Resources, Royal Society For The Conservation of Nature, Ministry of Public Works and Housing, Ministry of Water And Irrigation, Water Authority of Jordan, Ministry of Health, Ministry of Agriculture , Ministry of Labor, Department of Lands and Survey and many others. A detailed list of participants (sign-in sheet) attended the scoping session is provided in **Appendix 3**.

The stakeholders raised their concerns, comments, and questions; a summary of these deliberations is provided in the next section.

The main issues of that were raised during the session can be summarized as following bullets:

- Participants emphasized the importance of considering how the project could impact farming operations near the Disi wellfield. Besides the potential impacts on the Disi aquifer as a whole from the water over pumping operations (agricultural and regional water extraction).
- The importance of identifying any cultural or archaeological heritage before commencing construction was highlighted.
- Concerns were raised regarding the potential for collapses or earthquakes due to the water extraction from the Disi aquifer.
- The importance of having an on-site clinic and ambulance to ensure the health and safety of workers during both construction and operation phases.
- The importance of the social impact, which includes local community development and water availability to meet demand.
- Project security and safety and the risk of theft and vandalism.

2.2 Scoping Session Deliberations

A summary of the discussions is provided below, which includes the outcome from the session's questions and answers.

Table 1: Summary of Comments and Feedback Discussed During the Session

No.	Name	Organization	Comment/ Feedback/ Concern	Response
1	Eng. Ruba Ennab	PMU at Jordan Water Authority (WAJ)	**Eng. Ruba** emphasized the need to confirm whether water mixing is occurring and whether sensitivity maps are being used during the construction phases. Eng. Ruba also inquired whether DIWACO has taken into account the nearby farms around the wellfield, particularly their water pumping activities and how these might be impacting the Disi aquifer.	**Eng. Khalil Al-Wazir (DIWACO)** stated that there is no mixing of water in the field because the mixing occurs in the two main reservoirs in Abu Alanda and Dabouq. **Eng. Wafa Daibes (AJi)** stated that the Sensitivity maps will be evaluated as part of the Environmental Impact Assessment later on. **Eng. Khalil Al Wazir (DIWACO)** confirmed that an updated model is conducted every five years to assess the aquifer. He noted that the water level in the wells decreases by 2-4 meters annually. Based on current studies, the aquifer is expected to remain sustainable, assuming a 1% annual increase in water extraction from the surrounding farms. He also confirmed that the planned additional wells will be drilled within the same 20x20 km field area, which is owned by the Ministry of Water and Irrigation (MWI) and is restricted from residential presence. Over the past 25 years, no significant issues have been observed; however, a decrease in flow rate may occur within the next 50 years. As of now, water levels remain within acceptable limits, and the model continues to align with actual conditions.

No.	Name	Organization	Comment/ Feedback/ Concern	Response
2	Dr. Reem Qashtawi	Ministry of Energy and Mineral Resources	**Eng. Reem** emphasized the need to clarify the criteria used for selecting the wells and whether drilling the wells impacts the recharge of the Disi reservoir. Eng. Reem emphasized the concern that draining the water might lead to collapses and earthquakes.	**Eng. Wafaa Daibes (AJi)** stated that the Disi aquifer is a non-renewable aquifer, and therefore, it has no recharge areas. During the study, the geology of the entire aquifer was thoroughly examined, and the layers of the wells were studied, along with the 11 criteria, to identify the best areas for wells in terms of productivity and well depth. **Eng. Mohammad Abu Hamdeh (DAOM)**, explained that the Disi aquifer consists of sandstone with a void ratio characteristic of sandstone, ensuring stability during water extraction. He emphasized that water has been extracted from the aquifer for over 10 years without any incidents of collapse.
3	Eng. Dalia Bannoura	Ministry of Public Works and Housing	**Eng. Dalia** emphasized that If any work is to be carried out on the main roads, approval or a permit must be obtained from the Ministry of Public Works.	**Eng. Wafa Daibes (AJi)** confirmed that no work will be conducted on the main roads. Instead, construction will be limited to establishing new service roads (dirt roads) within the wellfield area.
4	Eng. Iyad Al Hajibi	Jordan Engineers Association	**Eng. Iyad** emphasized the critical importance of preserving any cultural heritage or archaeological sites within the project area, particularly noting that certain rocks in these locations may hold	**Eng. Mustafa Al Mazneh (DAOM)** confirmed that there are no designated archaeological sites within the wellfield or project area. DIWACO also assures that any cultural heritage or archaeological sites within the project area will be identified during this ESIA study.

No.	Name	Organization	Comment/ Feedback/ Concern	Response
			significant archaeological and cultural value.	
5	Mrs. Reem Al Rouisi	Ministry of Health	**Mrs. Reem** proposed the use of solar power to operate the wellfield and pumps. She also inquired about the number of workers that would be employed during both the construction and operational phases.	**Eng. Mustafa Al Mazneh (DAOM)** mentioned that the electricity demand is significantly high. He noted that MWI has already implemented a solar panel project that provides 24 megawatts of power to the Disi primary station. **Eng. Khalil Al Wazir (DIWACO)** highlighted that the construction phase for each well is expected to last approximately three months and will involve around 15-20 workers. Multiple contractors will work sequentially during this phase. Once in operation, only two guards will be stationed at each well, with no additional workforce required for the operator. **Eng. Mustafa Al Mazneh (DAOM)** confirmed the presence of a clinic and an ambulance at the Mudawara station.
6	Mr. Mohammed Jamal	Ministry of Health	**Mr. Mohammed Jamal** emphasized the need of having a Clinic and an Ambulance in the site.	
6	Mr. Ayman Al Bowari	Ministry of Labor	**Mr. Ayman Al Bowari** noted that the Ministry of Labor regulations require the presence of a clinic, an emergency responder, and a technical specialist.	**Eng. Khalil Al Wazir (DIWACO)** confirmed the presence of a clinic at the Mudawara station and that 110 guards from the local community have been employed to safeguard the existing wells, as part of the company's commitment to

No.	Name	Organization	Comment/ Feedback/ Concern	Response
			He also highlighted the importance of considering whether the local residents will receive any form of compensation from a community perspective.	supporting the community. Additionally, several local community members are employed by the operator. The operator is dedicated to community support, having provided a garbage compactor truck, an ambulance, and assistance to local schools by supplying backpacks and other necessities for students. Trees have also been planted in the area. Furthermore, MWI and the Ministry of Local Administration have established a committee "DPAC" to assess and address the needs of the local community, ensuring that the operator can meet these needs in the future. **Eng. Wafa Daibes (AJi)** confirmed that the well area is confined to a (20x20) km zone and is owned by the Ministry of Water and Irrigation, leased to the operator. The local communities are located more than 5 km away from the project perimeter, the project's impact is not expecting to have negative impacts. There are some local demands focusing on jobs and community development. A section on stakeholder engagement will be included in the study report to consider all social aspects related to the local community.
7	Eng. Rawan Farhan	WAJ	**Eng. Rawan** emphasized the importance of prioritizing the social impact, even though the environmental impact is more apparent. She highlighted the need to give greater attention to how the project will affect the local community.	

2.3 Groups Deliberations

Following the presentation, attendees were divided into three working groups. Each group received a form, as outlined in **Appendix 4**, to assess potential environmental impacts during both the construction and operational phases.

The forms were used to evaluate the severity of each environmental and social component and to identify any additional components that may not have been initially considered. The completed forms from each group are provided in **Appendix 5**.

Table 2: Summary of Working Group (1) Findings

Group	Level of Impact	Comments
1	1. **Air Quality:** High to very high impact on the air quality during the construction phase due to dust and vehicle emissions, and limited to negligible impact during operational phase. 2. **Noise:** High to very high impact during construction phase, and limited to negligible impact during operational phase. 3. **Soil and Land:** High to moderate impact during construction phase due to oil spills and soil erosion, and limited to negligible impact during operational phase. 4. **Water Resources:** Moderate to limited impact on surface/ground water pollution during construction phase, and limited to negligible impact during operational phase. 5. **Waste Management:** Moderate impact for solid/liquid/hazardous waste during construction, and limited or negligible impact during operation. 6. **Biodiversity:** Moderate impact in disturbing habitat and negligible impact on affecting vegetation cover during construction phase, and limited to negligible impact during operational phase. 7. **Socio-economic:** Moderate impact on creating job opportunities for both construction and operation phases. 8. **Public Infrastructure and Utilities:** Limited to negligible impact to main roads and other service utilities during construction phase and no impact during operational phase.	Additional Impacts: 1. **Security and Safety:** Very high or high impact during construction phase and operational phase, due to the heightened risk of theft and vandalism. 2. **Local Community Demands:** High to moderate impact in both construction and operation phases, due to increased water demand and heightened expectations for the project to contribute to local community development.

Group	Level of Impact	Comments
	9. **Public Health and Safety:** Moderate impact during construction phase due to noise and dust, and no impact during operational phase. 10. **Occupational Health and Safety:** High to very high impact during construction phase due to the harsh climate situation in disi, and moderate impact during operational phase. 11. **Archeology and Cultural Heritage:** Limited to negligible impact in construction phase and no impact during operational phase. 12. **Climate Risks:** High to very high impact during construction phase due to the possibility of occurrence for flash floods, and moderate impact during the operational phase.	

Table 3: Summary of Working Group (2) Findings

Group	Level of Impact	Comments
2	1. **Air Quality:** High to moderate impact on the air quality during the construction phase due to dust and vehicle emissions, and limited to negligible impact during operational phase. 2. **Noise:** Moderate to high impact during construction phase because of the construction works, and limited to negligible impact during operational phase. 3. **Soil and Land:** Moderate impact during construction phase due to oil spills and soil erosion, and limited to negligible impact during operational phase. 4. **Water Resources:** Limited to negligible impact on surface/ground water pollution during construction and operation phases. 5. **Waste Management:** Moderate impact for solid/liquid/hazardous waste during construction, and limited or negligible impact during operation. 6. **Biodiversity:** Moderate impact in disturbing habitat and negligible impact on affecting vegetation cover during construction phase, and limited to negligible impact during operational phase. 7. **Socio-economic:** Moderate impact on creating job opportunities for both construction and operation phases. 8. **Public Infrastructure and Utilities:** Limited to negligible impact to main roads and other service utilities during construction phase and no impact during operational phase. 9. **Public Health and Safety:** Limited to negligible impact during construction phase	

Group	Level of Impact	Comments
	due to noise and dust, and no impact during operational phase. 10. **Occupational Health and Safety:** Moderate impact during construction phase due to the harsh climate situation in disi, and limited to negligible impact during operational phase. 11. **Archeology and Cultural Heritage:** Limited to negligible impact in construction phase and no impact during operational phase. 12. **Climate Risks:** Moderate impact during construction phase due to the possibility of occurrence for flash floods, and moderate impact during the operational phase.	

Table 4: Summary of Working Group (3) Findings

Group	Level of Impact	Comments
3	1. **Air Quality:** High to very high impact on the air quality during the construction phase, and limited to negligible impact during operational phase. 2. **Noise:** Moderate impact during construction phase, and limited to negligible impact during operational phase. 3. **Soil and Land:** Moderate impact during construction phase, and limited to negligible impact during operational phase. 4. **Water Resources:** Moderate to limited impact on surface/ground water pollution during construction phase, and limited to negligible impact during operational phase. 5. **Waste Management:** Moderate impact for solid/liquid/hazardous waste during construction, and limited or negligible impact during operation. 6. **Biodiversity:** Moderate impact in disturbing habitat and negligible impact on affecting vegetation cover during construction phase, and limited to negligible impact during operational phase. 7. **Socio-economic:** Moderate impact on creating job opportunities for both construction and operation phases. 8. **Public Infrastructure and Utilities:** Limited to negligible impact to main roads and other service utilities during construction phase and no impact during operational phase. 9. **Public Health and Safety:** High to very high impact during construction phase due to noise	Additional Impacts: 1. The impact on water quantity in the case of excessive pumping 2. The impact on the local wells in nearby farms.

Group	Level of Impact	Comments
	and dust, and no impact during operational phase. 10. **Occupational Health and Safety:** Moderate impact during construction phase due to the harsh climate situation in disi, and moderate impact during operational phase. 11. **Archeology and Cultural Heritage:** Moderate impact in construction phase and no impact during operational phase. 12. **Climate Risks:** Moderate impact during construction phase due to the possibility of occurrence for flash floods, and no impact during operational phase.	

Appendices

Appendix 1: Scoping Session Presentation

مشروع تقييم الأثر البيئي والاجتماعي لحفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

20, August,2024

البرنامج

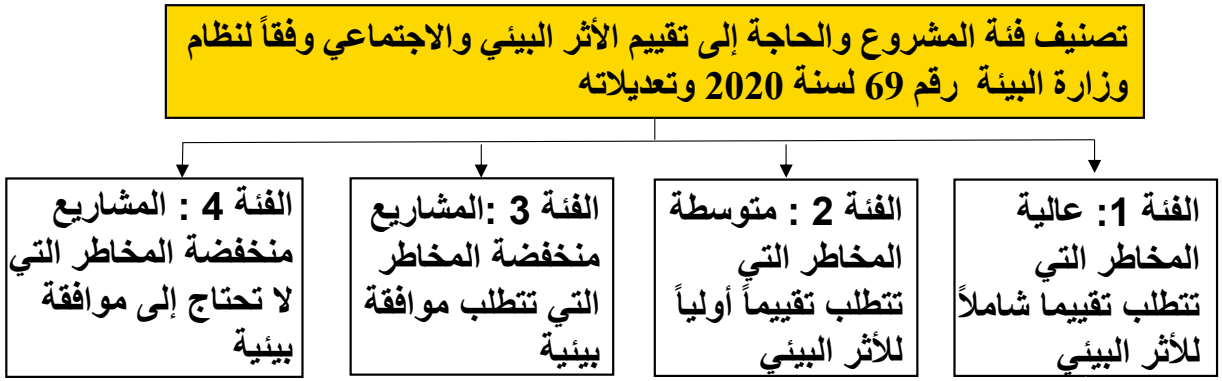
البرنامج

الوقت	النشاط
9:30 – 10:00	التسجيل
10:00 – 10:15	افتتاح الجلسة التشاورية والكلمات الترحيبية
10:15 – 10:20	الإجراءات المتبعة في تقييم الأثر البيئي
10:20 – 10:50	العرض الفني
10:50 – 11:05	استراحة
11:05 – 11:20	الآثار البيئية والاجتماعية المتوقعة
11:20 – 12:30	مجموعات العمل والنقاش
12:30 – 1:30	فترة الغداء

الكلمات الترحيبية

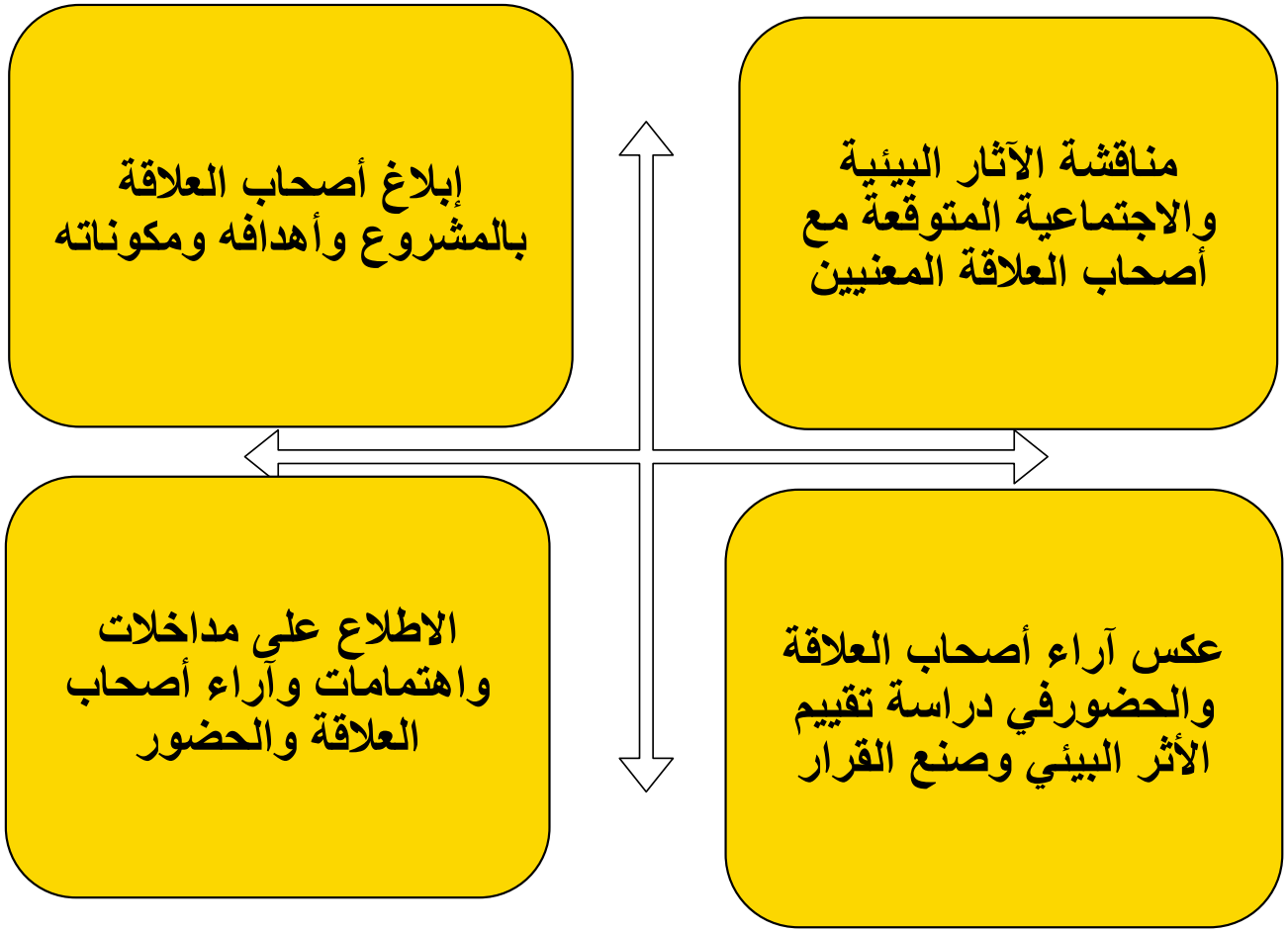
- افتتاحية وزارة البيئة :المهندس فواز الكراسنة، مدير مديرية التراخيص

الاجراءات المتبعة في تقييم الأثر البيئي

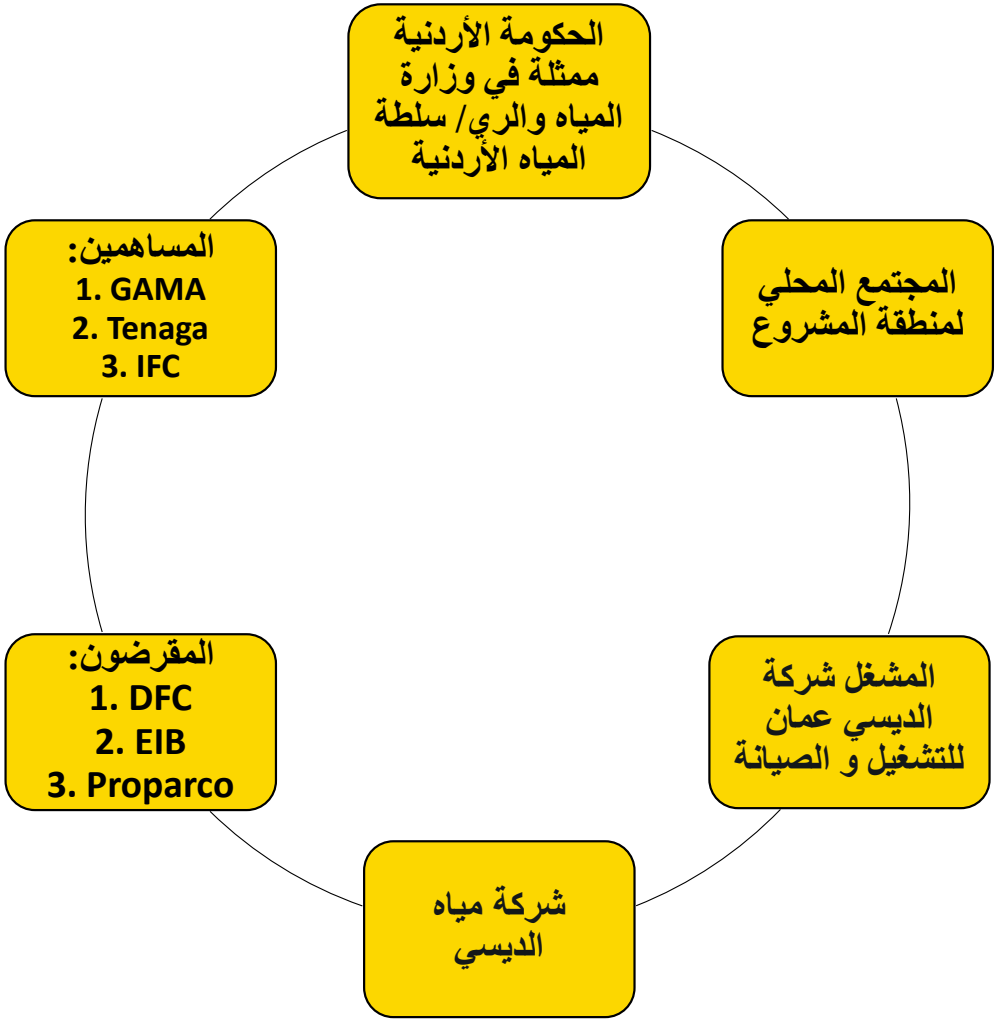


- إعداد وتقديم مسودة الشروط والأسس المرجعية
- إجراء الحلقة التشاورية
- إعداد وتقديم تقرير الحلقة التشاورية
- إرسال تقرير الشروط والأسس المرجعية النهائية
- البدء بإجراء دراسة تقييم الأثر البيئي وتقديم المسودة
- موافقة وزارة البيئة /عدم الموافقة

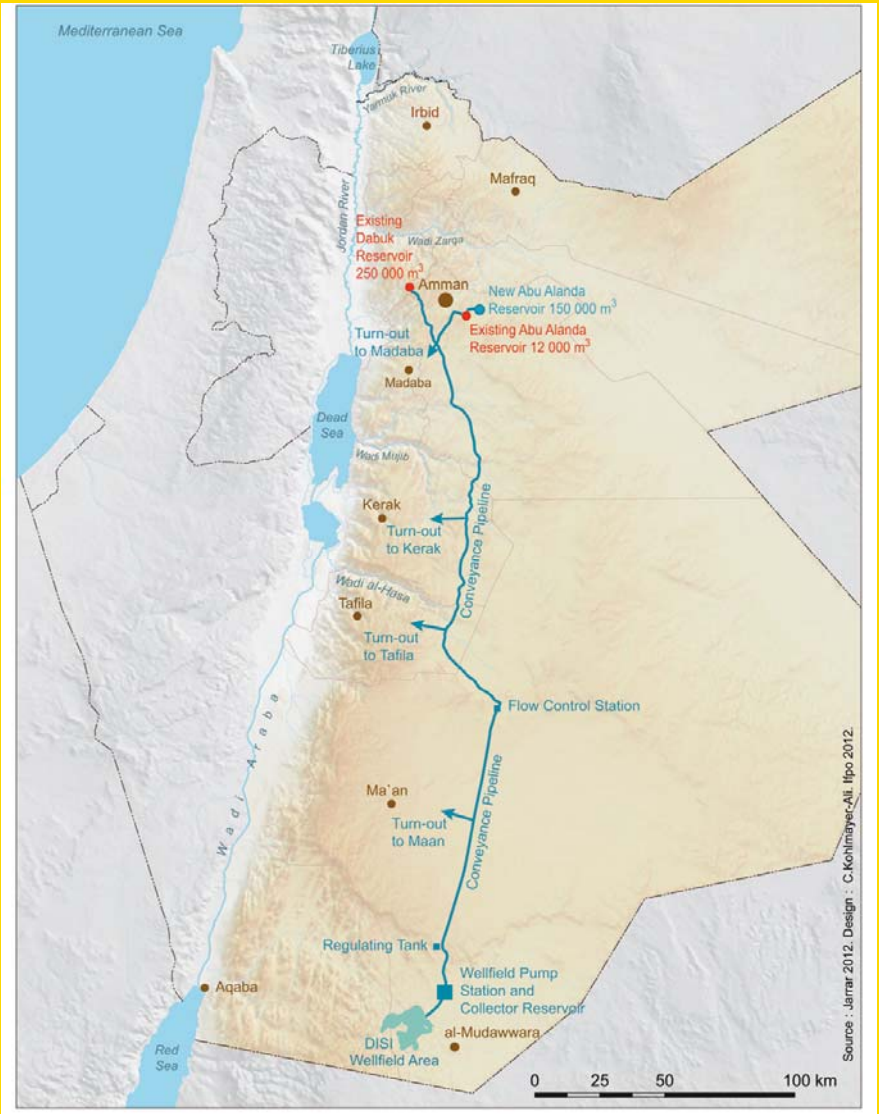
أهداف الجلسة التشاورية



أصحاب العلاقة الرئيسيون في الدراسة



العرض الفني



محتويات العرض الفني

- **وصف المشروع القائم :**
  - الموقع
  - المنطقة المخدومة للمشروع
  - مكونات وعناصر المشروع
- **مبررات المشروع الجديد " الآبار التعويضية المقترحة "**
  - وصف المشروع
  - مكونات المشروع
  - موقع المشروع
  - مراحل المشروع
- **بدائل المشروع**
  - تنفيذ المشروع / عدم تنفيذ المشروع
  - بدائل موقع الآبار

وصف المشروع

وصف مشروع الديسي القائم

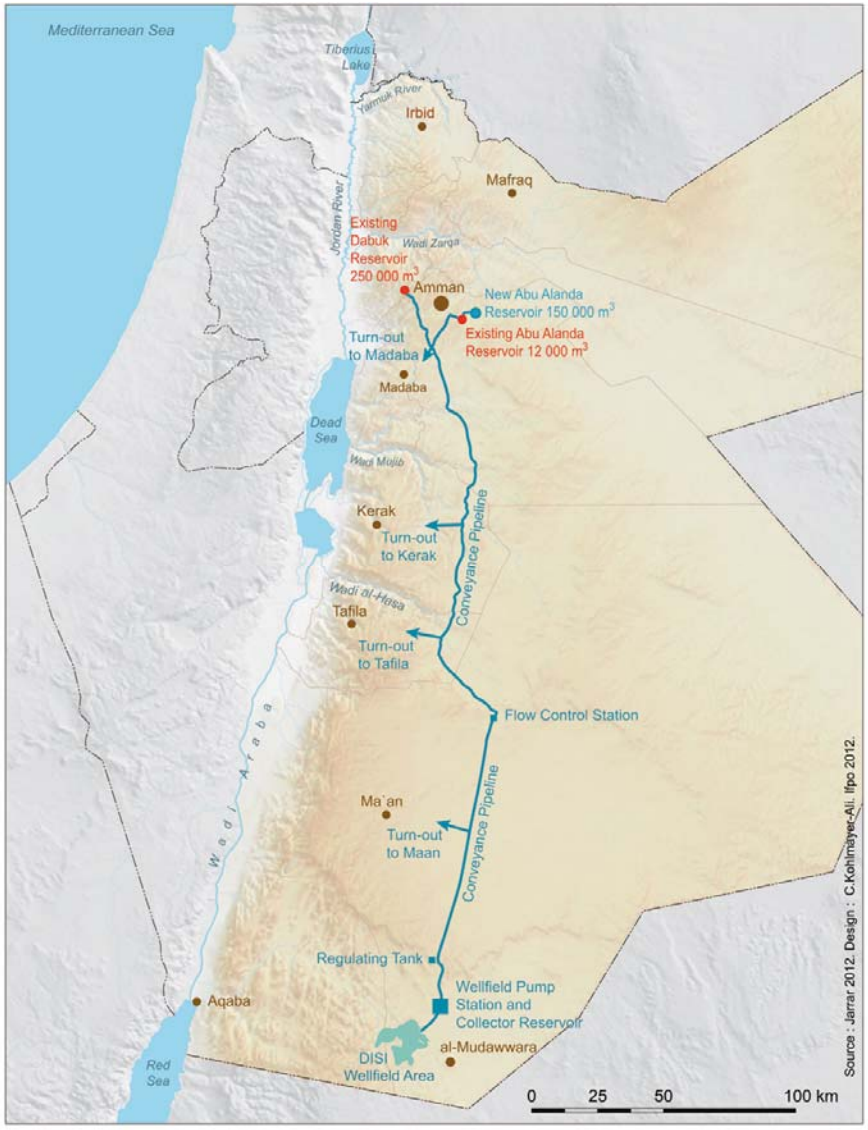
لمحة عامة :

- تم تصميم نظام نقل "مياه الديسي / المدورة إلى عمان" لتزويد 100 مليون متر مكعب سنوياً من مياه الشرب من طبقة الديسي الجوفية في جنوب الأردن "حقل بئر دبيدب" إلى منطقة عمان عبر خط أنابيب بمسافة 325 كم

- بدأ تشغيل المشروع 2014 حيث يعتبر المشروع جزءاً من الإطار الإقليمي الأكبر للحكومة الأردنية لإدارة المياه وتنمية الموارد الجديدة.

- يساهم المشروع في :

- حل مشكلة إمدادات المياه التي تعاني منها عمان والمنطقة المحيطة بها
- تحسين نوعية المياه التي يتم تزويدها إلى عمان
- تحسين ظروف الصحة العامة.



Source: Atlas

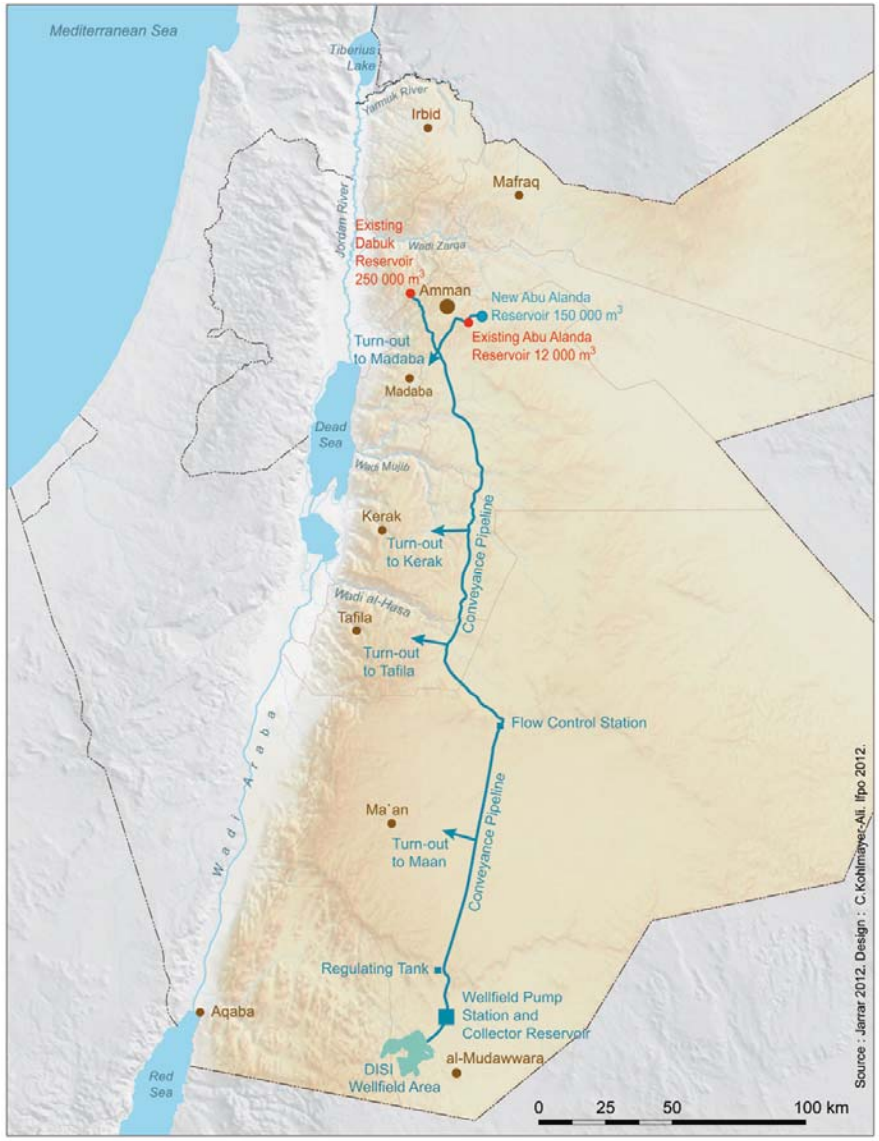
وصف مشروع الديسي القائم

موقع مشروع الديسي-عمان القائم

- منطقة المشروع هي المنطقة الواقعة على طول المسار الناقل للمياه من حقل بئر دبيدب إلى محافظة عمان مروراً بمعان و الطفيلة و الكرك و مادبا.
- يتم استخراج المياه بشكل رئيسي من حقل بئر دبيدب في منطقة الديسي- المدورة جنوب الأردن ونقلها إلى عمان.

المناطق المخدومة:

- مدينة عمان التي تستخدم مياه الديسي للاحتياجات المنزلية
- المدن الواقعة على طول مسار ناقل الديسي التي تُزود بمياه الطوارئ عند الحاجة : مادبا ، الكرك ، الطفيلة ،معان.



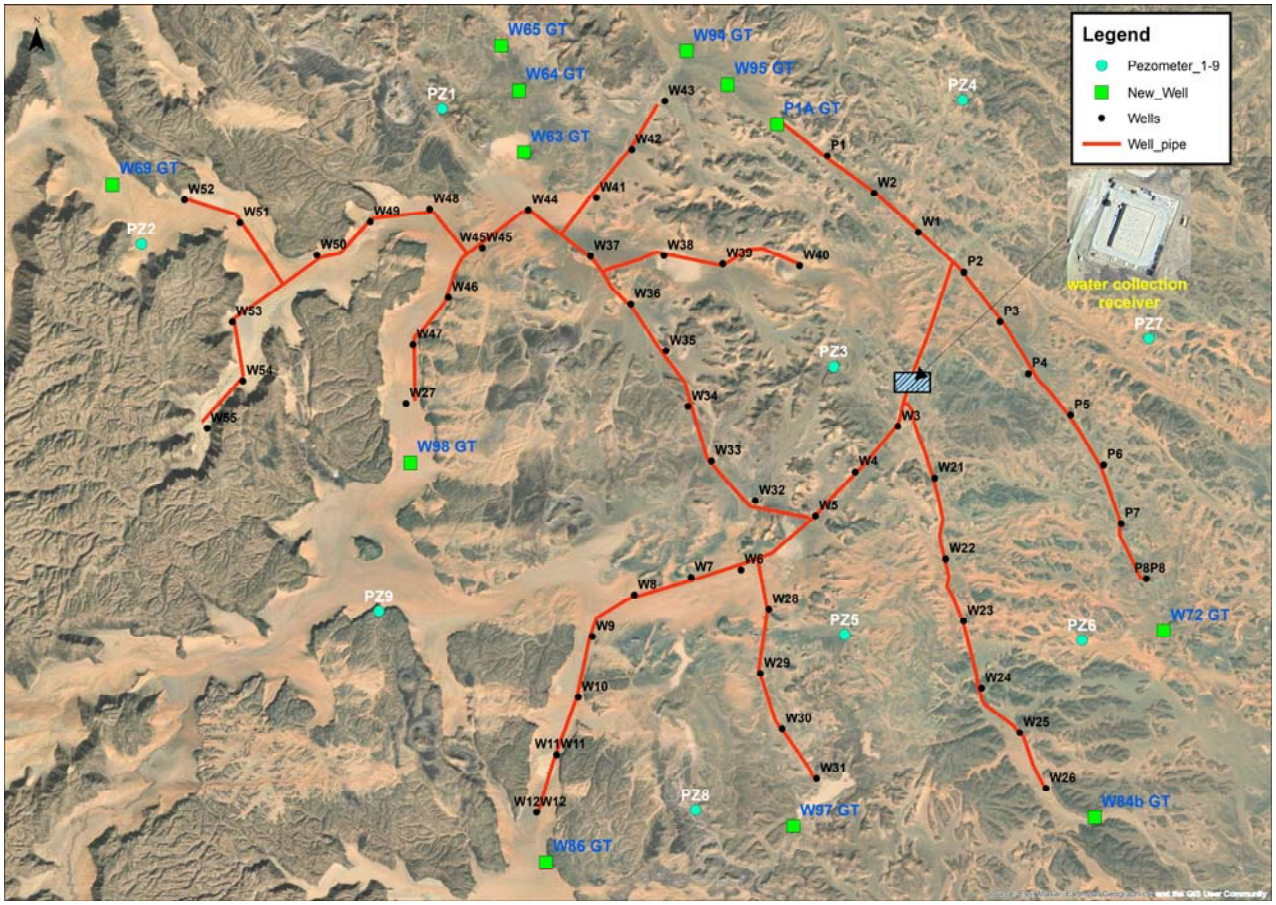
Source: Atlas

وصف مشروع الديسي القائم

لمحة عامة :

أ- مشروع الديسي-عمان القائم

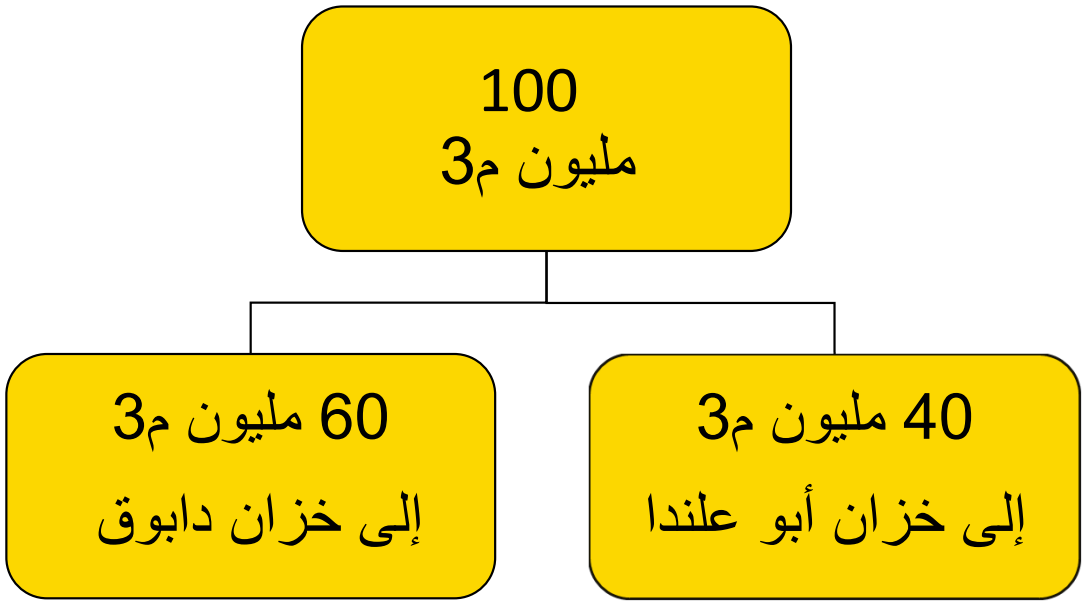
- يتكون مشروع الديسي-عمان القائم من 55 بئر جوفي إنتاجي: 46 بئرتم تشغيلها و 9 آبار احتياطية
- يتم جمع المياه من كل بئر من الآبار عبر شبكة تجميع "متفرعة" ويتم توصيلها إلى خزان تجميع شمال حقل الآبار بواسطة خط تجميع رئيسي.
- يتضمن المشروع 9 آبار مراقبة ومرافق تشغيلية التي تنقل المياه لمسافة حوالي 325 كم لتزويد 100 مليون م3 سنويًا من المياه إلى عمان.



وصف مشروع الديسي القائم

لمحة عامة

- يتم استقبال المياه في خزانين : خزان دابوق (غرب عمان) و خزان أبو علندا (شرق عمان)
- تم تصميم النظام لينقل تدفقًا سنويًا قدره 100 مليون متر مكعب :

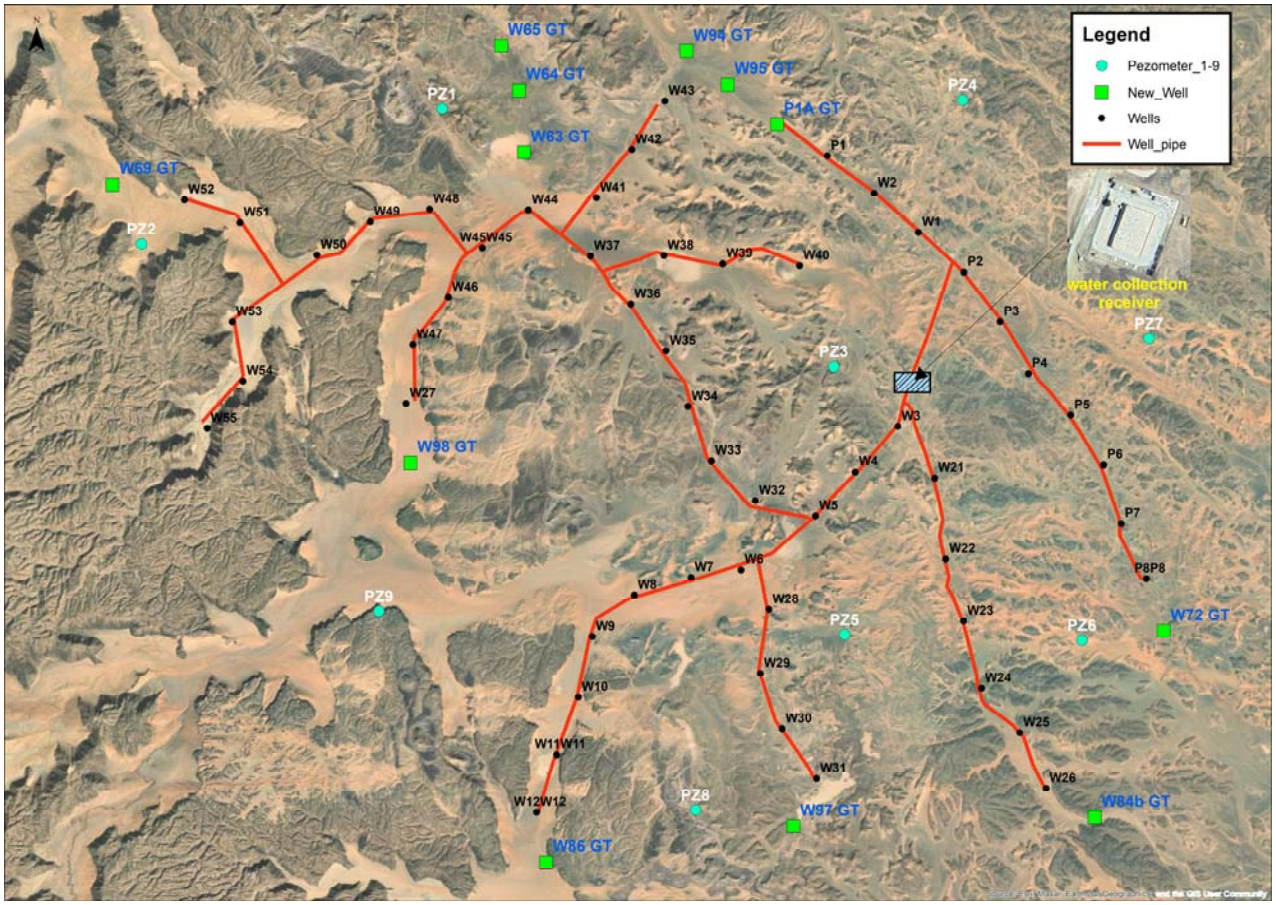


وصف مشروع الديسي القائم

لمحة عامة :

ب- تحسينات تم إجراءها على التصميم الرئيسي للمشروع بهدف زيادة إنتاج الآبار :

- تم تشغيل 4 آبار احتياطية (50 بئر تم تشغيها ، 5 آبار احتياطية.
- تم تحديث و زيادة سعة المضخات في محطة ضخ المدورة. إن كمية المياه التي تم ضخها من الآبارأصبحت حوالي 111.06 مليون م3 في عام 2023 .

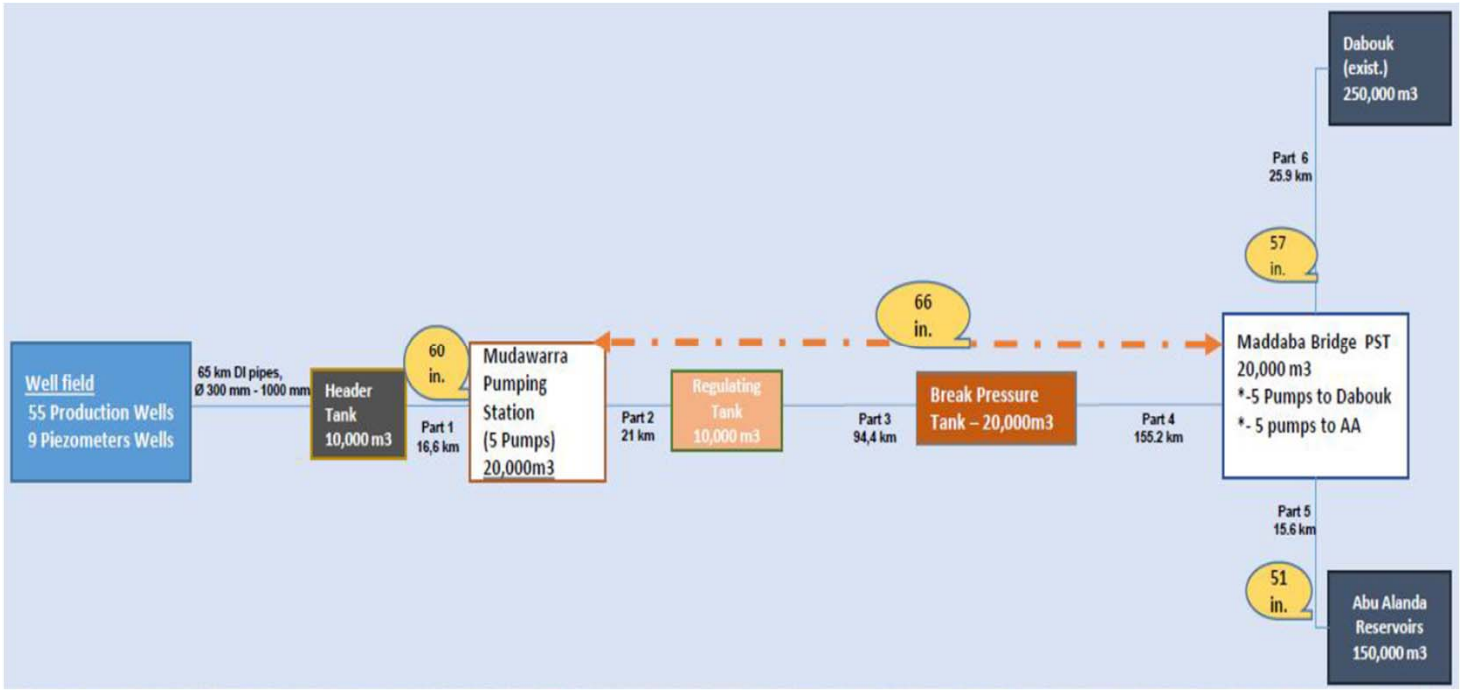


وصف مشروع الديسي القائم

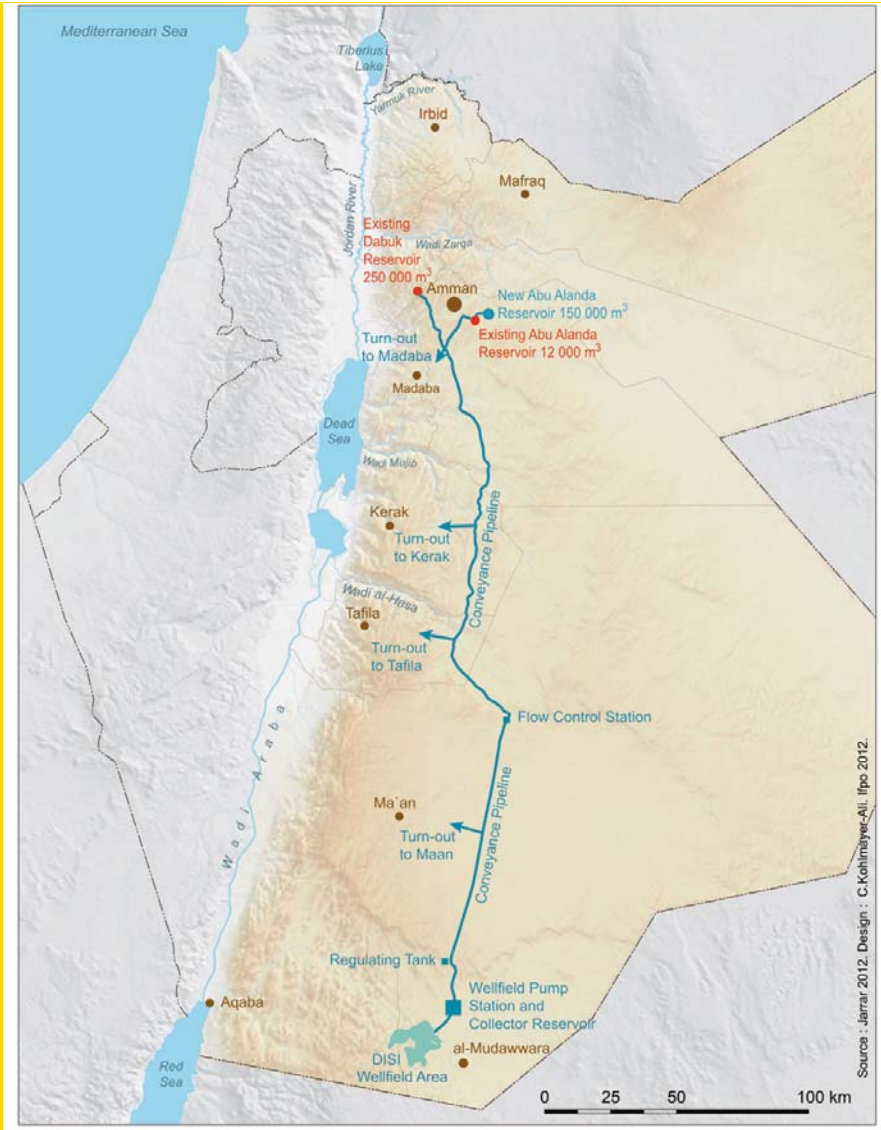
مكونات مشروع الديسي القائم:

تشمل المكونات الرئيسية القائمة لمشروع ديسي -عمان :

- حقل بئر يتكون من 55 بئر جوفي إنتاجي:
  - 50 بئراً قيد التشغيل و5 آبار احتياطية
- شبكة تجمع حقل الآبار
- خط الأنابيب الرئيسي
- خزان تجميعي
- محطتي ضخ في المدورة ومادبا على التوالي.
- خزانات منظم التدفق.
- خزان كاسر الضغط .
- الخزانات (خزان أبو علندا وخزان دابوق)
- المباني الملحقة المرتبطة بها
- البنية التحتية لإمدادات الطاقة والاتصالات
- طرق الوصول والخدمة



المخطط التفصيلي للمكونات الرئيسية لمشروع الديسي-عمان



Source: Atlas

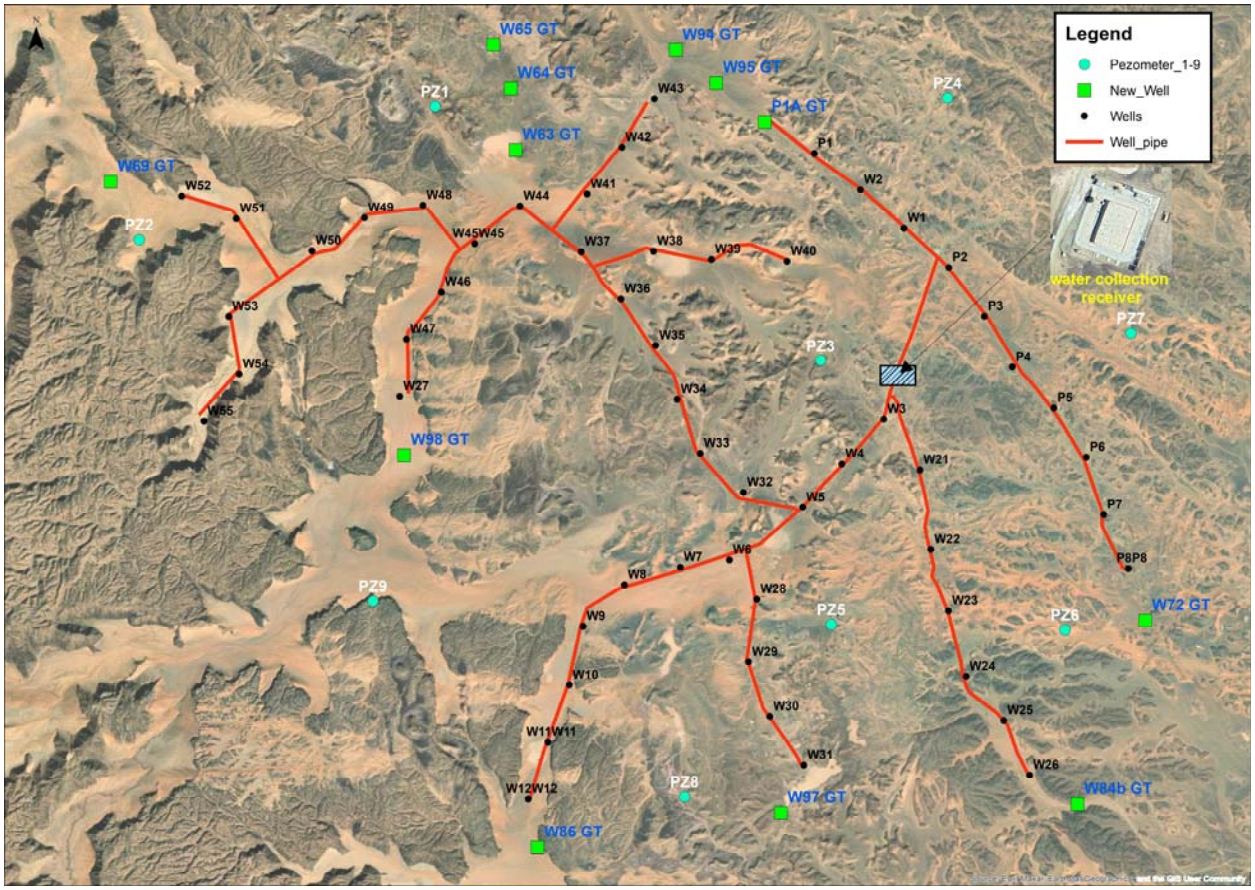
مبررات المشروع الجديد

- **مبررات المشروع :**

- نتيجة لارتفاع الطلب على المياه ،منذ عام 2018 وخصوصاً في فصل الصيف، فقد طلبت وزارة المياه والري من شركة مياه الديسي زيادة كميات تزويد المياه إلى أكثر من 100 مليون متر مكعب.

- لتلبية هذه الزيادة في الطلب على المياه ، تخطط شركة مياه الديسي لإجراء أعمال إضافية " حفرآبار إنتاجية جديدة إضافية (الآبارالتعويضية) " لزيادة إنتاج حقل الآبار بما يصل إلى 120 مليون متر مكعب سنويًا.

وصف المشروع

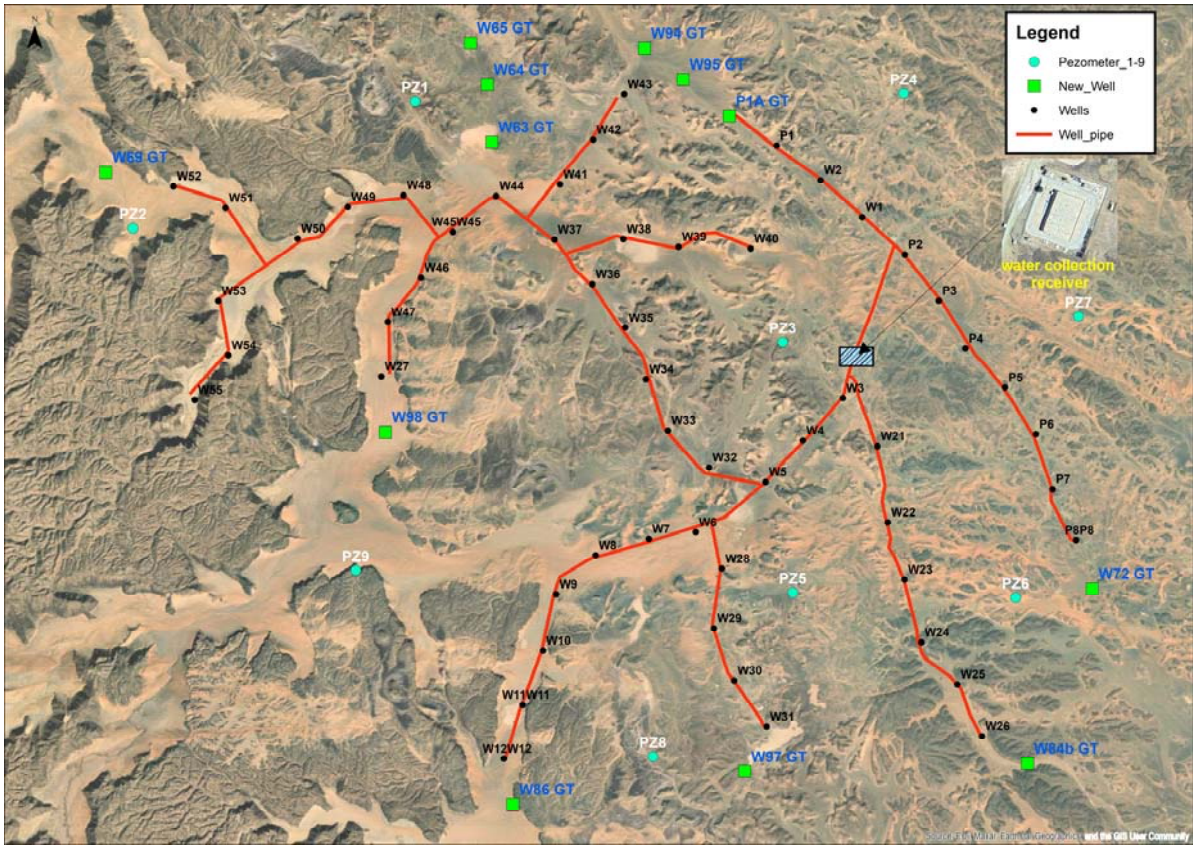


لمحة عامة :

أ- الآبار التعويضية المقترحة

- إضافة آبار حسب الحاجة
- الهدف الإنتاجي لكل بئر إنتاج جديد بين 70 إلى 80 لتر/ثانية.

مكونات المشروع



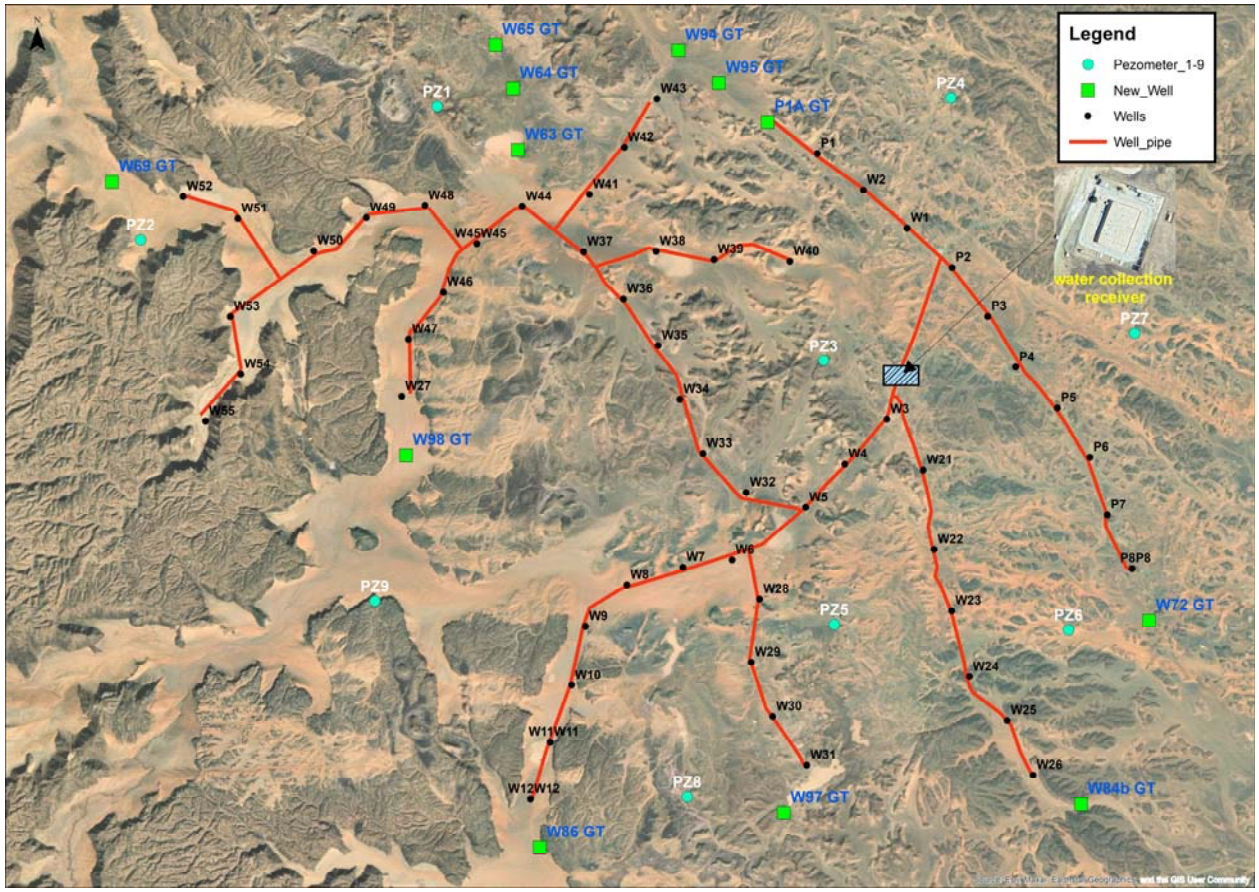
مكونات المشروع الرئيسية التي سيتم تغطيتها أثناء إعداد دراسة تقييم الأثر البيئي :

1. حفر آبار جوفية جديدة.
2. إنشاء البنية التحتية ذات الصلة لتجميع ونقل المياه إلى الخزان القائم.
3. إنشاء شبكة الطرق الداخلية لربط الآبار الجديدة بأجزاء المشروع القائمة في منطقة المدورة.

موقع الآبار المقترحة

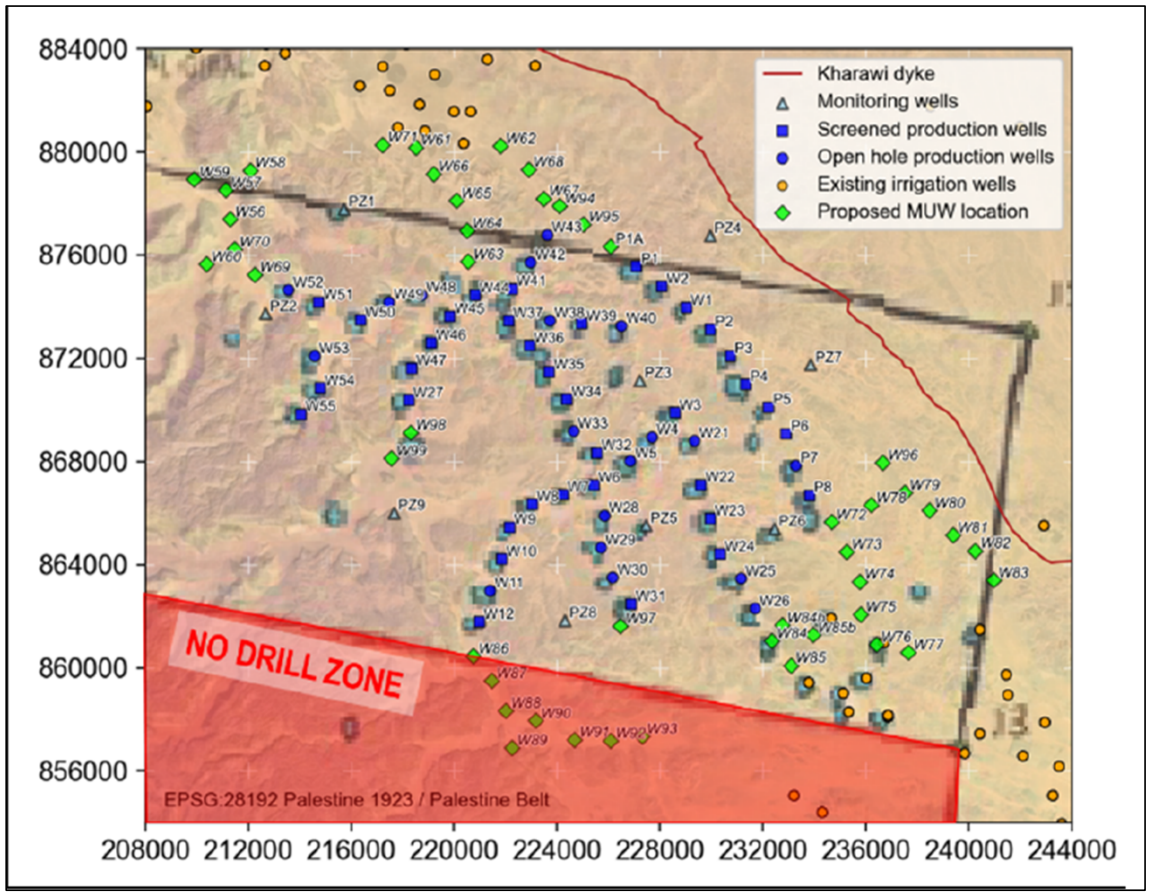
تم تحديد وتأكيد 12 موقع للآبار التعويضية الجديدة ضمن حقل آبار الدبيدب وذلك بناءً على:

- التضاريس و المعايير الجيولوجية
- متوسط المسافة بين الآبار البالغ 1,250 متر
- متطلبات أصحاب العلاقة .
- المنطقة المحمية التي يحظر فيها استخراج المياه الجوفية كما هو موضح بالاتفاقية بين حكومة الأردن و السعودية .



خريطة ل 12 موقع للآبار التعويضية الجديدة

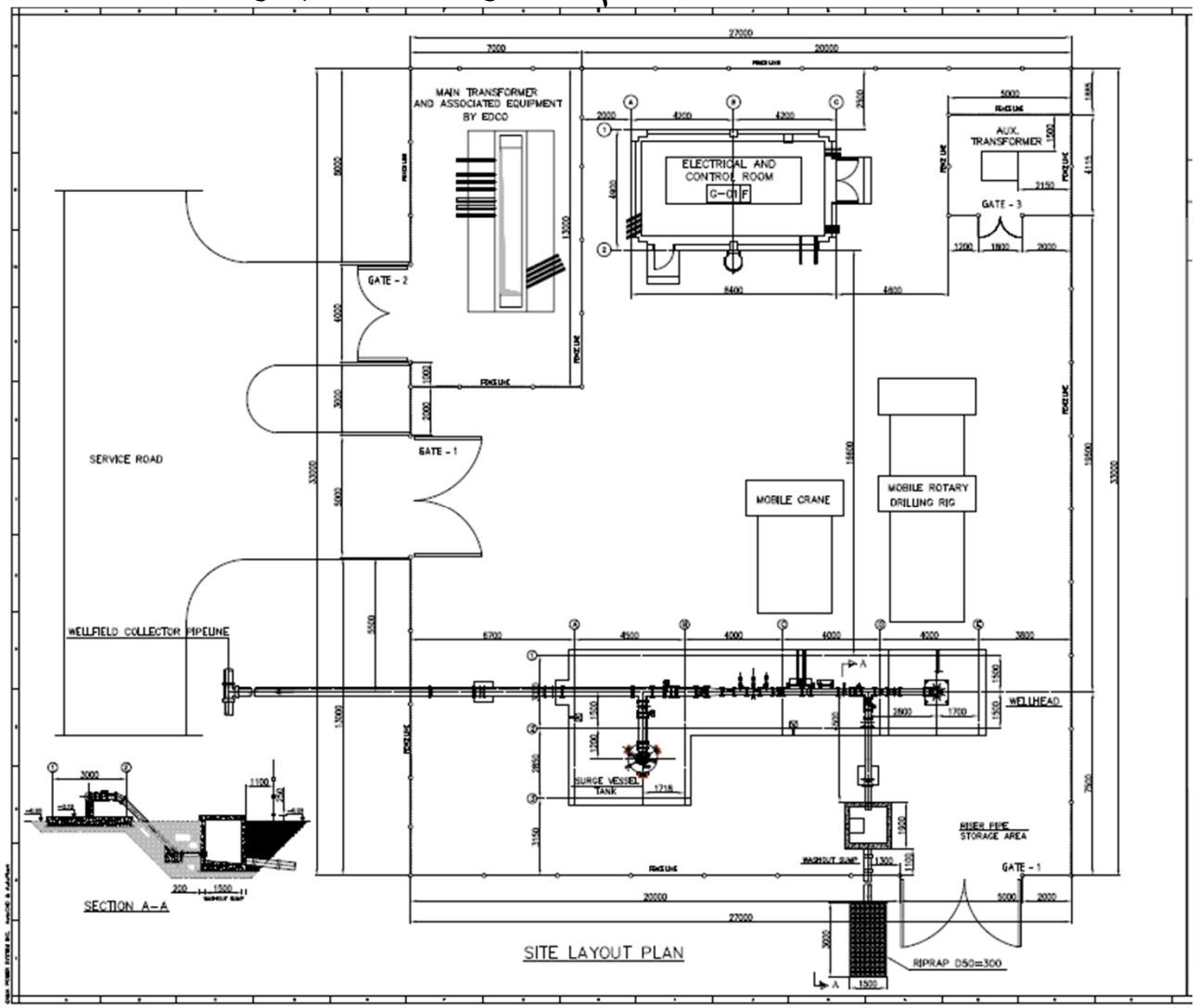
اتفاقية بين الأردن و السعودية لإدارة المياه الجوفية في طبقة الساق/الديسي



المنطقة المحمية (المحظورة) " المحددة في اتفاقية الأردن والمملكة العربية السعودية

- وقع الأردن والمملكة العربية السعودية "اتفاقية من أجل إدارة واستثمار المياه الجوفية في طبقة الساق/ الديسي" في عام 2015.
- تتضمن هذه الاتفاقية تعريف :
- "منطقة الإدارة"، حيث يجب أن تكون عمليات استخراج المياه الجوفية مخصصة لأغراض البلدية فقط.
- "المنطقة المحمية (المحظورة)"، حيث يحظر الحفر لاستخراج المياه الجوفية في هذه المنطقة.

المخطط العام لمكونات الآبار



صور تم التقاطها خلال زيارة موقع المشروع 30-31/7/2024

بئر إنتاجي

صور تم التقاطها خلال زيارة موقع المشروع 30-31/7/2024

بئر مراقبة

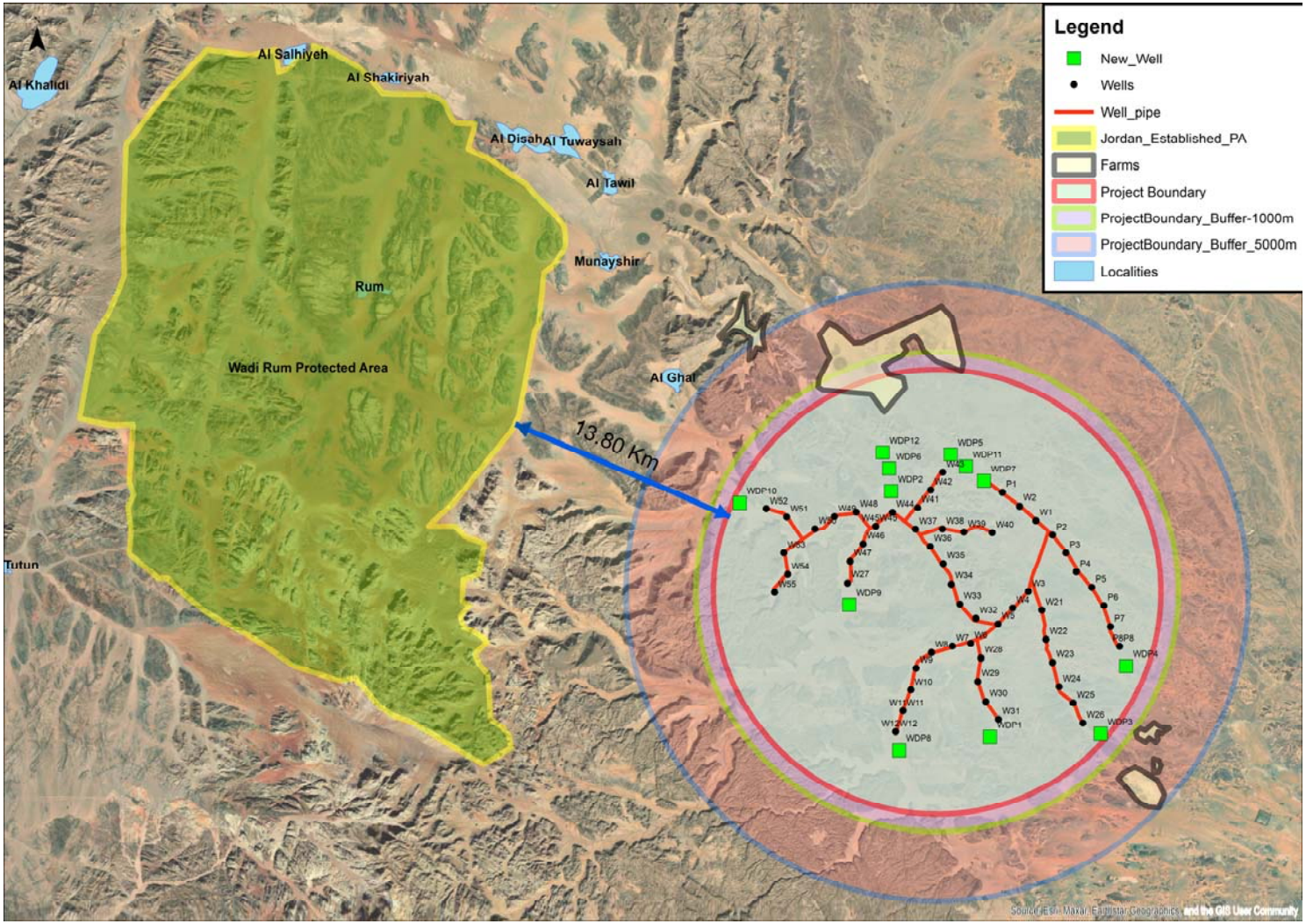
صور تم التقاطها خلال زيارة موقع المشروع 30-31/7/2024

محطة المدورة

صور تم التقاطها خلال زيارة موقع المشروع 30-31/7/2024

الموقع العام

العناصر المحيطة بالمشروع المقترح



مراحل المشروع

مكونات المشروع الرئيسية التي سيتم تغطيتها أثناء إعداد دراسة تقييم الأثر البيئي :

- سيغطي تقييم الأثر البيئي والاجتماعي المراحل التالية:

- مرحلة البناء التي تتضمن حفر آبار المياه التعويضية الجديدة، والربط بشبكة الأنابيب الحالية و/أو شبكة جديدة، وطريق الخدمة داخل منطقة حقل الآبار.
- مرحلة التشغيل لمختلف المرافق المشيدة حديثاً في جميع مراحل المشروع.
- مرحلة إنهاء تشغيل المشروع.

بدائل المشروع

بدائل المشروع

تنفيذ المشروع / عدم تنفيذ المشروع

بدائل الموقع

بدائل المشروع

عدم تنفيذ المشروع

عدم تنفيذ المشروع سيؤدي إلى أثار سلبية بما في ذلك :

- تدهور في إمدادات المياه في عمان و خصوصاً في فصل الصيف
- تأثير على الصحة العامة

بدائل المشروع

تنفيذ المشروع

المشروع لديه مساهمات إيجابية بما في ذلك :

المساهمة في حل مشكلة إمدادات المياه التي تعاني منها عمان والمنطقة المحيطة بها

تحسين نوعية المياه التي يتم تزويدها إلى عمان

تحسين ظروف الصحة العامة

توفير إمدادات المياه في حالات الطوارئ للمجتمعات على طول الخط الناقل

معايير اختيار مواقع الآبار

المعايير الأولية لاقتراح مواقع الآبار الجديدة

- التضاريس و المعايير الجيولوجية.
- متوسط المسافة بين الآبار البالغ 1,250 متر .

تم تقييم هذه المواقع المقترحة للآبار خلال 3 مراحل رئيسية:

المرحلة الأولى:

تمت مراجعة جميع البيانات الجيولوجية والعلمية المتاحة لحقل الآبارحيث تم تقييم كل موقع بئر جديد بناءً على 11 معيار، حيث تتوافق هذه المعايير مع خمسة (5) مخاطر رئيسية، هم:

- كمية المياه الجوفية.
- جودة المياه الجوفية.
- القدرة على تنفيذ الآبار.
- تكاليف الأنابيب.
- الموقع المقترح للبئر بالنسبة للمنطقة المحمية " المحظورة " بناءً على اتفاقية خاصة بين الأردن والمملكة العربية السعودية التي تمنع الحفر في المنطقة الجنوبية لحقل الآبار.

معايير اختيار مواقع الآبار

معايير اختيار مواقع الآبار

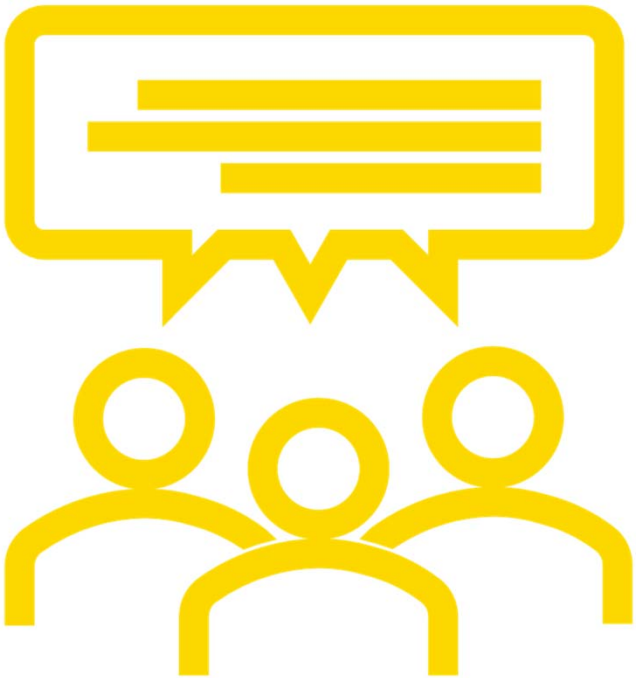
المرحلة الثانية:

تم حساب التقييم الإجمالي لجميع المعايير لكل بئر، وذلك كمجموع موزون لكل معيار. تُظهر هذه الطريقة الموزونة منظور إدارة المخاطر و منظور كل خطر من وجهة نظرأصحاب العلاقة .

المرحلة الثالثة:

تم عقد ورشة عمل جماعية في عمان مع أصحاب العلاقة الرئيسيين لحقل آبار الدبيديب. وتم تحديد اثني عشر موقعًا لإجراء مزيد من التقييم خلال الزيارات الميدانية ،حيث تم ترتيب الآبار ال 12 حسب أولوية الحفر .

أسئلة وأجوبة حول المشروع المقترح



تقييم الأثر البيئي و الاجتماعي

نظرة عامة على العرض التقديمي - تقييم الأثر البيئي والاجتماعي

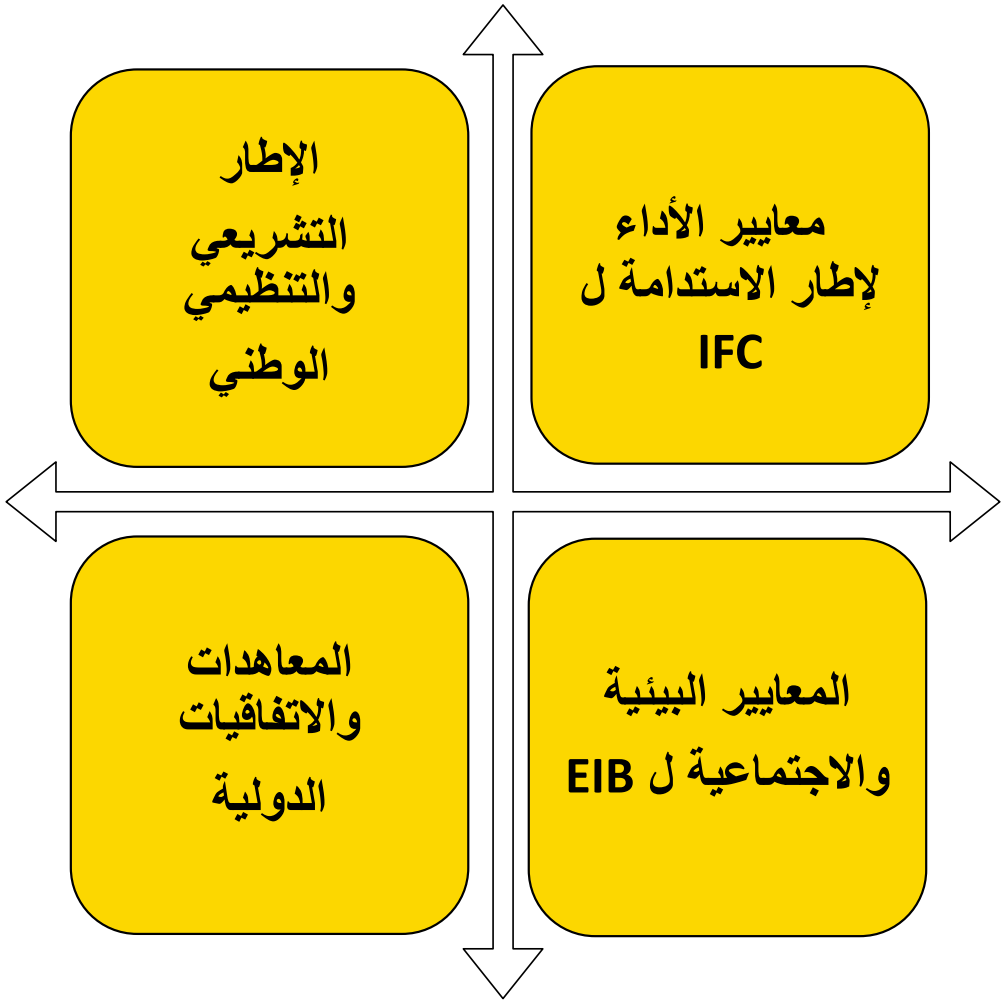
- أهداف تقييم الأثر البيئي والاجتماعي
- الإطار القانوني والتنظيمي
- المراحل الرئيسية لتنفيذ دراسة تقييم الأثر البيئي والاجتماعي
- أقسام تقرير دراسة تقييم الأثر البيئي والاجتماعي
- منهجية تقييم الوضع القائم
- الآثار البيئية المتوقعة للمشروع
- مجموعات العمل و النقاش

أهداف تقييم الأثر البيئي والاجتماعي

تهدف الدراسة إلى:

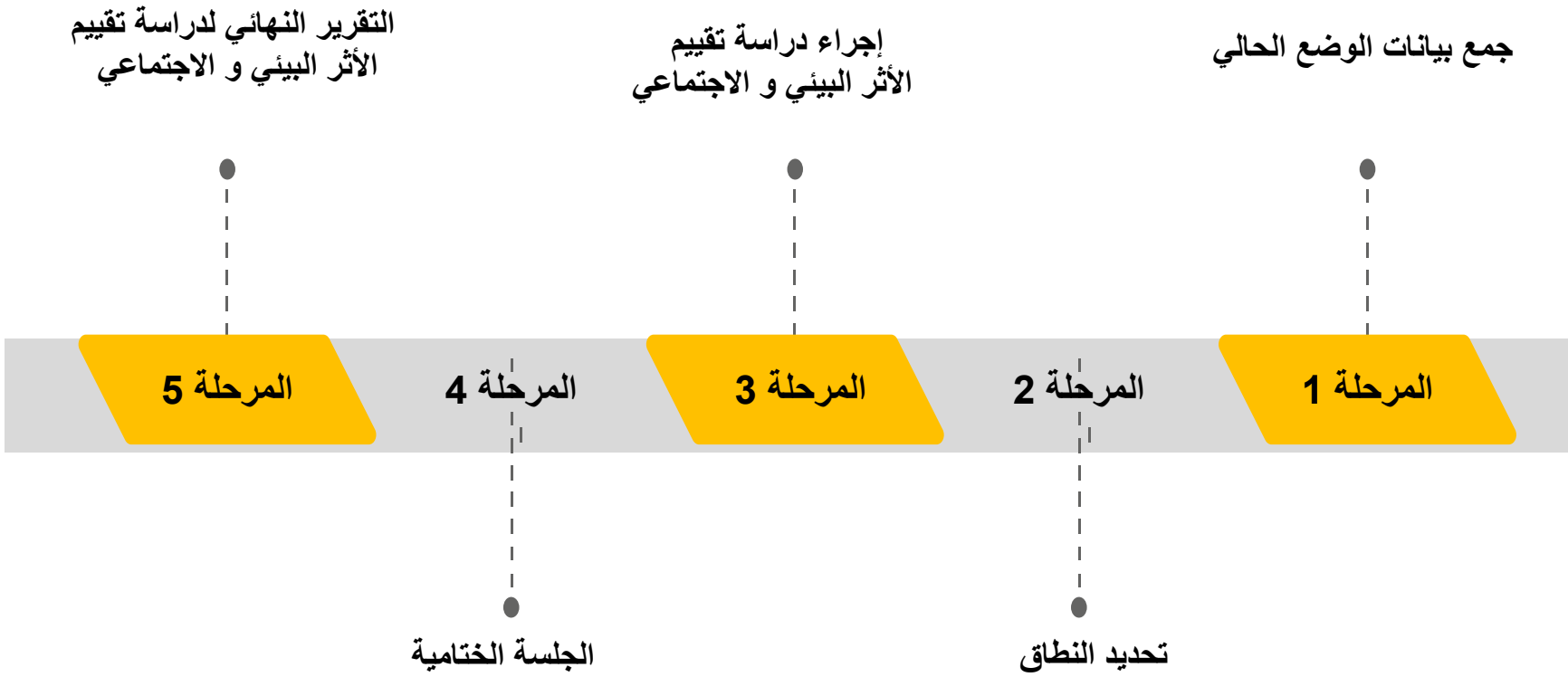
- تقييم الآثار البيئية والاجتماعية المحتملة للمشروع
- تغطي الدراسة دورة حياة المشروع بأكملها
- اقتراح تدابير مناسبة وقابلة للتنفيذ للحد من الآثار المحتملة ووضع خطة لإدارتها

الإطار القانوني والتنظيمي



المراحل الرئيسية – تقييم الأثر البيئي والاجتماعي

سيتم تنفيذ دراسة تقييم الأثر البيئي من خلال المراحل الرئيسية التالية:



أقسام تقرير دراسة تقييم الأثر البيئي والاجتماعي

وصف المشروع وتقييم البدائل

- وصف المشروع
- تقييم البدائل

تقييم الظروف البيئية والاجتماعية للوضع القائم

- قياسات نوعية الهواء والضجيج
- مراجعة الأدبيات والدراسات العامة
- استطلاعات وتقييمات ميدانية
- استشارة أصحاب العلاقة

تحديد وتقييم الأثر

- تحديد حساسية المستقبل كما تم تقييمها في الظروف الحالية
- تحديد طبيعة وقيمة الأثر
- تقييم أهمية الأثر

خطة الإدارة البيئة والاجتماعية

- تحديد تدابير التخفيف الممكنة لكل أثر سلبي

منهجية تقييم الوضع القائم

البيئة الفيزيائية

- نوعية الهواء، الضجيج، الأرصاد والمناخ، الجيولوجيا، التضاريس، التربة، موارد المياه، تقييم مخاطر المناخ... الخ.

البيئة البيولوجية

- النباتات والحيوانات والمناطق ذات الأهمية البيولوجية (المناطق المحمية ومناطق الطيور المهمة والمحميات الطبيعية والمناطق الحساسة).

الظروف الاجتماعية والاقتصادية

- السكان وطبيعة التركيب السكاني في محيط منطقة المشروع
- الوضع الاقتصادي
- البنية التحتية ومرافقها

الموارد الثقافية والآثرية

- قاعدة بيانات الآثار الأردنية ونظام المعلومات (MEGA Jordan)
- دائرة الآثار الأردنية

مصفوفة تقييم الأثر البيئي و الاجتماعي

المستقبلات		الفيزيائية						البيولوجية			الاجتماعية - الاقتصادية							
النشاط		جودة الهواء	الضجيج	التربة	المياه الجوفية	هيدرولوجيا	المناظر الطبيعية/ التضاريس	النباتات (الموائل)	طيور	الزواحف والثدييات	السلامة و الصحة العامة	السلامة و الصحة العامة	السكان	استخدام الأراضي	القوى العاملة والتوظيف	المرافق والبنية التحتية	النقل والمرور	التراث الثقافي والأثري
الأنشطة المخططة																		
ما قبل البناء	مسارات الوصول																	
	المسح الميداني																	
	التحقيق في الموقع																	
	الاستحواذ على الأراضي																	
البناء	طريق الوصول إلى الموقع																	
	اماكن الاقامه																	
	النقل																	
	مسح الموقع																	
	فحص تربة الموقع																	
	أعمال الحفر																	
	نقل العمالة والمعدات																	
	بناء المضخات																	
	تشييد المباني / الآلات																	
	النفايات الناتجة عن أنشطة البناء																	
	مياه الصرف الصحي الناتجة عن عمال الموقع																	

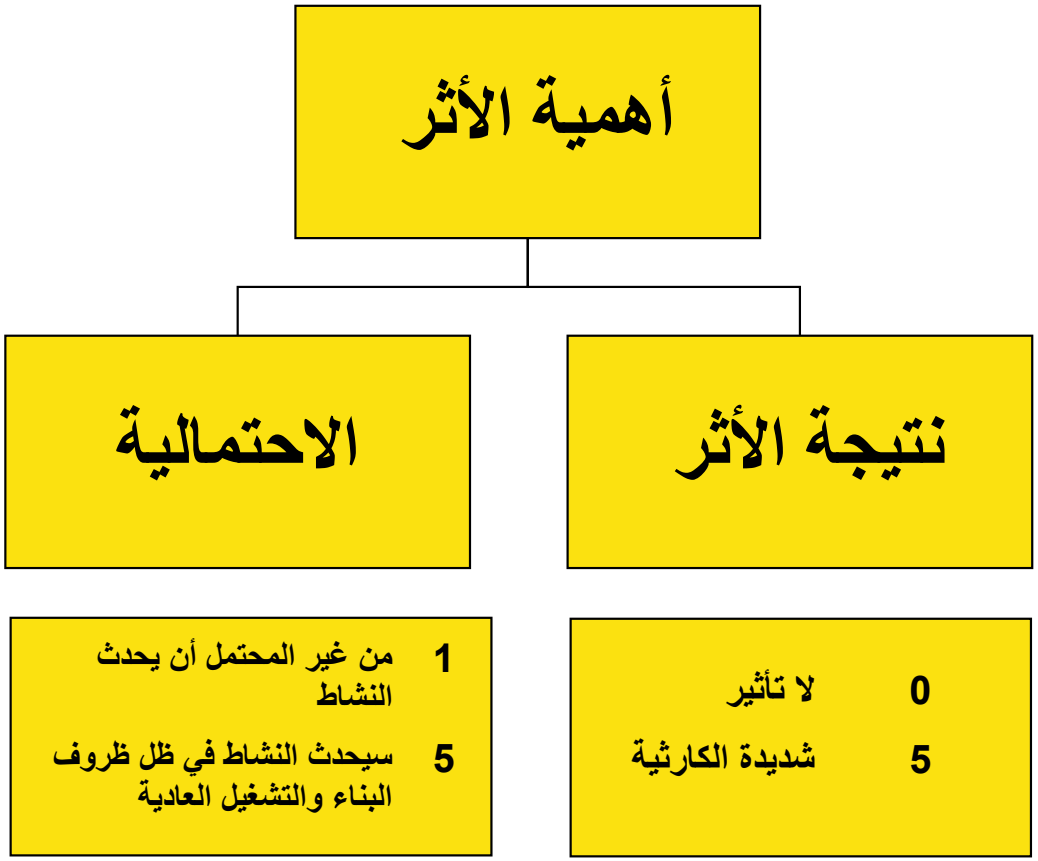
مصفوفة تقييم الأثر البيئي و الاجتماعي

المستقبلات		الفيزيائية						البيولوجية			الاجتماعية - الاقتصادية							
النشاط		جودة الهواء	الضجيج	التربة	المياه الجوفية	هيدرولوجيا	المناظر الطبيعية/ التضاريس	النباتات (الموائل)	طيور	الزواحف والثدييات	السلامة و الصحة العامة	السلامة و الصحة العامة	السكان	استخدام الأراضي	القوى العاملة والتوظيف	المرافق والبنية التحتية	النقل والمرور	التراث الثقافي والأثري
التشغيل	نقل مياه الصرف الصحي إلى الموقع																	
	المعالجة الأولية																	
	المعالجة الثانوية																	
	ضخ مياه الصرف الصحي المعالجة للتصريف																	
	معالجة الحمأة																	
	إدارة الحمأة																	
	معالجة النفايات الصلبة البلدية																	
	انبعاثات الهواء																	
	تخزين النفايات الخطرة / الكيميائية والتخلص منها																	
	استهلاك المواد الكيميائية / تخزين النفط																	
	تشغيل المركبات																	
	أنشطة الصيانة																	
الهدم	معدات التفكيك																	
	هدم البنية التحتية للمبانى والتخلص منها																	
	إزالة السياج																	
	الحفر والردم																	
	ترميم الموقع																	

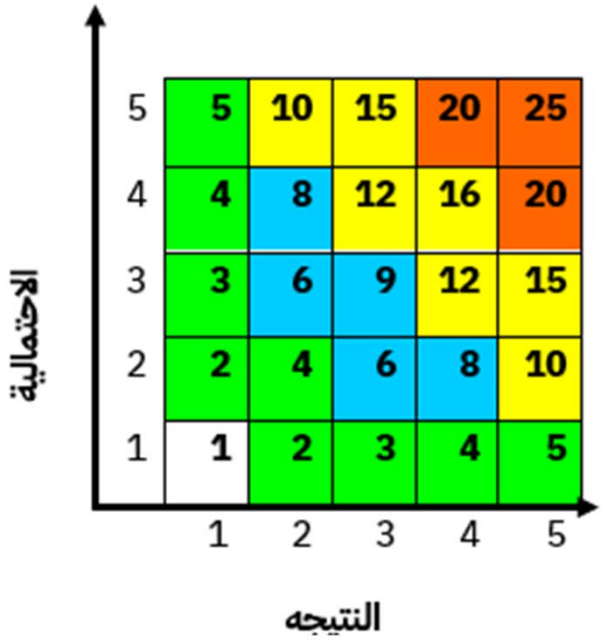
مصفوفة تقييم الأثر البيئي و الاجتماعي

المستقبلات		الفيزيائية						البيولوجية			الاجتماعية - الاقتصادية							
النشاط		جودة الهواء	الضجيج	التربة	المياه الجوفيه	هيدرولوجيا	المناظر الطبيعية/ التضاريس	النباتات (الموائل)	طيور	الزواحف والثدييات	السلامة و الصحة العامة	السلامة و الصحة العامة	السكان	استخدام الأراضي	القوى العاملة والتوظيف	المرافق والبنية التحتية	النقل والمرور	التراث الثقافي والأثري
أنشطة المشروع غير المخطط لها																		
البناء	تصادم المركبات																	
	انسكابات المواد الكيميائية أو الوقود السائل																	
	اشتعال المواد القابلة للاشتعال / الحرائق العرضية																	
التشغيل	انقطاع التيار الكهربائى																	
	تصادم المركبات																	
	انسكابات المواد الكيميائية أو الوقود السائل																	
	اشتعال المواد القابلة للاشتعال / الحرائق العرضية																	
الكوارث الطبيعية																		
البناء	زلزال "الأنشطة الزلزالية"																	
	الفيضانات																	
التشغيل	زلزال "الأنشطة الزلزالية"																	
	الفيضانات																	

منهجية تقييم الأثر



منهجية تقييم الأثر



تقدير أهمية الأثر المحتمل

تقدير أهمية الأثر المحتمل

الأهمية (Significance)	الترتيب (Ranking) (النتيجة×الاحتمال) (Consequence X Likelihood)
حرج	16<
عالي	16-10
متوسط	9-6
قليل	5-2
ضئيل (لا يذكر)	2>

تدابير تخفيفية

التأثيرات المتوقعة خلال مرحلة البناء والتشغيل

مرحلة البناء

- جودة الهواء
- الضجيج
- السلامة و الصحة العامة
- السلامة و الصحة المهنية
- التربة
- النفايات (الصلبة والسائلة والخطرة)
- الموارد المائية
- التنوع الحيوي
- البنية التحتية والخدمات العامة
- الآثار والتراث الثقافي
- مخاطر المناخ
- التوظيف (+)
- تأثيرات إضافية

مرحلة التشغيل

- الضجيج
- التربة
- النفايات (الصلبة والسائلة والخطرة)
- الموارد المائية
- التنوع الحيوي
- السلامة و الصحة المهنية
- التوظيف(+)
- البنية التحتية والخدمات العامة(+)
- السلامة و الصحة العامة (+)
- تأثيرات إضافية

مجموعات العمل و النقاش

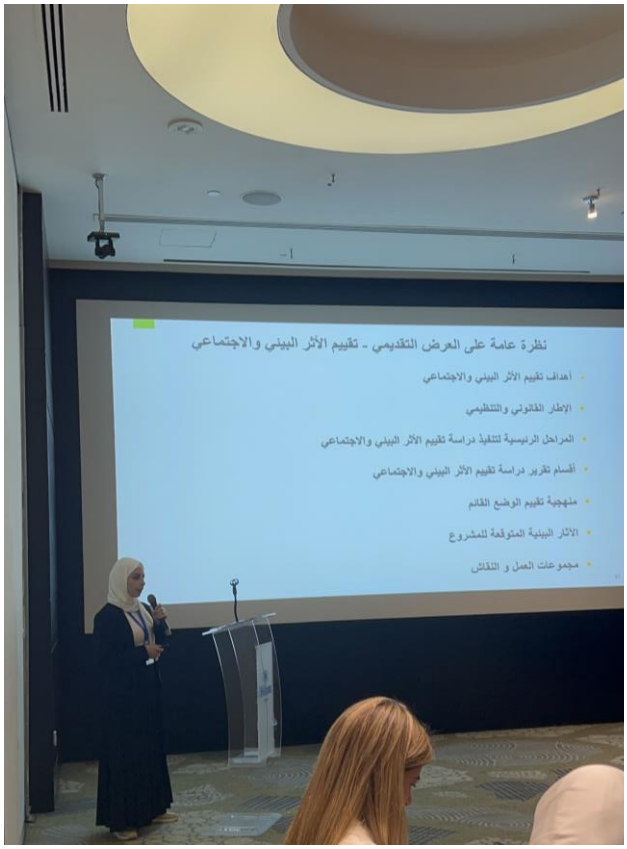
شكراً لاستماعكم

For more information
info@ajigroup.com

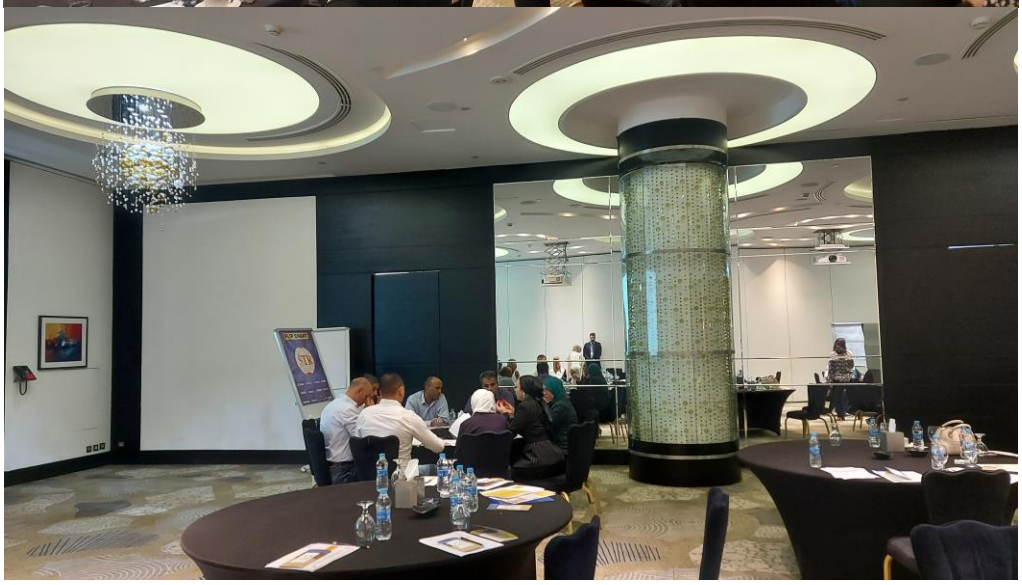
Appendix 2: Scoping Session Additional Photos

مشروع تقييم الأثر البيئي والاجتماعي
لحفر آبار جديدة وأعمال البنية التحتية
المرتبطة بها -حقل بئر ديبدب / الديسي
Diwaco
AJi

AJi


نظرة عامة على العرض التقديمي - تقييم الأثر البيئي والاجتماعي
أهداف تقييم الأثر البيئي والاجتماعي
الاطار القانوني والتنظيمي
المراحل الرئيسية لتنفيذ دراسة تقييم الأثر البيئي والاجتماعي
أقسام تقرير دراسة تقييم الأثر البيئي والاجتماعي
منهجية تقييم الوضع القائم
الآثار البيئية المتوقعة للمشروع
مجموعات العمل و النقاش

صور تم التقاطها خلال زيارة موقع المشروع 30-31/7/2024
بدر إنتاجي



Appendix 3: List of Attendees

Diwaco
Disi Water Company

Aji

وزارة البيئة

مشروع تقييم الأثر البيئي والاجتماعي لحفر آبار جديدة وأعمال البنية التحتية المرتبطة بها

حقل بئر دبيديب /الديسي

تاريخ : 2024/08/20

الرقم	اسم الجهة	اسم الشخص	رقم الهاتف	التوقيع
1	Operator / Disi Amman Operation & maintenance	نور غنه	0777212116	
2	DAOM	محمد عبد الهادي	0795706888	
3	WAJ	روان زهير مرجان	0780359564	
4	WAJ	صباح احمد عبد ربه	0795320960	
5	Aji	م. وفاء دعيبس	0777788644	
6	DIWACO	احمد علم الدين	0790867037	
7	وزارة الطاقة والثروة المعدنية MEMR	د. ريم طاهر شلاوي	0799803384	
8	operator/ Disi Amman Operation & Maintenance	م. محمد ابو عيد	0796708883	

Diwaco
Dist Water Company

AJi

وزارة البيئة

	التوقيع	رقم الهاتف	اسم الشخص	اسم الجهة	
9		0791661565	مصعب نصار - بزاد	DAoM	
10		0777512936	احمد البيدر	احمد البيدر وزارة البيئة	
11		-WWW.ENV	امين الشيخ	امين الشيخ	
12		0792926274	كريم عيسى اسماعيل ابو غنيمة	وزارة المياه والري / سلطة المياه / PMU	
13		0795000213	خليل ابراهيم الوزني	خليل الوزني	
14		0797427497	[illegible]	[illegible]	
15		.٧٧٧٤٨٠٧٠	[illegible] / وزارة البيئة	[illegible]	
16		0796521126	وزارة البيئة	[illegible]	
17		0779045528	MoenV	[illegible]	
18		0799491915	[illegible]	[illegible] / PMU	
19		0789148178	[illegible]	RSCN	

Diwaco
Dist Water Company

AJi

وزارة البيئة

	اسم الجهة	اسم الشخص	رقم الهاتف	التوقيع
20	علي الحوالط	وزارة الطاقة	0780395062	
21	عماد عياصره	وزارة الزراعة	0779426460	
22	وزارة الأشغال العامة	م. والي عصام سنونة	0795672792	
23	رامي الهيتمية	وزارة المياه		
24	م. عبير الشرمان	وزارة البيئة	0797446278	
25	د. سهاد الغزاوي	وزارة الأوقاف والشؤون	٠٧٩١٧٩٣٥٦	
26	عزام الروسان	وزارة الصحة	٠٧٩٥١٥٠٥١٧	
27	عيسى مكاوي	AJi		
28	غادة جبر	AJi		
29	غادة طلاوة	AJi		
30	محمد عرفة	AJi	0796372314	

Diwaco
Dist Water Company

AJi

وزارة البيئة

	اسم الجهة	اسم الشخص	الهاتف	التوقيع
31	هيا طراونة	AJi		
32	زينب الشريفات	AJi		
33	د. سحر حسن عمارنة	وزارة الصناعة والتجارة	0799727450	
34	د. محمد عجان العايد	مدير عام المياه	0796450987	
35				
36				
37				
38				
39				
40				
41				

Appendix 4: Questionnaire Form

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

ما هو تقييمك للآثار البيئية والاجتماعية المتوقعة للمشروع

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
1	جودة الهواء المحيط	الغبار							
		الروائح							
		انبعاث العوادم							
2	مستوى الضجيج								
3	الأرض والتربة	انسكاب زيوت							
		انجراف التربة							

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
		مواد البناء و النفايات							
4	الموارد المائية	تلوث المياه السطحية							
		تلوث المياه الجوفية							
5	إدارة النفايات بأنواعها	النفايات الصلبة							
		النفايات السائلة							
		النفايات الخطرة							
6	التنوع الحيوي	إزعاج/ تدمير الموائل							

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
		فقدان الغطاء النباتي							
7	الظروف الاجتماعية	توفير فرص العمل							
8	البنية التحتية والخدمات العامة	تعطيل مؤقت أو تعطيل لشبكات الطرق المحلية والخدمات المقدمة في محيط المواقع							
9	السلامة و الصحة العامة	الضجيج							
		الغبار							
		مخاطر صحية							

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
10	السلامة و الصحة المهنية	ظروف العمل السيئة وتجاهل حقوق العمال							
11	الأثار والتراث الثقافي	ضرر على البقايا الأثرية والمواقع التراثية							
12	مخاطر المناخ								

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
التأثيرات الإضافية									
13	غيرها، حدد:								
14	غيرها، حدد:								
15	غيرها، حدد:								

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
16	غيرها، حدد:								
17	غيرها، حدد:								

Appendix 5: Questionnaire Filled by Each Working Group

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

DAom مجموعة 1 ← مصدق

ما هو تقييمك للآثار البيئية والاجتماعية المتوقعة للمشروع

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
1	جودة الهواء المحيط	الغبار	X				X		
		الروائح		X				X	
		انبعاث العوادم	X					X	
2	مستوى الضجيج		X					X	
3	الأرض والتربة	انسكاب زيوت	X				X		
		انجراف التربة		X				X	

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
		مواد البناء و النفايات		X				X	
4	الموارد المائية	تلوث المياه السطحية		X				X	
		تلوث المياه الجوفية			X			X	
5	إدارة النفايات بأنواعها	النفايات الصلبة		X				X	
		النفايات السائلة		X				X	
		النفايات الخطرة		X				X	

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
6	التنوع الحيوي	إزعاج/ تدمير الموائل		X				X	
		فقدان الغطاء النباتي			X			X	
7	الظروف الاجتماعية	توفير فرص العمل		X			X		
8	البنية التحتية والخدمات العامة	تعطيل مؤقت أو تعطيل لشبكات الطرق المحلية والخدمات المقدمة في محيط المواقع			X			X	
9	السلامة و الصحة العامة	الضجيج		X				X	
		الغبار		X				X	

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
		مخاطر صحية			X			X	
10	السلامة و الصحة المهنية	ظروف العمل السيئة وتجاهل حقوق العمال	X				X		
11	الأثار والتراث الثقافي	ضرر على البقايا الأثرية والمواقع التراثية			X			X	

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)

لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
12	مخاطر المناخ		X				X		
التأثيرات الإضافية									
13	غيرها، حدد: الأسد والحمار	توفير الحماية للمنشآت من الرمال والسيول	X			X			
14	غيرها، حدد: الجمع الحمار	اكمه للحياه		X			X		

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)

لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
15	غيرها، حدد: المجتمع المحلي	توقعات المجتمع المحلي للتعويض	X			X			
16	غيرها، حدد:								
17	غيرها، حدد:								

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)

لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

مجموعة 2 ـ م. محمد الهلالات DOAM

ما هو تقييمك للآثار البيئية والاجتماعية المتوقعة للمشروع

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
1	جودة الهواء المحيط	الغبار	X				X		
		الروائح			X			X	
		انبعاث العوادم		X				X	
2	مستوى الضجيج			X				X	
3	الأرض والتربة	انسكاب زيوت		X				X	
		انجراف التربة		X				X	

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
		مواد البناء و النفايات		X				X	
4	الموارد المائية	تلوث المياه السطحية			X			X	
		تلوث المياه الجوفية			X			X	
5	إدارة النفايات بأنواعها	النفايات الصلبة		X				X	
		النفايات السائلة		X				X	
		النفايات الخطرة			X			X	

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
6	التنوع الحيوي	إزعاج/ تدمير الموائل		X				X	
		فقدان الغطاء النباتي			X			X	
7	الظروف الاجتماعية	توفير فرص العمل		X			X		
8	البنية التحتية والخدمات العامة	تعطيل مؤقت أو تعطيل لشبكات الطرق المحلية والخدمات المقدمة في محيط المواقع			X				
9	السلامة و الصحة العامة	الضجيج			X				
		الغبار			X				

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر ديبدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
		مخاطر صحية			✓				
10	السلامة و الصحة المهنية	ظروف العمل السيئة وتجاهل حقوق العمال		✓				✓	
11	الآثار والتراث الثقافي	ضرر على البقايا الأثرية والمواقع التراثية			✓				

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
12	مخاطر المناخ			X			X		
التأثيرات الإضافية									
13	غيرها، حدد:								
14	غيرها، حدد:								

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)

لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
15	غيرها، حدد:								
16	غيرها، حدد:								
17	غيرها، حدد:								

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)

لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

مجموعة (٣) ٠٣ زكمعتاب وزارة المياه
مركز سورية المعيرة

ما هو تقييمك للآثار البيئية والاجتماعية المتوقعة للمشروع

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
1	جودة الهواء المحيط	الغبار	✓				✓		
		الروائح			✓			✓	
		انبعاث العوادم		✓				✓	
2	مستوى الضجيج			✓				✓	محول + مخ ٢٥٠ لمضخات.
3	الأرض والتربة	انسكاب زيوت		✓				✓	
		انجراف التربة		✓				✓	

خلال سنة } فترة الحفر ٣ أشهر/بئر . عدد العمال الحفر ١٠ - ١٥ عامل
يوجد تناوب } حارسين على كل بئر وقت التشغيل فقط.

Diwaco AJi

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)

لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
		مواد البناء و النفايات	✓					✓	
4	الموارد المائية	تلوث المياه السطحية		✓				✓	على عمق ٢٠ م
		تلوث المياه الجوفية		✓				✓	على عمق ٣٠٠ م
5	إدارة النفايات بأنواعها	النفايات الصلبة		✓				✓	
		النفايات السائلة		✓				✓	
		النفايات الخطرة			✓			✓	

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
6	التنوع الحيوي	إزعاج/ تدمير الموائل		✓			✓		
		فقدان الغطاء النباتي			✓			✓	
7	الظروف الاجتماعية	توفير فرص العمل		✓			✓		
8	البنية التحتية والخدمات العامة	تعطيل مؤقت أو تعطيل لشبكات الطرق المحلية والخدمات المقدمة في محيط المواقع			✓				
9	السلامة و الصحة العامة	الضجيج	✓						
		الغبار	✓						

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)

لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
		مخاطر صحية	✓						
10	السلامة و الصحة المهنية	ظروف العمل السيئة وتجاهل حقوق العمال		✓					
11	الأثار والتراث الثقافي	ضرر على البقايا الأثرية والمواقع التراثية		✓					

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)

لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
12	مخاطر المناخ			✓					Flash flood
التأثيرات الإضافية									
13	غيرها، حدد: اتأثير على مصدر المياه في حال الضخ الجائر	الد							
14	غيرها، حدد: ~~التأثير على~~ تأثير عمال الآبار الخاصة ~~تأثير الآبار الخاصة~~ في المناطق المجاورة ~~على الآبار المجاورة~~	تأثير عمال الآبار الخاصة في المناطق المجاورة							

• الأمن والحماية للمنشآت (آبار)

استبيان الجلسة التشاورية لتقييم الأثر البيئي والاجتماعي (ESIA)
لمشروع حفر آبار جديدة وأعمال البنية التحتية المرتبطة بها -حقل بئر دبيدب /الديسي

الرقم	المعامل البيئي	الأثر البيئي	مستوى التأثير / الأهمية						ملاحظات
			مرحلة الإنشاء			مرحلة التشغيل			
			عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود وغير مهم	عالي الى عالي جداً	متوسط التأثير	لا يوجد تأثير أو تأثير محدود غير مهم	
15	غيرها، حدد:								
16	غيرها، حدد:								
17	غيرها، حدد:								

Annex 4: ToR Approval Letter

بسم الله الرحمن الرحيم

وزارة البيئة

الرقم ١٧١٧/٧/٤
التاريخ
الموافق ٢٠٢٥/٣/٢٣

السادة شركة ارابتك جردانة للمياه و البيئة

تحية طيبة وبعد ،،

إشارة لكتابكم رقم AW 146/123 تاريخ 2025/3/10 ومرفقه تقرير الاسس المرجعية المعدلة لمشروع حفر الآبار الجديدة و أعمال البنية التحتية المرتبطة بها- حقل بئر دبيدب الديسي و العائد للسادة وزارة المياه و الري.

أوافق على الأسس المرجعية المقترحة للدراسة أعلاه وذلك استناداً إلى توصية لجنة تقييم الأثر البيئي شريطة تضمين الملاحظات المرفقة في تقرير الدراسة.

وتفضلوا بقبول فائق الإحترام ،،،

وزير البيئة

الدكتور معاوية خالد الردايدة

الأمين العام بالوكالة
الدكتور جهاد السواعير

ملاحظات لجنة تقييم الاثر البيئى على تقرير الاسس المرجعية المعدلة لمشروع حفر الآبار الجديدة و أعمال البنية التحتية المرتبطة بها- حقل بئر دبيدب الديسى و العائد للسادة وزارة المياه و الرى:

- ان تتضمن الدراسة تحديد المسافة بين شبكة شركة توزيع الكهرباء ومنطقة المضخات.
- ان تتضمن الدراسة توضيح لتمديد الخطوط بمسارات علوية جديدة أو مسارات تحت الارض و تقاطعاتها مع أمور حيوية والاستملاكات وآثارها على هذه الأمور والتخفيف منها إن وجدت.
- اضافه تعليمات حماية الاراضي الزراعية رقم 11/ز لسنة 2022.
- اضافه تعليمات تنظيم وادارة الحراج الحكومي والاشجار الحرجية النامية على اراضي الخزينة والاراضي الحرجية رقم ز/1/2017.

Annex 5: Ambient Noise Monitoring Report

CONTROLLED

TEST REPORT

Report Number: 015-04-25- rev01[1]	**Issue Date:** 17/04/2025
Number of pages: 6 *(including cover page)*	
Customer Name: AJI Infrastructure & Environment.	**Al Shamil Air Quality Laboratory**
Customer Address: Amman.	**Address:** 48 Jordan University Investment Building
Contact Information (Name/ Phone No./ Email): Ms. Raneem Awadallah/ +962 6 585 7167 Raneem_Awadallah@ajigroup.com	**Contact Information (Name/ Phone No./ Email):** Ms. Sawsan Zawahreh/ Technical Manager/ +962 77 869 9099 sawsanzawahreh@shamileng.com.jo

1. Service(s) provided[2]:

a) Ambient Air Quality Monitoring Noise.

2. Monitoring Sites[3]: Ambient Noise monitoring at 4 points.

3. Number of Locations: 4.

4. Duration and dates of Testing:

a) Ambient Noise: 24-hr monitoring on (08-09/04/2025) & (09-10/04/2025)

5. Ambient Climatic Conditions:

Date	Temperature (˚C)		Wind speed km/hr	Wind direction	Relative humidity
	High	Low			
08/04/2025	27	17	16	E	15%
09/04/2025	32	15	14	E	20%
10/04/2025	28	16	11	E	21%

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[1] This report supercedes Report No. (015-04-25, dated 15/04/2025). Based on the client's review, two new aerial photographs were included and related noise guidelline was modified.

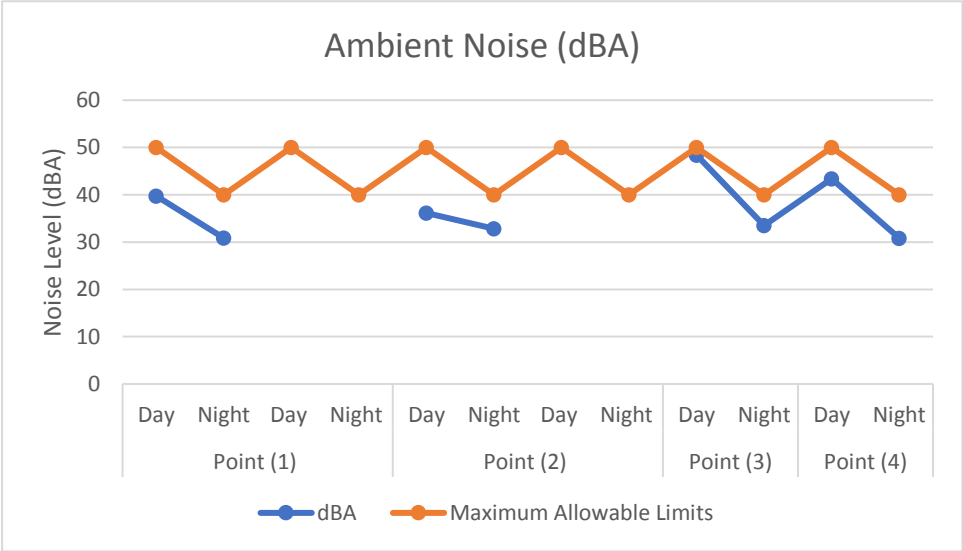
[2] Noise test in Ambient Air is out of our scope accreditation

[3] Satellite image of the monitoring site is attached.

Testing Results

Ambient Noise: 24-hr measurements

Date	Location	Day/Night	Result (dB(A))	Maximum Allowable Limits	Conformity	Test Method Used	Standard
08-09/04/2025	Point (1)	Day	39.74	50	PASS	Sound intensity method	The Guidelines for Noise Reduction and Prevention for the year 2003
		Night	30.83	40	PASS		
	Point (2)	Day	36.13	50	PASS		
		Night	32.81	40	PASS		
09-10/04/2025	Point (3)	Day	48.40	50	PASS		
		Night	33.52	40	PASS		
	Point (4)	Day	38.74	50	PASS		
		Night	31.24	40	PASS		



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Conclusions:

- Results are within Noise allowable limits put by "Noise Reduction and Prevention Guidelines for the year 2003.
- Statement of conformity is based on Noise Reduction and Prevention Guidelines for the year 2003 for day-time and night-time Noise levels for "Residential areas in villages ".
- The results relate only to areas tested under the specified conditions at the time of the test.

Prepared By	Checked By	Approved By
Lab Technician	**Technical Manager**	**Quality Manager**
Mr. Ahmad Z. Momani Mr. Mhammad A. Daradkeh	Ms. Sawsan A. Zawahreh 15/04/2025	Ms. Suha A. Nsour 15/04/2025

ALSHAMIL ENGINEERING
مكتب الشامل للهندسة

- *This Report Shall Not Be Reproduced, Except In Full, Without A Written Permission From Alshamil Air Quality Laboratory.*

- *The decision Rule is based on a simple acceptance method.*

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Annexes:

Annex (1): Names and models of instruments used in the monitoring program.

Annex (2): Satellite images showing the monitoring sites.

Annex (3): Some of the pictures taken during the monitoring program.

Annex (1): Names and models of instruments used in the monitoring program.

Parameter	Instrument Name	Serial Number
Noise	CENTER 323 Data logger Sound Level Meter	180611066
		220709681

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Annex (2): Satellite images showing the monitoring sites.

Location	Latitude	Longtude
Point (1)	29°27'38"N	35°43'58"E
Point (2)	29°28'52"N	35°46'04"E
Point (3)	29°22'50"N	35°44'15"E
Point (4)	29°20'35"N	35°50'46"E

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Annex (3): Some of the pictures taken during the monitoring program.

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مكتب الشامل للهندسة

_____ END OF TEST REPORT _____

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Annex 6: Climate Risk Vulnerability Assessment (CRVA)

Environmental & Social Impact Assessment (ESIA) for Drilling New Wells and Associated Infrastructure Works – Dubaydib Well Field / Disi

Climate Change Vulnerability Risk Assessment (CRVA)

July 2025

Contents

1. Introduction 3

2. Climate Risk Vulnerability Assessment Objective 4

3. Jordan Climate Context 4

4. Jordan Climate Sensitivity 5

5. Vulnerability Assessment Methodology 6

6. Sensitivity of the Project Components to Climate Conditions 8

CLIMATE CHANGE RISKS AND VULNERABILITY ASSESSMENT 11

CLIMATE CHANGE RISK MANAGEMENT 17

Institutional Responsibilities and Coordination 32

Conclusion 32

1. Introduction

The Disi Water Company (DIWACO) is contracted to Water and Irrigation (MWI)/Water Authority of Jordan (WAJ), and subcontracted the operation of the Dubaydib wellfield to Disi Amman Operation and Maintenance (DAOM). The principal objective of this project is to facilitate the resolution of the water supply problem experienced at Amman, the capital city of Jordan, and the surrounding area. Thus, increasing the supplied water to Amman and accordingly improving public health conditions.

The project is considered as part of the Government of Jordan's (GOJ's) larger regional framework of water management and development of new resources. The project started operation in 2014 and it comprises of 55 production wells (46 operational and 9 standby). Recently the Disi project activated 4 of the standby wells to be 50 abstraction wells and 5 standby wells, and in 2023, the Al-Mudawara pumping capacity was expanded, resulting in an annual rise in the amount of water pumped from wells to 111 MCM and since 2024, production has been increased to 115 MCM. Water is collected from each of the wells via a 'dendritic' collector network and delivered to a collector tank north of the well field by a main spinal collector.

As per the existing project agreement terms, DIWACO is required to deliver up to 100 MCM of water per year to Abu Alanda and Dabuk in Amman from the Dubaydib well field. However, MWI asked DIWACO to raise the water delivery quantities to 120 MCM for the longer term (2025 onwards) due to the high demand, particularly in the summer. After conducting an infrastructure evaluation, DIWACO verified that the project could accommodate the addition of new wells to meet the quantity need of 120 MCM/year.

To reliably meet the increased water quantity requested by MWI/WAJ (up to a total of 120 MCM/yr), DIWACO is planning to conduct additional activities described in the following subsection. These additional activities are herein referred to as "The Proposed wells "which will be covered in the Environmental and Social Impact Assessment (ESIA).

The proposed project includes the following activities which will be covered in the ESIA:

- Drilling new groundwater wells (will involve drilling of the well shafts, installation of well casing, screens and pump head).
- Drilling activities are tentatively scheduled to commence in January 2026, and continue through July 2027 for the completion of the first four additional wells (Contingent upon financial security conditions, the approval of study results by all relevant parties, and the GoJ approval of the ESIA). Additional wells will be drilled as required to ensure the continuous availability of three redundant wells at all times, while pumping 120 MCM per year. Constructing the relevant infrastructure, including wellheads, compounds, pipelines and electricity networks to collect and transfer water to the existing collection tank.
- Constructing the relevant infrastructure including wellheads, compounds, pipelines and electricity networks to collect and transfer water to the existing collection tank.
- Extend the internal road network to connect the new wells with the existing parts of the project.

- Expansion of the overhead power line system to connect the new wells.

2. Climate Risk Vulnerability Assessment Objective

The purpose of this climate vulnerability assessment is to gain a comprehensive understanding of the potential climate change risks facing the proposed project, ensuring that these risks are thoroughly evaluated to determine the project's level of vulnerability in the context of changing environmental conditions. By identifying specific climate-related risks, this assessment aims to establish a clear picture of how climate stressors—such as temperature fluctuations, changing precipitation patterns, extreme weather events, and other climate-induced challenges—might impact the project's functionality and sustainability over time. Moreover, this assessment seeks to provide strategic recommendations for resilience-building measures that enhance the project's adaptability to climate impacts. These recommended actions are designed not only to mitigate potential disruptions but also to fortify the project against long-term climate uncertainties, thereby supporting its overall resilience and sustained performance in alignment with broader climate adaptation goals. To achieve these objectives, the assessment focuses on evaluating key climate-related vulnerabilities, including:

- Assessing the exposure of wells, access roads, power infrastructure, and water networks to climate hazards such as droughts, extreme temperatures, and flash floods.
- Ensuring the adaptive capacity of infrastructure design and operational practices to withstand and respond to these climate risks effectively.
- The assessment will include the project life cycle of construction and operation phases.
- This Climate Risk Vulnerability Assessment (CRVA) has been developed in alignment with the environmental and social requirements of the European Investment Bank (EIB) and the International Finance Corporation (IFC). It forms an integral part of the Environmental and Social Impact Assessment (ESIA) for the project, ensuring compliance with international best practices in climate risk management.

3. Jordan Climate Context

Jordan's social, economic, and ecological sectors are all vulnerable to climate change. The agricultural, water, urban, biodiversity, coastal, social and economic development, and health sectors are the seven sectors that the National Adaptation Plan (NAP) has identified in order to assess their vulnerability and available adaptation options.

A strategic target was suggested for every sector, in addition to strategic programs. For the water sector, for instance, the sectoral strategic target is enhancing sustainable water demand and supply through climate resilient measures. Several programs were identified:

- Integrating climate adaptation and resilience in policy and institutional reforms in the water sector.
- Improved water demand management and reducing gap between water demand and supply.
- Improving adaptive capacity of water utilities.
- Improved efficiency in water uses for sustainable development.

- Improving contribution of non-conventional water resources to the national water budget.
- Improving rainfall early warning systems and reducing flood risks.
- Supporting watershed and basin level management of water resources including transboundary water(NAP,2021).

4. Jordan Climate Sensitivity

According to Jordan's 4th National Communication Report[1], the projected climate change impacts for Jordan as the following:

Temperature Increase: Jordan is expected to experience more frequent heat waves and fewer frost days. A predicted rise in annual maximum temperature of up to 5.1°C and a rise in annual minimum temperature of 3.8°C by 2085, including an increase in the frequency of heat waves. In addition, Jordan's Fourth National Communication Report, future predicted heatwave events are more severe in terms of duration and magnitude, where the probability of occurrence increases to an average of 120 % by 2100. Thus, it is very likely that more severe threats are expected in terms of heatwave exposure intensity and duration.

Drought Increase: Jordan is expected to become increasingly drier, with a predicted 10-day increase in the number of consecutive dry days from 2040 to 2070. The most significant drought conditions are expected in the southern Aqaba region where some models also predict the greatest temperature increase.

Precipitation: Precipitation projections are highly variable but, overall, are expected to decrease between 15% to 60 % from 2011 to 2099. The future trends indicate the probability of occurrence of potential intense precipitation, which seems to decrease with time. On the other hand, the severity is variable by location and tends to become more intense during the mid-21st century and reduces by the end of the 21st century.

These changes present significant risks to Jordan's water resources, since they may diminish the amount of water obtained from surface and groundwater sources and deteriorate the quality of the water. According to the Jordan National Water Strategy 2023-2040[2], Jordan is one of the most water-poor countries in the world for renewable freshwater with around 61 cubic meters per capita in 2021 which is far less than the 500 cubic meters per capita annually that is internationally recognized as the absolute water scarcity line. Climate change and overuse of water resources have further reduced groundwater and surface water resources, whereas in 2040 the annual renewable water resources per capita is expected to reach only 35 m^3.

Furthermore, the likelihood of such increased incidence of droughts and an increasingly warmer drier future has critical implications on the quantity and quality of Jordan's freshwater

[1] Jordan's Fourth National Communication on Climate Change | United Nations Development Programme
[2] National Water Strategy 2023-2040, Jordan. https://www.mwi.gov.jo/EBV4.0/Root_Storage/AR/EB_Ticker/National_Water_Strategy_2023-2040_Summary-English_-ver2.pdf

resources and aggravates its current challenges3. In general, water-related impacts would include (MWI ,2016) [4]:

- Reduced total water availability with less rain, thereby reducing yields from surface water catchments.
- Less reliable seasonal patterns.
- More extreme events where surface catchments are eroded with a decrease in water quality.
- Groundwater is not recharged and rain fed agriculture suffers damages due to changes in runoff distribution.
- Increasing intensity of droughts during which reservoirs are not refilled.
- High rainfall events also increase erosion which causes losses of soil water storage and siltation of reservoirs.
- Higher temperatures resulting in higher evaporative demand and hence higher irrigation water demand.
- Higher temperatures affect the efficiency of wastewater treatment plants.
- Increased agricultural and drinking water demands during heat waves and droughts, thus exacerbating water storage depletion.
- Future intensification of energy price shocks on international energy markets and since the Jordanian water sector is very energy-intensive and dependent on fossil fuels; it becomes vulnerable to such price shocks.
- Increasing intensity of flood events during which water and other infrastructure experience overflows and damage.

5. Vulnerability Assessment Methodology

The standard procedure for assessing how climate change may affect a project is to ascertain the current climate parameters, determine these parameters future projection due to global climate changes, evaluate the potential impacts of these climate hazards on the project design or assets, and then decide how to modify the project specifications. This CRVA puts this strategy into practice by reviewing the literature on readily accessible Jordanian climate change documents, which include the following:

- Jordan's 4th national communication (NC4).
- Jordan's national adaptation plan (NAP, 2021).
- World Bank Climate Change Knowledge Portal (2021).
- National Water Strategy (MWI,2023).

A key component of this assessment involves analyzing the project climate projections using projections and maps from the NC4 to identify critical trends, such as:

- Temperature extremes, which can impact machinery performance, electricity grid due to heat-induced equipment failure, water network and the pipe corrosion due to temperature shifts and worker safety.

[3] Jordan's Third National Communication on Climate Change https://unfccc.int/sites/default/files/resource/jdrnc3.pdf

[4] Jordan's Ministry of Water and Irrigation, 2016. Climate Change Policy for a Resilient Water Sector https://www.unescwa.org/sites/default/files/event/materials/23-jordan_mwi-cc_policy_for_a_resilient_water_sector-2016-eng.pdf

- Precipitation variability, which affects water availability and road and water network stability.
- Drought frequency and heatwaves.

Climate Projections and Risk Assessment:

The CRVA incorporates climate projections from Jordan's NC4 and utilizes the spatial hazard maps provided in the NC4 to assess and quantify climate risks specific to the project area. This analysis identifies key climate hazards, including rising temperatures, decreasing precipitation, and an increased frequency of extreme weather events such as heatwaves and droughts, ensuring a comprehensive understanding of the potential climate impacts on the project. These projections inform the assessment of sensitivity and exposure, helping to evaluate risks related to water availability, infrastructure resilience, and ecosystem stability.

Integration into Project Planning

By incorporating these projections, the assessment identifies the most climate-sensitive aspects of the project and determines exposure levels based on geographic and sectoral vulnerabilities. These insights guide the selection of adaptation strategies, ensuring alignment with national climate adaptation priorities and enhancing long-term project resilience. Furthermore, this assessment will inform the project's design team to integrate climate-resilient features and support future operations and maintenance practices, ensuring the project's sustainability and adaptability to evolving climate conditions.

The Climate Risk Management Plan

aims to assess and prioritize risks by evaluating their likelihood and impact to enhance project resilience, the plan includes targeted mitigation measures.

To align with EIB and IFC requirements, CRVA findings will be documented and submitted in accordance with lenders's Environmental and Social Impact Assessment (ESIA) requirements.

This plan will be established to ensure long-term adaptability, incorporating annual reviews of groundwater levels and infrastructure performance to guide necessary adjustments and improvements. The most relevant key messages of the climate projections in the 4th national communication relevant to the project area are described in **Table 1**.

Table 1: The Most Relevant Key Messages of the Climate Projections

Trend	Details
Intense precipitation and potential floods	There is no significant sign of heavy rain days (more than 20 mm), however future trends indicate the probability of occurrence of potential intense precipitation, that seems to decrease with time, especially at Representative Concentration Pathway (RCP) 8.5 as compared to RCP 4.5. On other hand, the severity is variable by location and tends to become more likely than not intense during the mid-21st century and reduces by the end of the 21st century. For the project area, projected annual precipitation under RCP 8.5 across the three future time horizons is estimated to range between 50–100 mm, with projected differences in annual precipitation falling between 20–30 mm. Furthermore, the ESIA recommends conducting a comprehensive hydrological study to support the effective design of flood mitigation measures.
More intense heatwaves	Future predicted heatwave events are more severe in terms of duration and magnitude, where the probability of occurrence increases to an average of 120% by 2100 (ranging from 54% to 398% based on spatial location) using RCP 4.5, and about a threefold increase (ranging from 1.5 to 9.0 times, based on spatial location) using RCP 8.5.

	The frequency of heatwaves in the project area is projected to increase by 100% to 150% by 2050, and will be between 150% to 200% until the year of 2040 to 2070.
Air Temperature	The minimum air temperature is projected to increase significantly, with an extremely likely rise of +1.2 °C [+0.6 °C to +2.9 °C] under RCP 4.5 and +2.7 °C [+2.1 °C to +4.5 °C] under RCP 8.5. Similarly, the maximum air temperature is extremely likely to increase by +1.1 °C [+0.7 °C to +1.7 °C] under RCP 4.5 and up to +3.1 °C [+2.6 °C to +3.7 °C] under RCP 8.5. For the Project area, the maximum average air temperature is expected to reach approximately 30–32 °C by 2050.
Insignificant wind changes	Wind speed forecasts didn't indicate significant changes; however, the Project area is about as likely as not to be subjected to wind bloom events exceeding 5.4 to 5.8 m/s in the Project area.

6. Sensitivity of the Project Components to Climate Conditions

For the purpose of this Project, the climate change hazards that may have implications on the proposed wells include higher temperatures, increased likelihood of droughts and infrequent but severe rainfall events, and concern of future intensification of energy price shocks on international energy markets. Therefore, the climate-change risks that have been identified of the proposed new wells as illustrated in **Table 2** below.

Table 2: Sensitivity of the Proposed Project Components to Climate/Weather Conditions

No.	Defined Activity/ Interventions		Identified Risk
1	**Design of the proposed project components:** ▪ New wells. ▪ Relevant infrastructure to collect and transfer water. ▪ Internal road network to connect the new wells with the existing parts of the project. ▪ Expansion of the overhead power line system to connect the new wells.		▪ Extreme weather conditions (High temperature and heavy rainfall) may impact the project components' design and specifications.
2	**Procurement, Construction, Installation, and Commissioning**		▪ Extreme weather conditions (High temperature and heavy rainfall) may impact the transport, delivery, and installation of equipment. Thus, affecting the project timelines. ▪ Higher temperatures would increase the daily water demand for labor uses which would consequently increase the onsite water & wastewater storage. ▪ Heavy rainfall/floods can disrupt drilling operations and damage equipment. Accordingly, causes machinery malfunctions and increased maintenance costs. ▪ High temperatures could cause potential power outages and /or equipment overheating, delaying the construction operations. ▪ According to Jordan 4th National Communication on Climate Change Report[5], the precipitation in the Eastern and Southern Badia regions is likely to increase up to the year 2050, that could reach a maximum of 40%, so the extreme weather conditions (storm) might halt drilling activities and delay project timelines. ▪ Higher temperatures would create aversive odors within waste storage areas. ▪ Higher temperatures and droughts would cause fires for the chemicals and fuels stored within the construction sites.
3	**Operation of Well Field**	**General Operation Activities**	▪ Extreme weather conditions might deteriorate the structural integrity of wellheads, pipelines, and associated infrastructure.
			▪ Extreme weather conditions (heavy rain/floods) might cause soil erosion increasing the risk of damaging of the pipelines/infrastructure.
			▪ Extreme temperatures can degrade road surfaces and building materials.

[5] https://www.undp.org/jordan/publications/jordans-fourth-national-communication-climate-change#:~:text=Jordan%27s%20Fourth%20National%20Communication%20Report%20investigates%20a%20set,the%20continued%20stress%20on%20the%20country%27s%20natural%20resources.

No.	Defined Activity/ Interventions		Identified Risk
		Energy Consumption	▪ Higher temperatures increase electricity loads leading to continuous blackouts that will affect wells operation.
			▪ The increased energy consumption raises energy expenses that will be used.
			▪ The increased energy consumption would increase the indirect generation of CO_2 emissions.
		Biodiversity	▪ Higher temperatures and scarcity of rain can exacerbate the degeneration of the area limiting the natural regeneration of plant species and leading to habitat disturbances.
			▪ Flash flood events might cause soil erosion increasing the risk of habitat disturbances and vegetation loss.
		Groundwater Temperature	▪ Rising groundwater temperatures can increase concentrations of harmful substances like arsenic or manganese, posing health risks when groundwater is used for drinking purposes. This is a significant concern for the drilling industry, which must adapt to these changing conditions6. However, The wells have a high depth with a total ranging from 394 to 600 m. ▪ Flooding and other extreme weather events may increase the risk of pollutants entering the groundwater system, deteriorating water quality.
		Groundwater Decline (Indirect Risks)	▪ Continued groundwater extraction will deepen the piezometric depression in the wellfield by an additional 20 to 25 meters, compared to the current groundwater table by 2038, and by over 50 meters in many parts of the field by 2065 [7] , extending beyond the wellfield and impacting surrounding areas, including agricultural zones in Disi and Al Mudawarra, which also rely on the aquifer for irrigation. thus, coupled with the extreme weather conditions, mainly higher temperatures, will exacerbate the groundwater extraction and the extent to which the agricultural zones will be affected.

[7] Simulations of abstraction scenarios for the Dubaydib wellfield, Final Report, BRGM/RC-73853-FR, 2024

[7] Simulations of abstraction scenarios for the Dubaydib wellfield, Final Report, BRGM/RC-73853-FR, 2024

CLIMATE CHANGE RISKS AND VULNERABILITY ASSESSMENT

Climate risk is the potential for negative consequences due to changing climatic conditions. The EIB approach for conducting a CRVA is based on the methodology developed by the European Financing Institutions Working Group on Adaptation to Climate Change [8]and is reviewed regularly to take account of new developments in this field. According to Joint Assistance in Supporting Projects in European Regions (JASPERS) Approach[9] which is a partnership between the Commission, the EIB and the European Bank for Reconstruction and Development (EBRD), the climate risk is evaluated based on the probability and the severity of the negative impact (high, medium, low).

The vulnerability of a project is determined by two key factors:

- The sensitivity of the project's components to climate hazards; and
- The likelihood of these hazards occurring at the project location, both now and in the future (exposure).

These aspects can be evaluated separately or together, depending on the stage of the project development cycle. In practice, they are often assessed in parallel. If the project location is known, specific climate hazards may already be identified or ruled out in terms of exposure. Similarly, if the technology has been selected, certain climate hazards may be deemed more or less relevant in the sensitivity analysis.

When considering a changing climate, the key changes are seen in the following climatic factors (these are also referred to as primary climate drivers):

- Temperature: changes in average temperatures and the frequency and magnitude of extreme temperatures;
- Precipitation (rain, snow, etc.) :changes in average precipitation and the frequency and magnitude of extreme precipitation events;
- Sea level : change in relative sea level;
- Wind speeds :changes in average wind speeds and maximum wind speeds;
- Humidity : changes in the amount of water vapor in the atmosphere;
- Solar radiation : changes in the energy from the sun.

This probability can cover 5 levels (Rare, Unlikely, Possible, Likely, Almost Certain) or otherwise. The scale used in the risk assessment of the Cost Benefit Analysis (CBA) Guide could be used for consistency with the wider risk assessment exercise[10]. The scale needs to be explained and each category needs to have a description about what that means (for example what is understood by "likely").

For some climate risks there can be considerable uncertainty about the likelihood of their occurrence. In such circumstances the assessment team should use their best judgement, based on currently available data, statistics and knowledge.

A general probability scale with five levels of probability is provided in **Table 3**.

[8] Microsoft Word - EUFIWACC Adaptation Note Version 1.0 ENGLISH FINAL 20160601 (econadapt.eu)

[9] The basics of climate change.pdf (eib.org)

[10] https://ec.europa.eu/regional_policy/sources/studies/cba_guide.pdf

Table 3: Scale for Assessing the Probability of Hazards Affecting the Project

	1	2	3	4	5
	Rare	Unlikely	Possible	Likely	Almost Certain
Meaning	Highly unlikely to occur	Given current practices and procedures, this incident is unlikely to occur	Incident has occurred in a similar country / setting	Incident is likely to occur	Incident is very likely to occur, possibly several times
OR					
Meaning	5% chance of occurring	20% chance of occurring	50% chance of occurring	80% chance of occurring	95% chance of occurring

Regarding the magnitude of the risk, the scale can cover 5 levels (insignificant, minor, moderate, major, catastrophic). The scale needs to be explained in relation to the project. Each category needs to have a description about what that means for the project (for example: what "Catastrophic" means). The consequences should be considered in terms of the physical assets and its operations, health and safety, environmental impacts, social impacts, financial implications, and reputational risk.

The severity scale with five levels of severity is provided in **Table 4**.

Table 4: Example Scale for Assessing the Severity of Consequence

	1	2	3	4	5
	Insignificant	Minor	Moderate	Major	Catastrophic
Meaning	Minimal impact that can be mitigated through normal activity.	An event which effects the normal project operation, resulting in impacts of a temporary nature.	A serious event requiring additional actions to manage, resulting in moderate impacts.	A critical event requiring extraordinary action, resulting insignificant, widespread or long term impacts.	Disaster with the potential to lead to shut down or collapse of the asset/network, causing significant harm and widespread long term impacts.

Having assessed the severity and probability of each hazard occurring, the significance level of each potential risk can be determined through a combination of the two factors. The risks can be plotted on a risk matrix to identify the most significant risks and those where future action is needed in terms of adaptation measures. **Table 5** presents an example of how such a risk matrix may look based on the example probably and severity scales.

Table 5: Monitoring and Evaluation Matrix for Climate Risks During Project Construction and Operation Phases, Based on Probability and Severity Ratings

	Probability	Rare	Unlikely	Probable	Likely	Almost Certain
Severity		1	2	3	4	5
Insignificant	1	1	2	3	4	5
Minor	2	2	4	6	8	10
Moderate	3	3	6	9	12	15
Major	4	4	8	12	16	20
Catastrophic	5	5	10	15	20	25

	Negligible Risk
	Low Risk
	Medium Risk
	High Risk
	Extreme Risk

Table 6 presents the evaluation and rationale for risk ratings for the proposed Project.

Table 6: Climate risk and vulnerability assessment for the new wells at Dubaydib wellfield

#	Defined Activity/ Interventions	Identified Risk	Severity of Impact Rating	Probability of Impact Rating	Significance of Impact Rating
1	**Design of the proposed project components:** ▪ New wells. ▪ Relevant infrastructure to collect and transfer water. ▪ Internal road network to connect the new wells with the existing parts of the project. ▪ Expansion of the overhead power line system to connect the new wells.	▪ Extreme weather conditions (High temperature and heavy rainfall) may impact the project components' design and specifications	Insignificant (1)*	Unlikely (2)	Low Risk (2)
2	**Procurement, Construction, Installation, and Commissioning**	▪ Extreme weather conditions (High temperature and heavy rainfall) may impact the transport, delivery, and installation of equipment. Thus, affecting the project timelines.	Minor (2)	Unlikely (2)	Low Risk (4)
		▪ Higher temperatures would increase the daily water demand for labor uses which would consequently increase the onsite water & wastewater storage.	Minor (2)	Unlikely (2)	Low Risk (4)
		▪ Heavy rainfall/floods can disrupt drilling operations and damage equipment. Accordingly, causes machinery malfunctions and increased maintenance costs.	Moderate (3)	Probable (3)	Medium Risk (9)
		▪ High temperatures could cause potential power outages and /or equipment overheating, delaying the construction operations.	Moderate (3)	Probable (3)	Medium Risk (9)
		▪ Extreme weather conditions (storms) might halt drilling activities and delay project timelines.	Minor (2)	Unlikely (2)	Low Risk (4)
		▪ Higher temperatures would create aversive odors within waste storage areas.	Minor (2)	Probable (3)	Low Risk (6)
		▪ Higher temperatures and droughts would cause fires for the chemicals and fuels stored within the construction sites.	Moderate (3)	Unlikely (2)	Low Risk (6)

#	Defined Activity/ Interventions		Identified Risk	Severity of Impact Rating	Probability of Impact Rating	Significance of Impact Rating
3	**Operation of Well Field**	**General Operation Activities**	▪ Extreme weather conditions might deteriorate the structural integrity of wellheads, pipelines, and associated infrastructure.	Major (4)	Unlikely (2)	Moderate Risk (8)
			▪ Extreme weather conditions (floods) might cause soil erosion increasing the risk of damaging of the pipelines/infrastructure.	Major (4)	Unlikely (2)	Moderate Risk (8)
			▪ Flooding and other extreme weather events may increase the risk of pollutants entering the groundwater system, deteriorating water quality.	Major (4)	Unlikely (2)	Medium Risk (8)
		Energy Consumption	▪ Extreme temperatures can degrade road surfaces and building materials.	Moderate (3)	Probable (3)	Medium Risk (9)
			▪ Higher temperatures increase electricity loads leading to continuous blackouts that will affect wells operation.	Moderate (3)	Probable (3)	Medium Risk (9)
			▪ The increased energy consumption raises energy expenses that will be used.	Moderate (3)	Probable(3)	Medium Risk (9)
			▪ The increased energy consumption would increase the indirect generation of CO_2 emissions.	Moderate (3)	Probable (3)	Medium Risk (9)
		Biodiversity	▪ Higher temperatures and scarcity of rain can exacerbate the degeneration of the area limiting the natural regeneration of plant species and leading to habitat disturbances.	Moderate (3)	Probable (3)	Medium Risk (9)
			▪ Flash flood events might cause soil erosion increasing the risk of habitat disturbances and vegetation loss.	Moderate (3)	Unlikely (2)	Low Risk (6)
		Groundwater Temperature	▪ Rising groundwater temperatures can increase concentrations of harmful substances like arsenic or manganese, posing health risks when groundwater is used for drinking purposes. This is a significant concern for the drilling industry, which must adapt to these changing conditions[11]. However, the wells have a total depth ranging from 394 to 600 m.	Major (4)	Rare (1)	Negligible Risk (4)

[12] Simulations of abstraction scenarios for the Dubaydib wellfield, Final Report, BRGM/RC-73853-FR, 2024

#	Defined Activity/ Interventions		Identified Risk	Severity of Impact Rating	Probability of Impact Rating	Significance of Impact Rating
			▪ Flooding and other extreme weather events may increase the risk of pollutants entering the groundwater system, deteriorating water quality.	Major (4)	Unlikely (2)	Medium Risk (8)
		Groundwater Decline (Indirect Risks), sustainable management of water resources is the responsibility of MWI	▪ Continued groundwater extraction will deepen the piezometric depression in the wellfield by an additional 20 to 25 meters, compared to the current groundwater table by 2038, and by over 50 meters in many parts of the field by 2065 [12] , extending beyond the wellfield and impacting surrounding areas, including agricultural zones in Disi and Al Mudawarra, which also rely on the aquifer for irrigation. thus, coupled with the extreme weather conditions, mainly higher temperatures, will exacerbate the groundwater extraction and the extent to which the agricultural zones will be affected.	Major (4)	likely (4)	High Risk (16)

*Assuming proper design

[12] Simulations of abstraction scenarios for the Dubaydib wellfield, Final Report, BRGM/RC-73853-FR, 2024

CLIMATE CHANGE RISK MANAGEMENT

Broad approaches to managing the identified climate risks are provided for the development of the proposed Project below and are detailed in **Table 7**.

Table 7: Summary of Adaptation and Mitigation Measures for Identified Climate Risks in the Project

#	Defined Activity/ Interventions	Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
1	**Design of the proposed project components:** ▪ New wells. ▪ Relevant infrastructure to collect and transfer water. ▪ Internal road network to connect the new wells with the existing parts of the project.	▪ Extreme weather conditions (High temperature and heavy rainfall) may impact the project components' design and specifications.	Low Risk (2)	▪ Climate data has been considered during the process design of the Project, including climate future projections and will include a detailed hydrology study. ▪ Use of climate-resilient material in construction and proper insulation of buildings and equipment.	▪ Sharing of best practices in climate risk assessments, adaptation planning, and design. ▪ Use energy-efficient pumps and motors to reduce energy consumption in the groundwater abstraction process. This reduces carbon emissions associated with the use of non-renewable energy sources. ▪ Install smart controls and sensors for real-time monitoring and optimization of water extraction, ensuring	▪ Contractor	▪ Documentation of integration of climate projections in design reports ▪ % of pumps/motors meeting energy-efficiency standards ▪ Number of wells equipped with smart monitoring systems ▪ Number of staff trained / workshops conducted on climate-resilient design	▪ Once during installation and Annual verification

#	Defined Activity/ Interventions	Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
					minimal energy use and avoiding over-pumping.			
2	Procurement, Construction, Installation, and Commissioning	▪ Extreme weather conditions (High temperature and heavy rainfall) may impact the transport, delivery, and installation of equipment. Thus, affecting the project timelines.	Low Risk (4)	▪ Develop flexible work schedules to adjust construction activities during high-temperature or heavy rainfall periods, minimizing weather-related delays. ▪ Use protective coverings and shelters for sensitive equipment to prevent weather damage during transport and installation. Install equipment during favorable weather conditions. ▪ Prepare contingency plans for extreme	▪ Design construction sites to include proper drainage and stormwater management systems to reduce the risk of flooding during heavy rains and ensure site access during extreme weather. ▪ Use equipment and materials designed to withstand extreme weather conditions, such as heat-	▪ Contractor	▪ % of sensitive equipment delivered and stored with appropriate protection. ▪ % of installations completed within safe weather windows. ▪ Availability of approved contingency plan with weather buffer. ▪ % of critical equipment and materials meeting climate-resilience specs	▪ Monthly during construction phase.

#	Defined Activity/ Interventions	Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
				weather events, including buffer periods in the project timeline to accommodate delays due to weather disruptions.	resistant materials and corrosion-proof equipment that can better handle heavy rainfall.			
		Higher temperatures would increase the daily water demand for labor uses which would consequently increase the onsite wastewater storage.	Low Risk (4)	▪ Increase the storage capacity of the water and wastewater collection tanks.	▪ Implement programs for workers on water conservation practices to reduce unnecessary water use. ▪ Install water-saving fixtures (e.g., low-flow taps and showerheads) in onsite facilities to reduce water consumption, helping manage wastewater generation at the source.	▪ Contractor	▪ Average daily water consumption per worker (L/day) . ▪ % of wastewater storage used relative to capacity. ▪ % increase in storage capacity compared to baseline design. ▪ Number of training sessions conducted / % of workforce trained.	▪ Monthly
		Heavy rainfall/floods can disrupt drilling operations and	Medium Risk (9)	▪ Proper planning and weather forecasting. ▪ Changes in the timing or length of construction shifts	▪ Store and operate drilling equipment on elevated platforms or	▪ Contractor	▪ Number of shift changes due to weather conditions. ▪ Number of maintenance	▪ Quarterly

#	Defined Activity/ Interventions	Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
		damage equipment. Accordingly, causes machinery malfunctions and increased maintenance costs.		and work seasons or changes in staff management plans may be required.	areas less prone to flooding to reduce the risk of water damage. ▪ Implement a maintenance schedule to check and repair equipment after heavy rainfall, minimizing long-term damage and repair costs.		inspections completed post-rain. ▪ % increase/decrease in maintenance costs related to weather events .	
		High temperatures could cause potential power outages and /or equipment overheating, delaying the construction operations.	Medium Risk (9)	▪ Install cooling systems such as air conditioning, fans, or heat dissipation units for equipment prone to overheating to ensure continuous operation during high temperatures. ▪ Ensure there are backup generators or alternative energy sources to maintain power during outages. Design workspaces with adequate shading or insulation to reduce heat buildup and	▪ Incorporate renewable energy sources, such as solar power, to reduce reliance on the grid, mitigate power outages, and lower the project's carbon footprint.	▪ Contractor	▪ % of critical equipment with active cooling systems. ▪ % of shaded/insulated areas in workspaces. ▪ Number of overheating incidents causing delays.	▪ Monthly

#	Defined Activity/ Interventions	Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
				lower the overall energy demand for cooling systems, enhancing worker comfort and productivity.				
		Extreme weather conditions (storms) might halt drilling activities and delay project timelines.	Low Risk (4)	▪ Implement flexible work schedules that allow drilling activities to be paused during severe weather and resumed once conditions improve, reducing the impact of weather-related delays. ▪ Build extra time into project timelines to account for potential delays caused by storms, ensuring that minor setbacks do not significantly impact the overall project schedule.	▪ Use portable or mobile drilling units that can be easily relocated or secured during the storms, minimizing damage and downtime.	▪ Contractor	▪ Number of delay incidents attributed to heat-related power/equipment issues. ▪ % of energy supplied from renewable sources. ▪ % of implemented heat-related mitigation measures from the plan.	▪ Quarterly
		Higher temperatures would create aversive odors within waste storage areas.	Low Risk (6)	▪ Implement a regular schedule for waste removal to prevent prolonged storage that can contribute to odor issues. Proper sealing of storage	▪ Design waste storage areas with shading or insulation to prevent temperature spikes that	▪ Contractor	▪ Number of waste removal operations completed on schedule. ▪ Number of odor-related complaints logged.	▪ Monthly

#	Defined Activity/ Interventions	Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
				containers will also help contain odors.	exacerbate odor production, thus improving climate resilience.		▪ % of measures implemented as per contractor's waste management plan.	
		Higher temperatures and droughts would cause fires for the chemicals and fuels stored within the construction sites.	Low Risk (6)	▪ Store chemicals and fuels in fire-resistant, temperature-controlled, and well-ventilated storage units to reduce the risk of combustion during high temperatures or drought conditions. ▪ Conduct routine inspections and audits of chemical and fuel storage areas to ensure compliance with fire safety standards and to identify potential hazards early.	▪ Improve waste management best practices. ▪ Design the construction site to include shaded areas and proper airflow around storage facilities, reducing heat buildup and enhancing the site's overall resilience to temperature extremes. ▪ Provide specialized training for workers on fire safety and prevention, focusing on the unique risks posed by high	▪ Contractor	▪ % of storage units meeting fire safety and ventilation standards. ▪ Presence of updated fire safety signage and drills conducted. ▪ % of compliance measures implemented as per HSE plan ▪ % of workforce trained / Number of refresher trainings conducted.	▪ Monthly

#	Defined Activity/ Interventions	Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
					temperatures and the proper handling of hazardous materials.			
		Extreme weather conditions might deteriorate the structural integrity of wellheads, pipelines, and associated infrastructure.	Moderate Risk (8)	▪ Design and implement drainage systems, berms, and erosion control measures around wellheads and pipelines to manage excess water during heavy rainfall or floods, preventing infrastructure weakening or collapse. ▪ Construct wellheads, pipelines, and infrastructure with climate-resilient materials such as corrosion-resistant alloys, reinforced concrete, and flexible pipeline materials that can withstand harsh environmental conditions (e.g., heavy rainfall, strong winds, and extreme temperatures).	▪ Utilize advanced predictive models for extreme weather to inform proactive infrastructure management, such as adjusting operations or reinforcing critical structures before severe weather events. ▪ Design infrastructure with flexibility and adaptability in mind, such as using flexible pipelines that can absorb the stresses caused by soil shifting during extreme	▪ Contractor	▪ % of completed and functional drainage and erosion control features. ▪ % of materials used conforming to climate-resilient specifications ▪ % of pipeline sections using flexible/resilient materials. ▪ % of design measures implemented according to specifications	▪ Once (post-installation) and Quarterly inspection

#	Defined Activity/ Interventions	Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
				▪ Design and install effective drainage systems to channel excess water away from pipelines and infrastructure, reducing the risk of erosion and water damage. This includes using ditches and culverts.	weather events, reducing the risk of pipeline breaks.			

#	Defined Activity/ Interventions		Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
3	**Operation of Well Field**	**General Operation Activities**	▪ Extreme weather conditions (heavy rain/floods) might cause soil erosion increasing the risk of damaging of the pipelines /infrastructure.	Moderate Risk (8)	▪ Conduct regular inspections of pipelines and infrastructure, particularly after heavy rainfall or flood events, to identify and address any erosion-related damage promptly. ▪ Reinforce the foundations and supports of pipelines and infrastructure to withstand potential erosion and shifting soil. This may involve using retaining walls, riprap, or other stabilization techniques.	▪ Design pipelines and infrastructure with adaptive features that can accommodate or mitigate the impacts of soil erosion, such as adjustable supports or flexible joints that can adjust to changing soil conditions. ▪ Use erosion-resistant materials for pipeline coating and construction that can better withstand the effects of soil erosion and reduce maintenance needs.	▪ Project company and the O&M contractor ▪ The project company to ensure that such measures (to address the climate risk)are considered during the design phase.	▪ Number of inspections conducted / % of erosion issues identified and resolved.	▪ After each major rainfall event and quarterly

#	Defined Activity/ Interventions		Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
			▪ Extreme temperatures can degrade road surfaces and building materials.	Medium Risk (9)	▪ Choose road surfaces and building materials specifically designed to withstand high temperatures. For roads, use asphalt mixtures with higher temperature tolerance, and for buildings, select materials with thermal stability.	▪ Design infrastructure to be adaptable to changing temperature conditions, incorporating features such as adjustable supports and temperature-regulating systems to handle extreme weather impacts effectively.	▪ The project company to ensure that such measures (to address the climate risk) are considered during the design phase.	▪ The degree of compliance with the Design specifications	▪ Semi-annually and after heatwaves.
		Energy Consumption	▪ Higher temperatures increase electricity loads leading to continuous blackouts that will affect wells operation.	Medium Risk (9)	▪ Use energy-efficient equipment and technologies to reduce the overall electricity load. This can help alleviate stress on the power grid and decrease the likelihood of blackouts.	▪ Incorporate renewable energy sources such as solar panels or wind turbines to reduce reliance on the grid and provide a stable power supply for well operations, even during high-temperature periods.	▪ The project company to ensure that such measures (adopted to address the climate risk) are considered during the design phase.	▪ % reduction in energy consumption / % of equipment upgraded. ▪ % of energy demand met by renewable sources.	▪ Annual

#	Defined Activity/ Interventions		Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
					▪ Perform regular maintenance and testing of backup power systems to ensure they are operational and ready to support well operations during power outages.	▪ Conduct energy efficiency audits to identify and implement measures that reduce overall energy consumption, thereby easing the load on the power grid and decreasing the risk of blackouts. ▪ Adopt operational practices that contribute to overall sustainability and energy efficiency, such as optimizing well operation schedules to avoid peak electricity demand periods. This approach helps mitigate energy shocks by reducing	▪ Project company and the O&M contractor		

#	Defined Activity/ Interventions		Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
						reliance on grid energy during periods of high demand.			
			▪ The increased energy consumption raises energy expenses that will be used.	Medium Risk (9)	▪ Use high-efficiency pumps and motors designed to reduce energy consumption ▪ Continuous maintenance to enhance pump efficiency and motors ▪ Wellhead orifice modifications	---------	▪ The project company to ensure that such measures (to address the climate risk) are considered during the design phase ▪ Project company and the O&M contractor	▪ % reduction in energy consumption	▪ Annual / performance review
			▪ The increased energy consumption would increase the indirect generation of CO2 emissions.	Medium Risk (9)	▪ Use high-efficiency pumps and motors designed to reduce energy consumption.	▪ Implement smart energy management systems that can optimize energy use and contribute to lower emissions.	▪ The project company to ensure that such measures (to address the climate risk) are considered during the design phase	▪ CO_2 emissions intensity (kg CO_2 per m^3 of water pumped). ▪ Operational efficiency of installed equipment (kWh/m^3).	▪ Annually

#	Defined Activity/ Interventions		Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
					▪ Continuous maintenance to enhance pump efficiency and motors		▪ Project company and the O&M contractor		
		Biodiversity	Higher temperatures and scarcity of rain can exacerbate the degeneration of the area, limiting the natural regeneration of plant species and leading to habitat disturbances.	Medium Risk (9)	▪ Use heat-resistant plant species for revegetation and Landscaping	▪ Full implementation of the existing endangered plant species regeneration initiative .	▪ Project company and the O&M contractor	▪ % of disturbance areas rehabilitated. ▪ % of landscaping area covered with heat-resistant plant species ▪ Number of trees planted and maintained under the initiative. ▪ % of road protection planting completed. ▪ % of regenerated endangered plant species.	▪ Annual
			▪ Flash flood events might cause soil erosion increasing the	Low Risk (6)	▪ Conduct site inspections after the flash flood event to identify and address	------	Project company and the O&M contractor	▪ % of site areas inspected after flood events / % of identified erosion issues addressed.	▪ Post-flood event (As needed)

#	Defined Activity/ Interventions		Climate Risk	Risk Rating	How climate Risks are addressed	Opportunities to Strengthen Climate Resilience or Climate Mitigation	Responsibility	KPI	Frequency
			risk of habitat disturbances and vegetation loss.		any erosion-related damage			▪ % of erosion control measures applied.	

Institutional Responsibilities and Coordination

While the project company is responsible for implementing climate resilience measures, several responsibilities—particularly related to stakeholder engagement, integration of socioeconomic factors, and long-term monitoring—lie within the mandate of MWI. The ESIA outlines the Ministry's role in conducting stakeholder engagement and socioeconomic impact assessments, which are essential for supporting broader climate adaptation efforts.

To achieve the desired climate resilience outcomes, strong coordination between the project company and MWI is essential. While certain responsibilities fall outside the project's direct scope, their successful implementation—especially ongoing monitoring and stakeholder involvement—is crucial to ensuring the adaptive capacity of local communities and long-term infrastructure sustainability.

Conclusion

The CRVA for this project has identified key climate hazards—extreme drought, flash floods, heatwaves, and precipitation variability—that could significantly impact project infrastructure and operations, and long-term sustainability. By utilizing Jordan's NC4 projections, regional climate models, and spatial risk assessments, this study provides a data-driven approach to understanding climate risks and integrating resilience measures into project planning.

This CRVA is a foundational step in integrating climate resilience into the project's lifecycle. The findings will directly inform the engineering design, financial planning, and operational strategies, ensuring that the project is climate-adaptive, sustainable, and aligned with international best practices. Future phases should focus on refining adaptation measures, assessing cost feasibility, and strengthening institutional coordination for effective climate risk management.

Overall, the project's climate vulnerability is rated as ***Medium***. While many risks can be mitigated through design improvements, resilient material selection, and adaptive operational measures. However, the decline in groundwater poses a high long-term risk, this issue is considered an external risk managed at the national level by the (MWI). The project itself does not control the abstraction policy.

Annex 7: Groundwater Quality Data

The Quality of Groundwater Discharge wells

W 1

Parameters	Year				
	2021	2022	2023	2024	Average
Nitrate	9.36	10.5	9.87	10.2	39.93
Sulphate	21.6	23.7	23.2	22.3	90.8
Aluminium	0.1	0.1	0.1	0.1	0.4
Chloride	28.7	29.2	28.4	29.3	115.6
Copper	0.05	0.05	0.05	0.05	0.2
Sodium	20.4	21.05	20.9	20.6	82.95
Zinc	0.05	0.05	0.05	N.A	0.15
Manganese	0.05	0.05	0.05	0.05	0.2
Iron	0.1	0.1	0.1	0.1	0.4
Nitrite	0.003	0.003	0.003	0.003	0.012
Ammonium	0.08	0.08	0.08	0.08	0.32
Cadmium	0.003	N.A	N.A	0.003	0.006
Total Chromium	0.02	N.A	N.A	0.02	0.04
Mercury	0.001	N.A	N.A	0.001	0.002
Barium	0.1	N.A	N.A	0.1	0.2
Silver	0.1	N.A	N.A	0.05	0.15
Arsenic	0.01	N.A	N.A	0.01	0.02
Antimony	0.01	N.A	N.A	0.01	0.02
Boron	0.1	N.A	N.A	0.01	0.11
Selenium	0.01	N.A	N.A	0.01	0.02
Cyanide	0.05	N.A	N.A	0.04	0.09
Fluoride	0.156	N.A	N.A	0.173	0.329
Molybdenum	0.01	N.A	N.A	0.01	0.02
Lead	0.01	N.A	N.A	0.01	0.02
Nickel	0.05	N.A	N.A	0.05	0.1
DDT	0.15	N.A	N.A	0.15	0.3
Dieldrin	0.03	N.A	N.A	0.03	0.06
Aldrin	0.03	N.A	N.A	0.03	0.06
Heptachlor epoxide and Heptachlor	0.03	N.A	N.A	0.03	0.06
Lindane	0.1	N.A	N.A	0.1	0.2
Endrin	0.1	N.A	N.A	0.1	0.2
Benzene	10	N.A	N.A	5	15
Trichloroethylene (TCE)	20	N.A	N.A	5	25
Tetrachloroethylene	20	N.A	N.A	5	25
Ethylbenzene	20	N.A	N.A	5	25
Toluene	20	N.A	N.A	5	25
Total Xylene	20	N.A	N.A	15	35
2-4-5T	1	N.A	N.A	1	2
2,4-D	1	N.A	N.A	1	2
Chemical disinfectants (Abs)	N.A	N.A	N.A	N.A	0
colour	N.A	N.A	N.A	0	0
odur	N.A	N.A	N.A	0	0
perchloroethylene (PCE)	N.A	N.A	N.A	5	5

Average	2024	2023	2022	2021	Year		
11.45	11.7	11.3	12	10.8	Nitrate		
21.6	21.5	22	22.6	20.3	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
26.075	26.3	25.4	26.9	25.7	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
20.1475	19.6	24	19.29	17.7	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide	Parameters	W 2
0.158	0.167	N.A	N.A	0.149	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 3

Average	2024	2023	2022	2021	Year
11.425	12.2	11.1	11.2	11.2	Nitrate
19	19.2	18.3	20.7	17.8	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
26.025	26.4	25.1	26.4	26.2	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
17.0325	17.49	17.7	16.74	16.2	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.182	0.188	N.A	N.A	0.176	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 3

W 4

Average	2024	2023	2022	2021	Year		
11.675	11.7	11	12.5	11.5	Nitrate		
18.3	18	18	19.5	17.7	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
25.4	25.7	25.6	25.7	24.6	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.9075	17.48	17.7	16.15	16.3	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide	Parameters	W 4
0.1905	0.204	N.A	N.A	0.177	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 5

Average	2024	2023	2022	2021	Year	Parameters	W 5
12.025	12.4	11.4	12.8	11.5	Nitrate		
18.225	18.4	17.7	19.6	17.2	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
24.975	25.1	24.8	25.4	24.6	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.8475	17.82	17.7	15.97	15.9	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.18	0.188	N.A	N.A	0.172	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 6

Average	2024	2023	2022	2021	Year	Parameters	W 6
11.275	11.8	10.5	11.9	10.9	Nitrate		
19.375	19.9	18.7	20.4	18.5	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
24.725	25	24.4	25.2	24.3	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.69	17.09	17.2	16.87	15.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.171	0.171	N.A	N.A	0.171	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 7

Average	2024	2023	2022	2021	Year		
11.875	12.5	11.3	12.3	11.4	Nitrate		
16.5	16.5	17.3	17	15.2	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
23.675	23.9	23.7	23.9	23.2	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
15.3975	15.79	15.7	16.1	14	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium	Parameters	W 7
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.1405	0.137	N.A	N.A	0.144	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 8

Average	2024	2023	2022	2021	Year	Parameters	W 8
11.825	12.4	11	12.5	11.4	Nitrate		
16.65	16.5	17.5	17.2	15.4	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
24.2	24.9	24.2	24.8	22.9	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
15.805	16.19	16.2	16.23	14.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.138	0.133	N.A	N.A	0.143	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 9

Average	2024	2023	2022	2021	Year
10.805	11.5	9.82	11.6	10.3	Nitrate
16.375	16.6	17.1	17.1	14.7	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
24.45	24.6	24.1	24.6	24.5	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
15.6025	15.92	16	16.29	14.2	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.1285	0.128	N.A	N.A	0.129	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 9

W 10

Average	2024	2023	2022	2021	Year	Parameters	W 10
11.45	11.8	10.8	12	11.2	Nitrate		
15.075	14.6	16	15.4	14.3	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
23.15	23.3	23.5	23.4	22.4	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
15.0875	15.25	15.4	16.1	13.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.145	0.146	N.A	N.A	0.144	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 11

Average	2024	2023	2022	2021	Year
11.825	12.4	11.4	11.5	12	Nitrate
14.65	14.5	15.6	14.2	14.3	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
24.125	24.1	23.3	25.9	23.2	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
14.565	15.05	15.3	14.21	13.7	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.1475	0.147	N.A	N.A	0.148	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 11

W 12

Average	2024	2023	2022	2021	Year	Parameters	W 12
10.17	10.5	9.58	10.6	10	Nitrate		
15.15	14.7	15.9	15.6	14.4	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
17.17575	0.003	23.1	23.3	22.3	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
14.7525	15.43	14.9	15.38	13.3	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.135	0.133	N.A	N.A	0.137	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 21

Average	2024	2023	2022	2021	Year
11.275	12.2	10.7	11.1	11.1	Nitrate
20.85	20.5	20.1	22.6	20.2	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
27.175	27	27.2	27.6	26.9	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
17.66	18.3	18.3	17.14	16.9	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.1595	0.154	N.A	N.A	0.165	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 21

W 22

Average	2024	2023	2022	2021	Year		
11.35	11.8	10.6	12	11	Nitrate		
19.4	19.8	18.7	20.6	18.5	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
26.275	26.9	25.9	26.7	25.6	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
17.41	18	17.9	17.24	16.5	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide	Parameters	W 22
0.1635	0.156	N.A	N.A	0.171	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 23

Average	2024	2023	2022	2021	Year
11	11.6	10.3	11.6	10.5	Nitrate
18.85	19.2	18.2	20	18	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
25.25	25.5	24.9	25.9	24.7	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
17.3025	18.1	17.6	17.21	16.3	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.1565	0.155	N.A	N.A	0.158	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 23

W 24

Average	2024	2023	2022	2021	Year
10.975	11.6	10.1	11.7	10.5	Nitrate
19.275	19.8	18.5	20.6	18.2	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
25.275	25.1	25.6	25.7	24.7	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
17.34	17.95	18	17.11	16.3	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.1595	0.153	N.A	N.A	0.166	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 24

W 25

Average	2024	2023	2022	2021	Year	Parameters	W 25
8.0825	8.94	8.52	7.22	7.65	Nitrate		
21.4	21.6	21.3	22	20.7	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
30.325	30.5	30.5	30.8	29.5	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
19.6775	20.34	20.4	19.07	18.9	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.1735	0.173	N.A	N.A	0.174	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 26

Average	2024	2023	2022	2021	Year
8.23	8.63	8.27	8.48	7.54	Nitrate
20.55	20.8	20.1	21.7	19.6	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
29.95	30	29.8	30.1	29.9	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
19.6475	20.13	20.3	19.56	18.6	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.152	0.154	N.A	N.A	0.15	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 26

W 27

Average	2024	2023	2022	2021	Year	Parameters	W 27
8.493333333	N.A	8.52	9	7.96	Nitrate		
16.2	N.A	16.2	17.1	15.3	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
24.46667	N.A	24.1	25.1	24.2	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.19667	N.A	17.6	16.39	14.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.239	N.A	N.A	N.A	0.239	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

Average	2024	2023	2022	2021	Year		
11.35	11.8	10.6	11.8	11.2	Nitrate	Parameters	W28
16.15	17.1	18.3	18	11.2	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
23.75	23.7	23.7	24.3	23.3	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.4725	17.19	16.8	16.9	15	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.1545	0.152	N.A	N.A	0.157	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 29

Average	2024	2023	2022	2021	Year		
11.0475	10.8	10.5	11.89	11	Nitrate	Parameters	W 29
17.5	16.3	18.8	18.2	16.7	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
23.825	23.5	23.6	24.3	23.9	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.495	16.98	16.8	17.3	14.9	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.154	0.151	N.A	N.A	0.157	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 30

Average	2024	2023	2022	2021	Year	Parameters	W 30
11.025	11.6	10.4	11.4	10.7	Nitrate		
17.35	17.3	18.2	17.6	16.3	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
23.925	24	24	24.2	23.5	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
15.9425	16.92	16.7	15.25	14.9	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.184	0.162	N.A	N.A	0.206	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 31

Average	2024	2023	2022	2021	Year	Parameters	W 31
11.9	12.5	11.2	12.3	11.6	Nitrate		
16.675	16.7	17.3	17	15.7	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
22.725	22.8	23	22.6	22.5	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
15.7	16.36	15.9	15.94	14.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.163	0.151	N.A	N.A	0.175	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 32

Average	2024	2023	2022	2021	Year
11.325	11.4	11.1	11.7	11.1	Nitrate
18.45	18.5	18.6	19.1	17.6	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
24.95	25.6	24.5	25	24.7	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
16.9725	17.33	18.4	16.66	15.5	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.156	0.148	N.A	N.A	0.164	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 32

W 33

Average	2024	2023	2022	2021	Year	Parameters	W 33
10.0975	10.5	9.74	10.4	9.75	Nitrate		
18.75	19	18.5	19.4	18.1	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
26.25	26.6	26.2	25.8	26.4	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
17.13	17.17	18.4	17.35	15.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.1385	0.133	N.A	N.A	0.144	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 34

Average	2024	2023	2022	2021	Year	Parameters	W 34
10.8	11.8	10.2	11	10.2	Nitrate		
18.625	16.9	19.1	20.3	18.2	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
25.3	24.6	25.1	25.8	25.7	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.6825	16.48	18.1	16.95	15.2	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.147	0.147	N.A	N.A	0.147	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 35

Average	2024	2023	2022	2021	Year	Parameters	W 35
11.5	10.9	11.6	12.1	11.4	Nitrate		
17.8	19.1	17.3	17.9	16.9	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
26.375	25.6	24.1	31.2	24.6	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.205	16.82	17.5	15.9	14.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.143	0.139	N.A	N.A	0.147	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 36

Average	2024	2023	2022	2021	Year	Parameters	W 36
11.875	12.1	11.5	12.4	11.5	Nitrate		
18.125	18	17.9	19.1	17.5	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
25.75	26.1	24.9	26.2	25.8	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
17.165	17.76	18.8	16.2	15.9	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.1515	0.15	N.A	N.A	0.153	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 37

Average	2024	2023	2022	2021	Year	Parameters	W 37
8.62575	12	11.6	0.003	10.9	Nitrate		
17.625	17.7	17.9	18.6	16.3	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
25.6	25.7	25.5	26	25.2	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.995	17.58	18.7	16	15.7	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
3.05225	0.003	0.003	12.2	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	0.003	N.A	Cadmium		
0.02	0.02	N.A	0.02	N.A	Total Chromium		
0.001	0.001	N.A	0.001	N.A	Mercury		
0.1	0.1	N.A	0.1	N.A	Barium		
0.075	0.05	N.A	0.1	N.A	Silver		
0.01	0.01	N.A	0.01	N.A	Arsenic		
0.01	0.01	N.A	0.01	N.A	Antimony		
0.055	0.01	N.A	0.1	N.A	Boron		
0.01	0.01	N.A	0.01	N.A	Selenium		
0.045	0.04	N.A	0.05	N.A	Cyanide		
0.1585	0.165	N.A	0.152	N.A	Fluoride		
0.01	0.01	N.A	0.01	N.A	Molybdenum		
0.01	0.01	N.A	0.01	N.A	Lead		
0.05	0.05	N.A	0.05	N.A	Nickel		
0.15	0.15	N.A	0.15	N.A	DDT		
0.03	0.03	N.A	0.03	N.A	Dieldrin		
0.03	0.03	N.A	0.03	N.A	Aldrin		
0.03	0.03	N.A	0.03	N.A	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	0.1	N.A	Lindane		
0.1	0.1	N.A	0.1	N.A	Endrin		
5	5	N.A	N.A	N.A	Benzene		
12.5	5	N.A	20	N.A	Trichloroethylene (TCE)		
12.5	5	N.A	20	N.A	Tetrachloroethylene		
12.5	5	N.A	20	N.A	Ethylbenzene		
12.5	5	N.A	20	N.A	Toluene		
17.5	15	N.A	20	N.A	Total Xylene		
1	1	N.A	1	N.A	2-4-5T		
1	1	N.A	1	N.A	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 38

Average	2024	2023	2022	2021	Year
11.325	12.3	10.6	12	10.4	Nitrate
19.325	19.6	19.8	20.3	17.6	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
25.05	24.9	25.2	25.3	24.8	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
16.125	16.79	16.41	16.3	15	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.1675	0.136	N.A	N.A	0.199	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
15	5	N.A	20	20	Trichloroethylene (TCE)
15	5	N.A	20	20	Tetrachloroethylene
15	5	N.A	20	20	Ethylbenzene
15	5	N.A	20	20	Toluene
18.33333	15	N.A	20	20	Total Xylene
1	1	N.A	1	1	2-4-5T
1	1	N.A	1	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 38

W 39

Average	2024	2023	2022	2021	Year
11.525	12.1	10.9	12.2	10.9	Nitrate
18.675	19.2	18.6	19.7	17.2	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
24.75	25.5	25	24.2	24.3	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
15.9875	16.7	15.75	16.5	15	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.1475	0.148	N.A	N.A	0.147	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 39

W 40

Average	2024	2023	2022	2021	Year
11.975	12.3	11.8	12.7	11.1	Nitrate
18.4	18.5	18.6	19.6	16.9	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
25.5	25.6	24.9	26.1	25.4	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
16.785	17.14	18.6	15.9	15.5	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.169	0.15	N.A	N.A	0.188	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
15	5	N.A	20	20	Trichloroethylene (TCE)
15	5	N.A	20	20	Tetrachloroethylene
15	5	N.A	20	20	Ethylbenzene
15	5	N.A	20	20	Toluene
18.33333	15	N.A	20	20	Total Xylene
1	1	N.A	1	1	2-4-5T
1	1	N.A	1	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 40

W 41

Average	2024	2023	2022	2021	Year
11.7	12.3	11.4	12.1	11	Nitrate
17.225	17.6	17.7	17.8	15.8	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
24.25	25.3	24.4	23.5	23.8	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
16.1675	16.47	17.8	15.6	14.8	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.1725	0.155	N.A	N.A	0.19	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
15	5	N.A	20	20	Trichloroethylene (TCE)
15	5	N.A	20	20	Tetrachloroethylene
15	5	N.A	20	20	Ethylbenzene
15	5	N.A	20	20	Toluene
18.33333	15	N.A	20	20	Total Xylene
1	1	N.A	1	1	2-4-5T
1	1	N.A	1	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 41

W 42

Average	2024	2023	2022	2021	Year
11.175	11.7	11	11.6	10.4	Nitrate
18.725	19	19.1	19.5	17.3	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
25.025	25.3	24.5	25.3	25	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
16.465	16.96	18	15.7	15.2	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.165	0.148	N.A	N.A	0.182	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
15	5	N.A	20	20	Trichloroethylene (TCE)
15	5	N.A	20	20	Tetrachloroethylene
15	5	N.A	20	20	Ethylbenzene
15	5	N.A	20	20	Toluene
18.33333	15	N.A	20	20	Total Xylene
1	1	N.A	1	1	2-4-5T
1	1	N.A	1	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 42

W 43

Average	2024	2023	2022	2021	Year
11.725	12.1	11.4	12.4	11	Nitrate
19.175	19.4	19.3	20.2	17.8	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
24.375	25	23.7	24.3	24.5	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
16.0525	16.51	17.7	15.2	14.8	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.1705	0.149	N.A	N.A	0.192	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
15	5	N.A	20	20	Trichloroethylene (TCE)
15	5	N.A	20	20	Tetrachloroethylene
15	5	N.A	20	20	Ethylbenzene
15	5	N.A	20	20	Toluene
18.33333	15	N.A	20	20	Total Xylene
1	1	N.A	1	1	2-4-5T
1	1	N.A	1	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 43

Average	2024	2023	2022	2021	Year
12.15	12.5	12.1	12.7	11.3	Nitrate
16.8	16.9	17.5	17.4	15.4	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
24.45	24.9	24.3	24.4	24.2	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
16.295	16.58	17.9	15.8	14.9	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.204	0.175	N.A	N.A	0.233	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
15	5	N.A	20	20	Trichloroethylene (TCE)
15	5	N.A	20	20	Tetrachloroethylene
15	5	N.A	20	20	Ethylbenzene
15	5	N.A	20	20	Toluene
18.33333	15	N.A	20	20	Total Xylene
1	1	N.A	1	1	2-4-5T
1	1	N.A	1	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 45

Average	2024	2023	2022	2021	Year
11.025	11.3	10.6	11.7	10.5	Nitrate
17	16.9	17.2	18	15.9	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
25.075	25.5	24.7	25.3	24.8	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
16.755	16.66	17.8	17.56	15	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.2095	0.183	N.A	N.A	0.236	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
15	5	N.A	20	20	Trichloroethylene (TCE)
15	5	N.A	20	20	Tetrachloroethylene
15	5	N.A	20	20	Ethylbenzene
15	5	N.A	20	20	Toluene
18.33333	15	N.A	20	20	Total Xylene
1	1	N.A	1	1	2-4-5T
1	1	N.A	1	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 45

W 46

Average	2024	2023	2022	2021	Year
10.135	10.7	9.68	10.6	9.56	Nitrate
17.375	17.8	17.8	18	15.9	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
27.225	27.3	27.2	27.9	26.5	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
16.735	16.86	17.5	17.48	15.1	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.2355	0.192	N.A	N.A	0.279	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
15	5	N.A	20	20	Trichloroethylene (TCE)
15	5	N.A	20	20	Tetrachloroethylene
15	5	N.A	20	20	Ethylbenzene
15	5	N.A	20	20	Toluene
18.33333	15	N.A	20	20	Total Xylene
1	1	N.A	1	1	2-4-5T
1	1	N.A	1	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 46

W 47

Average	2024	2023	2022	2021	Year	Parameters	W 47
8.9275	9.45	8.56	9.4	8.3	Nitrate		
17.225	17	16.9	18.3	16.7	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
27.275	26.7	26	28.4	28	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.8575	16.4	17.8	17.93	15.3	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.21	0.228	N.A	N.A	0.192	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
15	5	N.A	20	20	Trichloroethylene (TCE)		
15	5	N.A	20	20	Tetrachloroethylene		
15	5	N.A	20	20	Ethylbenzene		
15	5	N.A	20	20	Toluene		
18.33333	15	N.A	20	20	Total Xylene		
1	1	N.A	1	1	2-4-5T		
1	1	N.A	1	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 48

Average	2024	2023	2022	2021	Year
7.12575	9.62	9.14	9.74	0.003	Nitrate
12.905	16.8	17.2	17.6	0.02	Sulphate
0.07525	0.1	0.1	0.1	0.001	Aluminium
19.775	26.7	25.8	26.5	0.1	Chloride
0.0625	0.05	0.05	0.05	0.1	Copper
13.05	16.8	17.8	17.59	0.01	Sodium
0.04	0.05	0.05	0.05	0.01	Zinc
0.0625	0.05	0.05	0.05	0.1	Manganese
0.0775	0.1	0.1	0.1	0.01	Iron
0.01475	0.003	0.003	0.003	0.05	Nitrite
0.1065	0.08	0.08	0.08	0.186	Ammonium
0.0065	0.003	N.A	N.A	0.01	Cadmium
0.015	0.02	N.A	N.A	0.01	Total Chromium
0.0255	0.001	N.A	N.A	0.05	Mercury
0.125	0.1	N.A	N.A	0.15	Barium
0.04	0.05	N.A	N.A	0.03	Silver
0.02	0.01	N.A	N.A	0.03	Arsenic
0.02	0.01	N.A	N.A	0.03	Antimony
0.055	0.01	N.A	N.A	0.1	Boron
0.055	0.01	N.A	N.A	0.1	Selenium
5.02	0.04	N.A	N.A	10	Cyanide
10.094	0.188	N.A	N.A	20	Fluoride
10.005	0.01	N.A	N.A	20	Molybdenum
10.005	0.01	N.A	N.A	20	Lead
10.025	0.05	N.A	N.A	20	Nickel
10.075	0.15	N.A	N.A	20	DDT
0.515	0.03	N.A	N.A	1	Dieldrin
0.515	0.03	N.A	N.A	1	Aldrin
4.18	0.03	N.A	N.A	8.33	Heptachlor epoxide & Heptachlor
9.1	0.1	N.A	N.A	18.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
16.45	5	N.A	N.A	27.9	Benzene
8.35	5	N.A	20	0.05	Trichloroethylene (TCE)
13.76667	5	N.A	20	16.3	Tetrachloroethylene
8.35	5	N.A	20	0.05	Ethylbenzene
8.35	5	N.A	20	0.05	Toluene
11.7	15	N.A	20	0.1	Total Xylene
0.667667	1	N.A	1	0.003	2-4-5T
0.693333	1	N.A	1	0.08	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

W 48

W 49

Average	2024	2023	2022	2021	Year	Parameters	W 49
8.94	9.82	8.55	9.3	8.09	Nitrate		
17.775	18.1	17.9	18.6	16.5	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
28.9	29.6	28.9	28.9	28.2	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
18.475	18.5	19.4	19.4	16.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.166	0.158	N.A	N.A	0.174	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
15	5	N.A	20	20	Trichloroethylene (TCE)		
15	5	N.A	20	20	Tetrachloroethylene		
15	5	N.A	20	20	Ethylbenzene		
15	5	N.A	20	20	Toluene		
18.33333	15	N.A	20	20	Total Xylene		
1	1	N.A	1	1	2-4-5T		
1	1	N.A	1	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 50

Average	2024	2023	2022	2021	Year		
11.66666667	N.A	11.5	12.3	11.2	Nitrate		
17.525	19.8	16.9	17.5	15.9	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
25.025	24.9	25.1	25.7	24.4	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.2775	14.45	18.2	17.46	15	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide	Parameters	W 50
0.1775	0.136	N.A	N.A	0.219	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
15	5	N.A	20	20	Trichloroethylene (TCE)		
15	5	N.A	20	20	Tetrachloroethylene		
15	5	N.A	20	20	Ethylbenzene		
15	5	N.A	20	20	Toluene		
18.33333	15	N.A	20	20	Total Xylene		
1	1	N.A	1	1	2-4-5T		
1	1	N.A	1	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 51

Average	2024	2023	2022	2021	Year		
10.33	11.1	10	10.6	9.62	Nitrate		
16.7	17.2	16.9	17.1	15.6	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
26.625	27.7	26.3	26.9	25.6	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
17.5975	17.9	18.8	18.09	15.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide	Parameters	W 51
0.2155	0.177	N.A	N.A	0.254	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
15	5	N.A	20	20	Trichloroethylene (TCE)		
15	5	N.A	20	20	Tetrachloroethylene		
15	5	N.A	20	20	Ethylbenzene		
15	5	N.A	20	20	Toluene		
18.33333	15	N.A	20	20	Total Xylene		
1	1	N.A	1	1	2-4-5T		
1	1	N.A	1	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

Average	2024	2023	2022	2021	Year	Parameters	W 52
10.08	10.1	10	10.6	9.62	Nitrate		
17	18.4	16.9	17.1	15.6	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
27.425	30.9	26.3	26.9	25.6	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
17.8475	18.9	18.8	18.09	15.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.2285	0.203	N.A	N.A	0.254	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
15	5	N.A	20	20	Trichloroethylene (TCE)		
15	5	N.A	20	20	Tetrachloroethylene		
15	5	N.A	20	20	Ethylbenzene		
15	5	N.A	20	20	Toluene		
18.33333	15	N.A	20	20	Total Xylene		
1	1	N.A	1	1	2-4-5T		
1	1	N.A	1	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 53

Average	2024	2023	2022	2021	Year	Parameters	W 53
12.6	12.4	12.7	13.2	12.1	Nitrate		
16.625	16.3	17.2	17.3	15.7	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
26.7	27.4	26.3	27.3	25.8	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
16.5375	16.8	18.2	16.05	15.1	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.159	0.148	N.A	N.A	0.17	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
15	5	N.A	20	20	Trichloroethylene (TCE)		
15	5	N.A	20	20	Tetrachloroethylene		
15	5	N.A	20	20	Ethylbenzene		
15	5	N.A	20	20	Toluene		
18.33333	15	N.A	20	20	Total Xylene		
1	1	N.A	1	1	2-4-5T		
1	1	N.A	1	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 54

Average	2024	2023	2022	2021	Year		
10.2675	10.3	10.1	10.9	9.77	Nitrate		
15.2	16	14.9	15.8	14.1	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
23.875	23.4	24.2	24.4	23.5	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
14.675	13.28	16.2	15.62	13.6	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide	Parameters	W 54
0.1595	0.141	N.A	N.A	0.178	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
15	5	N.A	20	20	Trichloroethylene (TCE)		
15	5	N.A	20	20	Tetrachloroethylene		
15	5	N.A	20	20	Ethylbenzene		
15	5	N.A	20	20	Toluene		
18.33333	15	N.A	20	20	Total Xylene		
1	1	N.A	1	1	2-4-5T		
1	1	N.A	1	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

W 55

Average	2024	2023	2022	2021	Year	Parameters	W 55
12.025	12	12.1	12.6	11.4	Nitrate		
16.775	15.4	14.3	14.9	22.5	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
22.7	22.4	22.8	23.1	22.5	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
14.39	14.07	15.4	15.09	13	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.055	0.01	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.1735	0.165	N.A	N.A	0.182	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
15	5	N.A	20	20	Trichloroethylene (TCE)		
15	5	N.A	20	20	Tetrachloroethylene		
15	5	N.A	20	20	Ethylbenzene		
15	5	N.A	20	20	Toluene		
18.33333	15	N.A	20	20	Total Xylene		
1	1	N.A	1	1	2-4-5T		
1	1	N.A	1	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

Average	2024	2023	2022	2021	Year	Parameters	P 1
12.075	12.3	11.8	12.8	11.4	Nitrate		
19.25	19.9	19.1	20.1	17.9	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
25.075	25.4	25.2	25.2	24.5	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
17.535	18.2	19.1	16.84	16	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.1	0.1	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.146	0.129	N.A	N.A	0.163	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

Average	2024	2023	2022	2021	Year	Parameters	P 2
9.16	9.68	9.47	9.31	8.18	Nitrate		
24.7	24.9	24.3	26.2	23.4	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
31.675	31.6	31	32.1	32	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
22.23	23.1	22.6	21.52	21.7	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.1	0.1	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.156	0.145	N.A	N.A	0.167	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
20	<5.0	N.A	N.A	20	Trichloroethylene (TCE)		
20	N.A	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

Average	2024	2023	2022	2021	Year	Parameters	P 3
8.5225	9.1	8.63	8.71	7.65	Nitrate		
25.9	25.7	25.7	27.4	24.8	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
33.425	33.5	33.2	33.8	33.2	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
23.385	23.7	23.5	23.54	22.8	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.1	0.1	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.1685	0.175	N.A	N.A	0.162	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

P5

Average	2024	2023	2022	2021	Year	Parameters	P5
8.265	8.33	8.4	8.76	7.57	Nitrate		
28.4	27.5	28.3	30.4	27.4	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
37.125	37.8	36.6	37.6	36.5	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
25.4725	25.9	25.6	25.19	25.2	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	N.A	N.A	0.003	Cadmium		
0.02	0.02	N.A	N.A	0.02	Total Chromium		
0.001	0.001	N.A	N.A	0.001	Mercury		
0.1	0.1	N.A	N.A	0.1	Barium		
0.075	0.05	N.A	N.A	0.1	Silver		
0.01	0.01	N.A	N.A	0.01	Arsenic		
0.01	0.01	N.A	N.A	0.01	Antimony		
0.1	0.1	N.A	N.A	0.1	Boron		
0.01	0.01	N.A	N.A	0.01	Selenium		
0.045	0.04	N.A	N.A	0.05	Cyanide		
0.1795	0.189	N.A	N.A	0.17	Fluoride		
0.01	0.01	N.A	N.A	0.01	Molybdenum		
0.01	0.01	N.A	N.A	0.01	Lead		
0.05	0.05	N.A	N.A	0.05	Nickel		
0.15	0.15	N.A	N.A	0.15	DDT		
0.03	0.03	N.A	N.A	0.03	Dieldrin		
0.03	0.03	N.A	N.A	0.03	Aldrin		
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	N.A	N.A	0.1	Lindane		
0.1	0.1	N.A	N.A	0.1	Endrin		
7.5	5	N.A	N.A	10	Benzene		
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)		
12.5	5	N.A	N.A	20	Tetrachloroethylene		
12.5	5	N.A	N.A	20	Ethylbenzene		
12.5	5	N.A	N.A	20	Toluene		
17.5	15	N.A	N.A	20	Total Xylene		
1	1	N.A	N.A	1	2-4-5T		
1	1	N.A	N.A	1	2,4-D		
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)		
0	0	N.A	N.A	N.A	colour		
0	0	N.A	N.A	N.A	odur		
5	5	N.A	N.A	N.A	perchloroethylene (PCE)		

Avg	2024	2023	2022	2021	Year
8.57	9.18	8.48	8.78	7.84	Nitrate
29.55	29.5	29.6	30.6	28.5	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
39.125	39.5	39.6	39.2	38.2	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
26.2325	26.8	27	25.83	25.3	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.1	0.1	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.178	0.183	N.A	N.A	0.173	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

P 6

P 7

Average	2024	2023	2022	2021	Year	Parameters	P 7
8.7075	9.18	8.81	9.03	7.81	Nitrate		
30.075	30	30	32	28.3	Sulphate		
0.1	0.1	0.1	0.1	0.1	Aluminium		
38.05	39.8	34.3	39.5	38.6	Chloride		
0.05	0.05	0.05	0.05	0.05	Copper		
26.7375	27.5	26.9	26.65	25.9	Sodium		
0.05	0.05	0.05	0.05	0.05	Zinc		
0.05	0.05	0.05	0.05	0.05	Manganese		
0.1	0.1	0.1	0.1	0.1	Iron		
0.003	0.003	0.003	0.003	0.003	Nitrite		
0.08	0.08	0.08	0.08	0.08	Ammonium		
0.003	0.003	*	*	0.003	Cadmium		
0.02	0.02	*	*	0.02	Total Chromium		
0.001	0.001	*	*	0.001	Mercury		
0.1	0.1	*	*	0.1	Barium		
0.075	0.05	*	*	0.1	Silver		
0.01	0.01	*	*	0.01	Arsenic		
0.01	0.01	*	*	0.01	Antimony		
0.1	0.1	*	*	0.1	Boron		
0.01	0.01	*	*	0.01	Selenium		
0.045	0.04	*	*	0.05	Cyanide		
0.185	0.191	*	*	0.179	Fluoride		
0.01	0.01	*	*	0.01	Molybdenum		
0.01	0.01	*	*	0.01	Lead		
0.05	0.05	*	*	0.05	Nickel		
0.15	0.15	*	*	0.15	DDT		
0.03	0.03	*	*	0.03	Dieldrin		
0.03	0.03	*	*	0.03	Aldrin		
0.03	0.03	*	*	0.03	Heptachlor epoxide & Heptachlor		
0.1	0.1	*	*	0.1	Lindane		
0.1	0.1	*	*	0.1	Endrin		
7.5	5	*	*	10	Benzene		
12.5	5	*	*	20	Trichloroethylene (TCE)		
12.5	5	*	*	20	Tetrachloroethylene		
12.5	5	*	*	20	Ethylbenzene		
12.5	5	*	*	20	Toluene		
17.5	15	*	*	20	Total Xylene		
1	1	*	*	1	2-4-5T		
1	1	*	*	1	2,4-D		
0	0	*	*	*	Chemical disinfectants (Abs)		
0	0	*	*	*	colour		
0	0	*	*	*	odur		
5	5	*	*	*	perchloroethylene (PCE)		

Average	2024	2023	2022	2021	Year
8.76	9.38	8.72	8.92	8.02	Nitrate
29.65	29.5	29.6	31.1	28.4	Sulphate
0.1	0.1	0.1	0.1	0.1	Aluminium
39.325	39.6	39.1	39.9	38.7	Chloride
0.05	0.05	0.05	0.05	0.05	Copper
26.9225	27.6	27.2	26.79	26.1	Sodium
0.05	0.05	0.05	0.05	0.05	Zinc
0.05	0.05	0.05	0.05	0.05	Manganese
0.1	0.1	0.1	0.1	0.1	Iron
0.003	0.003	0.003	0.003	0.003	Nitrite
0.08	0.08	0.08	0.08	0.08	Ammonium
0.003	0.003	N.A	N.A	0.003	Cadmium
0.02	0.02	N.A	N.A	0.02	Total Chromium
0.001	0.001	N.A	N.A	0.001	Mercury
0.1	0.1	N.A	N.A	0.1	Barium
0.075	0.05	N.A	N.A	0.1	Silver
0.01	0.01	N.A	N.A	0.01	Arsenic
0.01	0.01	N.A	N.A	0.01	Antimony
0.1	0.1	N.A	N.A	0.1	Boron
0.01	0.01	N.A	N.A	0.01	Selenium
0.045	0.04	N.A	N.A	0.05	Cyanide
0.1875	0.196	N.A	N.A	0.179	Fluoride
0.01	0.01	N.A	N.A	0.01	Molybdenum
0.01	0.01	N.A	N.A	0.01	Lead
0.05	0.05	N.A	N.A	0.05	Nickel
0.15	0.15	N.A	N.A	0.15	DDT
0.03	0.03	N.A	N.A	0.03	Dieldrin
0.03	0.03	N.A	N.A	0.03	Aldrin
0.03	0.03	N.A	N.A	0.03	Heptachlor epoxide & Heptachlor
0.1	0.1	N.A	N.A	0.1	Lindane
0.1	0.1	N.A	N.A	0.1	Endrin
7.5	5	N.A	N.A	10	Benzene
12.5	5	N.A	N.A	20	Trichloroethylene (TCE)
12.5	5	N.A	N.A	20	Tetrachloroethylene
12.5	5	N.A	N.A	20	Ethylbenzene
12.5	5	N.A	N.A	20	Toluene
17.5	15	N.A	N.A	20	Total Xylene
1	1	N.A	N.A	1	2-4-5T
1	1	N.A	N.A	1	2,4-D
0	0	N.A	N.A	N.A	Chemical disinfectants (Abs)
0	0	N.A	N.A	N.A	colour
0	0	N.A	N.A	N.A	odur
5	5	N.A	N.A	N.A	perchloroethylene (PCE)

Parameters

P 8

Annex 8: Department of Antiquities Letter

وزارة السياحة والآثار
دائرة الآثار العامة

الرقم ----- ٥٢-١-١١٩١٥-
التاريخ ----- ٢٠٢٤/١١/٢٥-
المرافق ----------

السادة شركة آرابتك جردانة للمياه والبيئة

الموضوع: بيان الرأي الأثري

إشارة إلى كتابكم رقم AW 136-309 تاريخ 2024/9/23 بخصوص طلبكم الكشف الميداني على مشروع حفر الآبار الجديدة وأعمال البنية التحتية المرتبطة بها في منطقة مشروع حقل دبيدب الديسي.

للتفضل بالعلم بأن دائرة الآثار العامة قامت بالكشف الحسي على المنطقة وبعد مراجعة سجلاتها تبين أن المنطقة المذكورة أعلاه لا تحوي أية مواقع أو ظواهر أثرية أو بقايا مادية، ولا مانع من تنفيذ أعمال المشروع حسب الإحداثيات المقدمة من قبلكم وإبلاغ دائرة الآثار العامة فوراً في حال العثور على أي لقى أو شواهد أثرية.

وتفضلوا بقبول الاحترام

أ.د. فادي عبدالله بلعاوي

مدير عام دائرة الآثار العامة بالوكالة

نسخة/ مديرية التنقيبات والمسوحات الأثرية
نسخة/ مديرية آثار محافظة العقبة
م ن / ع ب

Annex 9: Internal and External Grievance Template

Disi Water Company PSC

Diwaco
Disi Water Company

Operation & Maintenance Phase

Internal & External Grievances Register

Quality Control Sheet

Document Title: Internal & External Grievances Register		**Document Ref.:**DWC-HRM-OM-QAP-GR-018			
Rev. no.	**Reason for issue**	**Date**	**Prepared by**	**Checked by**	**Approved by**
0	Initial Issuance	16/6/2021	**AA**	**KW**	**ML/TK**

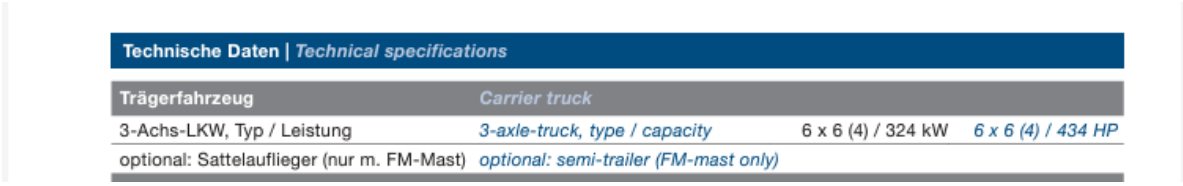
Internal Grievances Register

#	Name of Employee	Job Title	Date	Description of Grievance	Response/Action Taken	Status (Open/Closed)

External Grievances Register

#	Name of Party	Date	Description of Grievance	Response/Action Taken	Status (Open/Closed)

Annex 10: Technical Specification and Estimation of the amount of Diesel Fuel Utilized



Technische Daten | *Technical specifications*			
Trägerfahrzeug	***Carrier truck***		
3-Achs-LKW, Typ / Leistung	*3-axle-truck, type / capacity*	6 x 6 (4) / 324 kW	*6 x 6 (4) / 434 HP*
optional: Sattelauflieger (nur m. FM-Mast)	*optional: semi-trailer (FM-mast only)*		

Rig Calculation		
https://carefreeboats.com/how-to-calculate-fuel-consumption		
(GPH) = (specific fuel consumption x HP)/Fuel Specific Weight		
Engine Power	HP	434
Specific gravity (diesel fuel)	Lb/Gal	7.2
Standard Diesel engine multiplier		0.4
(GPH) gallon per hour	Gal/h	24.1
gal to lt		3.785
liter per hour	Lt/h	91.3
Historical (Rate of Drilling)	m/h	1.5
meter well depth	meter	600
Drilling duration	hours	400
liters of diesel needed (drilling)	Liter	36,504
Estimated cementation and development	hours	48
Cementation and development consumption	Liter	4,381
Total Rig	**Liter**	**40,885**
110Kw Camp Generator		
historical BPT Generator 110kw generator	L/month	7,490.00
liter / hours 110kw generator	L/month	10.40
Total Generator consumption	Liters	**4,660**
Total diesel Consumption	Liter	**45,545**

Annex 11: Biodiversity Study

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT OF DISI WELLFIELD PROJECT

Biodiversity Study

Anwar Elhalah
Biodiversity Expert

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1. Introduction

1.1 Background

The Dubaydib Wellfield Expansion Project, which was launched in 2024 as a component of the Jordanian Ministry of Water and Irrigation's nationwide plan, aims to enhance the water provision to the Greater Amman Area. The project entails the digging of supplementary wells to augment the production capacity of the Disi aquifer, guaranteeing the provision of an additional 20 million cubic meters of water per year. This increased supply is crucial in order to fulfill the growing water needs of Amman and the surrounding areas, hence supporting the long-term viability of Jordan's water resources.

In accordance with the environmental impact assessment (EIA) standards set by the Ministry of Environment, it is necessary to conduct a thorough biodiversity study to examine the possible impacts of the wellfield expansion on the nearby ecosystems. This report presents an analysis of the expected impacts of the Dubaydib Wellfield Expansion on biodiversity, encompassing both flora and fauna. It also offers a structured approach to implementing methods that would minimize any negative consequences. The assessment evaluates both the phases of construction and operation, emphasizing possible impacts and suggesting actions to prevent, reduce, or offset negative effects on biodiversity.

1.2 Study Objectives

The study aims to:

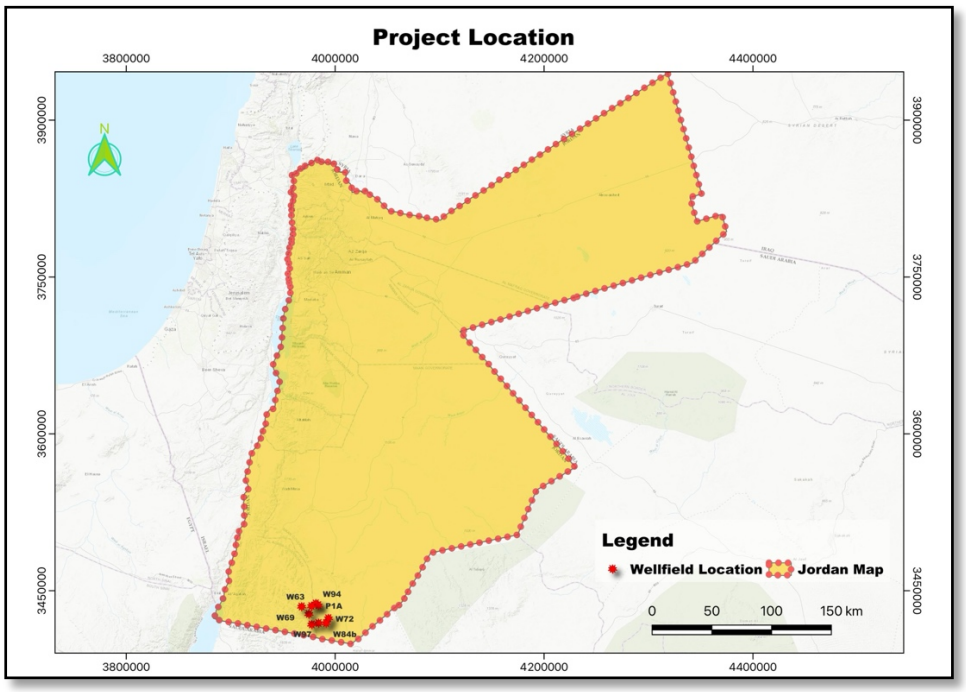
- Review and update terrestrial flora and fauna species recorded in the site and adjacent areas.
- Establish a comprehensive baseline of the biodiversity within the project area, including species inventories of flora and fauna, ecosystem types, and key ecological processes.
- Identify key species and habitats of conservation concern within the project area, including threatened or endemic species, and assess their sensitivity to the proposed development activities.
- Identify potential impact on terrestrial fauna and flora species from the project operation.
- Assess the project direct and indirect impact on biodiversity aspects during the two phases of the project: construction and operation.
- Propose mitigation measures where necessary to ensure protecting species and their habitats.

- Develop a long-term biodiversity monitoring plan to track the effectiveness of mitigation measures and ensure that biodiversity is preserved throughout the project lifecycle.

1.3 Location

The Dubaydib Wellfield Expansion Project is located in southern Jordan, within the Disi-Mudawarra region, which is part of the vast Arabian Desert. This area is characterized by its arid and semi-arid climate, with low annual rainfall and high temperatures. The landscape is dominated by desert plains, rocky outcrops, and sparse vegetation, typical of the Saharo-Arabian biogeographic zone. Despite its harsh environment, the area supports a unique biodiversity, including drought-tolerant plant species and wildlife adapted to the desert conditions. The project area also lies near key ecological zones, with certain sections located close to wadis (valleys) that contain vegetation such as Acacia and Haloxylon plants, which serve as important habitats for various species.

In addition to its environmental significance, the project area is strategically important for Jordan's water security. The Disi aquifer, a fossil water resource, extends beneath this region, supplying water to major cities like Amman and Aqaba. The wellfield is located approximately 325 km south of Amman (Map 1) and is connected to the capital via an extensive water conveyance system. The project area's proximity to the Rum Important Bird Area (IBA) and its unique desert ecosystems necessitates a careful consideration of biodiversity impacts, ensuring that water extraction activities do not compromise the ecological integrity of the surrounding landscapes.



Map 1: Project Location

2. Biodiversity Baseline Conditions

2.1 Study Approach for Biological Environment

The study adopted a comprehensive approach to evaluate the biological environment by analyzing key ecological components in relation to their physical settings. This method allows for a holistic understanding of the potential environmental impacts the project may have. The following key biological elements were targeted and linked with the physical environment units of the project area:

Biogeographical Zones and Vegetation Types: The study focused on identifying the specific biogeographical zones and vegetation types present within the project area. These zones are essential for understanding the environmental conditions, including soil type, climate, and natural plant communities, which in turn influence the distribution of flora and fauna.

Flora: An assessment of plant species within the project area was conducted to identify the diversity, abundance, and conservation status of the vegetation. Special attention was paid to endemic, rare, or threatened plant species that could be impacted by project activities.

Fauna: The study selected key wildlife groups to assess the status of fauna in the project area. Mammals, birds, and reptiles were chosen based on their national conservation status, ecological importance, and sensitivity to habitat disturbance. The focus was on species that are vulnerable to habitat changes or disturbances from human activities.

Sensitive Habitats: The study identified and analyzed areas of significant biological importance within and around the project area, such as Protected Areas, Rangeland Reserves, and Important Bird Areas (IBA). These habitats are crucial for the survival of certain species and require special consideration during project planning and execution.

Critical Habitat: A Critical Habitat Screening was conducted to determine whether any areas within the project site meet the criteria for critical habitat as defined by IFC Performance Standard 6 (PS6) and EIB Social and Environment Standard 4. This includes habitats of significant importance for endangered and endemic species, migratory birds, and unique or threatened ecosystems.

Ecosystem Services: The study also assessed the range of ecosystem services provided by the local environment. The potential impacts of the project on these services were analyzed to ensure that ecosystem functions are maintained and not compromised by development activities.

2.1.1 Literature review

As part of the study, the team conducted an extensive literature review to gather all relevant data previously collected from the project site and its surrounding areas. This involved reviewing a wide range of sources, including:

- Previous Environmental Impact Assessments: These assessments provided baseline data on environmental conditions, species inventories, and potential environmental risks.
- Surveys and Biodiversity Assessments: If available, data from earlier surveys were incorporated to supplement the existing information and offer a more comprehensive view of the site's ecological characteristics.
- Additional Scientific Research: The team also consulted relevant scientific literature and databases to gather information on regional biodiversity trends, habitat types, and conservation priorities.

The desktop study focused on analyzing the available information and identifying knowledge gaps that needed to be addressed through further field visits. The key areas of focus during this review were:

- **Flora and Fauna Species**: The presence and distribution of plant and animal species in the project area were examined, paying particular attention to species of conservation concern, such as those that are threatened, endangered, or endemic to the region.
- **Habitat Types and Species Communities**: The study investigated the types of habitats present, such as desert ecosystems, wadis, and rangelands, and the characteristic species that define these habitats. This provided a broader understanding of the ecological dynamics and species interactions within the project area.

By combining the findings from the literature review with field assessments, the study aimed to provide a detailed and scientifically robust evaluation of the biological environment and the potential impacts of the project on biodiversity.

2.1.2 Field Work rapid assessment

The field visit for the rapid biodiversity assessment was conducted over two days, from the 6th to the 7th of August 2024. The assessment involved surveying the wells' locations and the access roads to twelve wells (W63, W69, W72, W84b, W86, W94, W97, W98, W95GT, W65GT, W64GT and P1A). At each well site, flora and fauna species were observed and recorded within a 50-meter radius from the well location. To maximize wildlife observation opportunities, visits to each site were scheduled for early morning or late afternoon, as these times are optimal for detecting wildlife activity.

Data collection during the fieldwork was carefully organized. Handheld GPS devices were used to mark the exact coordinates of each point and to log the locations of any species of conservation importance. Observations were systematically documented on specially designed data sheets, ensuring accurate and efficient recording of data. This methodical approach enabled a precise assessment of biodiversity in the area while facilitating effective data management for subsequent analysis.

2.2 Baseline Conditions for Biological Environment

2.2.1 Biogeographic Zones

Jordan is categorized into four separate biogeographic regions: the Mediterranean, the Irano-Turanian, the Saharo-Arabian, and the Sudanian. The lines delineating the zones are purely suggestive, and many species can be observed in more than one region. (Al-Eisawi, 1996)

The project site is situated within two biogeographic zones: the Sudanian and Saharo-Arabian zones. Five wells (W84b, W86, W97, W98, and W69) are located in the Sudanian zone, sometimes referred to as the subtropical or Afrotropical region. This zone is confined to the warmest parts of Jordan, including areas such as Wadi Rum, Wadi Araba, and the region around the Dead Sea. Extending north toward Dair 'Alia, it is characterized by extremely hot summers, with temperatures ranging from 15 to 45°C, and relatively warm winters. Occasionally, temperatures may exceed these limits on certain days. This region is notable for its location in the lowest point on Earth, the Dead Sea, which lies around -400 meters below sea level. The region receives minimal rainfall, ranging between 50 and 100 millimeters annually, and the soil is predominantly saline, sandy, or Hammada, often found in sand dunes. The vegetation here consists of tropical species, including *Acacia spp.*, *Ziziphus spina-christi*, and other important shrubs and annual herbs. Over 300 plant species in this region are endemic to Jordan, adding significant ecological value to the area. (Al-Eisawi, 1996)

The Saharo-Arabian zone, where the remaining seven wells (W63, W72, W94, W95GT, W65DT, W64GT and P1A) are located, represents the vast desert or Badia region of Jordan. This region is characterized by extremely arid conditions, with very poor soils that are generally saline, sandy-loam, or Hammada in texture. The landscape is dominated by gravelly plains rather than sand dunes, which are typical of other deserts. Rainfall is scarce, averaging between 50 to 100 millimeters per year, and temperatures can soar above 40°C in summer and drop below freezing in winter. Vegetation in this zone is sparse and mainly restricted to wadis where moisture is available. Common plant species include *Artemisia herba-alba*, *Achillea fragrantissima*, *Phlomis spp.*, *Astragalus spp.*, and *Stipa spp.*, which are well-adapted to the harsh desert environment. (Al-Eisawi, 1996)

Dominant plants that can be referred to the Sudanian element include many trees shrubs and herbs, such as: (Al-Eisawi, 1996)

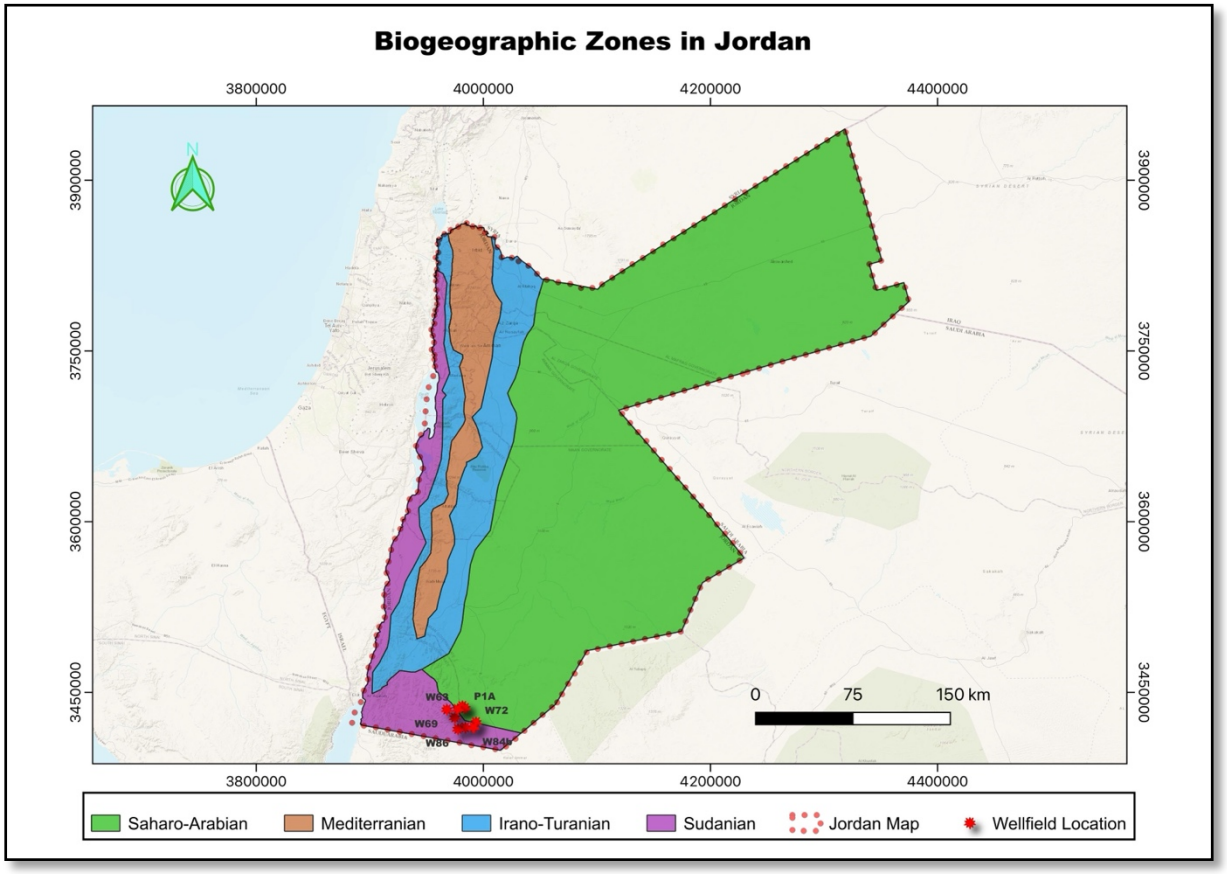
Haloxylon persicum, *Calitropos procera,*

Moringa peregirena, Acacia raddiana,

Ziziphus spina cristi, Belanites aegyptiaca,

Zygophylum dumosum, Salvadora persica,

Ochradenus baccatus Cucumis prophetarum.



Map 2: Biogeographic Zones of Jordan (Al-Eisawi, 1996)

2.2.2 Vegetation Types

There are three vegetation types present in the project area as shown on Map 3 these are:

Sand Dune Vegetation Type

This vegetation can only be found in the Sudanian Biogeographical Region, and the Wadi Rum Protected Area in Jordan is where the best examples of it can be seen. It is dominated by shrubs, which are known as sand dunes fixatives. The most prominent species of these shrubs include *Haloxylon persicum, Retama raetam, Calligonum comosum, Neurada procumbens* and *Hammada scopiara*. (Al-Eisawi, 1996)

Acacia and Rocky Sudanian Vegetation Type

This vegetation type can only be found in the rocky regions of the area. Occasionally, it is seen in conjunction with the Sand Dune Vegetation Type in certain locations. These are the primary species that are representative of this type: *Acacia raddiana, Anabasis articulata, Caralluma spp., Fagonia spp., Gymnocarpos decndrum* and *Helianthemum lippii*. (Al-Eisawi, 1996)

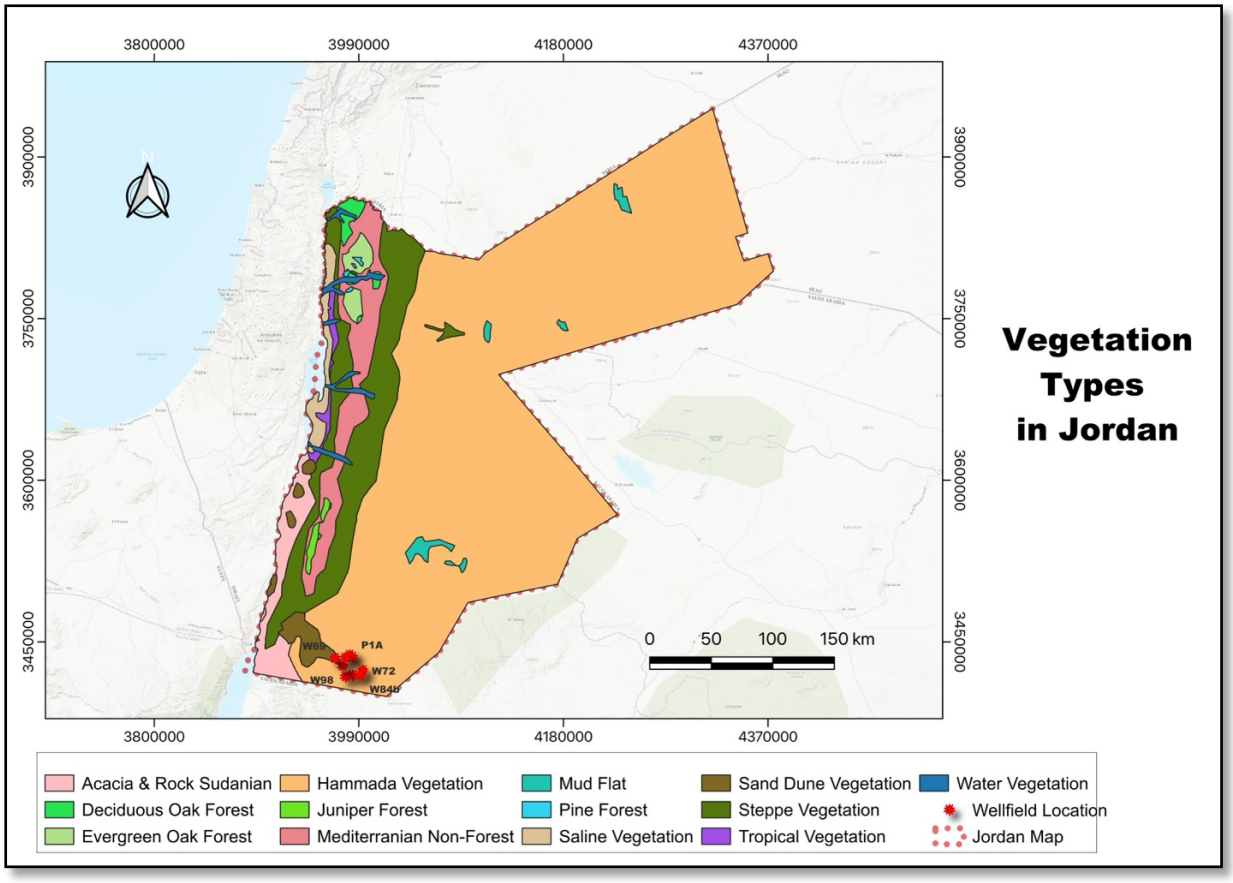
Hammada Vegetation

The majority of the Saharo-Arabian region in Jordan is classified as Hammada, covering approximately 50% of the country's total area. Hammada is further divided into four main types based on soil composition and topography: run-off hammada, gravel hammada, pebble hammada, and sandy hammada (Al-Eisawi, 1996). Three types present in the project area:

Run-off Hammada: Vegetation in run-off hammada is mainly confined to wadis and watershed areas, where water collects and supports denser plant life compared to the surrounding arid zones. The size of these areas can vary significantly, from a few meters to over a kilometer wide. For example, Wadi Bayer can exceed one kilometer in width, while Wadi Rajil and Wadi AL-Hazeem are typically much narrower. Vegetation varies by location; for example, along the Ma'an-Mudawarah road, common species include *Acacia tortilis*, *Acacia raddiana*, and *Tamarix spp.*

Gravel Hammada: This is the largest and flattest part of Jordan's Eastern Desert, characterized by clayey loam soils covered in gravels. The vegetation consists mainly of low shrubs such as *Seidlitzia rosmarinus* and various annual herbs. Leading species include *Mesembryanthemum nodiflorum*, *Filago desertorum*, and *Gymnarrhena micrantha*.

Sandy Hammada: This type is most common along Jordan's borders with Iraq and Saudi Arabia, and parts of it are found in the Ash-Shumari Reserve. The soil here is a mixture of gravel, pebbles, and sandy deposits originating from Saudi Arabia. In some areas, sand becomes dominant, leading to sand dune formations. Key species include *Seidlitzia rosmarinus*, *Atriplex spp.*, *Artemisia herba-alba*, and *Anabasis articulata*.



Map 3: Vegetation Types in Jordan (Al-Eisawi, 1996)

The table that follows presents a selection of vegetation species that have been documented from the region that are of significant conservation importance.

Table 1: List of important plant species reported from the area (Taifour & El-Oqlah, 2014)

Family	Species	National Status
CARYOPHYLLACEAE	*Silene danaensis*	Rare, endemic South Jordan
CHENOPODIACEAE	*Haloxylon persicum*	Vulnerable
COMPOSITAE	*Anthemis melampodina*	Critically Endangered
	Anthemis scrobicularis	Critically Endangered
	Artemisia jordanica	Endangered
	Artemisia judaica	Vulnerable
	Onopordum jordanicolum	Rare, endemic
	Onopordum transjordanicum	Rare, endemic
	Verbesina encelioides	Critically Endangered
CUPRESSACEAE	*Juniperus phoenicea*	Endangered
LABIATAE	*Lavandula coronopifolia*	Near Threatened
	Micromeria graeca	Vulnerable
LEGUMINOSAE	*Acacia gerrardii*	Vulnerable
	Vachellia tortilis	Vulnerable
POLYGONACEAE	*Calligonum comosum*	Endangered
SCROPHULARIACEAE	*Scrophularia xylorrhiza*	Rare

The project area is part of a desert ecosystem, characterized by arid conditions and minimal vegetation. Due to the harsh environment, vegetation is typically confined to wadis, where water collects during sporadic rainfall events. However, the area has been significantly degraded by human activities, exacerbated by climate change and the scarcity of rain. Overgrazing, the expansion of vehicle tracks, and other forms of land disturbance have contributed to the degradation of the ecosystem, limiting the natural regeneration of plant species.

Within the wadis near the well locations, *Acacia gerrardii* and *Retama raetam* were among the primary species observed, indicating the resilience of these plants in such dry conditions. Despite the presence of vegetation in these pockets, the majority of the land surrounding the wells remains barren, with almost no vegetation cover. The high level of human disturbance, including grazing and vehicle movement, has further hindered the potential for vegetation to thrive, leaving the landscape in a highly degraded state. Following is each well location description:

W94 and W95GT

The area surrounding Well W94 and W95GT is classified as Hammada, characterized by a barren, gravelly landscape with minimal to no vegetation directly at the site. However, close to the wells, a small wadi provides a more favorable microhabitat for plant life, where species such as *Seetzenia lanata*, *Acacia tortilis*, *Artemisia judaica*, *Pulicaria undulata*, *Citrullus colocynthis* and *Ochradenus baccatus* were observed. These species are typical of desert environments, thriving in areas where moisture can accumulate, and support limited but vital vegetation.

Picture 1: W94 Location

Despite the presence of these species in the nearby wadi, the overall area is highly disturbed by human activity. Heavy movement of vehicles has resulted in numerous tracks crisscrossing the landscape, contributing to significant land degradation. These disturbances further limit the potential for vegetation recovery and reduce the overall biodiversity at the site, leaving much of the surrounding area bare and unable to support a robust ecosystem.

Picture 2: Acacia tortilis

P1A

The area around Well P1A is completely devoid of any flora species, with no vegetation observed at the site. It is classified as a Hammada landscape, characterized by barren, gravelly soil. The site shows clear signs of heavy disturbance, with numerous vehicle tracks crisscrossing the area, further contributing to the degradation of the already harsh environment. The lack of vegetation and the evident human impact make this location particularly susceptible to continued environmental degradation.

Picture 3: P1A sign of high disturbance

Picture 4: P1A sign of high disturbance

W72

The area surrounding Well W72 is a bare Hammada desert, with little to no vegetation directly at the site. However, a small seasonal water stream from the surrounding hills creates a more favorable environment for the growth of annual flora during brief periods of water

availability. These seasonal streams support limited plant life, providing a temporary habitat for species that can take advantage of the short bursts of moisture. Despite the overall barren landscape, this small water stream plays a critical role in sustaining pockets of biodiversity in the otherwise harsh desert environment.

Picture 5: Annuals close to W72

W84b

The site surrounding Well W84b has some vegetation cover, with a few common species observed, including *Citrullus colocynthis*, *Asteriscus graveolens*, and *Artemisia judaica*. The area is classified as a runoff Hammada, where water from occasional rainfall collects and supports vegetation growth. This type of landscape allows for slightly denser plant life compared to the barren Hammada, especially in areas where runoff channels or small wadis provide essential moisture. The presence of these species highlights the site's ability to sustain limited biodiversity in an otherwise arid environment.

Picture 6: W84b location

Picture 7: Vegetation at W84b

W86

The area surrounding Well W86 is dominated by sand dunes with no vegetation cover directly at the site. However, nearby, there is a wadi that supports a dense growth of *Retama raetam*. This wadi acts as a important habitat in the otherwise barren landscape, providing a refuge for plant life that can thrive in areas where water occasionally accumulates.

Picture 8: W86 Location

Picture 9: Vegetation close to W86

W97

The area surrounding Well W97 is a bare land located at the edge of a mud flat, where vegetation growth is extremely limited. The harsh conditions of the mud flat, with poor soil and minimal moisture retention, make it difficult for plant species to establish and thrive. As a result, the site is largely devoid of vegetation, reflecting the challenging environmental conditions typical of such areas in desert ecosystems.

W63

The area around Well W63 is a mud flat with no vegetation present.

W69

The area around Well W69 is characterized by sand dunes with scattered plant species.

W98

The area surrounding Well W98 consists of a combination of mud flats and sand dunes, with no vegetation cover observed at the site.

W64GT and W65GT

The wells W65GT and W64GT are located in a bare, rocky area that has been heavily disturbed by extensive vehicle tracks. The disturbance has significantly impacted the local environment, with only very limited vegetation present.

Picture 10: W97 location

Picture 11: W63 location

Picture 12: W69 location

Picture 13: W98 location

Access Roads

All wells in the project area are accessible via dirt roads that are commonly used by locals to reach the region. These access roads are generally devoid of vegetation, as they are situated far from water collection points such as wadis and small seasonal water streams. The lack of proximity to these moisture-rich areas results in barren, dry conditions along the roads, further limiting the potential for any plant life to establish.

2.2.3 Fauna

Reptiles

Studies have identified a total of 35 reptile species in the project area and its vicinity, representing nine different families. These families include *Gekkonidae* (geckos), *Chamaeleonidae* (chameleons), *Agamidae* (agamas), *Lacertidae* (lizards), *Scincidae* (skinks), *Varanidae* (monitor lizards), *Leptotyphlopidae* (thread snakes), *Colubridae* (non-venomous snakes), and *Viperidae* (vipers). This diversity reflects the adaptability of reptile species to the arid desert environment, where they play an essential role in the local ecosystem.

Among these species, two are of special conservation concern according to the IUCN Red List. *Uromastyx aegyptia* (Egyptian spiny-tailed lizard) is classified as vulnerable, while *Coluber sinai* (Sinai racer) is listed as near threatened. Additionally, three species—*Chamaeleo chamaeleon* (common chameleon), *Ablepharus rueppellii* (Rüppell's snake-eyed skink), and *Lacerta cf. kulzeri*—are believed to be relicts from a former, more humid period in the area's history. These species inhabit limited and fragmented habitats, making their conservation particularly important. (Abu Baker, et al., 2004)

Table 2: List of species and their ecological importance (Disi, et al., 2001) (IUCN, 2024)

Family	Species	Common Name	IUCN Status
Gekkonidae	*Bunopus tuberculatus*	Baluch Ground Gecko	Least Concern
	Hemidactylus mindiae		Least Concern
	Pristurus rupestris	Rock Semaphore Gecko	Least Concern
	Ptyodactylus guttatus	Fan-footed Gecko	Least Concern
	Ptyodactylus hasselquistii		Least Concern
	Stenodactylus doriae	Dune Sand Gecko	Least Concern
	Stenodactylus sthenodactylus	Elegant Gecko	Least Concern
	Tropiocolotes nattereri	Natterers Gecko	Least Concern
Chamaeleonidae	*Chamaeleo chamaeleon*	Mediterranean Chameleon	Least Concern
Agamidae	*Laudakia stellio*	Starred Agama	Least Concern
	Phrynocephalus arabicus	Arabian Toad-headed Agama	Least Concern
	Pseudotrapelus sinaitus	Sinai Agama	Least Concern
	Uromastyx aegyptia	Egyptian Spiny–tailed Lizard	Vulnerable
Lacertidae	*Acanthodactylus boskianus*	Bosc's Fringe-toed Lizard	Least Concern
	Acanthodactylus opheodurus	Snake-tailed Fringe-toed	Least Concern
	Acanthodactylus schmidtii	Schmidt's Fringe-toed Lizard	Least Concern
	Lacerta cf. kulzeri		Rare
	Mesalina brevirostris		Least Concern
	Mesalina guttulata	Small-spotted Desert Racer	Least Concern
	Mesalina olivieri		Least Concern
Scincidae	*Ablepharus rueppellii*		Least Concern
	Chalcides ocellatus	Ocellated Skink	Least Concern
	Scincus scincus	Common Skink	Least Concern
Varanidae	*Varanus griseus*	Desert Monitor	Least Concern
Leptotyphlopidae	*Leptotyphlops macrorhynchus*	Hook-snouted Worm Snake	Least Concern
Colubridae	*Coluber elegantissimus*	Elegant Racer	Least Concern
	Coluber rhodorachis	Wadi Racer	Least Concern
	Coluber Sinai	Sinai Banded Racer	Near Threatened
	Eirenis coronella		Least Concern
	Lytorhynchus diadema	Crowned Leaf-nosed Snake	Least Concern
	Psammophis schokari	Forskal's Sand Snake	Least Concern
	Spalerosophis diadema	Diadem Snake	Least Concern
	Telescopus dhara	Arabian Cat Snake	Least Concern

Viperidae	*Cerastes gasperettii*	Arabian Horned Viper	Least Concern
	Echis coloratus	Hajar Saw-scaled Viper	Least Concern

Although the study area is known to host a rich diversity of reptiles, including 35 species across nine families, no reptiles were recorded during the field visit. This absence is likely due to the short duration of the study.

Mammals

In their native environments, a total of 26 different species of mammals were observed and documented from previous studies. These mammals were classified into the following categories: one ungulate, nine carnivores, eleven rodents, three bats, one insectivore, and one species of the family Hyraxidae. The conservation and ecological significance of a number of species is particularly noteworthy (Table 3).

Table 3: Conservation Important Species Reported from the Area

Common Name	Scientific Name	Global Status	National Status
Canidae			
Grey Wolf	*Canis lupus*	Least Concern	Endangered
Blanford's Fox	*Vulpes cana*	Vulnerable Mediterranean	Endangered
Felidae			
Caracal	*Caracal caracal*	Near threatened Mediterranean	Critically endangered
Sand Cat	*Felis margarita*	Near threatened Mediterranean	Critically endangered
Hyaenidae			
Hyena	*Hyaena hyaena*	Endangered	Near threatened
Rodentia			
Asian Dormouse	*Eliomys melanurus*	Least Concern	Near threatened
Hyraxidae			
Rock Hyrax	*Procavia capensis*	Least Concern	Endangered
Artiodactyla			
Dorcas Gazelle	*Gazella dorcas*	Vulnerable	Critically endangered
Nubian Ibex	*Capra ibex nubiana*	Vulnerable	Endangered

No mammal species were recorded during the survey. This absence of mammalian observations could indicate two possibilities, the presence of human activity within the area deterring wildlife, or the areas surveyed lacking sufficient habitat features to support a visible population of mammals.

Avifauna

A significant portion of the migration path that birds take between Africa, Asia, and Europe passes through Jordan. There are millions of birds that migrate over Jordan every year, and the majority of the avifauna that lives in Jordan also belongs to this migration. As a result of the large number of migratory birds that visit Jordan twice a year, the country has become an extremely important location for the avifauna of the entire world. According to BirdLife International, it is estimated that at least 500 million migratory birds belonging to more than 230 different species travel through Jordan twice a year and rest in Important Bird Areas (IBAs) located in the Middle East. There are 18 locations in Jordan that have been designated as Important Birds Areas. (Birdlife International , 2024)

An instrument for sensitivity mapping has been created by Birdlife International in order to evaluate the migratory soaring birds. For the purpose of determining the significance of the place for migrating soaring birds, this instrument was utilized. The soaring species that may be found on the site are listed in Table 4, along with their current conservation status. (Birdlife International , 2024)

Table 4: Important birds reported from the Area (Birdlife International , 2024)

Scientific Name	**Common Name**	Status
Aquila heliaca	Imperial Eagle	Vulnerable
Gypaetus barbatus	Bearded Vulture	Near Threatened
Neophrom percnopterus	Egyptian Vulture	Endangered
Falco concolor	Sooty Falcon	Vulnerable
Falco biarmicus	Lanner	Regionally Near Threatened
Falco cherrug	Saker Falcon	Endangered
Aquila Verreauxii	Verreaux's Eagle	Regionally Threatened
Circus cyaneus	Hen Harrier	Regionally Vulnerable

A total of 18 bird species were recorded during the survey, reflecting the avian diversity of the project area. Notably, two species observed have conservation status: the *Sooty Falcon* (*Falco concolor*), which is listed as Near Threatened, and the *Lesser Kestrel* (*Falco naumanni*), which is classified as Vulnerable according to the IUCN Red List. Both species are significant in terms of regional conservation efforts. The remaining bird species identified during the survey are considered common and resident to the area, indicating a stable avian population adapted to the local desert ecosystem.

Table 5: Bird Species Recorded during the field visit

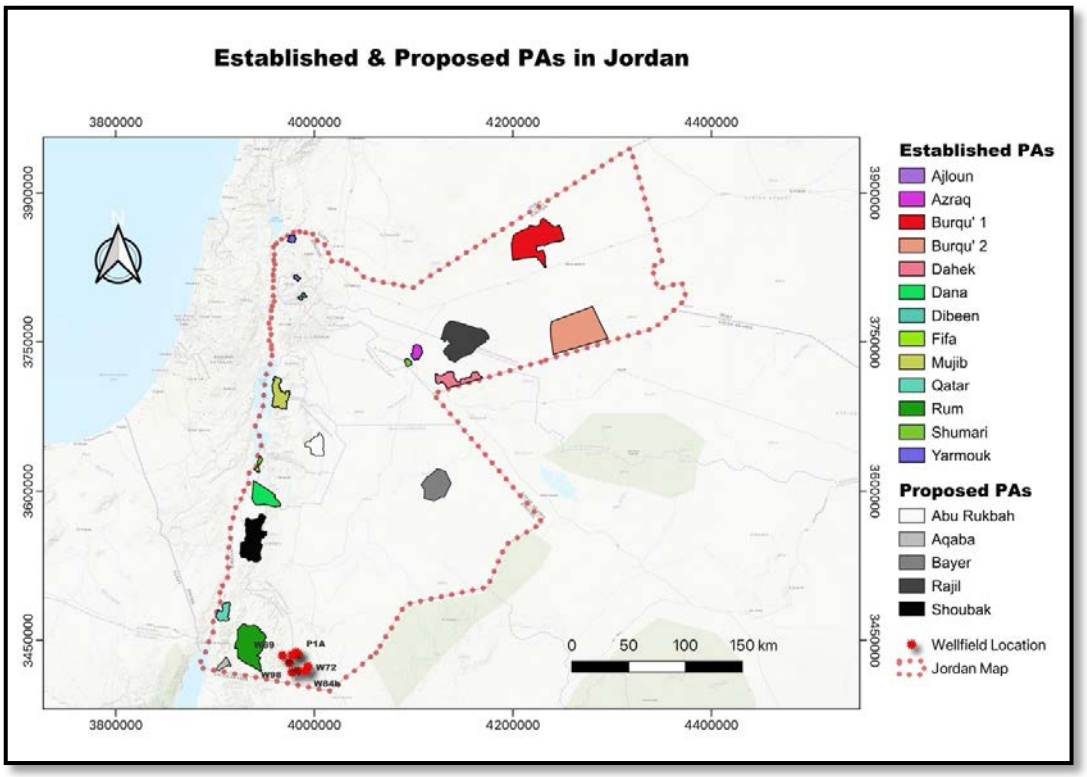
Scientific Name	Common Name	Conservation Status
Aquila nipalensis	Steppe Eagle	Least Concern
Falco tinnunculus	Kestrel	Least Concern
Falco naumanni	Lesser Kestrel	Vulnerable
Falco concolor	Sooty Falcon	Near Threatened
Ammomanes cincturus	Bar-tailed Lark	Least Concern
Eremophila bilopha	Temminck's Horned Lark	Least Concern
Galerida cristata	Crested Lark	Least Concern
Calandrella rufescens	Lesser Short Toed Lark	Least Concern
Ammomanes deserti	Desert Lark	Least Concern
Corvus ruficollis	Brown Necked Raven	Least Concern
Oenanthe leucopyga	White Crowned Wheatear	Least Concern
Oenanthe isabellina	Isabelline Wheatear	Least Concern
Oenanthe deserti	Desert Wheatear	Least Concern
Hirundo rustica	Barn Swallow	Least Concern
Spilopelia senegalensis	Palm Dove	Least Concern
Columba livia	Rock Dove	Least Concern
Oena capensis	Namaqua Dove	Least Concern
Sylvia nana	Desert Warbler	Least Concern

2.2.4 Sensitive Habitats

Protected Areas

Jordan has established a total of 12 protected areas, covering approximately 5.3 % of the country's total land area. These protected areas, managed primarily by the Royal Society for the Conservation of Nature (RSCN), play a crucial role in conserving the country's unique biodiversity, safeguarding ecosystems, and providing refuge for endangered species. The RSCN continues to work toward expanding and managing these areas to ensure long-term ecological sustainability and balance with human development.

The closest protected area to the project site is the Rum Protected Area, located approximately 18 kilometers away (Map 4). While the project site does not fall within the boundaries of this protected area, its proximity to Rum Protected Area is notable due to the ecological significance of the region. Rum Protected Area is a vital habitat for numerous species, including some that are of conservation concern. The distance from the project suggests that direct impacts on the protected area are unlikely, but indirect effects, such as disturbances to wildlife corridors or migration patterns, should be considered during the assessment process.

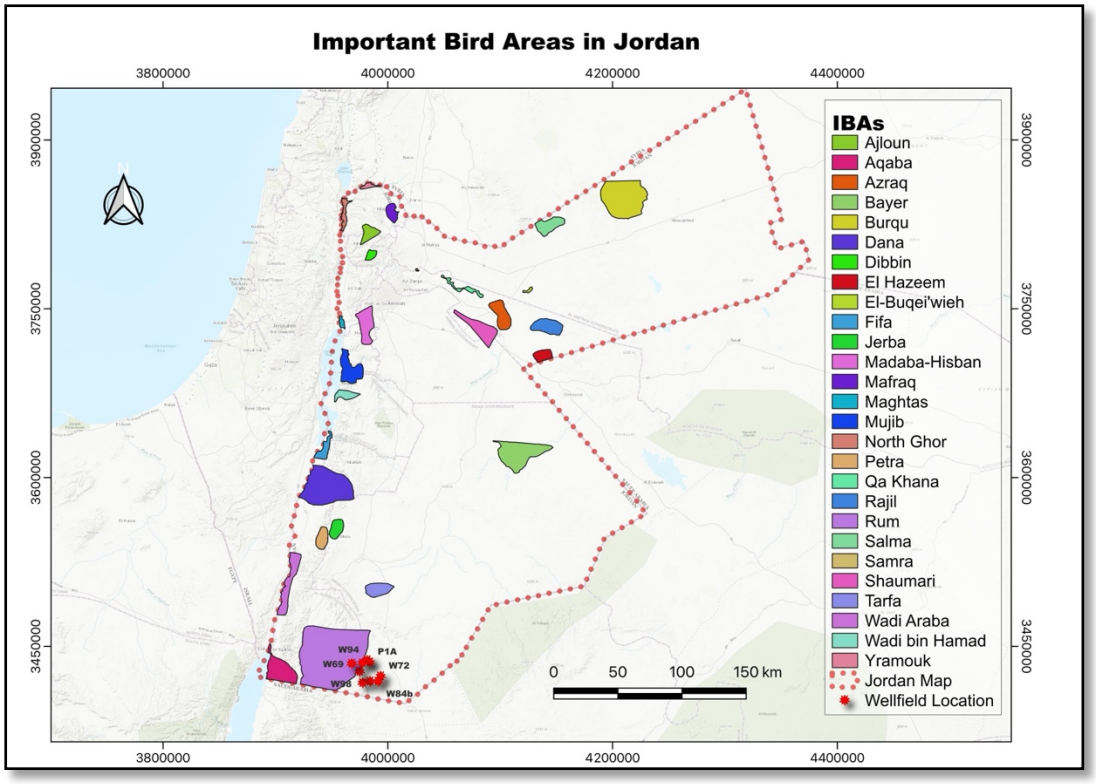


Map 4: Protected Areas in Jordan (RSCN, 2024)

Important Bird Areas

The Rum Important Bird Area (IBA) is a vital site for avian conservation in Jordan (Map 5). Its diverse landscape, dominated by rugged mountains, vast sandy plains, and deep valleys, provides a variety of habitats that are crucial for both migratory and resident bird species. Serving as a important stopover for migratory birds, the Rum IBA plays a pivotal role in connecting Africa with Europe and Asia along important migratory routes. Among the notable species found here are the *Sooty Falcon* and the *Sinai Rose Finch*, both of which are of high conservation concern due to their specialized adaptations to the harsh desert environment. Additionally, the area's high cliffs offer essential nesting grounds for raptors such as the *Lappet-faced Vulture* and the *Egyptian Vulture*, which depend on the scarce water sources found in some valleys for their survival. This combination of unique habitats and important conservation species makes the Rum IBA an invaluable conservation site within Jordan. (Birdlife International , 2024)

As part of the project, two wells, W69 and W98, are situated within the boundaries of the Rum Important Bird Area (IBA), highlighting the need for careful consideration of potential impacts on the area's bird populations and habitats. These wells lie in a region of the IBA that is essential for both resident and migratory bird species. The remaining wells in the project are located close to the IBA's eastern borders, further underscoring the importance of implementing measures to minimize disturbances to the surrounding environment.

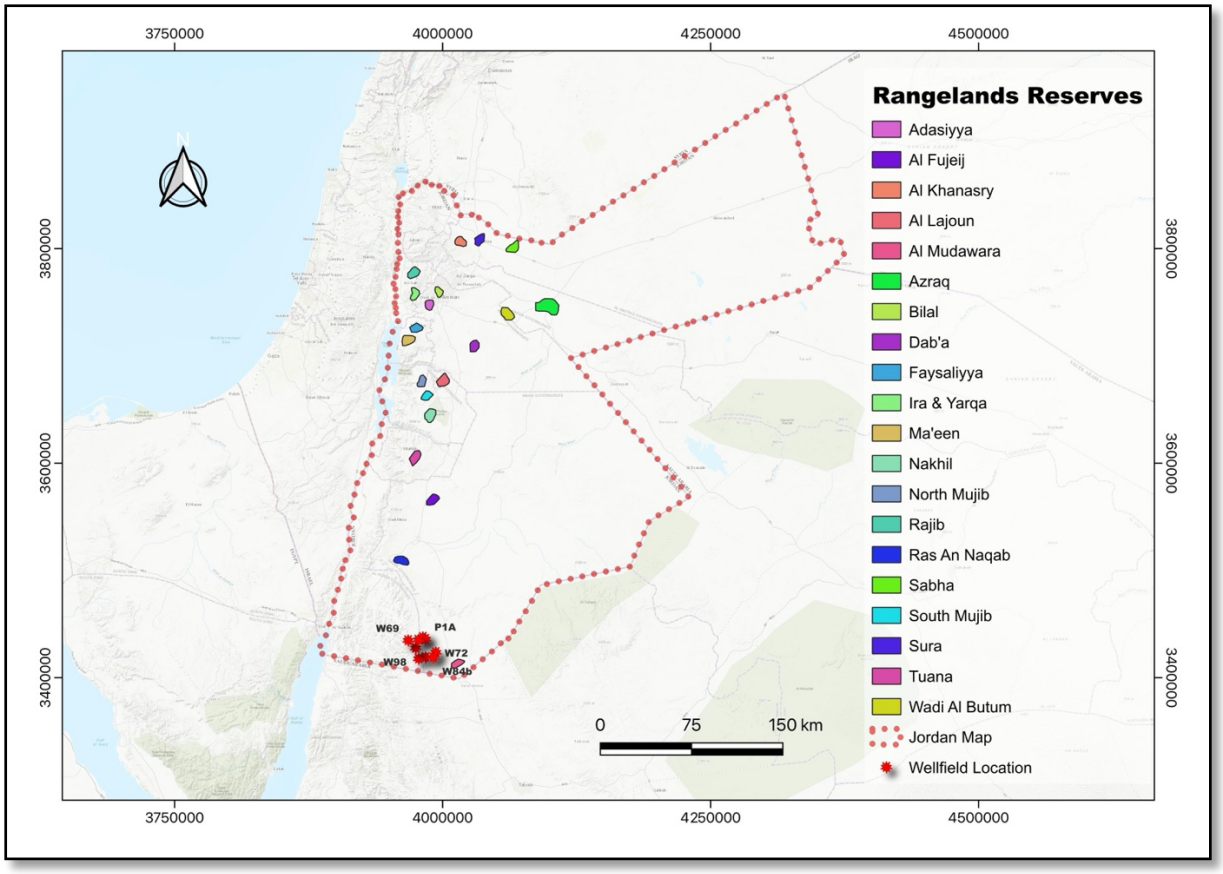


Map 5: Important Bird Areas in Jordan (RSCN & Birdlife, 2000)

Rangeland Reserves

Jordan has established 20 rangeland reserves, which play a role in conserving the country's fragile desert ecosystems and supporting sustainable land use. These reserves are essential for maintaining the health and productivity of natural rangelands. Rangeland reserves provide grazing areas for livestock, helping to regulate grazing pressures on more vulnerable ecosystems while promoting sustainable land management practices. They also act as habitats for a variety of wildlife species, particularly in arid and semi-arid regions, supporting biodiversity and mitigating the effects of land degradation caused by overgrazing, desertification, and climate change.

The project site is located approximately 15 kilometers from the nearest rangeland reserve, Al Mudawara. Al Mudawara Rangeland Reserve, like others in Jordan, plays a vital role in preserving the delicate balance of the desert ecosystem and ensuring that natural resources are used sustainably. Ensuring that the project does not disrupt these efforts is crucial to maintaining the ecological and economic benefits provided by rangeland reserves.



Map 6: Rangelands Reserves in Jordan

Critical Habitat

The Critical Habitat (CH) screening has been developed to evaluate the potential presence of critical habitat within and around the footprint of the Disi Wellfield project area. The report is prepared in accordance with the International Finance Corporation's (IFC) Performance Standard 6 and the European Investment Bank (EIB) Environmental and Social Standard 4. These standards require projects financed by international institutions to assess and avoid adverse impacts on critical habitats and ensure the conservation of biodiversity. (Full CH Screening **Annex 12** within the ESIA Report)

The Disi Wellfield project involves the drilling of several groundwater wells and the construction of associated infrastructure, such as access roads and electricity transmission lines. While the project footprint is limited in size and many areas show signs of ecological degradation and sparse vegetation, its proximity to sensitive ecological features, especially the Rum Important Bird Area (IBA), necessitates a thorough review of potential impacts on habitats and species of conservation concern.

Critical habitat, as per international standards, refers to areas with high biodiversity value that are essential for the survival of species or the functioning of ecosystems. This may include habitats supporting threatened or endemic species, important congregations, or ecosystems with unique ecological functions.

The methodology for this critical habitat screening followed the guidance of IFC Performance Standard 6 (PS6), as well as the complementary framework outlined by EIB Environmental and Social Standard 4. The process involved the following key steps:

Desktop Assessment and Field Survey

A comprehensive desktop review was conducted to gather information on biodiversity features relevant to the Disi Wellfield project area. The desktop review followed by a field visit was conducted over two days (6–7 August 2024) to ground-truth the desktop findings and document local flora and fauna.

Application of IFC PS6 Critical Habitat Criteria

Each of the five criteria for defining critical habitat under IFC PS6 was assessed systematically, using a combination of field data, literature sources, and spatial analysis. The criteria are

- Habitat of significant importance to critically endangered and/or endangered species (International Union for Conservation of Nature and Natural Resources (IUCN) Red List)
- Habitat of significant importance to endemic and/or restricted-range species
- Habitat supporting globally significant concentrations of migratory species and/or congregatory species
- Highly threatened and/or unique ecosystems
- Areas associated with key evolutionary processes

Species or ecosystems that triggered any of the above criteria were examined to determine the following:

- Whether their presence or use of the area is confirmed, likely, or unlikely.
- Whether the project footprint overlaps or is near important habitat features.
- Whether impacts are expected to be significant, residual, or irreversible.

Application of EIB E&S Standard 4: Biodiversity and Ecosystem

Critical habitat is the most sensitive of the high-value biodiversity features and is defined as comprising one of the following:

1. A highly threatened and/or unique ecosystem.
2. A habitat of priority and/or significant importance to critically endangered, endangered, or vulnerable species, as defined by the IUCN Red List of threatened species and in relevant national legislation.
3. A habitat of priority and/or significant importance to a population, range, or distribution of endemic or restricted-range species, or highly distinctive assemblages of species.

4. A habitat required for the survival of migratory species and/or congregatory species.
5. Biodiversity and/or an ecosystem of significant social, economic, or cultural importance to local communities and indigenous groups.
6. A habitat of key scientific value and/or associated with key evolutionary processes.

Risk Assessment

An expert evaluation was used to determine the potential likelihood of critical habitat triggers. In addition, consideration was given to the scale of project activities, the condition of the habitat, and existing disturbances. Where ambiguity existed, a **precautionary principle** was applied, recommending further investigation where necessary.

Conclusion of Screening

Based on the comprehensive assessment of the five Critical Habitat (CH) criteria under the IFC Performance Standard 6 and EIB Environmental and Social Standard 4, the following conclusions are drawn:

1. **Critically Endangered or Endangered Species: Not Triggered**

Although species of conservation concern have been recorded regionally, including Uromastyx aegyptia and Falco naumanni, the project site itself is highly degraded, and no significant populations were recorded.

2. **Restricted-range and Endemic Species: Not Triggered**

No endemic or restricted-range species were confirmed through literature review or the walkover survey, and none of the well locations support the required threshold of ≥10% of a global population.

3. **Migratory and Congregatory Species: Not Triggered**

Not formally triggered. While the eastern part of the project overlaps with the Rum IBA, and several migratory bird species of conservation concern (e.g., Sooty Falcon, Lesser Kestrel) were observed during the field visit, the scale of the project, the limited and disturbed footprint, and the absence of core nesting or roosting habitats reduce the likelihood of significant impact. According to IFC PS6 thresholds, the site does not appear to regularly support ≥1% of any migratory species' global population. Therefore, Criterion 3 is not formally triggered, although precautionary measures are still advised due to the ecological sensitivity of the area.

4. **Threatened Ecosystems: Not Triggered**

The site includes Saharo-Arabian and Sudanian habitats, but these are not listed as CR or EN in the IUCN Red List of Ecosystems, nor are they identified as high conservation priority by national planning frameworks.

5. **Key Evolutionary Processes: Not Triggered**

The site does not support recognized evolutionary processes such as major ecological gradients, refugia, centers of endemism, or unique species assemblages. No evidence of key ecological connectivity or evolutionary significance was identified through the literature or field visits. Consequently, Criterion 5 is not triggered.

6. **Ecosystems of Importance to Communities: Not Triggered**

Although rangelands are used locally, the project area is located in degraded and rarely used lands, and no biodiversity features of social, cultural, or economic significance to local communities were identified.

Ecosystem Services

The location of the project, which is situated within the arid desert ecosystems of Jordan, offers a wide range of ecosystem services that, despite their inconspicuous nature, significantly contribute to the preservation of environmental health and the provision of support for both human and wildlife populations. The regulation of water resources is one of the most important ecosystem services that the region provides because of its importance. Seasonal wadis and water collection points serve a crucial role in recharging groundwater, which is essential for supporting limited plant life, wildlife, and human activities. This is the case despite the fact that rainfall is scarce. In spite of the fact that they are only transitory, these water flow regions contribute to the preservation of soil moisture in specific locations, which in turn fosters the growth of vegetation that would otherwise be impossible in such a dry climate.

It is also important to note that the provision of habitat for biodiversity is an essential ecological service. wadis and tiny valleys support species such as Acacia gerrardii and Retama raetam, which in turn give shelter and food for a variety of desert fauna, including reptiles and migrating birds. Despite the fact that the area is generally devoid of vegetation, wadis and valleys help to sustain these species. Several species of conservation concern, including as the Sooty Falcon and the Sinai Rose Finch, rely on the project area as a stopping place during migration or as nesting grounds. These habitats are essential for the survival of these species, which are important for the conservation of environmental resources. Through the stabilization of soil, the provision of food for herbivores, and the support of the larger food web, the presence of diversified flora, despite its restricted presence, contributes to the overall sustainability of the ecological system.

Additionally, the project site offers regulating services, such as carbon sequestration and soil stabilization, which are important in mitigating the effects of desertification and climate

change. The vegetation, although sparse, helps to prevent soil erosion by anchoring the sandy and gravelly soil, particularly in the wadis. In areas like the Saharo-Arabian and Sudanian zones, this natural soil stabilization is crucial for preventing further land degradation, which could worsen desertification and reduce the area's ability to support both human and ecological needs. Furthermore, the limited plant life in the region contributes to carbon sequestration, helping to mitigate the global impact of greenhouse gas emissions, although at a small scale.

For the local communities surrounding the project site, particularly those engaged in pastoralism, rangelands are an essential resource for their livelihoods. These lands provide important grazing areas for livestock, which is a primary source of income, food, and cultural identity for many nomadic and semi-nomadic communities in Jordan. The natural vegetation in the rangelands, such as *Acacia* and other drought-resistant species, offers forage for sheep, goats, and camels, helping to sustain local economies and preserve traditional ways of life. The well-being of these rangelands directly affects the economic stability of the local communities, as overgrazing or land degradation can lead to diminished forage availability.

3. Assessment of Potential Environmental and Social Impacts

3.1 Assessment Approach

The assessment strategy for evaluating the implications on biodiversity and ecosystem services for the Disi Wellfield project incorporates both desktop studies and fieldwork to ensure a full understanding of the ecological baseline and potential impacts. This technique was established to ensure that the project would be successful. In the beginning, a comprehensive review of the present environmental data was carried out. This review made use of prior environmental impact assessments, surveys, and biodiversity assessments that were pertinent to the area where the project was being carried out. A significant number of species, habitats, and ecosystem services that are present inside and around the project site were identified with the assistance of this literature review.

Field surveys were then planned and executed to validate the findings from the desktop study and to provide up-to-date information on the biodiversity and ecological features. The field teams recorded all flora and fauna observed, emphasizing species of conservation concern and indicators of ecosystem health. This dual approach of combining historical data with fieldwork is crucial for assessing the direct and indirect impacts of the project on local ecosystems and for developing targeted mitigation measures to maintain ecological integrity.

Incorporating the findings from the biodiversity study, the assessment approach also includes an analysis of potential impacts during both the construction and operation phases of the project. The biodiversity study concluded that the project activities are unlikely to cause significant adverse impacts on biodiversity, especially with the implementation of the proposed mitigation measures.

The carefully planned mitigation measures, detailed below, are designed to minimize any potential impacts on these species and the broader ecosystem to the lowest possible extent. This proactive approach aims to ensure that the project adheres to environmental sustainability principles while mitigating potential disturbances to the local biodiversity and ecosystem services.

3.2 Potential Impacts on the Biological Environment

The impact assessment for the project evaluates the potential effects of activities such as drilling, road construction, and the installation of electricity transmission lines on the local environment, with a focus on flora, fauna, sensitive habitats, and ecosystem services. The project area is located in a desert ecosystem characterized by low vegetation cover and significant human disturbance from activities such as grazing and vehicle movement. These factors have already degraded much of the local environment, reducing its ecological sensitivity. As a result, the overall impact of the project is likely to be somewhat mitigated by the existing disturbances and the sparse vegetation, which limits the extent of habitat destruction and species displacement. Nevertheless, careful consideration is required to ensure that remaining sensitive habitats, such as wadis, and species of conservation concern are protected from further degradation.

The following sections will cover the impacts of both the construction and operation phases of the project. Each phase will be analyzed in detail, focusing on the specific activities involved—such as drilling, road construction, and the installation of electricity transmission lines—and their potential effects on the local environment.

3.2.1 Construction Phase

1. Impact on Flora

During the construction phase the potential impacts on flora can be significant, primarily due to physical disturbances and habitat alterations.

- **Direct Loss of Vegetation**: Land clearance for drilling sites leads to the removal of plant species, particularly in wadis and runoff zones where vegetation like *Acacia gerrardii* and *Retama raetam* are concentrated. Desert ecosystems regenerate slowly, so once vegetation is removed, it may take years or decades for plants to re-establish, resulting in prolonged habitat degradation.
- **Soil Compaction**: The use of heavy machinery during drilling compacts the soil, making it difficult for plant roots to penetrate and for seeds to germinate, hindering vegetation recovery.
- **Increased Soil Erosion**: With vegetation removed, there is a higher risk of wind and water erosion, particularly in sandy and loose soil areas, leading to further habitat degradation.
- **Loss of Water Retention Capacity**: Vegetation in wadis helps retain water during rare rain events, and its removal decreases the area's ability to store moisture, negatively affecting plant growth.

- **Reduction in Biodiversity**: The destruction of habitats due to drilling, road opening, and other activities reduce plant diversity, affecting the ecological balance and reducing the overall health of the ecosystem.
- **Pollution**: Project activities can introduce pollutants such as drilling fluids, fuel, oil, and other chemicals into the environment. Accidental spills or improper waste disposal can contaminate the soil and nearby water sources, particularly in wadis, negatively affecting plant life and degrading habitats.
- **Workers' Illegal Activities**: Workers involved in operations may engage in illegal activities, such as unauthorized cutting of plants for firewood or other uses, further depleting the already scarce vegetation.
- **Improper Waste Disposal**: If waste from different operations, including non-biodegradable materials and hazardous waste, is not properly managed, it could accumulate in the area, leading to long-term pollution that affects both flora and fauna.
- **Disturbance to Wildlife and Habitat from Human Presence**: Increased human activity during the construction phase, including workers and machinery, could disturb local wildlife and contribute to further degradation of plant habitats, particularly in sensitive areas like wadis.
- **Introduction of Invasive Species**: Workers and equipment may unintentionally introduce non-native plant species into the area, which could outcompete local flora and further disrupt the fragile desert ecosystem.
  It has been observed that several non-native tree species have been planted near the already operating wells, which is considered an introduction of non-native species into the site. Introducing such species can disrupt the local ecosystem by outcompeting native flora and altering habitat conditions for local fauna. To protect the integrity of the desert ecosystem, it is recommended that this practice be prohibited near the new wells. Additionally, the existing non-native trees should be gradually replaced with native species that are better adapted to the local environment, promoting biodiversity and ecosystem balance.
- **Edge Effects**: Roads create new micro-environments along their edges, altering moisture, light, and temperature conditions, which can negatively impact the growth of native plants.

2. Impact on Fauna

- **Habitat Displacement**: Project activities may lead to the loss or degradation of key habitats, forcing fauna to relocate. This displacement can increase stress on wildlife, particularly for reptiles, small mammals, and birds that rely on specific microhabitats.
- **Disturbance from Noise and Human Activity**: The noise and increased human presence associated with construction work can disrupt wildlife behavior, including feeding, breeding, and migration patterns. Sensitive species may abandon areas near roads due to disturbance.

- **Increased Mortality Risk**: The movement of heavy machinery and vehicles poses a direct threat to small fauna such as reptiles and small mammals.
- **Pollution Impact on Fauna**: Spills of chemicals, fuels, or other pollutants from machines can contaminate water sources, which can harm or even kill animals that drink from these contaminated areas. The spread of toxic substances can also affect the food chain, impacting predators and prey alike.
- **Disruption of Breeding Cycles**: Increased human activity, noise, and habitat disruption during drilling and construction works may interfere with the breeding cycles of certain species. For example, bird species may abandon their nests, leading to lower reproductive success.
- **Introduction of Non-native Species**: Human activity related to construction work may unintentionally introduce non-native species such as pets, which can compete with local fauna for resources, further stressing already fragile wildlife populations.
- **Illegal Hunting**: The presence of workers in remote areas may increase the risk of illegal hunting. Some workers may engage in hunting local wildlife for food or sport, which can severely impact already vulnerable species. Roads provide easier access for humans to previously remote areas, increasing the risk of poaching and illegal hunting, which can further threaten wildlife populations.
- **Collision Risk for Birds**: Overhead transmission lines pose a significant risk of collisions for birds, particularly larger species such as raptors, and migratory birds like the *Sooty Falcon* and *Lesser Kestrel*, which can be injured or killed by striking the wires.
- **Electrocution Risk**: Birds and other wildlife that perch on power lines or towers may be at risk of electrocution, particularly larger birds that may span across conductive components.
- **Disturbance to Migratory Routes**: Transmission lines could interfere with established migratory routes for birds, especially in sensitive areas such as Rum Important Bird Areas, which may cause birds to alter their natural migration patterns, leading to exhaustion or decreased survival rates.

3. Impact on Sensitive Habitat

The drilling activities and associated infrastructure development near or within the Rum IBA pose a significant disturbance to bird populations, particularly species of conservation concern such as the Sooty Falcon, Lesser Kestrel, and Sinai Rose Finch. Increased noise, vibrations, and human presence can disrupt key behaviors such as nesting, feeding, and migratory stopovers. Sensitive species may abandon their nesting sites or experience lower breeding success due to these disturbances, leading to long-term population declines. Migratory birds, which rely on the IBA as an essential stopover during their journeys, may be forced to alter their routes or stop at suboptimal locations, further impacting their survival. Additionally, large raptors, which are particularly sensitive to human activity, could face habitat abandonment, diminishing the ecological value of the IBA for bird conservation.

However, given the relatively limited size of the project activities and the possibility of implementing targeted mitigation measures, these impacts can be minimized or avoided altogether, preserving the ecological integrity of the IBA.

4. Impact on Ecosystem Services

The project's activities, including drilling, road construction, and the installation of electricity transmission lines, are likely to affect several ecosystem services in the region. One of the most significant services is water regulation, particularly in desert environments where water is scarce. Wadis and runoff areas play a crucial role in collecting and storing water during rare rain events, supporting vegetation and wildlife that depend on these moisture-rich zones. Drilling and road construction may disrupt natural water flow, reducing the ability of these areas to retain water, leading to decreased availability for plants and animals. Additionally, the compaction of soils and removal of vegetation can increase runoff and erosion, further reducing the water retention capacity of the land and threatening both flora and fauna that rely on these water sources.

Another key ecosystem service impacted by the project is soil stabilization. In desert ecosystems, vegetation plays a vital role in preventing soil erosion by anchoring the soil with its roots. The removal of plants for drilling operations, road construction, and transmission lines can lead to soil erosion, particularly in sandy or loose soils. Without vegetation cover, the area is more vulnerable to wind and water erosion, which can degrade the land and lead to desertification. The loss of vegetation also reduces carbon sequestration, although it is minimal in desert ecosystems, contributing to the global challenge of climate change. Furthermore, the degradation of habitats may impair the area's ability to support biodiversity, disrupting the intricate balance of ecosystem services that sustain both wildlife and local communities.

3.2.2 Operation Phase

During the operation phase of the project, there are potential ongoing impacts on flora, fauna, sensitive habitats, and the broader ecosystem services that require careful management to minimize long-term environmental damage.

1. Impact on Flora

- **Continued Vegetation Disturbance**: The operation of wells, roads, and transmission lines may prevent the natural regeneration of vegetation in disturbed areas, particularly in desert ecosystems where recovery is already slow. Regular maintenance activities could further compact the soil and limit plant regrowth.

- **Invasive Species Spread**: During the operation phase, human activities and continued presence in the area may unintentionally promote the spread of invasive plant species, which can outcompete native flora and further degrade the ecosystem.
- **Edge Effects from Infrastructure**: Infrastructure such as roads and transmission lines will continue to create edge effects, altering light, moisture, and temperature conditions that negatively affect native plant species near the infrastructure, making it difficult for them to thrive

2. Impact on Fauna

- **Habitat Displacement**: The continued operation of wells and associated infrastructure may displace wildlife, especially if regular maintenance activities increase human presence in the area. Species that are sensitive to disturbances, such as birds and reptiles, may abandon habitats near the wells.
- **Collision and Electrocution Risks for Birds**: Overhead transmission lines remain a collision hazard for birds during the operation phase, especially for larger birds and migratory species. Electrocution risks also persist for birds that may perch on power lines or towers.
- **Noise and Human Activity Disturbance**: Maintenance activities, vehicle movements, and noise associated with the operation of the project can disturb local wildlife. Sensitive species may alter their foraging, nesting, or breeding behavior in response to the ongoing disturbance.
- **Increased Access for Illegal Activities**: The presence of operational infrastructure may provide easier access to remote areas, leading to increased risk of illegal hunting or poaching, which could threaten vulnerable wildlife species in the area.
- **Alteration of Migration and Movement Patterns**: Wildlife corridors may be further impacted during the operation phase as infrastructure continues to act as a barrier to the movement of animals, especially for migratory birds and larger mammals that rely on large, connected habitats.

3. Impact on Sensitive Habitats

The operation phase of the project poses ongoing risks to sensitive habitats, particularly in areas like wadis and the Rum Important Bird Area. Habitat fragmentation remains a major concern, as the presence of infrastructure such as roads and transmission lines can disrupt wildlife corridors and reduce the connectivity of key habitats. This fragmentation limits the movement of migratory birds and other wildlife, leading to isolated populations and reduced biodiversity. In particular, species of conservation concern, like those that rely on the IBA, may experience reduced breeding success and altered migration patterns due to ongoing human disturbance and infrastructure presence.

Furthermore, increased human activity during the operation phase, including maintenance work and vehicle access, also introduces the risk of continued disturbance to wildlife and the potential spread of invasive species, which could further degrade these crucial habitats.

4. Impact on Ecosystem Services

The operation phase of the project is likely to have lasting effects on key ecosystem services in the region, particularly water regulation and soil stabilization. Soil stabilization, a vital service provided by desert vegetation, may be compromised by the continued disturbance of flora around operational infrastructure, increasing the risk of erosion and land degradation.

In addition, ecosystem services related to carbon sequestration, though minimal in desert environments, could also be impacted by the removal or degradation of vegetation over time. As native plants are slow to recover in arid conditions, any long-term damage to flora may further reduce the ecosystem's capacity to sequester carbon. The degradation of sensitive habitats may also diminish their ability to provide essential services like habitat provision for wildlife, further disrupting the ecological balance and affecting the communities that depend on these natural systems for grazing, water collection, and other resources.

3.3 Impact Assessment

The following tables summarize the environmental impacts identified during the assessment process for construction and operation phases. Each impact is categorized by its **severity** and **likelihood**. These factors help to understand the potential consequences of project activities (drilling, road construction, and electricity transmission) on key environmental components. The severity of each impact reflects the degree of harm it may cause, while likelihood indicates the probability of its occurrence.

- **Severity**: High (H), Moderate (M), Low (L)
- **Likelihood**: High (H), Moderate (M), Low (L)

Table 6: Impact Assessment During Construction Phase

Construction Phase				
Environmental Component	**Impact Type**	**Severity**	**Likelihood**	**Comments**
Flora	Vegetation loss and degradation	High	Moderate	Direct removal of native species in wadis and other sensitive areas.
	Invasive species introduction	High	Low	Roads and human activity may introduce non-native species that outcompete natives.
	Increased Soil Erosion	Moderate	High	Wind and water erosion, especially on sandy and loose soils, increases with vegetation removal, degrading habitat.
	Soil compaction	Moderate	High	Machinery use and construction activities compact the soil, limiting plant regrowth.

Construction Phase				
Environmental Component	**Impact Type**	**Severity**	**Likelihood**	**Comments**
	Loss of Water Retention Capacity	Moderate	Low	Changes in runoff areas affect plant growth, especially in wadis.
	Reduction in Biodiversity	High	Low	Construction work destroys habitats, lowering plant diversity and ecosystem health.
	Pollution	Low	Low	Fuel, drilling fluids, and other substances can pollute the environment during construction. In wadis, accidental spills or inappropriate trash disposal can contaminate soil and water supplies, harming plant life and habitats.
	Workers' Illegal Activities	Moderate	Low	Workers may illegally chop plants for firewood or other usage, depleting precious vegetation.
	Improper Waste Disposal	Moderate	Low	If non-biodegradable and hazardous trash from operations is not adequately managed, it could accumulate and pollute the environment for years.
	Disturbance to Wildlife and Habitat from Human Presence	Moderate	High	Workers and machines may disturb local wildlife and degrade plant habitats, especially in sensitive places like wadis, while drilling.
	Edge Effects	Moderate	High	Road edges produce new micro-environments that change moisture, light, and temperature, which can harm native plant growth.
Fauna	Wildlife disturbance	Moderate	High	Noise, human presence, and construction activities disrupt natural behaviors.
	Habitat loss	Moderate	Moderate	Loss of key habitats affects wildlife populations, particularly in sensitive areas.
	Mortality risk (vehicle collisions)	Moderate	High	Increased traffic leads to higher risks for small fauna, especially reptiles.
	Bird collisions with power lines	High	Moderate	Power lines pose significant risks for birds, particularly large species and raptors.
	Electrocution	Moderate	Low	Birds perched on transmission lines are at risk of electrocution.
	Illegal hunting and poaching	Moderate	Low	Increased human access may lead to illegal hunting, threatening local wildlife.
	Disruption of migratory patterns	High	Low	Infrastructure may interfere with bird migration routes, particularly near IBAs.

Construction Phase				
Environmental Component	**Impact Type**	**Severity**	**Likelihood**	**Comments**
	Pollution Impact on Fauna	High	Low	Roads and infrastructure cut across natural wildlife corridors, disrupting movement.
	Disruption of Breeding Cycles	High	Low	Key areas like wadis and IBAs may be severely fragmented by project activities.
	Introduction of Non-native Species	Moderate	Low	Wells and roads may alter natural water retention areas, affecting sensitive habitats.

Table 7: Impact Assessment During Operation Phase

Operation Phase				
Environmental Component	**Impact Type**	**Severity**	**Likelihood**	**Comments**
Flora	Continued Vegetation Disturbance	Moderate	Low	Wells, roads, and transmission lines may limit vegetation regeneration in disturbed environments, especially desert ecosystems with delayed recovery. Regular maintenance may compact soil and hinder plant development.
	Invasive Species Spread	Moderate	Low	Human activities and presence during operation may propagate invasive plant species, which can outcompete local flora and harm the ecology.
	Edge Effects from Infrastructure	Low	Low	Edge impacts from roadways and transmission lines will continue to modify light, moisture, and temperature, making it hard for native plant species to thrive.
Fauna	Habitat Displacement	Moderate	Moderate	Wells and infrastructure may displace wildlife, especially if maintenance increases human presence. Birds and reptiles may leave well zones due to disruptions.
	Collision and Electrocution Risks for Birds	Moderate	Moderate	In operation, overhead electricity wires provide a collision risk for birds, especially larger and migratory species. Birds perched on electrical lines or towers risk electrocution.
	Noise and Human Activity Disturbance	Moderate	High	Project maintenance, vehicle movements, and noise might disturb wildlife. Due to the disruption, sensitive animals may change their foraging, nesting, or breeding habits.
	Reduction in Food Availability	Low	Low	Wells and associated infrastructure can reduce local vegetation, which can reduce food availability for

				herbivorous species and predator populations that depend on them.
	Increased Access for Illegal Activities	Low	Low	Operational infrastructure may make distant locations more accessible to illegal hunting and poaching, which could endanger sensitive wildlife species.
	Alteration of Migration and Movement Patterns	Low	Low	During operation, infrastructure may hinder wildlife mobility, especially migratory birds and larger mammals that need extensive, connected habitats.

4. Recommended Mitigation Measures

4.1 Recommended Mitigation Measures for Biological Environment

4.1.1 Construction Phase

Environmental Component	Impact Type	Mitigation Measures
Flora	Vegetation loss and degradation	• Implement strict controls on clearing and grading activities, limit them to designated areas only. • When possible, save and transplant native plants. • Re-vegetate disturbed areas with native species using appropriate seed mixes and planting techniques.
	Invasive species introduction	• Clean construction equipment and vehicles thoroughly before entering the site to prevent the introduction of invasive plant seeds. • Regularly monitor the site for invasive species and implement control measures if necessary. • Prohibit workers from planting invasive species
	Increased Soil Erosion	• Implement erosion control measures. • Minimize soil disturbance during construction.
	Soil compaction	• Limit vehicle access to designated areas. • Use low ground pressure machinery when possible.
	Loss of Water Retention Capacity	• Design roads and structures to minimize disruption of natural drainage patterns. • Install erosion control measures to prevent sedimentation in wadis and other water bodies. • Implement water conservation measures during construction.
	Reduction in Biodiversity	• Avoid construction in sensitive areas. • Create buffer zones around sensitive areas to minimize disturbance.
	Pollution	• Implement a Spill Prevention, Control, and Countermeasure (SPCC) Plan to manage potential spills of fuel and other hazardous materials. • Properly dispose of all construction waste and debris at designated landfills. • Train workers on proper handling and disposal of hazardous materials.
	Workers' Illegal Activities	• Educate workers about the importance of environmental protection and the consequences of illegal activities. • Supervise workers during construction activities. • Implement penalties for violations.
	Improper Waste Disposal	• Implement a comprehensive waste management plan that includes recycling and reuse of materials where possible. • Ensure that hazardous waste is disposed of at approved facilities. • Conduct regular waste audits to ensure compliance with waste management plan.

Environmental Component	Impact Type	Mitigation Measures
	Disturbance to Wildlife and Habitat from Human Presence	• Restrict construction activities during sensitive periods like breeding seasons. • Implement noise and light mitigation measures to minimize disturbance to wildlife.
	Edge Effects	• Minimize the creation of new edges by limiting road width and footprint. • Re-vegetate road edges with native plants to create a buffer zone.
Fauna	Wildlife disturbance	• Restrict construction activities during sensitive periods like breeding seasons. • Implement noise and light mitigation measures to minimize disturbance to wildlife.
	Habitat loss	• Avoid construction in sensitive habitats. • Minimize habitat fragmentation by clustering construction activities. • Create wildlife corridors to connect fragmented habitats.
	Mortality risk (vehicle collisions)	• Implement speed limits and traffic calming measures in construction areas. • Install wildlife crossing structures where necessary. • Educate workers about wildlife awareness.
	Bird collisions with power lines	• Design power lines with bird-friendly features like markers and diverters. • Monitor bird activity and implement mitigation measures if necessary.
	Electrocution	• Design power lines with bird-friendly features like insulated perches. • Regularly inspect and maintain power lines to prevent electrocution hazards.
	Illegal hunting and poaching	• Educate workers about the importance of wildlife conservation and the consequences of illegal hunting. • Increase surveillance and enforcement in construction areas.
	Disruption of migratory patterns	• Avoid construction in sensitive areas during migration seasons. • Implement lighting and noise mitigation measures to minimize disturbance to migrating birds.
	Pollution Impact on Fauna	• Implement strict erosion and sediment control measures to prevent pollution of waterways. • Properly manage and dispose of hazardous materials to prevent contamination of soil and water. • Conduct regular water quality monitoring.
	Disruption of Breeding Cycles	• Avoid construction in sensitive habitats during breeding seasons. • Implement noise and light mitigation measures to minimize disturbance to breeding wildlife.
	Introduction of Non-native Species	• Prohibit workers from introducing animals to the site • Educate workers about the impact of non-native species on wildlife

4.1.2 Operation Phase

To mitigate the impacts during operation phase, it is important to implement effective management strategies during this phase. These should include:

Environmental Component	Impact Type	Mitigation Measures
Flora	Continued Vegetation Disturbance	• Implement a long-term monitoring and maintenance plan for vegetation in disturbed areas. • Minimize soil disturbance during maintenance activities. • Use native plant species for revegetation and landscaping.
	Invasive Species Spread	• Continue regular monitoring for invasive species and implement control measures promptly. • Educate staff and contractors about invasive species identification and control.
	Edge Effects from Infrastructure	• Plant native vegetation along infrastructure edges to create buffer zones and reduce edge effects. • Monitor vegetation health along edges and implement corrective measures if necessary.
Fauna	Habitat Displacement	• Conduct regular wildlife monitoring to assess impacts on habitat use. • Implement measures to minimize human presence and disturbance in sensitive areas. • Create artificial habitats or nesting structures to compensate for habitat loss.
	Collision and Electrocution Risks for Birds	• Install bird flight diverters on power lines. • Implement regular maintenance and inspection of power lines to prevent electrocution hazards.
	Noise and Human Activity Disturbance	• Implement noise mitigation measures such as mufflers and sound barriers. • Schedule maintenance activities during periods of low wildlife activity. • Restrict vehicle access to designated areas.
	Increased Access for Illegal Activities	• Increase surveillance and enforcement in remote areas. • Educate workers and local communities about the importance of wildlife conservation and the consequences of illegal activities.
	Alteration of Migration and Movement Patterns	• Maintain or create wildlife corridors to facilitate movement. • Implement measures to reduce barriers to movement, such as fencing and roads. • Monitor wildlife movement patterns and adjust management practices if necessary.

Bibliography

1. Abu Baker, M. et al., 2004. Results Of Herpetofaunal Inventory Of Wadi Ramm Protected Area, With Notes On Some Relict Species. *Russian Journal of Herpetology,* 11(1), pp. 1-5.
2. Al-Eisawi, D., 1996. *Vegetation of Jordan.* Cairo: UNESCO.
3. Al-Eisawi, D., 1998. *Wild Flowers of Jordan.* Amman: Jordan Press Foundation.
4. Al-Eisawi, D., Oran, S., El-Oqlah, A. & Lahham, J., 2000. *Jordan Country Study on Biological Diversity-Plant Biodiveristy,* Amman: United Nations Environment Program.
5. Amr, Z. S., 2000. *Jordan Country Study on Biological Diversity-Mammals of Jordan,* Amman: United Nations Environment Program.
6. Andrews, I. J., 1995. *The Birds of the Hashemite Kingdome of Jordan.* Midlothian: I. J. Andrews.
7. ASEZA, 2014. *The Wadi Rum Protected Area Management Plan,* Aqaba: Wadi Rum Protected Area.
8. Birdlife International , 2024. *Data Zone.* [Online]
   Available at: https://datazone.birdlife.org/country/jordan/ibas
   [Accessed 9 August 2024].
9. Birdlife International , 2024. *Soaring Birds Sensitivity Mapping Tool.* [Online]
   Available at: https://maps.birdlife.org/MSBtool/
   [Accessed 29 July 2024].
10. Disi, A. M., 2011. Review of the lizard fauna of Jordan. Issue Supplementum 3, p. 89–102.
11. Disi, A., 2002. *Jordan Country Study on Biological Diversity: The Herpetofauna of Jordan.* Amman: UNDP.
12. Disi, A., Amr, Z. & Hamidan, N., 2014. Diversity, Threats, And Conservation of the Terrestrial and Freshwater Herpetofauna of Jordan. *Russian Journal of Herpetology,* 21(3), pp. 221-233.
13. Disi, A., Modry, D., Necas, P. & Rifai, L., 2001. *Amphibians and Reptiles of the Hashemite Kingdom of Jordan.* Frankfurt: Andreas S. Brahm.
14. Eid, E., Abu Baker, M. & Amr, Z., 2020. *National Red data book of mammals in Jordan.* Amman: IUCN Regional Office for West Asia Amman.
15. Eid, E., Qaneer, T. & El-Moghrabi, L., 2013. *State of Jordan's Birds Report.* Amman, Jordan: The Royal Society for the Conservation of Nature.
16. Eid, E., Soultan, A. & Elalqamy, H., 2022. Habitat Suitability Modelling for Feline Species in Jordan: A tool for Climate-Responsive Conservation Planning. *Journal of Wildlife and Biodiversity ,* 6(3).
17. Hatough-Bouran, A., Abu Jaafar, M. & Bani Hani, R., 2000. *Jordan Ecology, Ecosystems and Habitats.* Amman: UNDP.
18. IUCN, 2024. *The IUCN Red List of Threatened Species.* [Online]
   Available at: https://www.iucnredlist.org/
   [Accessed August 2024].
19. Ministry of Environment, 2021. *The National Climate Change Adaptation Plan of Jordan,* Amman: Ministry of Environment.
20. RSCN & Birdlife, 2000. *Jordan Important Bird Areas.* Amman: Birdlife.
21. Taifour, H. & El-Oqlah, A., 2014. *Jordan Plant Red List.* Amman, Jordan: Royal Botanic Garden.

Annex 12: Critical Habitat Screening Study

Disi Wellfield Project

CRITICAL HABITAT SCREENING

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1 Introduction

The Critical Habitat (CH) screening report has been developed to evaluate the potential presence of critical habitat within and around the footprint of the Disi Wellfield project area. The report is prepared in accordance with the International Finance Corporation's (IFC) Performance Standard 6 and the European Investment Bank (EIB) Environmental and Social Standard 4. These standards require projects financed by international institutions to assess and avoid adverse impacts on critical habitats and ensure the conservation of biodiversity.

The Disi Wellfield project involves the drilling of several groundwater wells and the construction of associated infrastructure, such as access roads and electricity transmission lines. While the project footprint is limited in size and many areas show signs of ecological degradation and sparse vegetation, its proximity to sensitive ecological features, especially the Rum Important Bird Area (IBA), necessitates a thorough review of potential impacts on habitats and species of conservation concern.

This screening is a preliminary assessment tool used to determine whether the project is located within or near critical habitats as defined by IFC PS6 and EIB Environmental and Social Standard 4. It aims to:

- Identify whether any of the IFC PS6 and EIB Environmental and Social Standard 4 criteria for critical habitat are met.
- Assess the biodiversity value of the project site and its surrounding areas.
- Determine whether a Critical Habitat Assessment (CHA) is required.
- Support biodiversity risk management and inform mitigation planning in the early project stages.

The report relies on a combination of data sources, including:

- A literature review and desktop analysis of IUCN Red List species and known ecological values in the area.
- Walkover field visit and rapid biodiversity assessments conducted in August 2024.
- Mapping of proximity to protected areas, Important Bird Areas (IBAs), rangeland reserves, and known sensitive habitats.
- Review of vegetation types and ecosystem services specific to the Saharo-Arabian and Sudanian biogeographic zones where the wells are located.

2 Methodology

Critical habitat, as per international standards, refers to areas with high biodiversity value that are essential for the survival of species or the functioning of ecosystems. This may include habitats supporting threatened or endemic species, important congregations, or ecosystems with unique ecological functions.

The methodology for this critical habitat screening followed the guidance of **IFC Performance Standard 6 (PS6)**, as well as the complementary framework outlined by **EIB Environmental and Social Standard 4**. The process involved the following key steps:

2.1 Desktop Assessment and Field Survey

A comprehensive desktop review was conducted to gather information on biodiversity features relevant to the Disi Wellfield project area. The desktop review followed by a field visit was conducted over two days (6–7 August 2024) to ground-truth the desktop findings and document local flora and fauna.

2.2 Application of IFC PS6 Critical Habitat Criteria

Each of the five criteria for defining critical habitat under IFC PS6 was assessed systematically, using a combination of field data, literature sources, and spatial analysis. The criteria are

- Habitat of significant importance to critically endangered and/or endangered species (International Union for Conservation of Nature and Natural Resources (IUCN) Red List)
- Habitat of significant importance to endemic and/or restricted-range species
- Habitat supporting globally significant concentrations of migratory species and/or congregatory species
- Highly threatened and/or unique ecosystems
- Areas associated with key evolutionary processes

Species or ecosystems that triggered any of the above criteria were examined to determine the following:

- Whether their presence or use of the area is confirmed, likely, or unlikely.
- Whether the project footprint overlaps or is near important habitat features.
- Whether impacts are expected to be significant, residual, or irreversible.

2.3 Application of EIB E&S Standard 4: Biodiversity and Ecosystem

Critical habitat is the most sensitive of the high-value biodiversity features and is defined as comprising one of the following:

1. A highly threatened and/or unique ecosystem.
2. A habitat of priority and/or significant importance to critically endangered, endangered, or vulnerable species, as defined by the IUCN Red List of threatened species and in relevant national legislation.
3. A habitat of priority and/or significant importance to a population, range, or distribution of endemic or restricted-range species, or highly distinctive assemblages of species.
4. A habitat required for the survival of migratory species and/or congregatory species.
5. Biodiversity and/or an ecosystem of significant social, economic, or cultural importance to local communities and indigenous groups.
6. A habitat of key scientific value and/or associated with key evolutionary processes.

2.4 Risk Assessment

An expert evaluation was used to determine the potential likelihood of critical habitat triggers. In addition, consideration was given to the scale of project activities, the condition of the habitat, and existing disturbances. Where ambiguity existed, a **precautionary principle** was applied, recommending further investigation where necessary.

2.5 Delineation of Areas of Influence

The screening also considered the project's area of influence, including indirect impacts. The spatial scope was extended to buffer zones around the project footprint (typically up to 5 km) to capture relevant features such as Rum IBA and potential ecological corridors.

3 Results and Screening Against Critical Habitat Criteria

This section presents the findings of the critical habitat screening for the Disi Wellfield Project, structured in accordance with the five criteria of IFC Performance Standard 6 and six criteria of EIB Environmental and Social Standard 4. The evaluation integrates both desktop review findings and data collected from the rapid field assessment conducted in August 2024. The study area encompasses the well locations and their

surrounding landscape, which includes sensitive areas such as the Rum Important Bird Area (IBA) and Rum Protected Area.

3.1 IFC PS6 Criterion 1, EIB E&S Standard 4 Criterion 2:

Habitat of Critically Endangered (CR) and/or Endangered (EN) Species

According to the IUCN Red List and national red lists, several species of conservation concern have been documented in the broader region surrounding the project area. Literature reviews and field surveys indicate that the area supports, or lies near the range of, species that are either globally or nationally threatened due to factors such as habitat degradation, overexploitation, and climate-related pressures. While a few of these species may occasionally utilize habitats within or adjacent to the project's area of influence, their observed presence was minimal, seasonal, or inferred from secondary sources.

Importantly, the proposed well locations are situated in areas that are already highly disturbed, dominated by bare ground, mudflats, degraded hammada, or sand dune habitats with limited vegetation cover. The small scale and spatial footprint of the project activities, including the nature of well drilling and related infrastructure, further reduce the likelihood of significant impacts on such species. Therefore, while species of concern are acknowledged, Criterion 1 is not considered triggered under current conditions. Nonetheless, precautionary mitigation is recommended to ensure that potential effects on sensitive species remain negligible.

Thus, **Criterion 1 is not triggered.**

3.2 IFC PS6 Criterion 2, EIB E&S Standard 4 Criterion 3:

Endemic and/or Restricted-Range Species

Based on the literature review and findings from the walkover field assessment, no endemic or restricted-range species were recorded within the project footprint. While Jordan does support a number of endemic plant species, these are typically associated with specific biogeographic zones or isolated microhabitats. The Sudanian biogeographic zone, which partially overlaps with the project area, includes species such as *Acacia tortilis, Ochradenus baccatus*, and *Retama raetam*, which are regionally common and often found in wadis and ephemeral watercourses.

However, the areas selected for well drilling and associated infrastructure are characterized by degraded habitats such as bare hammada plains, disturbed sandy flats, and mudflats, none of which provided suitable or intact habitat for restricted-range or endemic species. Furthermore, the criteria for Critical Habitat under IFC PS6 require that the area of assessment support ≥10% of the global population of a species

with a global range ≤50,000 km², which was not met based on available data. As such, Criterion 2 is not considered triggered for this project.

Thus, **Criterion 2 is not triggered**.

3.3 IFC PS6 Criterion 3, EIB E&S Standard 4 Criterion 4:

Migratory and/or Congregatory Species

According to IFC PS6, migratory species are defined as those whose members cyclically and predictably move between geographical areas, while congregatory species are those that gather in large numbers on a regular basis for breeding, foraging, roosting, or migration. Examples of congregatory behaviors include colonial breeding, formation of large non-breeding foraging flocks, or use of migration bottlenecks.

The IFC PS6 Guidance Note further elaborates that such species include:

- Species that form colonies, either for breeding or non-breeding purposes.
- Species that utilize bottleneck sites, where large numbers pass through in a short time (e.g., raptors migrating through a desert corridor).
- Species with clumped distributions, where few sites support a disproportionate number of individuals.
- Source populations, which contribute significantly to recruitment across the species' range.

To trigger Critical Habitat under Criterion 3, the thresholds defined by IFC PS6 GN78 must be met:

- Sites that support ≥1% of the global population of a migratory or congregatory species on a cyclical basis.
- Sites that predictably support ≥10% of the global population during periods of environmental stress.

The Rum Important Bird Area (IBA), internationally recognized for its role in supporting migratory birds, overlaps with the western portion of the project area, particularly in the vicinity of wells W69 and W98. According to literature and regional bird data, this IBA serves as an important nesting, stopover, and foraging site for a variety of species of conservation concern, including

Aquila heliaca	Eastern Imperial Eagle	Vulnerable
Neophron percnopterus	Egyptian Vulture	Endangered
Falco cherrug	Saker Falcon	Endangered

Gypaetus barbatus	Bearded Vulture	Near Threatened
Falco concolor	Sooty Falcon	Near Threatened
Falco biarmicus	Lanner Falcon	Regionally Near Threatened
Aquila verreauxii	Verreaux's Eagle	Regionally Threatened
Circus cyaneus	Hen Harrier	Regionally Vulnerable

During the walkover field assessment, two species of global conservation concern were recorded:

Falco naumanni	Lesser Kestrel	Vulnerable
Falco concolor	Sooty Falcon	Near Threatened

These observations confirm that the project area is used by migratory raptors and other bird species, likely as a temporary stopover or foraging ground during migration. The IBA supports a range of habitat types, including rocky cliffs, wadis, and desert plains, which are essential for nesting and feeding, especially for raptors and arid-land species.

While the project area lies partially within a recognized migratory corridor and IBA, and some species of conservation concern were observed, there is insufficient evidence that the site meets the quantitative thresholds defined under IFC PS6 Criterion 3. As such, Critical Habitat under this criterion is not formally triggered at this time.

Nevertheless, due to the sensitivity of the IBA and the observed presence of threatened migratory birds, the project should adopt precautionary measures. These include minimizing construction noise and activity during peak migration seasons, avoiding unnecessary lighting during operation, and monitoring avifaunal activity during sensitive periods. Continued coordination with bird conservation experts and institutions, particularly with the Royal Society for the Conservation of Nature, the Birdlife International regional office, and Rum Protected Area management, is also advised to ensure alignment with IBA conservation priorities.

Thus, **Criterion 3 is not triggered**.

3.4 IFC PS 6 Criterion 4, EIB E&S Standard 4 Criterion 1:

Highly Threatened and/or Unique Ecosystems

As per IFC Performance Standard 6 Guidance Note 79, the identification of critical habitat under Criterion 4 requires reference to the IUCN Red List of Ecosystems where formal assessments exist. In the absence of formal global assessments, systematic evaluations at the national or regional level conducted by government agencies,

academic institutions, or recognized NGOs can also be used to determine ecosystem conservation status and priority.

Thresholds under IFC PS6 GN80 to trigger critical habitat include:

- Areas representing ≥5% of the global extent of an ecosystem type that qualifies as Critically Endangered (CR) or Endangered (EN) under IUCN criteria.
- Ecosystems that, although not yet formally assessed, are recognized as high conservation priorities through national or regional conservation planning.

The project area spans two major biogeographic zones:

- Saharo-Arabian: Dominated by gravel hammada, runoff hammada, and sandy plains.
- Sudanian: Found in parts of southern Jordan, characterized by sand dunes, scattered Acacia and Haloxylon species, and ephemeral watercourses (wadis).

These ecosystems are part of Jordan's natural desert landscape and support a variety of desert-adapted species and key ecosystem services, such as water retention and groundwater recharge through wadis, erosion control through perennial vegetation and shrubs, and grazing value for pastoralist communities.

However, based on a literature review and field reconnaissance, the project's footprint is concentrated in highly degraded, bare, and disturbed areas, such as mudflats, rocky flats, and disturbed hammada, which lack intact vegetation structure or sensitive ecological features.

Neither the Saharo-Arabian nor Sudanian desert ecosystems in the project area have been classified as Critically Endangered or Endangered under the IUCN Red List of Ecosystems. Furthermore, no evidence suggests that the project area comprises a significant portion (≥5%) of the global extent of any threatened ecosystem type, nor has it been flagged in national conservation plans as a priority conservation ecosystem.

Based on the current data and site condition, Criterion 4 is not triggered. The project site does not lie within an ecosystem type that is formally listed as threatened or identified as irreplaceable at the global or national level. However, efforts should still be made to maintain ecosystem services, avoid further degradation, and prevent indirect impacts such as erosion or disruption of natural runoff channels.

Thus, **Criterion 4 is not triggered**.

3.5 IFC PS6 Criterion 5, EIB E&S Standard 4 Criterion 6:

Key Evolutionary Processes or Biodiversity Support Functions

No areas within the project site have been identified as centers of endemism, refugia, or as providing critical support for long-distance ecological connectivity. The ecological function of the area is limited, given extensive historical degradation, low productivity, and existing infrastructure.

Thus, **Criterion 5 is not triggered**.

3.6 EIB S&E Standard 4 Criterion 5:

Biodiversity and/or Ecosystem of Significant Importance to Local Communities

Under the EIB Environmental and Social Standard 4, critical habitat may include biodiversity or ecosystems that hold significant social, economic, or cultural value for local communities. This includes areas important for traditional livelihoods, food security, cultural identity, or spiritual practices. Even if such areas are not formally protected or classified as ecologically sensitive, their human dependence and cultural value can qualify them as critical habitat under this criterion.

The Disi wellfield project is situated in a remote arid region of southern Jordan, historically used for pastoralism and rangeland grazing. Local Bedouin communities have long relied on these landscapes, particularly wadis and runoff hammada, for seasonal grazing, water collection, and the harvesting of native plants with traditional medicinal or fodder value.

The ecosystem services provided by wadis (such as water retention and forage production) are essential to local livelihoods, particularly in a region where rainfall is scarce and drought frequency is increasing. The surrounding rangelands support extensive grazing systems, forming a cornerstone of the social and economic fabric of the local population.

However, the specific well locations selected for drilling and access roads are situated in areas that are highly degraded, such as bare mudflats and disturbed hammada, with little to no current productive or cultural use.

While the broader project region has ecosystem services of importance to local communities, the project footprint does not overlap with any actively used traditional lands, water sources, or culturally sensitive ecosystems. There is no evidence that the project will cause displacement, disruption of traditional practices, or restriction of access to resources of social or cultural significance.

Therefore, EIB E&S Standard 4 Criterion 5 is not triggered. Nonetheless, continued engagement with local users and implementation of mitigation measures to avoid

accidental restrictions or disturbance of grazing and water access routes are strongly recommended.

4 Conclusion of Screening

Based on the comprehensive assessment of the five Critical Habitat (CH) criteria under the IFC Performance Standard 6 and EIB Environmental and Social Standard 4, the following conclusions are drawn:

1. **Critically Endangered or Endangered Species: Not Triggered**

Although species of conservation concern have been recorded regionally, including *Uromastyx aegyptia* and *Falco naumanni*, the project site itself is highly degraded, and no significant populations were recorded.

2. **Restricted-range and Endemic Species: Not Triggered**

No endemic or restricted-range species were confirmed through literature review or the walkover survey, and none of the well locations support the required threshold of ≥10% of a global population.

3. **Migratory and Congregatory Species: Not Triggered**

Not formally triggered. While the eastern part of the project overlaps with the Rum IBA, and several migratory bird species of conservation concern (e.g., Sooty Falcon, Lesser Kestrel) were observed during the field visit, the scale of the project, the limited and disturbed footprint, and the absence of core nesting or roosting habitats reduce the likelihood of significant impact. According to IFC PS6 thresholds, the site does not appear to regularly support ≥1% of any migratory species' global population. Therefore, Criterion 3 is not formally triggered, although precautionary measures are still advised due to the ecological sensitivity of the area.

4. **Threatened Ecosystems: Not Triggered**

The site includes Saharo-Arabian and Sudanian habitats, but these are not listed as CR or EN in the IUCN Red List of Ecosystems, nor are they identified as high conservation priority by national planning frameworks.

5. **Key Evolutionary Processes: Not Triggered**

The site does not support recognized evolutionary processes such as major ecological gradients, refugia, centers of endemism, or unique species assemblages. No evidence of key ecological connectivity or evolutionary significance was identified through the literature or field visits. Consequently, Criterion 5 is not triggered.

6. **Ecosystems of Importance to Communities: Not Triggered**

Although rangelands are used locally, the project area is located in degraded and rarely used lands, and no biodiversity features of social, cultural, or economic significance to local communities were identified.

5 Recommendations

Based on the results of the screening, it is concluded that the Disi Wellfield Project does not trigger a formal Critical Habitat designation under IFC PS6 and EIB E&S Standard 4. However, the proximity of certain project components to the Rum IBA necessitates a precautionary approach. While the project footprint does not intersect nesting cliffs or core habitats, several wells fall within or near the IBA boundary, and a number of bird species of conservation concern were recorded or are known to use the broader area.

Therefore, instead of initiating a full Critical Habitat Assessment, the following avoidance and management recommendations are proposed to ensure biodiversity safeguards are upheld and that project activities do not result in adverse or irreversible residual impacts:

5.1 Mitigation and Avoidance Measures

- Minimize construction and drilling during peak breeding and migration seasons for sensitive bird species. Activity scheduling should take this into account to minimize disturbance.

- Implement buffer zones around active nesting or roosting sites (if any are discovered) during construction and operation, especially in areas near cliffs or dense vegetation within the IBA.

- Restrict vehicle access and movement to pre-designated tracks to minimize habitat degradation and edge effects, particularly in the vicinity of the IBA and ephemeral wadis.

- Avoid nighttime lighting and reduce unnecessary noise during construction, especially near W98 and W69, which fall within the IBA. Bright artificial lighting can disorient nocturnal species and attract or repel birds in unintended ways.

- Prohibit illegal hunting or collection of fauna by workers. Include biodiversity protection protocols in worker induction and codes of conduct, with regular awareness briefings and enforcement mechanisms.

- Ensure no introduction of non-native species (e.g., trees planted around wells). Existing non-native vegetation near operational wells should be gradually

replaced with native drought-resistant species, consistent with the local flora of the Saharo-Arabian and Sudanian zones.

5.2 Monitoring and Oversight

- Establish a site-level biodiversity monitoring plan, with a focus on observing bird activity near wells located within or adjacent to the Rum IBA. Monitoring during construction and early operation phases will help verify that impacts are within acceptable thresholds.
- Involve local biodiversity experts or ornithologists in pre-construction checks to identify any active nests or roosting sites in the vicinity of works.
- Maintain regular coordination with the Royal Society for the Conservation of Nature (RSCN), Birdlife International regional office, Rum Protected Area management, and local environmental authorities to share monitoring findings and adopt any additional mitigation if new sensitive elements are detected.

Annex 13: Disi & DAOM Project Stakeholder Engagement Plan

DISI AMMAN OPERATION & MAINTENANCE

DAOM Stakeholder Engagement Plan

Document Summary

This document describes the different identified stakeholders / Interested parties related to DAOM operations, their needs, and the communication requirements.

Revision History

Rev #	Summary of Changes	Date	Prepared By	Checked By	Approved By
0	Initial issuance	2021/01/26	NGH	MAH, EMD	PAS
1	Add details for contract persons from DWC and DAOM for communicating social related issues	2021/02/25	NGH	MAH, EMD	PAS
2	Update according to IFC comments: 1. Add the responsibilities of DPAC 2. Modify the part related to external grievances (add communication to MWI)	2021/04/15	NGH	MAH, EMD	PAS

This document is addressed for:

	For Information	For Action
DAOM		x
DIWACO	x	

List of related documents:

None.

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1. INTRODUCTION

The purpose of this document is to identify DAOM's process in ensuring effective two-way communication with the identified stakeholders during the Operation and Maintenance period of the DISI project. Any outcomes of this process are taken as inputs for making any required updates for the any of DAOM's processes and plans (e.g. ESMP).

2. IDENTIFIEIED STAKEHOLDERS

The below table shows the identified stakeholders and their identified needs:

Interested Parties	Interested Parties detailed	Type of Needs and Expectations	Related Documents/ Records
The Client	DIWACO Ministry of Water & Irrigation [MWI] (indirectly) The Lenders (Investors) (indirectly)	Fulfill the contractual obligations	Project/O&M Agreement, Lenders Agreement (CTA), Asset Management Roadmap and related documents and results, Client Satisfaction Evaluation
Indirect Service Providers (through the client)	Insurance company	Fulfill the Insurance Agreement requirements (reduce the operational and asset-related risks)	Insurance Agreement, outcomes of insurance company visits
	Electricity Providers (JEPCO, EDCO)	Fulfill the contractual obligations (uninterrupted compliant electrical supply to minimize asset-related risks))	Electricity Supply agreement
Employees	Steering Committee / Top Management Middle Management Non-managerial Workers	Safe working conditions and means	SOP's, CMMS (AlaTool365), JD's, Engagement Survey, OHSA indoor air and noise regulations, clean water JS, health assessment, safety risk assessment, Toolbox Talks (TBT's), Employees contracts, Training Plan, Job descriptions, Payroll process, H&S Committee, Fair Culture policy, IMS Declaration, HR Policy, Internal By-laws, Business Continuity/Recovery Plans
		Job security	
		Training and development, clear instructions	
		Salary accurate and on time	
		Participation and consultation	
Local Community	MEU University Neighbors residents Heads of Tribes DISI Project Advisory Committee (DPAC) Local Association Local authorities (Example: Badia Police in MUS)	Safe neighborhood	Emergency Response Plan, Crisis Management and communication
		Environmental protection	ESMP documents
		Sustainable development (employment, access to clean water)	ESMP documents
Government	Ministry of Water & Irrigation Ministry of Labor Ministry of Environment Jordan Institution for	Legal/compliance requirements	Legal Requirements register

Interested Parties	Interested Parties detailed	Type of Needs and Expectations	Related Documents/ Records
	Standards and Metrology Ministry of Health Ministry of Industry and Trade Ministry of Finance Tax Authority Customs Department Social Security Corporation		
SUEZ	SUEZ Head Quarters	Technical Expertise, support, and knowledge sharing	Technical Assistance missions and training
		SUEZ Technology to support Water Production activities	New software packages (e.g. Well and Pump Factory and Asset Management)
		Innovation to address Environmental and H&S issues (in addition to operational)	Innovation program, Safety/Health Day
		H&S / Env incidents prevention (investigation, communication in case of occurrence)	Flash alerts, social security documents & process
		Developing a HSE culture	Fair culture, H&S contract
		Ethics values are the core of SUEZ's strategy and development. Ethics values to be the reference for SUEZ employees' behaviors and actions	Ethics Charter
		Work as per the international best practices and guidelines	OHSA, NEBOSH
		External recognition	ISO 9001, ISO 14001, ISO 45001, ISO 55001
Suppliers/ Subcontractors	See document No. DAOM-HQ-PRO-1546-15	Safe working conditions and means	Material Management procedure
		Sustainable business/ timely payments/ accurate delivery versus Purchase Order	Supplier Evaluation
		Provide accurate data	Reports

3. GRIEVANCES

DAOM has set up a process for receiving and handling internal and external grievances.

- ✓ Employees' Grievances are received and handled according to the process documented in the HR Policy (Document no. DAOM-HRE-POL-0137-14).
- ✓ External grievances from local community and neighbors received are communicated to the project company, who will then communicate it directly to its client, the Ministry of Water and Irrigation (MWI). Dealing with external grievances follows the requirements of the Project Agreement and the O&M Agreement.
- ✓ Grievances received from subcontractors are received by the concerned supervisor from DAOM and/or the Procurement department. The received grievance is discussed with the concerned parties to find the proper solution.

All received grievances are recorded in a dedicated register.

3.1 EXTERNAL GRIEVANCES CONTACTS

Two contacts persons for the DISI project have been identified to receive and communicate external grievances. One person from DIWACO and one person from DAOM.

DIWACO
Chief Financial Officer: Mohiddin Abu Lughod
Telephone: +962 79 7650 905
Email: mlughod@gamaenergy.com

DAOM:
O&M Manager: Mohammad Abu Hamdeh
Telephone: +962 79 6708 883
Email: mohammed.abuhamdeh@suez.com

4. GENERAL NOTES

The below notes are to be observed regarding the Stakeholder Engagement practices implemented at DAOM:

- ✓ The social aspects of the DISI project are managed through the DISI Project Advisory Committee (DPAC).
- ✓ Main communication methods used are official letters, face-to-face meetings, and on-line meetings. Other methods can be used on as needed basis.

5. DISI PROJECT ADVISORY COMMITTEE

The DISI Project Advisory Committee (DPAC) comprises the review unit for DP environmental performance. Its members will be drawn primarily from MWI and representatives from other stakeholders.

5.1 DISI PROJECT ADVISORY COMMITTEE MEMBERS

The DPAC Committee is formed from members from the below entities:

- ✓ Ministry of Water and Irrigation (MWI).
- ✓ Water Authority of Jordan (WAJ).
- ✓ DISI Water Company (DIWACO).
- ✓ DISI Amman Operation and Maintenance (DAOM).

5.2 ROLES AND RESPONSIBILITIES

The responsibilities of the Committee are as follows:

- ✓ Assess the adequacy of the management of the ESMP through annual reviews to ensure its continuing suitability and effectiveness.
- ✓ Setting performance indicators and targets for DP environmental management and review performance against those targets.
- ✓ Recommend levels of resourcing necessary to implement the ESMP, including human resources, specialized skills, technology and financial provision.
- ✓ Approve an Annual Environmental Report for submission to MWI.

Disi Water Company PSC

Operation & Maintenance Phase

Stakeholder Engagement Plan

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Quality Control Sheet

Document Title: Stakeholder Engagement Plan

Document Ref.: DWC-HRM -OM-QAP-SEPL-015

Rev. no.	Reason for issue	Date	Prepared by	Checked by	Approved by
0	Initial Issuance	25/4/2021	AA	KW	ML/TK
1	Add more details about the DIWACO grievance mechanism	13/6/2021			

Introduction

The purpose of this document is to identify DIWACO's process in ensuring effective two-way communication with the identified stakeholders during the Operation and Maintenance period of the DISI project.

Identified Stakeholders

The below table shows the identified stakeholders and their identified needs:

Interested Parties	Interested Parties detailed	Type of Needs and Expectations	Related Documents/ Records
Shareholder	GAMA Energy Water International B.V. • GAMA Enerji A.Ş: - GAMA Holding (50.5%) - TNB (30%) - IFC (14.5%) - GIF (5%)	Owners	Owners
The Client	Ministry of Water & Irrigation (MWI/WAJ)	Fulfill the contractual obligations	Project Agreement
The Lenders	Investors	Fulfill the contractual obligations	Common Terms Agreement (CTA)
The Operator	DISI Amman Operation & Maintenance (DAOM)	Fulfill the contractual obligations	Project/O&M Agreement
Gama HQ	Head Quarters (Ankara, Turkey)	Technical expertise, support and knowledge sharing	Technical assistance missions and requested reports
Service Providers	Insurance company	Fulfill the Insurance Agreement requirements (reduce the operational and asset-related risks)	Insurance Agreement, outcomes of insurance company visits
	Electricity Providers (JEPCO, EDCO)	Fulfill the contractual obligations (uninterrupted compliant electrical supply to minimize asset-related risks))	Electricity supply agreement
	External auditors (PWC & EY)	Audit and consultation (Financial and taxes)	Engagement letters and audit reports

Interested Parties	Interested Parties detailed	Type of Needs and Expectations	Related Documents/ Records
	External auditors (SGS Jordan)	Quality management audit	Contract Agreement and audit reports
Employees	- Top Management - Middle Management - Non-managerial workers	Safe working conditions and means	Jordanian labor law, Employees contracts, Job descriptions, HR Policy, Internal By-laws and Training Plan
		Job security	
		Training and development, clear instructions	
		Salary accurate and on time	
		Participation and consultation	
Local Community	- MEU University - Neighbors' residents - Heads of Tribes - DISI Project Advisory Committee (DPAC) - Local Association Local authorities (Example: Badia Police in MUS)	Safe neighborhood	Emergency Response Plan, Crisis Management and communication (managed by the operator)
		Environmental protection	ESMP documents (managed by the operator)
		Sustainable development (employment, access to clean water)	ESMP documents (managed by the operator)
Government	- Ministry of Water & Irrigation - Ministry of Labor - Ministry of Environment - Jordan Institution for Standards and Metrology - Ministry of Health - Ministry of Industry and Trade - Ministry of Finance - Tax Authority - Customs Department - Social Security Corporation	Legal/compliance requirements	Project Agreement Jordanian labor law Company Commercial Registration Social Security Corporation Law DAOM Legal Requirements register
Suppliers/ Subcontractors	All DIWACO Suppliers/ Subcontractors	Safe working conditions and means	Supplier Evaluation
		Sustainable business/ timely payments/ accurate delivery versus Purchase Order	Supplier Evaluation
		Provide accurate data	Reports

Grievances

DIWACO has set up a process for receiving and handling internal and external grievances. (see DIWACO Grievance Policy Ref.: DWC-HRM -OM-QAP-GP-013).

DIWACO have identified one person to receive, record and communicate internal/external grievances:

Chief Financial Officer (CFO): Mohiddin Abu Lughod

Mobile: +962 79 765 0 905

Telephone: +962 6 429 3 520

Fax: +962 6 412 0 215

Email: mlughod@gamaenergy.com

Airport Street – Next to Middle East University

P.O Box 3389 Amman 11821 Jordan.

General Notes

The below notes are to be observed regarding the Stakeholder Engagement practices implemented at DIWACO:

- The social aspects of the DISI project are managed through the DISI Project Advisory Committee (DPAC).
- Main communication methods used are official letters, face-to-face meetings, and on-line meetings. Other methods can be used on as needed basis.

DISI Project Advisory Committee

The DISI Project Advisory Committee (DPAC) comprises the review unit for DP environmental performance. Its members will be drawn primarily from MWI and representatives from other stakeholders.

DISI Project Advisory Committee is formed from members from the below entities:

- Ministry of Water and Irrigation (MWI).
- Water Authority of Jordan (WAJ).
- DISI Water Company (DIWACO).
- DISI Amman Operation and Maintenance (DAOM).

Roles and Responsibilities

The responsibilities of the DPAC are as follows:

- Assess the adequacy of the management of the ESMP through annual reviews to ensure its continuing suitability and effectiveness.
- Setting performance indicators and targets for DP environmental management and review performance against those targets.
- Recommend levels of resourcing necessary to implement the ESMP, including human resources, specialized skills, technology and financial provision.
- Approve an Annual Environmental Report for submission to MWI.

Annex 14: High-Level Outline of a Potential Environmental and Social Management Framework (ESMF) for the Ministry of Water and Irrigation (MWI)

High-Level Outline of a Potential Environmental and Social Management Framework (ESMF) for the Ministry of Water and Irrigation (MWI)

This outline is a non-binding technical recommendation for how to manage the Disi aquifer sustainably for a long term. The Ministry of Water and Irrigation (MWI) is not required to follow this, but it is meant to be looked at as part of its national water governance mandate. The ESMF would work with the project-specific ESMP to address long-term and cumulative aquifer risks that go beyond the project's current scope and timeline.

1. Purpose and Scope

- Establish a long-term institutional governance structure to ensure the Disi aquifer is managed sustainably.
- Discuss the long-term social and environmental impacts of continuing abstraction through 2065 and beyond.
- Encourage adherence to pertinent international standards and national water strategies.

2. Institutional Roles and Responsibilities

- MWI: National water planning, regulatory enforcement, and strategic oversight, Stakeholder engagement.
- Project Company: operational monitoring, and reporting in accordance with the ESMP.
- Additional Stakeholders: regional organizations (for example, transboundary coordination), academic partners, local governorates, and the Ministry of Environment.

3. Key Components

- **Policy and Regulation**: Supervision of aquifer protection regulations, and abstraction limits.
- **Data management and monitoring**: Long-term tracking of social and environmental indicators; data utilization to guide adaptive policies.
- **Stakeholder engagement**: includes public outreach, grievance resolution, and collaborative planning with impacted communities.
- **Transboundary Coordination**: Regional collaboration on common aquifer systems, including data sharing and, when appropriate, cooperative governance.
- **Water Quality Management**: Regular evaluation of treatment and blending plans to guarantee adherence to WHO and national regulations.
- **Aquifer drawdown-affected communities** are identified and supported (for example, through restoration or compensation mechanisms) through livelihood and community measures.

4. Implementation and Financing Considerations

- May need phased implementation, backed by national budgets, outside technical assistance, or donor engagement;
- to be developed at MWI's discretion, based on institutional capacity and national priorities.

5. Review and Update

- To guarantee applicability and efficacy, it is advised to conduct a periodic review every five years or whenever new hydrogeological or social data becomes available.

6. Disclaimer

MWI or any other government agency is not bound by the terms of this outline. It is offered as a technical guide to help guide upcoming institutional planning for aquifer governance.

Annex 15: Response to Lenders' Environmental and Social Comments provides the consolidated clarifications submitted to lenders and serves as an integral part of this ESIA

Annex 15 – Response to Lenders' Environmental and Social Comments

(Lender's Review – November 2025)

Project: Environmental & Social Impact Assessment (ESIA) for Drilling New Wells and Associated Infrastructure Works – Dubaydib Well Field / Disi

Proponent: DIWACO (Disi Water Company)
Implementing Authority: Ministry of Water and Irrigation (MWI), Hashemite Kingdom of Jordan
Consultant: Arabtech Jardaneh for Water & Environment
Date: November 2025

Preface
This annex provides the formal responses of DIWACO, AJI and MWI to the comments and clarifications raised by the European Investment Bank (EIB) and other lenders during the review of the Environmental and Social Impact Assessment (ESIA) for the Disi Water Conveyance Project – Dubaydib Wellfield Expansion.
The responses are based on the ESIA (Final, July 2025) and supported by updated technical documentation, including:

- BRGM (2023) – Additional Production Well Targeting and Well Design – Final Report, and
- Dubaydib Groundwater Model Recalibration Results (2022) – Hydrogeological Model Update.

This annex forms an integral part of the final ESIA package and should be read in conjunction with Chapter 8 (Impact Assessment), Chapter 10 (Environmental and Social Management), and the Executive Summary and the MWI ESMF.

No.	Lender's Comment	Response and Clarification	Supporting Reference
1	Transboundary Aquifer	There has been no change in the status of the Memorandum of Understanding (MoU) or Agreement between the Government of Jordan (GoJ) and the Government of the Kingdom of Saudi Arabia (GoKSA) concerning the joint management of the transboundary Disi–Saq Aquifer. The MoU defines a	ESIA Chapter 8.3 ESIA Chapter 10 MWI ESMF Annex 14

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Annex 15 – Response to Lenders' Environmental and Social Comments

(Lender's Review – November 2025)

		management area within Jordan and a *no-drill zone* along the border, which are fully respected by all existing and proposed production wells. No new drilling is planned within the restricted zone, in full compliance with the 2015 Agreement. According to this MoU, the Hashemite Kingdom of Jordan is not required to obtain prior approval from, or formally notify, the Government of Saudi Arabia regarding changes in abstraction volumes within its national territory. Coordination between the Ministry of Water and Irrigation (MWI) / Water Authority of Jordan (WAJ) and their Saudi counterparts continues through the established Joint Technical Committee, under which annual abstraction and groundwater-level data are shared for monitoring purposes. While no recent formal coordination meetings have been reported specifically on the proposed expansion of the Disi wellfield to 120 MCM/year, both parties remain committed to efficient management, responsible investment, and the sustainability of the shared aquifer system, consistent with Article 2 of the Jordan–KSA Agreement. With respect to potential transboundary impacts, the only anticipated effect concerns variations in groundwater levels, which have been incorporated into BRGM's ongoing transboundary hydrogeological modelling for both countries. According to the latest BRGM analyses, continued wellfield development is projected to deepen the piezometric depression within the wellfield by approximately 20 m under the 100 MCM scenario and up to 25 m under the 120 MCM scenario by 2038, relative to current groundwater levels. The BRGM (2023) model further indicates that, relative to the 100 MCM case, the incremental deepening within the Jordanian management area is only about 5 m, with no significant drawdown extending across the border.	

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		Accordingly, abstraction under the 120 MCM/year scenario remains within Jordan's allocation and consistent with both the cooperative provisions of the Jordan–KSA MoU and the institutional responsibilities defined in the MWI Environmental and Social Management Framework (ESMF) for long-term transboundary resource management.	
2	Drawdown & Sustainability	In relation to the sustainability of the 120 MCM/year abstraction scheme, the BRGM (2023) analysis and 2022 Dubaydib model recalibration confirm that, compared to the baseline (100 MCM/year) scenario, this level of annual abstraction will result in an additional drawdown of approximately 5 m by 2038 and up to 10 m by 2065. Current decline rates (1.4–4.2 m/year) remain within the range of long-term historical observations. The modelling shows that, under both the 100 MCM and 120 MCM abstraction scenarios, continued drawdown of the aquifer is expected beyond 2038, reflecting the fossil and non-recharging nature of the Disi aquifer. Within the project period, all production wells remain operational with sufficient water levels above the pumps; however, groundwater levels in several wells are projected to approach current operational thresholds toward the end of the concession. Operational adjustments—such as lowering pumps, modifying pump design, or optimizing flow rates—will therefore be required in selected wells to maintain efficiency. To sustain the current operational setup and provide redundancy across three existing wells, the development of three additional production wells will be required before 2030. Beyond 2038, further wells may be needed under both abstraction scenarios to maintain production continuity as part of national groundwater management.	ESIA Baseline / hydrogeological section ESIA Chapter 8.3 Wellfield Groundwater Extraction Scenarios & Chapter 10 Environmental and Social management plan

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		The BRGM findings confirm that the 120 MCM scheme remains hydrogeologically sustainable through 2038–2040. These results have been provided to and endorsed by the Ministry of Water and Irrigation (MWI), which is aware of the associated long-term operational and resource-management requirements. The long-term sustainability and cumulative management of the Disi aquifer are under the exclusive mandate of MWI, as defined in the ESIA (Chapter 10) and the MWI Environmental and Social Management Framework (ESMF), which governs strategic resource planning beyond project hand-back in 2038.	

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3	Farmers	The ESIA acknowledges that regional drawdown from groundwater abstraction could affect agricultural users in the broader Disi and Al Mudawwarah areas over the long term. Based on the updated BRGM and 2022 model results, increasing abstraction from 100 to 120 MCM/year will cause only 2–8 m of additional drawdown by 2038–2040, which is within normal operational variability and will not measurably affect farmer wells or yields during the project lifetime. Potential agricultural impacts are projected beyond 2065, well after the project term, as part of the cumulative depletion of the fossil aquifer. Management of these long-term, basin-wide effects—including livelihood considerations—falls under the Ministry of Water and Irrigation's mandate, as outlined in the ESIA conclusion and the MWI Environmental and Social Management Framework (ESMF). The Project Company's role is limited to routine monitoring and reporting of groundwater levels and community feedback through DPAC, enabling MWI to manage future policy or livelihood responses at the national level. Stakeholder engagement and information-sharing on groundwater and community matters are facilitated through the DPAC, a coordination platform that includes DIWACO/DOAM, MWI/WAJ, and other governmental bodies. DIWACO/DOAM continues to participate in DPAC meetings to support transparent communication and community dialogue, while overall management and continuity of the committee are the responsibility of MWI/WAJ.	ESIA Executive summary 1.4.2 abstraction scenarios ESIA Conclusion MWI ESMF Annex 14
4	Water Quality	From the early stages of the project, the water quality of the Disi supply and the associated blending procedures were addressed and agreed upon following detailed studies conducted by the Laboratory Affairs Directorate of MWI/WAJ. Water quality has been continuously managed and	ESIA Section 5.2.7.2 The Quality of Groundwater Discharge Wells

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		monitored since project inception, with full traceability through MWI/WAJ laboratory records. The Environmental and Social Management Plan (ESMP2) was originally executed in 2009, and an updated redline version was circulated during 2017–2018, at the time of constructing the cross-connection from AA R1 to the Al-Khaw pipeline. Although this updated version does not appear to have been formally executed, its provisions remain embedded within current MWI/WAJ operational practices for water quality management and monitoring. In terms of water quality and natural radioactivity, MWI has confirmed that the current 117–118 MCM/year supply from the Disi wellfield is blended at two main locations to maintain natural radioactivity within permissible levels: • Dabouq Reservoir: approximately 50 MCM/year blended at a 75% ratio with Zay water; • Abu Alanda Reservoir: approximately 10 MCM/year blended at a 20% ratio with Zara–Ma'en water. Routine WAJ monitoring confirms that, following blending, radioactivity levels remain within safe regulatory limits and in full compliance with both Jordanian and WHO drinking-water standards. On rare occasions when blending water availability is constrained, minor temporary variations may occur but remain within acceptable thresholds. To strengthen blending reliability and sustain water quality, MWI and WAJ have implemented several improvement measures: • The Abu Alanda Reservoir will shortly receive additional supply from the Al-Halabat wells, fully resolving blending challenges at that site;	& Potential Natural Radioactivity MWI answer

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		• The Dabouq Reservoir is being supported by nearby Miyahuna wells, which are being integrated to stabilize blending capacity; and • The National Conveyor Project (expected 2029) will provide a sustainable, high-quality desalinated water source for Amman, ensuring a permanent and reliable supply that will maintain optimal blending ratios and remove blending as a critical operational constraint. The BRGM (2023) report further confirms that all proposed production wells target potable-quality aquifer zones, with potential radionuclide-bearing strata avoided through spectral gamma logging and appropriate casing design. These measures ensure long-term compliance with natural radioactivity standards and guarantee that the Disi water supply remains safe for blending and distribution throughout the project period and beyond.	

Summary and Conclusion

All lenders' comments have been reviewed and addressed through this annex. The clarifications provided herein confirm that:

- The Project remains in full compliance with the Jordan–Saudi Arabia MoU.
- Abstraction at 120 MCM/year is technically sustainable throughout the project lifetime.
- Local agricultural users are not affected during the project period; any long-term, cumulative issues fall under MWI's national mandate.
- Water quality remains safe and compliant with all national and WHO standards.

These responses are supported by the BRGM (2023) and 2022 model recalibration studies, which form part of the technical documentation submitted to lenders.

No further material changes to the ESIA impact ratings are required.

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Annex 16:MWI Water Quality (Radioactivity Monitoring 2023–2024)

Annual Technical report of round 2023-2024

Evaluation of Radioactivity in Dubaydib well field Disi Raw Water, Combined well field, and Blended

Water (Dabuk, and Abu Alanda)

Laboratories and Water Quality Affairs

Approved by: Res. Moheydeen Hosein

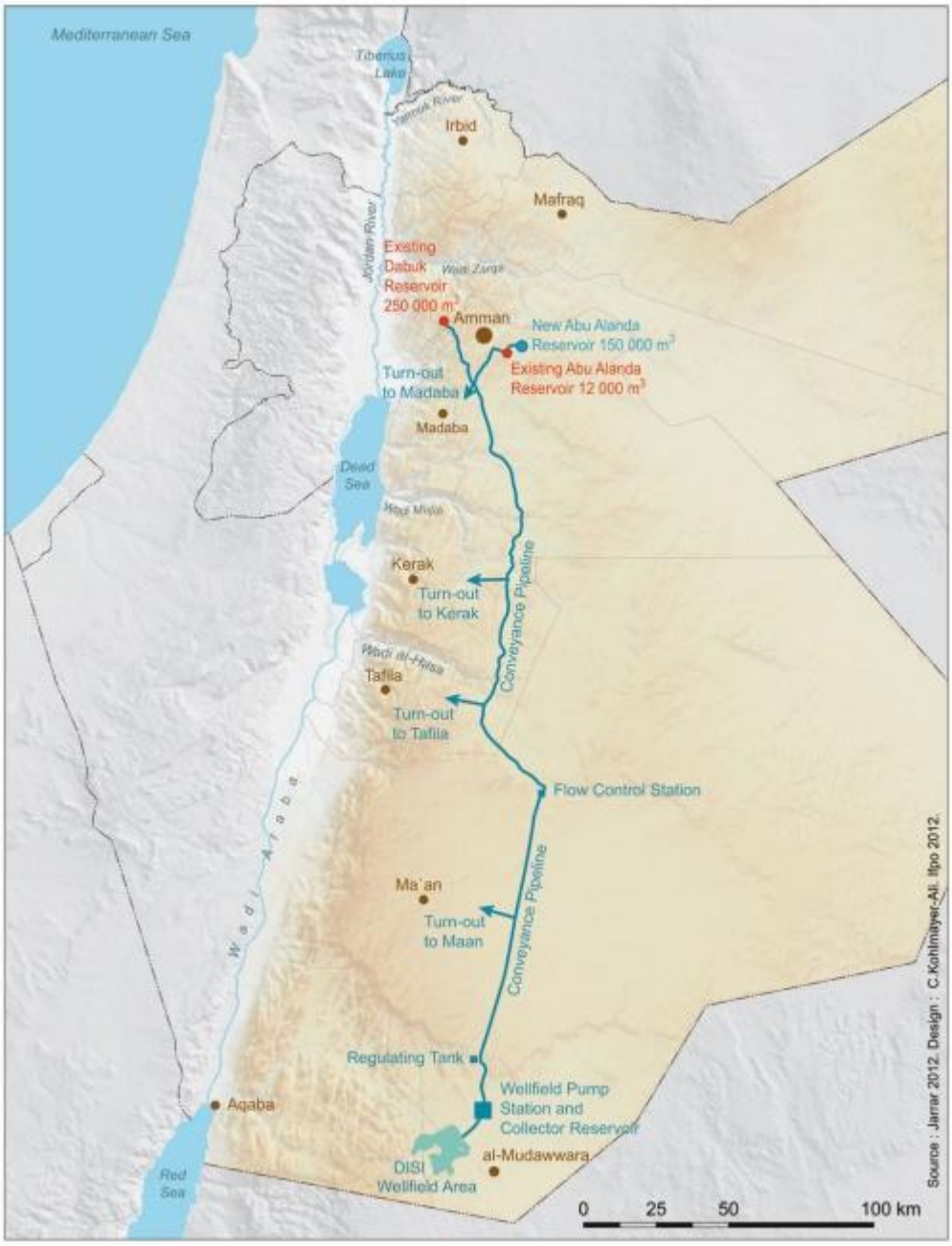
ASG / Laboratories and Water Quality Affairs

Reviewed by: Eng. Suzan Yaseen

Directorate / Laboratories and Quality Management directorate

Prepared by: Eng. Faten Abu Salim

Section Head of Environmental Isotopes



Disi Water Conveyance Project

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Glossary and abbreviations

MWI: Ministry of Water and Irrigation.

WAJ: Water Authority of Jordan.
GL: guidance level for radionuclide in drinking water.
IDC: Individual dose criterion, equal to 0.5 mSv/y (JS286).
DC: Dose Coefficient for ingestion by adults (mSv/Bq).
Q: annual ingested volume of drinking water, assumed to be 730 liters / year.
DAOM: Disi Amman Operation and Maintenance
TED: Total annual Equivalent Dose (mSv/y)
CRa-226, CRa-228, CPb-210: Concentration of Radium-226, Radium-228 and Lead-210 respectively (Bq/l)
LSC:Liquid Scintillation Counter
ESMP#2: Environmental and Social Management Plan #2.
BH: Boreholes.
BA: Zai water treatment plant
BB: Zara water treatment plant
SA: Booster dabuk outlet
SB: Marghab outlet
ERA: Environmental Resource Associates.
NIST: National institute of Standards and technology.
QSM: Quality System Manual.
RDL: Radioactive Dose Limit.
UNSCEAR: The United Nations Scientific Committee on the Effects of Atomic Radiation
Aquifer: Formations, or part of formation that is water bearing.
JS286/2015: Jordanian Drinking Water Standard 286/2015.
mSv/y: Unit of Annual Effective Dose (mille Sievert /y).
Bq/l: Becquerel per liter
HPGE: High purity Germanium Detector
FWHM: Full width of half maximum.
OECD: the Organization for Economic Co-operation and Development
Ra_{eq}:Radium equivalent activity (Bq/kg),

AED: Annual Equivalent Dose

1. Introduction

Ministry of Water and Irrigation required monitoring regime under this ESMP 2, for the Disi Project is based on the principles of the Jordanian Drinking Water Standards 286:2008 – 5th Edition (JS 286), the WHO Guidelines for Drinking-Water Quality, information provided by MWI to Lenders and the requirements under the Sovereign Loans. The water quality and flow monitoring procedure and the blending requirements are specifically targeted at ensuring that the water supply from the Disi Project is compliant with JS 286 by the time that it reaches drinking water users.

The Disi Water Conveyance Project is a major infrastructure project in Jordan that aims to address the country's chronic water shortages. Jordan is one of the most water-scarce countries in the world, with limited natural water resources and a rapidly growing population.in addition to climate change problem, in which affect the water resources either.

The Disi project involves pumping water from the Disi aquifer, located in the southern part of Jordan near the Saudi Arabian border, to the capital city of Amman, which is located about 325 kilometers away.

The project consists of a pipeline that runs from the Disi area to Amman, with a total length of approximately 325 kilometers. The pipeline has a capacity of 100 million cubic meters per year, which is equivalent to about 300,000 cubic meters per day. The water is pumped from wells located in the Disi area, which are about 600 meters deep in average, and is transported to Amman through a system of pumps and pipelines

While the Disi project has helped to address some of Jordan's water shortages, it is important to note that it is a temporary solution that will not solve the underlying water scarcity issues in the country. Jordan will need to continue to explore and develop sustainable water resources to ensure that its population has access to safe and reliable water in the long term.

The Disi aquifer has been known to contain naturally occurring radionuclides such as radium and uranium.

The Jordanian Ministry of Water and Irrigation has conducted several studies to monitor the radioactive quality of groundwater in the Disi aquifer. However, it is important to note that continued monitoring of the quality of groundwater in the Disi aquifer is essential

, starting in 2023a new assessment for Disi aquifer has been started done upon agreement with AFD, BRGM, MWI and WAJ.

2. Responsibility of MWI/WAJ

This report is prepared in accordance with MWI/WAJ's obligations, stipulated under the Environmental and Social Management Plan #2 (ESMP2), to demonstrate the compliance with requirements of section 3.2.2 of ESMP2. The purpose of this report is to assess the radioactivity level of groundwater in the Disi well field (BH), Combined well field (CO), Blending water from Zai and Zara water treatment plants (BA and BB),and blended water from Dabuk network which is Boster Dabuk and Abu Alanda network which is Al Margab (SA and SB respectively)

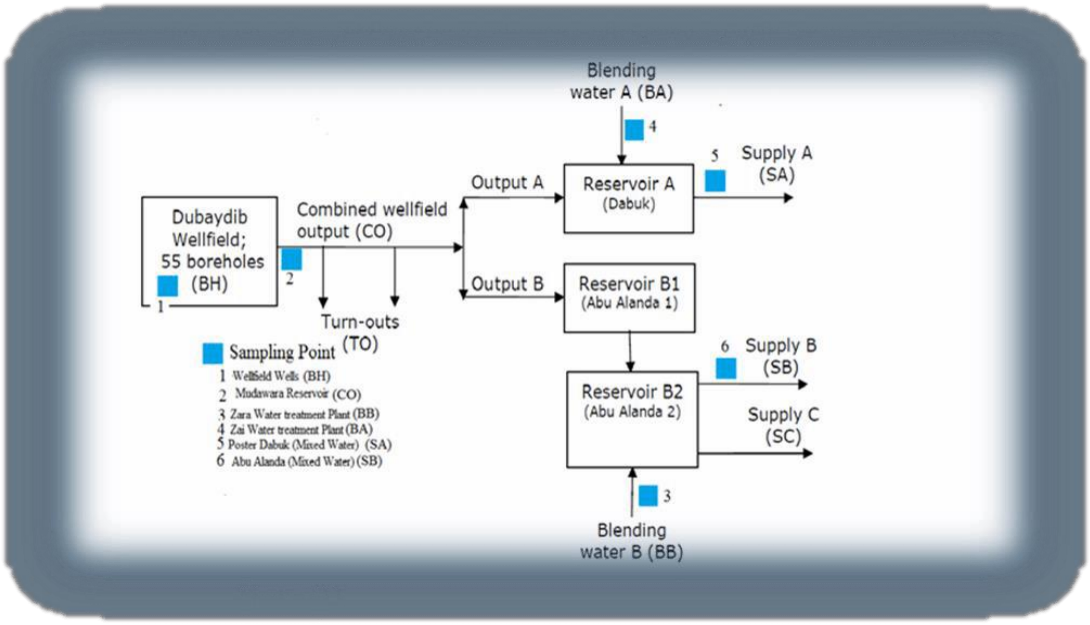


Fig (1) schematic diagram of the transition stages from Disi wells field to network and sampling points.

With reference to Monitoring Phase 3.2 of Part 2 of ESMP2:

"3.2.2 Operational Phase
MWI is required to prepare a consolidated report on water quality (for radioactivity and other related parameters) on an annual basis. The report shall be submitted to the Lenders and the Project Company. As a minimum during commercial operation, MWI is required to undertake and report on the following sampling regime and activities:

• **Sample all operating boreholes (BH) and the blending water (BA and BB)** at a minimum frequency of every 3 months for the first 12 months of operation, and every two years thereafter, to determine the blending requirements for providing drinking water according to JS

286, and to assess any seasonal variations in radionuclide concentrations. Sampling must include the following :

- **Total alpha and total beta activity**
- **Activities for radionuclides including radium (Ra-226 and Ra-228)**

• **Sample the combined flow (CO) and the blended water (SA, SB and SC**), supplied to the distribution network at a minimum frequency of every month for the first two years of operation and quarterly thereafter except as otherwise agreed between MWI and the Lenders, to determine compliance with JS 286. Sampling must include the following:

- **Total alpha and total beta activity**
- **Activities for radionuclides including radium (Ra-226 and Ra-228)**

•**Sample the combined flow (CO),** at a minimum frequency of every quarter during the first year of operation and annually thereafter for the following parameters :

- **Activities for radon (Rn-222) and lead (Pb-210) radionuclides**

3. Methodology

3.1 Sample Collection and Preparation

Twenty liters (20L) of water from each operating boreholes (55 wells), Blending water point (BA), Combined flow (CO), and Blended water points (SA and SB) were collected at the same needed frequency.

Each unfiltered sample (20 liters) was used to provide three sub-samples: 8 liters for Ra^{228}, and Ra^{226}, 1 liter for Pb^{210} analysis and 1 liter for gross alpha and gross beta analysis. The remaining volume was retained to facilitate repeat analysis if required and QC needs.

Samples for Ra^{226}, Ra^{228} and Pb^{210} analysis were collected in virgin polyethylene containers and acidified to a pH of<2 in the laboratory using 69% HNO3.
Samples for gross alpha and gross beta analysis were collected in 1Lpolyethylene and acidified to a pH of<2 in the laboratory using 69% HNO3 ,this method has been modified in2023 to be as per listed in the standard method 24th edition Each sample was allowed to stand for at least 24 hours prior to chemical analysis to ensure that all acid-soluble substances entered solution.
For the BA, CO, SA&SB a sampler has been installed and a monthly samples were collected in a 20L polyethylene container acidified prior replacement of the filled ones and analyzed as alpha, beta, Ra^{226} &Ra^{228} to represent the monthly pumping radioactive water quality.

3.2 Measurement of sample

3.2.1 Determination of gross alpha and gross beta activity

Gross alpha and gross beta analysis were performed via evaporative enrichment, method has been modified in 2023 to be based on the 100ml of acidified sample till dryness then re dissolve the sample with 8 ml of 0.1 M of HNO3, The acidified sample is transferred quantitatively to around 10

ml and to the Packard counting vial, and then10 ml of Ultima Gold LLT (liquid scintillation cocktail) is added. The vial is sealed and counted 5 times for 30 minutes each time by Liquid Scintillation Analyzer model **3110**.& Liquid Scintillation Analyzer model **4910**(a new LSC purchased and installed in 2023)

Liquid scintillation counting (LSC) using a Canberra Packard liquid scintillation analyzer equipped with alpha discriminator (pulse decay analysis). This methodology was modified from standard method for the Examination of water and waste water 24th edition, and the manufacturer instruction via the instrument handling, and has been validated for the determination of gross alpha and beta radioactivity by laboratory quality control schemes and accredited to ISO 17025:2017 in the WAJ/MWI laboratories. The quoted lower reported value (0.20 Bq/l and 0.50 Bq/l, respectively) and combined uncertainty for these methodologies (7.45% and 7.45%, respectively) for 3110,and The quoted lower reported value for 4910 (0.20 Bq/l,0.60 Bq/l respectively)

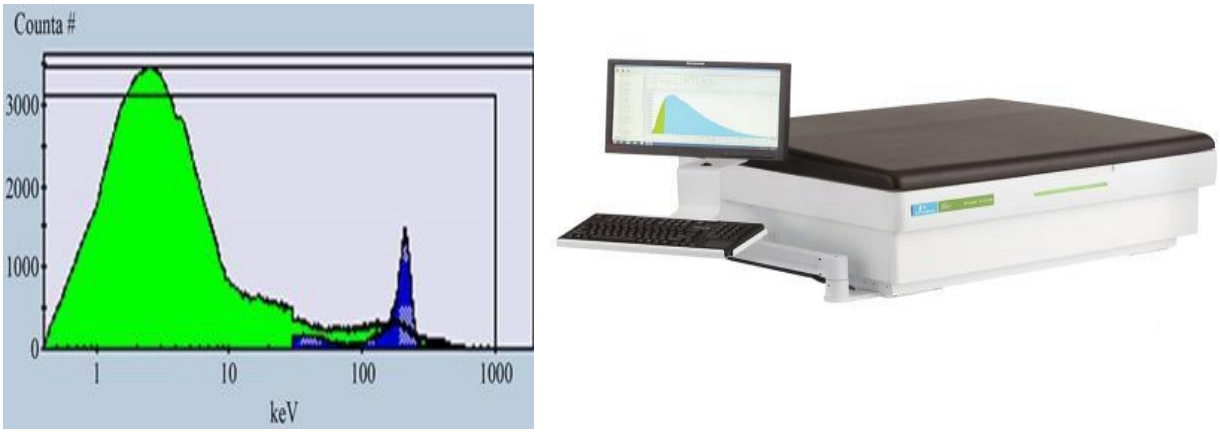


Fig (2) A Canberra Packard 3110TR liquid scintillation analyzer and spectrum of gross Alpha and Beta.

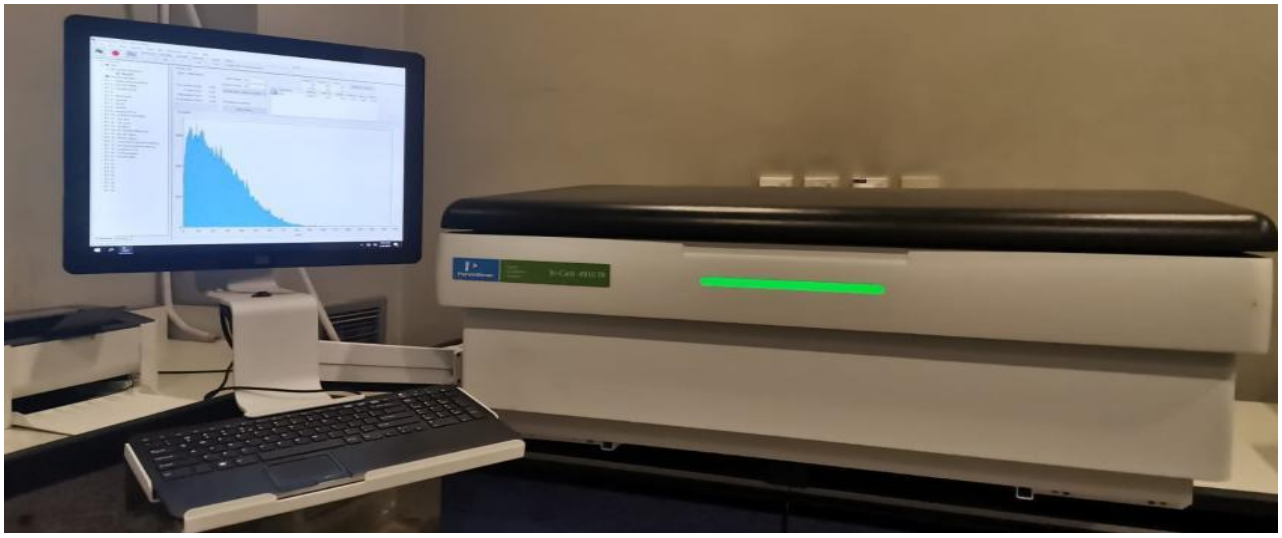


Fig (2) B Canberra Packard 4910 TR liquid scintillation analyzer and spectrum of gross Alpha and Beta

3.2.2 Determination of Ra^{226} and Ra^{228}

Two Gamma Spectrometers are used, equipped with extended range Low Level High Purity Germanium; the old one is installed in 2010 BE 5030 detector (HPGE) with 104mm End cap and 0.3 mm carbon window, 50% efficiency and high resolution FWHM 2.2 at 1332 Kev. The Detector is connected to standard extra processor DSA 1000 desktop inspector electronics

The newest one installed and operated in 2018 GEM-C5970-RB-ST with 70mm end cap diameter carbon window. With a resolution of 2.08 at1330kev. The Detector is connected to standard extra processor DSA 1000 desktop inspector electronics

The detectors are surrounded with 15 cm thick lead shield in order to reduce the background and 0.5 cm copper layer to attenuate X-rays emitted by lead shield. The energy calibration of the spectrum is done using a multi gamma radioactive standard source prepared in the same geometry as the samples to be analyzed (Eckert&Ziegler isotope Products) with total activity of 37kbq. The efficiency calibration for both spectrometers is done by using Standard Ra228 and Ra226 from Ekert&Zighler and Isotope Product Laboratories (IPL) respectively, another source of standards from Environmental Resource Associates (ERA) for Ra226 isotope is used as a Calibration Verification Standards which are prepared by dilution. While different Eckert and Ziegler standard Batch is used for Ra228 as Calibration verification Standards are NIST traceable.

An 8-litre acidified sample was evaporated to a final volume of 1 liter. Transferred and closed and stored for 1 month to allow secular equilibration of Ra^{226} with ingrowing. The water samples should be tightly sealed to stop radon (Rn^{222}) escaping from Marinelli beakers. The methodology relies on measuring the gamma energy of Ra^{228} via Ac^{228} at 911 Kev. And gamma energy of Ra^{226} via Bi^{214} at 609.31 Kev .for Canberra instrument This method provides a low lower reported value (0.13 Bq/l and 0.12 Bq/l respectively) and is validated and accredited to ISO 17025:2017 in the WAJ/MWI laboratories for the determination of Ra^{228} and Ra^{226} in drinking water with a combined uncertainty of (7.17% and 9.8% respectively).while a and lower reported value (0.15 Bq/l ,0.10Bq/l respectively)| a combined uncertainty of(6.43 % and11.07% respectively) for Ortec.

Fig.3 Gamma spectrometry (HPGE) Canberra & Ortec

3.2.3 Determination of Lead-210

One liter acidified sample enriched to 50 ml, after preparing 10ml cation exchange column , sample is passed through .Lead is separated from other elements on an Eichrom Pb Resin Column. The purified lead fraction is collected and sealed for 30 days to allow completion of secular equilibrium with Bi210 ingrowths, then sample is counted by Liquid Scintillation Analyzer (Quantulus 1220).[Ref. 7] (ultra low background)

The method of this analysis is based on the method suggested by Eichrom Technologies, Inc. (OTW01 Rev. 1.8).

This method provides a low lower reported value (0.02 Bq/l) and is validated to ISO 17025:2017 in the WAJ/MWI laboratories for the determination of Pb210 in drinking water.

3.2.3 Determination of Radon-222 Gas

Radon gas is performed via DURRIDGE RAD7 which has a measurement chamber containing an electrostatic field. When radon atoms enter the RAD7 and decay Po^{218} (half-life 3.05 minutes) deposited onto the surface of the RAD7's Canberra Alpha detector .After about 4.3 half-lives or 13 minutes, the RAD7 count rate reaches 95% of its equilibrium value.RAD7 also detect the decay of Po^{214}, a later daughter of radon which takes about three hours to reach equilibrium with radon in the measurement chamber. Using the default settings, The RAD7 will being recording measurements with increased precision after three hours by counting both Po^{218} and Po^{214} decays.
This makes the RAD7 uniquely suited for Radon testing. It is built to withstand demanding use in the field.
This method provides a low detection limit 1 pCi/L (40 Bq/m3) .
In the WAJ/MWI laboratories for the determination of Rn222 in drinking water.
Rn222is also analyzed using liquid scintillation counters with a precise technique of sampling with a special type of cocktail -Opti flour(for gases) taking into consideration correction of time from sampling up to counting time .

3.3 Quality control:

The laboratory has been internationally accredited to ISO 17025 by UKAS since 2005. Accreditation continued through Accreditation Unit of the Jordanian Accreditation and Standardization System (JAS-AU) The department operates in compliance with relevant QA/QC requirements and continually participates in International Proficiency Testing (PT) programs, generally annually, as conducted by external proficiency testing providers such as IAEA, ERA and Aqua check.
Throughout sample handling, preparation and measurement , all the requirement of the ISO 17025:2017 were followed that includes quality assurance and quality control protocols according to the laboratory Quality System Manual (QSM) and supporting quality documents. The quality control results of the blank, matrix spike, and replicate analysis can be furnished upon request.

4. WATER RADIOACTIVITY

Methodologies for the calculation of an individual's annual radiological effective committed dose from the consumption of naturally occurring and man-made radionuclides via the drinking water pathway, and/or the concentration of a specific radionuclide in drinking water that would result in a dose that exceeds a specific individual dose criterion, are laid out in the WHO and Jordanian standards for drinking water quality (WHO 1993, 2004, 2011).
In these calculations (Table 1) Jordanian regulations (JS 286/2015) require the use of an adult drinking water consumption rate of 730 L/y, an individual dose criterion of 0.5 mSv/y and the use of dose coefficients listed in Table 1 (as derived from WHO 1993, 2008, 2011). When more than one of these radionuclides are present, the resulting AED represents a summation of AED equivalents from each of the radioelements present

Based on data from previous studies of groundwater from the Ram aquifer, radionuclides that are the highest contributors to radiological dose through the consumption of Disi water directly at the well head are Ra226, and Ra228 whereas concentration of lead Pb210 was equal or less than detection limit (0.02Bq/l) for most of the wells which means that it has no contribution on Annual Effective Dose (AED).

Accordingly the Total Annual Effective Dose is calculated by the following equation:

$$\mathbf{AED = [C_{Ra\text{-}226} * DC_{Ra\text{-}226} * Q] + [C_{Ra\text{-}228} * DC_{Ra\text{-}228} * Q]} \qquad \mathbf{eq.\ (1)}$$

Indicative levels of radionuclides in drinking water are presented in Table 1. Assuming that each of the mentioned nuclides is the only source of radioactivity in water, that is, we calculated the concentration of the specific nuclide if it was the only source of radioactivity in drinking water, and it alone would constitute the entire radioactive dose.
The following equation calculated the indicative levels of radionuclides in drinking water:

$$GL = AED / (DC * Q) \qquad \text{eq. (2)}$$

Radionuclide	Dose Coefficient (mSv/Bq) (DC)	Guidance level (Bq/litre) (GL)
Radium-226	$2.8X10^{-4}$	2.44
Radium-228	$6.9X10^{-4}$	0.99

Table (1) Guidance levels for the radionuclides contributed in AED.

5. Results and interpretation of data:

According to ESMP No. 2, three major categories should be covered by the tour which are the radioactivity of 55 wells which were covered in the first part, the radioactivity at delivery points (mixing points), which were covered in the second part and the third category is the activity radioactivity in the combined wellfield, which was covered in the third part of this section

The following results and data will discuss the radioactive quality of water in the three parts of the project mentioned above and the safety of the water provided to the population of Jordan.

5.1 PART ONE: Radioactivity in the Boreholes (BH)

Sampling for the current two years round began at the beginning of 2023 and continued during 2024 Regular field visits were carried out to the Disi project every three months to cover 6-8 wells depending on several factors in the field.

All results required for boreholes according to ESMP No. 2 for the round 2023-2024 of gross alpha, gross beta, Ra^{226} and Ra^{228} in water from all Disi wellfield for the samples wells (55) are shown in Table No. 1 in Appendix No. 1

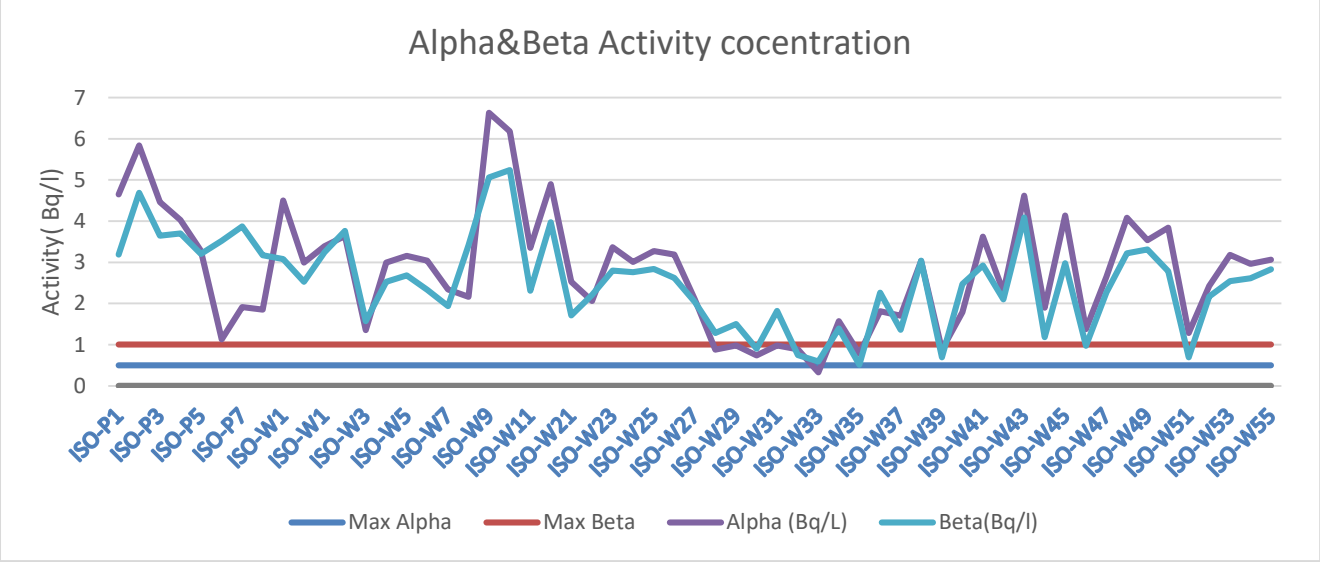


Fig.4 Disi wells against Alpha and Beta concentration for each of them, note that Max Alpha &Beta refers to JS(J286/20215) which is 0.50Bq/l for Alpha &1.0Bq/l for Beta.

as per required in ESMP No. 2,and according to the Jordanian Standard (J286/2015) as well, it's a must to determine Ra^{226} and Ra^{228} values in order to calculate the AED ,for the samples that's exceeds the limits for gross alpha and beta

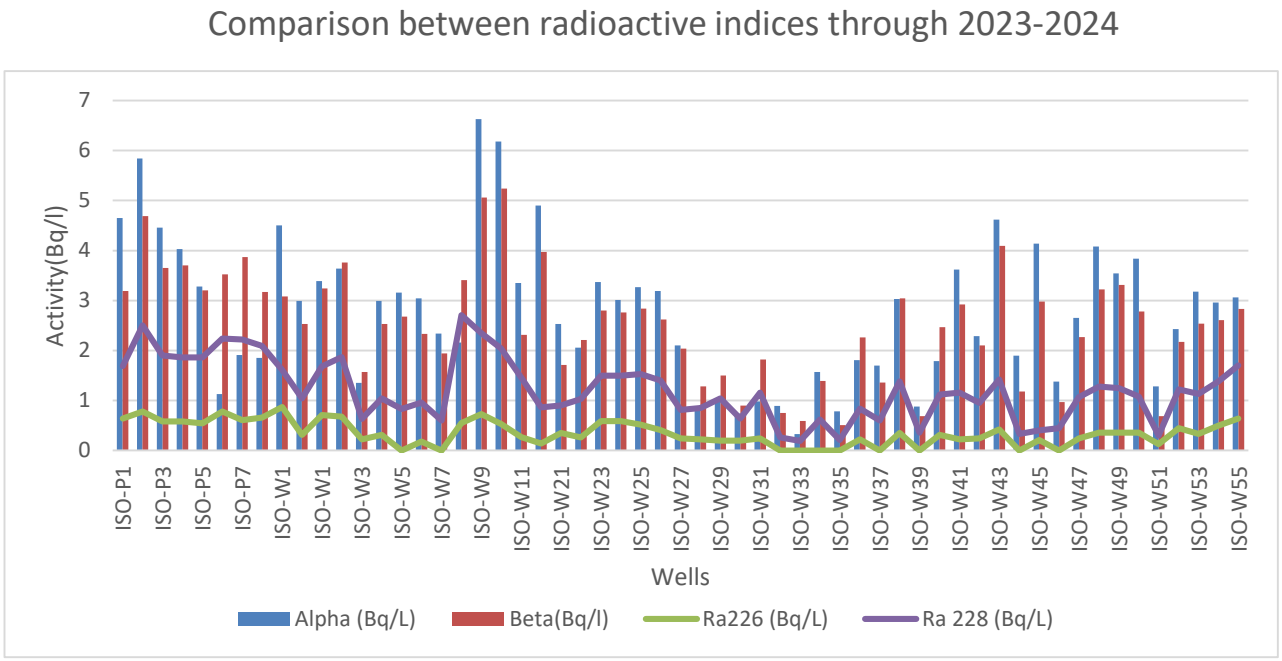


Fig.5 shows the relation between alpha, beta with Ra^{226}&Ra^{228}, it's obviously noticed that the presence of alpha and beta will surely be a first indication if there is Radium in the wells, on the other hand Ra^{228}activity is more than the Ra^{226} activity for the same well

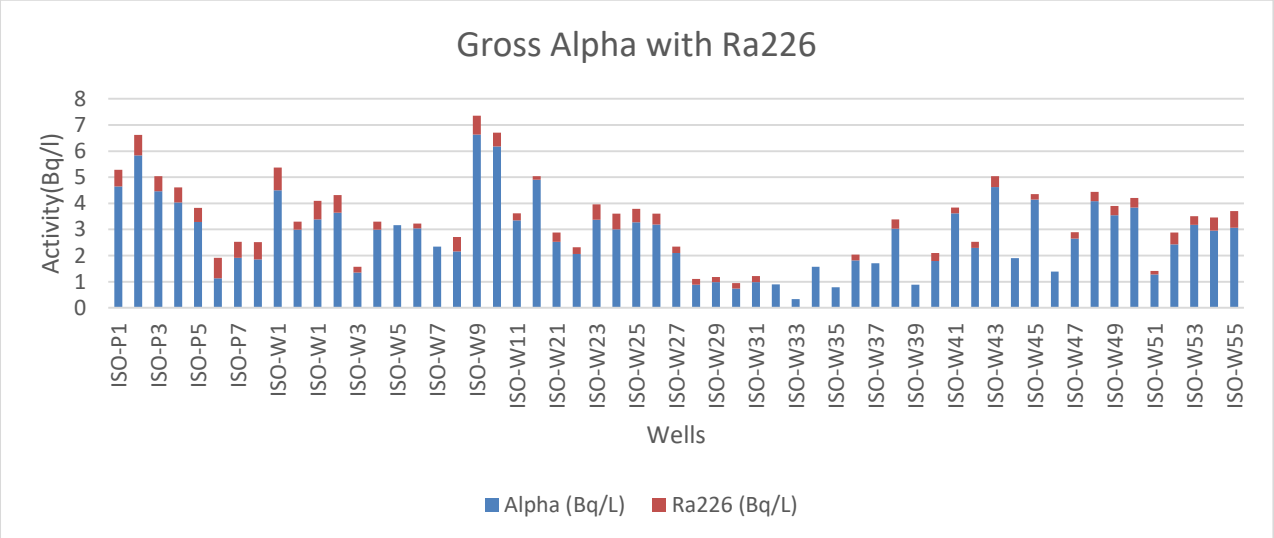


Fig.6 shows the relation between the gross alpha and Ra^{226}, in which presence of alpha is the first indication for Ra^{226} presence.

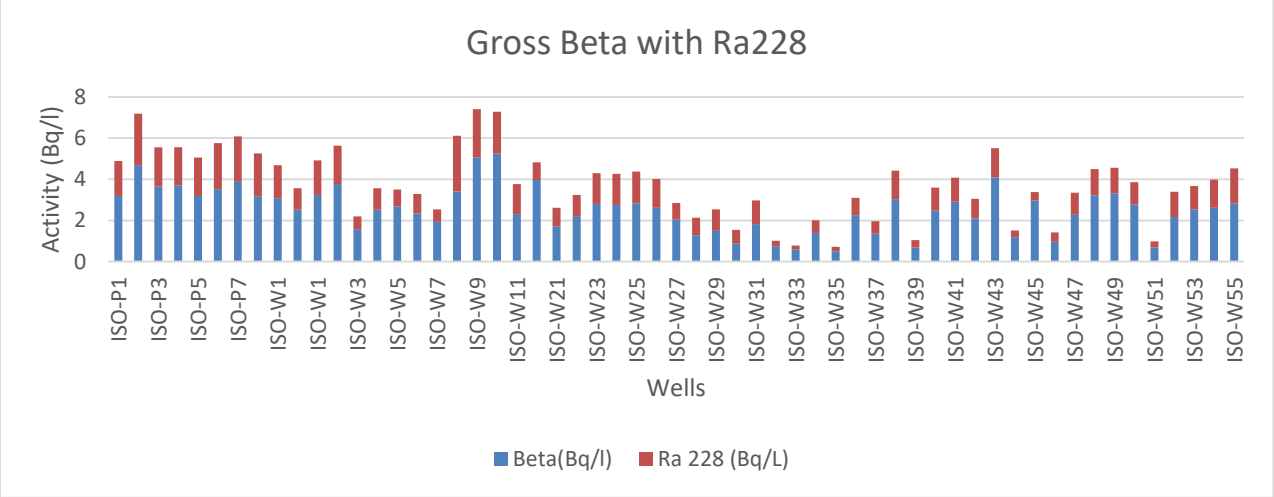


Fig.7 shows the relation between the gross beta and Ra^{228}, in which presence of beta is is the first indication for Ra^{228} presence.

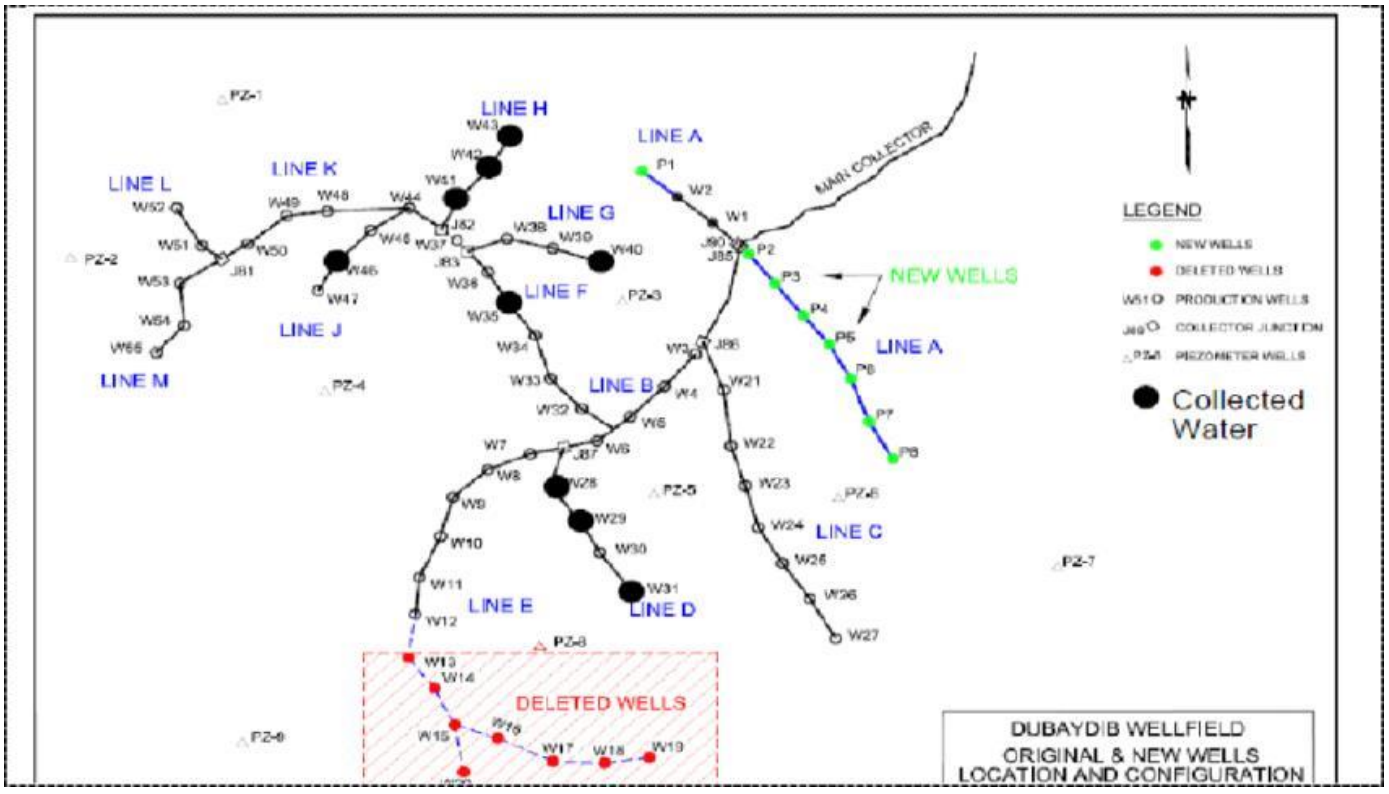


Fig.8.a shows the classification of the Disi wells into categories -depend on location

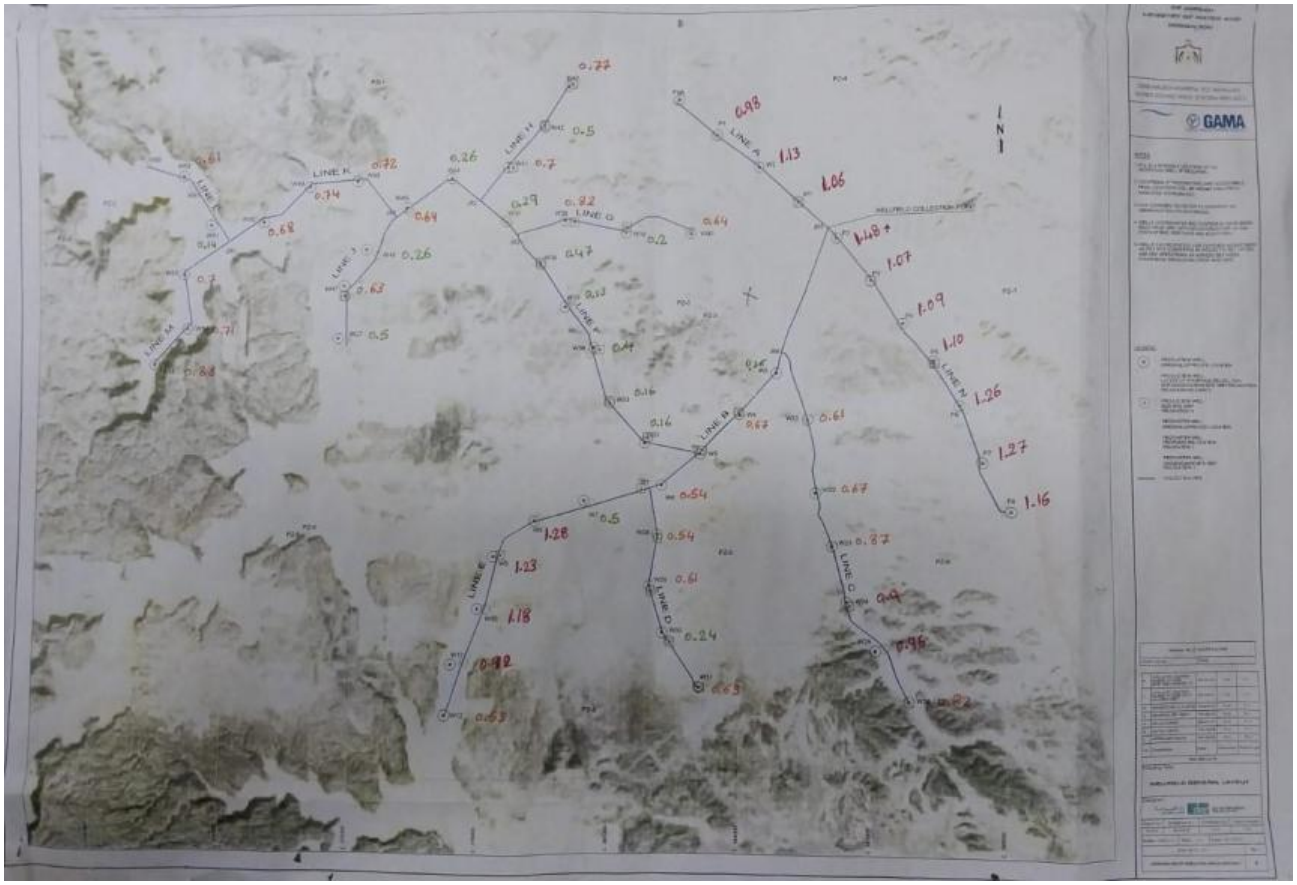


Fig.8.b classification of wells into categories -depend on location

LINE A	LINE D	LINE E	LINE G	LINE F	LINE C	LINE B	LINE H	LINE J	LINE K	LINE L	LINE M
P1	W28	W7	W38	W32	W21	W3	W41	W44	W48	W51	W53
P2	W29	W8	W39	W33	W22	W4	W42	W45	W49	W52	W54
P3	W30	W9	W40	W34	W23	W5	W43	W46	W50		W55
P4	W31	W10		W35	W24	W6		W47			
P5		W11		W36	W25						
P6		W12		W37	W26						
P7					W27						
P8											
W1											
W2											

Table (2) wells names listed in the categories (Line A,B,C,D,E,F,G,H,J,K,L,and M)

LINE A	LINE D	LINE E	LINE G	LINE F	LINE C	LINE B	LINE H	LINE J	LINE K	LINE L	LINE M
P1	W28	W7	W38	W32	W21	W3	W41	W44	W48	W51	W53
P2	W29	W8	W39	W33	W22	W4	W42	W45	W49	W52	W54
P3	W30	W9	W40	W34	W23	W5	W43	W46	W50		W55
P4	W31	W10		W35	W24	W6		W47			
P5		W11		W36	W25						
P6		W12		W37	W26						
P7					W27						
P8											
W1											
W2											

Table (3) well names analyzed through 2023(listed in black), and wells collected and analyzed in 2024(listed in red).

	Alpha (Bq/L)	Beta(Bq/l)	Ra226 (Bq/L)	Ra 228 (Bq/L)	DOSE(msv/y)
LINE A	3.53	3.58	0.67	1.98	1.14
LINE D	1.92	2.40	0.22	0.92	0.51
LINE E	4.26	3.66	0.44	1.67	0.93
LINE G	3.75	3.21	0.33	0.95	0.55
LINE F	1.85	1.98	0.22	0.55	0.32
LINE C	2.75	2.42	0.45	1.31	0.75
LINE B	3.06	2.51	0.25	0.94	0.52
LINE H	3.51	3.04	0.29	1.18	0.65
LINE J	2.52	1.85	0.23	0.56	0.33
LINE K	3.82	3.10	0.36	1.20	0.68
LINE L	1.86	1.43	0.29	0.76	0.44
LINE M	3.07	2.66	0.49	1.40	0.81

Table #4 indicates the higher dose achieved through the Disi wells (Line A) and the lowest dose (Line F and line J)
See Fig.9 below.

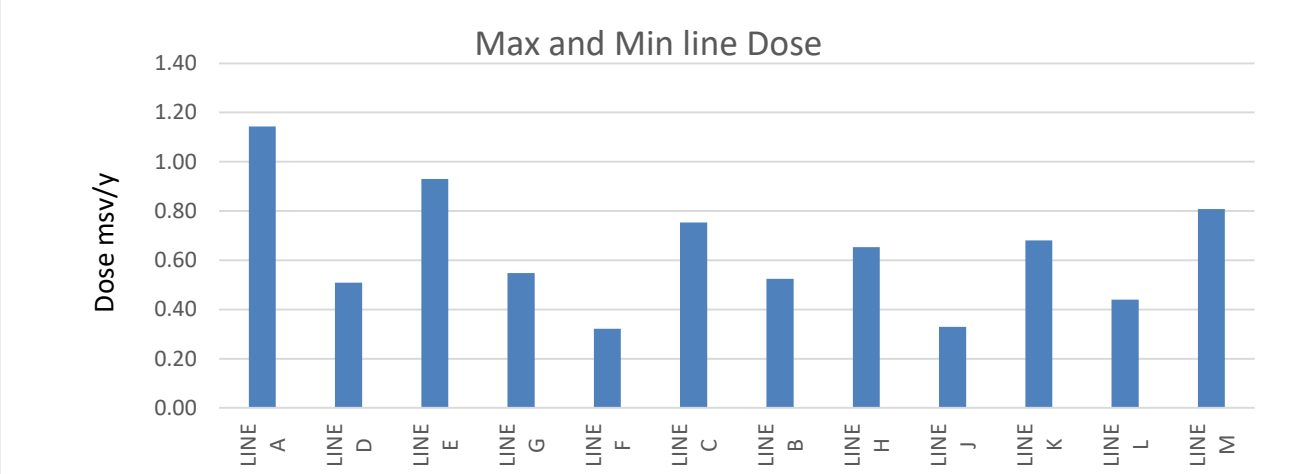


Fig.9 shows that the max dose is at location Line A (P1-P8, W1&W2) while the min dose at Line F (W32,W33,W34,W35,W36 and W37),and line J (W44,W45,W56&W47)

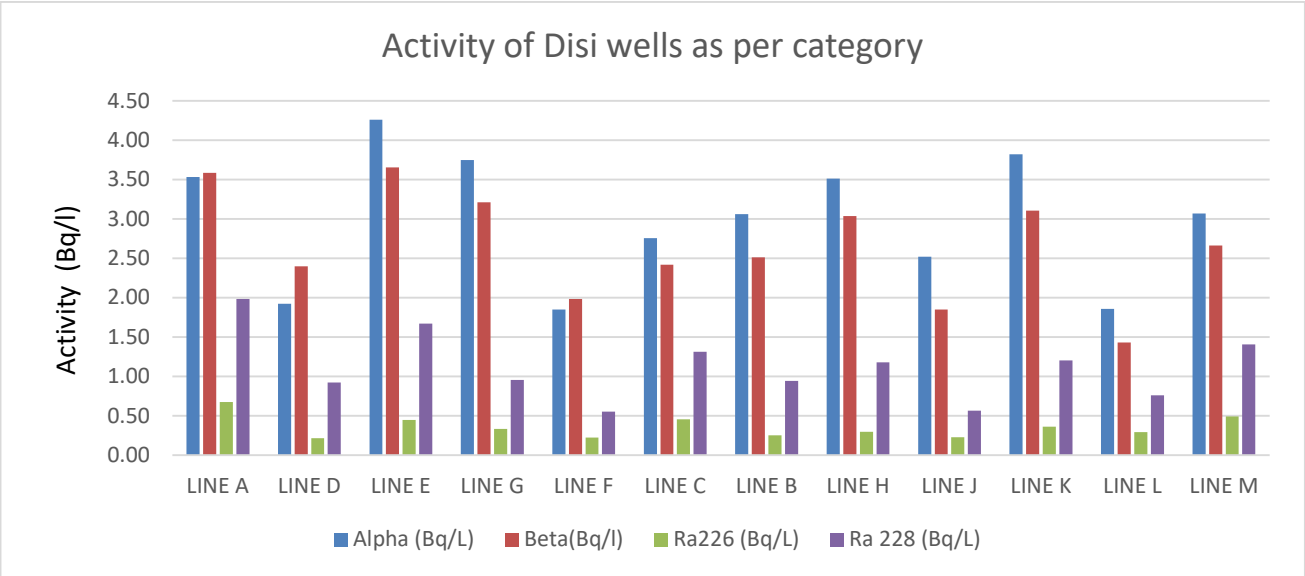


Fig.10 shows the Avg of the activity for Radium in the Disi wells as per categories shown in the Fig#8

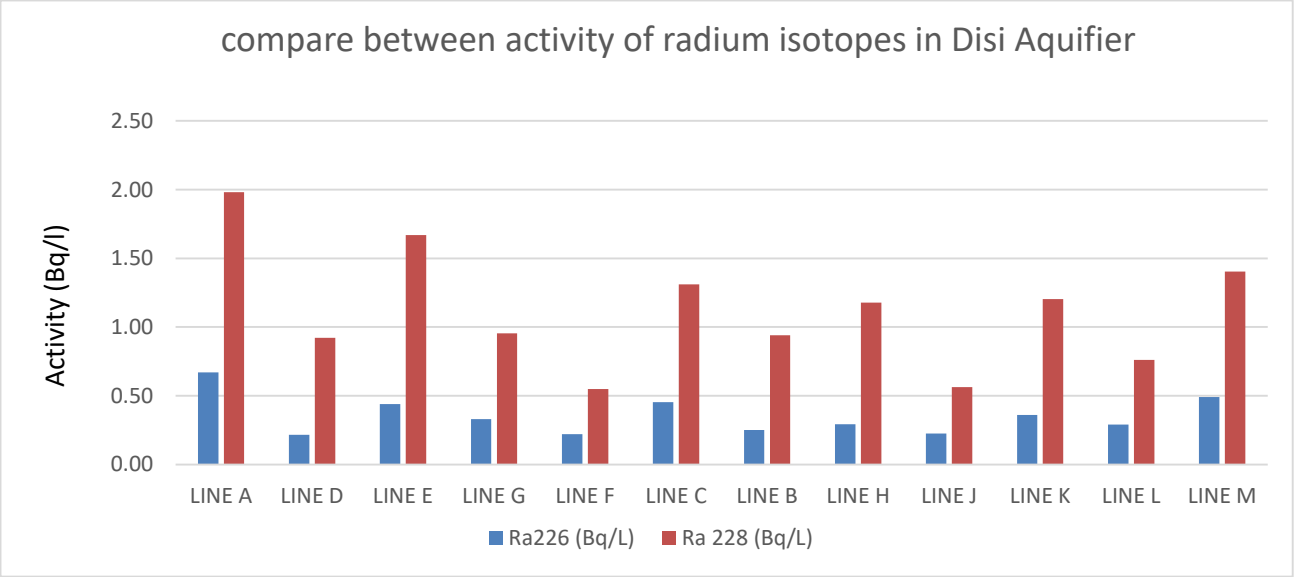


Fig.11 shows the characteristics of Rum Aquifer -in which Disi wells locates- , Ra^{228} activity consider to be higher than the Ra^{226} activity (about 3 times higher).

WELL NAME	Dose(mSv/y) 2024	Dose (msv/y) 2022
ISO-P1	0.98	0.99
ISO-P2	1.42	1.67
ISO-P3	1.08	1.06
ISO-P4	1.06	1.07
ISO-P5	1.05	1.00
ISO-P6	1.29	1.12
ISO-P7	1.25	1.12
ISO-P8	1.19	1.43
ISO-W1	0.99	1.10
ISO-W2	1.08	1.01
ISO-W3	0.36	0.44
ISO-W4	0.59	0.62
ISO-W5	0.45	0.52
ISO-W6	0.52	0.56
ISO-W7	0.33	0.60
ISO-W8	1.40	1.18
ISO-W9	1.34	1.22
ISO-W10	1.14	1.22
ISO-W11	0.79	0.51
ISO-W12	0.46	0.46
ISO-W21	0.53	0.89
ISO-W22	0.57	0.56
ISO-W23	0.88	1.83
ISO-W24	0.88	0.80
ISO-W25	0.88	0.81
ISO-W26	0.79	0.74
ISO-W27	0.46	0.49
ISO-W28	0.47	0.46
ISO-W29	0.57	0.54
ISO-W30	0.36	0.35
ISO-W31	0.63	0.66
ISO-W32	0.16	0.23
ISO-W33	0.12	0.18
ISO-W34	0.34	0.37
ISO-W35	0.13	0.17
ISO-W36	0.47	0.44
ISO-W37	0.33	0.35
ISO-W38	0.77	0.80
ISO-W39	0.21	0.21
ISO-W40	0.63	0.62
ISO-W41	0.63	0.68
ISO-W42	0.53	0.52
ISO-W43	0.80	0.86
ISO-W44	0.19	0.22
ISO-W45	0.24	0.59
ISO-W46	0.25	0.28
ISO-W47	0.59	0.64
ISO-W48	0.72	0.63
ISO-W49	0.70	0.71
ISO-W50	0.62	0.64
ISO-W51	0.18	0.18
ISO-W52	0.71	0.54
ISO-W53	0.64	0.65
ISO-W54	0.80	0.75
ISO-W55	0.99	0.84
MAX	1.42	1.83
MIN	0.12	0.17

Table #5 a AED comparison for the same measured wells through cycle (2021-2022)& cycle (2023-2024).

The above table shows that the characteristics –depend on dose values-of the wells were almost the same for the most them.
And the highest dose was arise in well P2 (Line A), while the min dose is for well W33 (Line F) as shown below

WELL NAME	Dose(msv/y) 2024	Dose(msv/y) 2023
ISO-P2	1.42	1.42
ISO-W33	0.12	0.12

Table #6 Max and Min AED for the measured wells for cycle 2023-2024

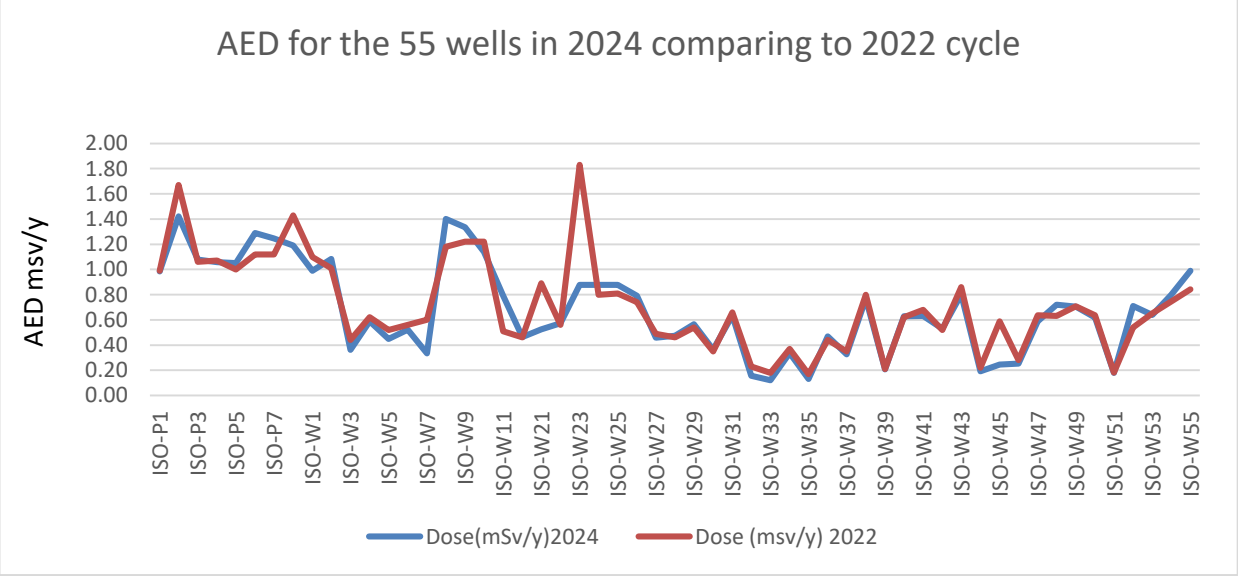


Fig #12 clearly shows that there is consistency between AED through2022 and 2024

The radioactive results for the measured wells as shown in the tables and the charts shows a consistency of data, that there is a wells with high activity and wells with low activity in which there is a slight deviation through years except for the results for W23 (the sample collected in June 2021) after comparing all the well results through years up to 2024 an obvious high activity for both Ra226 and Ra228 appear in the mentioned well , in which raise the dose value as well , but the results for W23 in cycle 2023-2024 matches the historical data ,this well will be under consideration in the next cycle in order to check the reason of this high values , one of the scenarios lead us to the sampling issue .

5.2 PART TWO: Radioactivity in the Delivery points (Blending Points)

MWI must carry out progressive sampling of the operational boreholes (BH) to identify and mitigate the problem, and provide a monthly report (Red Flag report) to the Lenders and the Project Company

with the proposed measures to ensure that the blended water output (SA, SB or SC) does not exceed the threshold of 0.5 mSv/y and progress relating to their implementation. Sampling of BH must include the following:

- Total alpha and total beta activity
- Activities for radionuclides including radium (Ra226 and Ra228) as per mentioned in ESMP 2 Rev2
- as per ESMP plan section 3 WATER QUALITY COMPLIANCE: MONITORING AND BLENDING there is two major tanks (AA1 and Dabuk Boaster) established and prepared to receive anon radioactive water from AlZara maen and Zai effluent plant respectively -in addition to the quantity of water supplied from Al-Disi line

The required monitoring regime under this ESMP Part 2, for the Disi Project is generally based on the principles of the Jordanian Drinking Water Standards 286:2015 – 6th Edition, the WHO Guidelines for Drinking-Water Quality, and information provided by MWI to Lenders prior to commencement of the project.

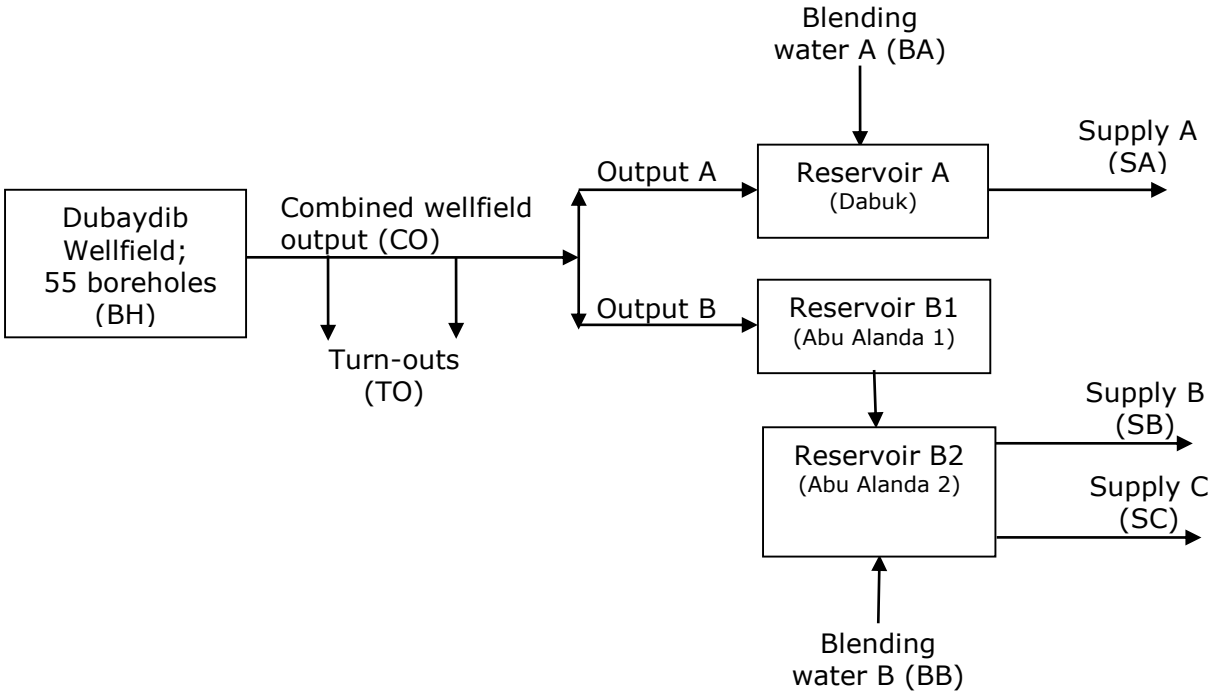


Fig #13 Schematic diagram of the Delivery points (Blending Points)

The programmed automatic sampler continuously takes an equal sized sample each day and collects it in a pre-acidified 20 liter container which is collected at the end of each month for analysis and replaced with another one to repeat the procedure.
A reliable monitoring procedure ensures that a representative sample is available for one full month. The monitored blending and delivery points are:-

1- **Dabuq reservoir** The main inflow from Disi
2- **Boaster Dabuq** (point SA in Fig.12) which represents Dabuk network (Dabuk after blending).
3- **Shmisani** another network point which has additional source for blending water after Boster Dabuk.

4- **Al Margab** (point SB in Fig.12) which represents Abu Alanda network (Abu Aland after blending).

The Report depend on results from the above sampling requirements with respect to the level of radioactivity in the water from the operating boreholes (BH), combined flow from the wellfield (CO), blending water blended water and water at turn

Abu Alanda and boaster blended with Zara Maen and Zai respectively, because after radiological analysis for both water sources, the AED <0.02 msv/y which is the appropriate water quality to mix with both (Abu Alanda and Boaster).

As shown in Table #7 (A&B) the data is for 2023 &2024 respectively

		Total Quantity Supplied from Disi	Equivalent Dose in Disi line	Quantity Supplied from Zara-Main to Abu Alanda Res.	Quantity Supplied from Disi to Abu Alanda Res.	Mixing ratio (ZARA-Main) /Disi in Abu Alanda Res.	Equivilent Dose in Abu Alanda Res.	Quantity Supplied from Zai to Dabouk Booster Res.	Quantity Supplied from Disi to Dabouk Booster Res.	Mixing ratio Zai /Disi in Dabouk Booster Res.	Eqivalent Dose in Dabouk Booster Res.	Eqivalent Dose in Shmisani Res.	Quantity Supplied from AA1 to Zatary Res.	Eqivalent Dose in Zatary Res.
Month	Date of colllection	(m3/month)	mS/year	(m3/month)	(m3/month)	%	mS/year	(m3/month)	(m3/month)	%	mS/year	mS/year	(m3/month)	mS/year
Jan	31/1/2023	9495664	0.68	712490	3734672	0.19	0.55	3479108	5760992	0.60	0.48	0.26		
Feb	1/3/2023	8548544	0.61	676770	3503264	0.19	0.56	3350465	5045280	0.66	0.47	0.29		
Mar	30/3/2023	9514018	0.67	705970	3891966	0.18	0.55	3843687	5622052	0.68	0.48	0.24		
Apr	1/5/2023	9187730	0.65	701800	4000978	0.18	0.53	4058902	5186752	0.78	0.43	0.19		
May	30/5/2023	9469296	0.61	727250	4148432	0.18	0.52	4655708	5320864	0.87	0.50	0.21		
Jun	30/6/2023	9185344	0.64	676600	4078976	0.17	0.56	4863188	5106368	0.95	0.41	0.25		
Jul	31/7/2023	9117629	0.66	668300	3475624	0.19	0.57	4956685	5272860	0.94	0.44	0.23	369145	0.09
Aug	31/8/2023	9119083	0.69	781040	3500734	0.22	0.61	4945962	5265220	0.94	0.46	0.32	353129	0.11
Sep	1/10/2023	9165574	0.69	754004	3883949	0.19	0.56	4693750	5101120	0.92	0.45	0.27	180505	0.10
Oct	30/10/2023	9641902	0.71	989965	3812601	0.26	0.49	4248588	5605116	0.76	0.44	0.27	224185	0.10
Nov	30/11/2023	9061748	0.69	1047774	3590167	0.29	0.47	3645910	5402406	0.67	0.46	0.30	69175	<0.09
Dec	31/12/2023	8939360	0.62	897168	3663520	0.24	0.56	4108085	5275840	0.78	0.44	0.30		
Average			0.66	778260.92	3773740.3	0.21	0.543707			0.80	0.45423667	0.26251		0.10
Total (m3/year)		110445892		9339131	45284883			50850038	63964870				1196139	

Table #7A: mixing ratios and dose values for the year 2023

		Total Quantity Supplied from Disi	**AED in Disi line**	**Quantity Supplied from Zara-Main to Abu Alanda Res.**	**Quantity Supplied from Disi to Abu Alanda Res.**	**Mixing ratio (ZARA-Main) /Disi in Abu Alanda**	**AED in Abu Alanda Res.**	**Quantity Supplied from Zai to Dabouk Booster Res.**	**Quantity Supplied from Disi to Dabouk Booster Res.**	**Mixing ratio Zai /Disi in Dabouk Booster Res.**	**AED in Dabouk Booster Res.**	**AED in Shmisani Res.**
Month	**Date of colllection**	**(m^3/month)**	**mSv/year**	**(m^3/month)**	**(m^3/month)**	**%**	**mSv/year**	**(m^3/month)**	**(m^3/month)**	**%**	**mSv/year**	**mSv/year**
Jan	31/1/2024	9814848	0.63	490758	4088704	0.12	0.59	3713295	5726144	0.65	0.44	0.22
Feb	30/2/2024	9180224	0.69	480042	3853184	0.12	0.60	4127753	5327040	0.77	0.42	0.27
Mar	31/3/2024	9729344	0.65	482110	4027104	0.12	0.59	4072121	5702240	0.71	0.45	0.29
Apr	1/5/2024	9491344	0.72	693140	3893840	0.18	0.54	3808183	5597504	0.68	0.45	0.25
May	30/5/2024	9824544	0.67	600244	4071168	0.15	0.59	4189433	5753376	0.73	0.44	0.20
Jun	1/7/2024	9512192	0.66	534700	4013120	0.13	0.61	4736827	5499072	0.86	0.47	0.34
Jul	1/8/2024	9722928	0.66	688468	4089520	0.17	0.61	4762122	5633408	0.85	0.44	0.26
Aug	1/9/2024	9820816	0.67	764344	4126672	0.19	0.63	4751120	5694144	0.83	0.44	0.25
Sep	1/10/2024	9508864	0.65	934994	3988224	0.23	0.56	4552983	5520640	0.82	0.44	0.32
Oct	31/10/2024	9508200	0.62	1185814	3934920	0.30	0.56	3762636	5573280	0.68	0.44	0.29
Nov	1/12/2024	9496816	0.71	1066380	3844048	0.28	0.52	3680573	5652768	0.65	0.49	0.31
Dec	2/1/2025	9814848	0.71	490758	4088704	0.12	0.55	3713295	5726144	0.65	0.49	0.33
Average			0.67			0.18	0.58			0.75	0.45	0.28
Total (m3/year)		115424968		8411752	48019208			49870341	67405760			

Table #7B: mixing ratios and dose values for the year 2024

	Ra226 in Disi line	Ra228 in Disi line	AED in Disi line	Ra226 in Abu Alanda Res.	Ra228in Abu Alanda Res.	AED in Abu Alanda Res	Ra226 in Dabouk Booster Res.	Ra228 in Dabouk Booster Res.	AED inDabouk Booster Res	Ra226 in Shamisani Res.	Ra228 in Shamisani Res.	AED in Shamisani Res	Ra226 in Zatary Res.	Ra228 in Zatary Res.	AED in Zatary Res.
Month	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year
Jan	0.37	1.20	0.68	0.26	0.99	0.55	0.23	0.85	0.48	0.17	0.45	0.26			0.00
Feb	0.31	1.08	0.61	0.28	1.00	0.56	0.25	0.84	0.47	0.14	0.52	0.29			0.00
Mar	0.40	1.17	0.67	0.29	0.97	0.55	0.25	0.85	0.48	0.23	0.39	0.24			0.00
Apr	0.28	1.18	0.65	0.25	0.96	0.53	0.17	0.79	0.43	0.14	0.33	0.19			0.00
May	0.31	1.08	0.61	0.25	0.93	0.52	0.24	0.9	0.50	0.12	0.37	0.21			0.00
Jun	0.31	1.14	0.64	0.25	1.00	0.56	0.22	0.73	0.41	0.15	0.43	0.25			0.00
Jul	0.34	1.17	0.66	0.31	1.00	0.57	0.21	0.78	0.44	0.18	0.39	0.23	<0.12	<0.13	<0.50
Aug	0.36	1.23	0.69	0.31	1.08	0.61	0.24	0.81	0.46	0.17	0.56	0.32	<0.12	0.16	<0.50
Sep	0.35	1.23	0.69	0.29	0.99	0.56	0.27	0.78	0.45	0.17	0.47	0.27	<0.12	0.14	<0.50
Oct	0.34	1.27	0.71	0.25	0.87	0.49	0.23	0.77	0.44	0.21	0.46	0.27	<0.12	0.14	<0.50
Nov	0.34	1.23	0.69	0.26	0.83	0.47	0.24	0.81	0.46	0.21	0.52	0.30	<0.12	<0.13	<0.50
Dec	0.31	1.10	0.62	0.26	1.01	0.56	0.22	0.79	0.44	0.19	0.52	0.30			0.00
Avg	0.34	1.17	0.66	0.27	0.97	0.54	0.23	0.81	0.45	0.17	0.45	0.26	<0.12	0.15	<0.50

Table 8.a shows monthly radioactive indicators of the four delivery/blending points through 2023

	Ra226 in Disi line	**Ra228 in Disi line**	AED in Disi line	**Ra226 in Abu Alanda Res.**	**Ra228in Abu Alanda Res.**	Equivalent Dose in Abu Alanda Res	**Ra226 in Dabouk Booster Res.**	**Ra228 in Dabouk Booster Res.**	Equivalent Dose inDabouk Booster Res	**Ra226 in Shamisani Res.**	**Ra228 in Shamisani Res.**	Equivalent Dose in Shamisani Res
Month	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year
Jan	0.32	1.13	**0.63**	0.30	1.04	**0.59**	0.21	0.78	**0.44**	0.16	0.38	**0.22**
Feb	0.35	1.23	**0.69**	0.26	1.08	**0.60**	0.19	0.76	**0.42**	0.20	0.46	**0.27**
Mar	**0.34**	**1.15**	**0.65**	**0.27**	**1.07**	**0.59**	**0.22**	**0.81**	**0.45**	**0.18**	**0.50**	**0.29**
Apr	0.32	1.30	**0.72**	0.23	0.98	**0.54**	0.20	0.81	**0.45**	0.16	0.43	**0.25**
May	0.38	1.18	**0.67**	0.31	1.05	**0.59**	0.23	0.77	**0.44**	0.16	0.34	**0.20**
Jun	0.34	1.18	**0.66**	0.26	1.11	**0.61**	0.22	0.84	**0.47**	0.18	0.60	**0.34**
Jul	0.45	1.12	**0.66**	0.34	1.07	**0.61**	0.25	0.78	**0.44**	0.17	0.45	**0.26**
Aug	0.32	1.20	**0.67**	0.29	1.13	**0.63**	0.24	0.77	**0.44**	0.15	0.43	**0.25**
Sep	0.30	1.16	**0.65**	0.26	1.00	**0.56**	0.21	0.78	**0.44**	0.16	0.57	**0.32**
Oct	0.34	1.09	**0.62**	0.25	1.01	**0.56**	0.23	0.77	**0.44**	0.16	0.51	**0.29**
Nov	0.35	1.26	**0.71**	0.24	0.94	**0.52**	0.23	0.87	**0.49**	0.2	0.53	**0.31**
Dec	0.44	1.23	**0.71**	0.27	0.98	**0.55**	0.35	0.83	**0.49**	0.26	0.54	**0.33**
Avg			0.67			**0.58**			**0.45**			0.28

Table 8.b shows monthly radioactive indicators of the four delivery/blending points through 2024

Year	**Total Quantity Supplied from Disi**	**AED in Disi line**	**Quantity Supplied from Zara-Main to Abu Alanda Res.**	**Quantity Supplied from Disi to Abu Alanda Res.**	**Mixing ratio (ZARA-Main) /Disi in Abu Alanda Res.**	**AED in Abu Alanda Res.**	**Quantity Supplied from Zai to Dabouk Booster Res.**	**Quantity Supplied from Disi to Dabouk Booster Res.**	**Mixing ratio Zai /Disi in Dabouk Booster Res.**	**AED in Dabouk Booster Res.**	**AED in Shmisani Res.**
	(m^3/Year)	mS/year	(m^3/Year)	(m^3/Year)	%	mS/year	(m^3/Year)	(m^3/Year)	%	mS/year	mS/year
2023	110445892	0.66	9339131	45284883	0.21	0.54	50850038	63964870	0.80	0.45	0.26
2024	115424968	0.67	8411752	48019208	0.18	0.58	49870341	67405760	0.75	0.45	0.28

Table#9 comparing between the two Years of 2023&2024 of supplying amounts and mixing ratios.

	Equivilent Dose Dabuk (main Disi line)mS/year	Equivilent Dose Abu Alanda Res.(Almargab)mS/year	Eqivalent Dose in Dabouk Booster Res.mS/year	Eqivalent Dose Shmisani. mS/year
2024	0.67	0.58	0.45	0.28
2023	0.66	0.54	0.45	0.26

Table 10.shows Avg AED for blending points through 2023 and 2024.

The above tables describes clearly the annual effective dose for the four mixing points (Dabuk,Abu Alanda,Boaster and Alshmesani), comparing the Average data resulted through 2023 with the ones resulted through 2024

As seen in the above tables:
-There is an increment of average results of the annual effective dose for Dabuk Abu Alanda Reservoirs, it's clearly shown that the AED for Dabuk reservoir mainline increased with a slight percentage , but the AED At Abu Alanada is higher in 2024 rather than in 2023,

- even the mixing ratio slightly decreased, The AED at Dabuk Booster was the same through 2023-2024 and kept within acceptable limits (<0.50msv/y) while the AED in Al Shmesani Res in 2024 is higher than the AED in 2023 but still within acceptable limits, there is two additional supplying water resources at al shmesani (Nwejees and Ras Alien).

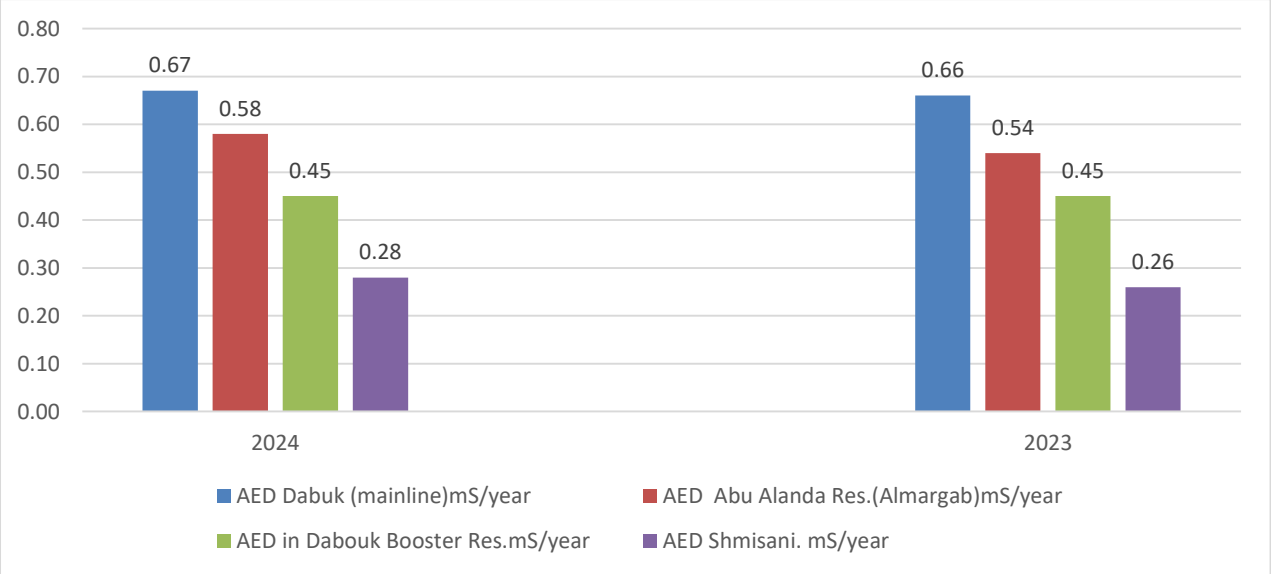


Fig # 14 shows the AED differences for the monitoring points through 2023 comparing to AED resulted in 2024

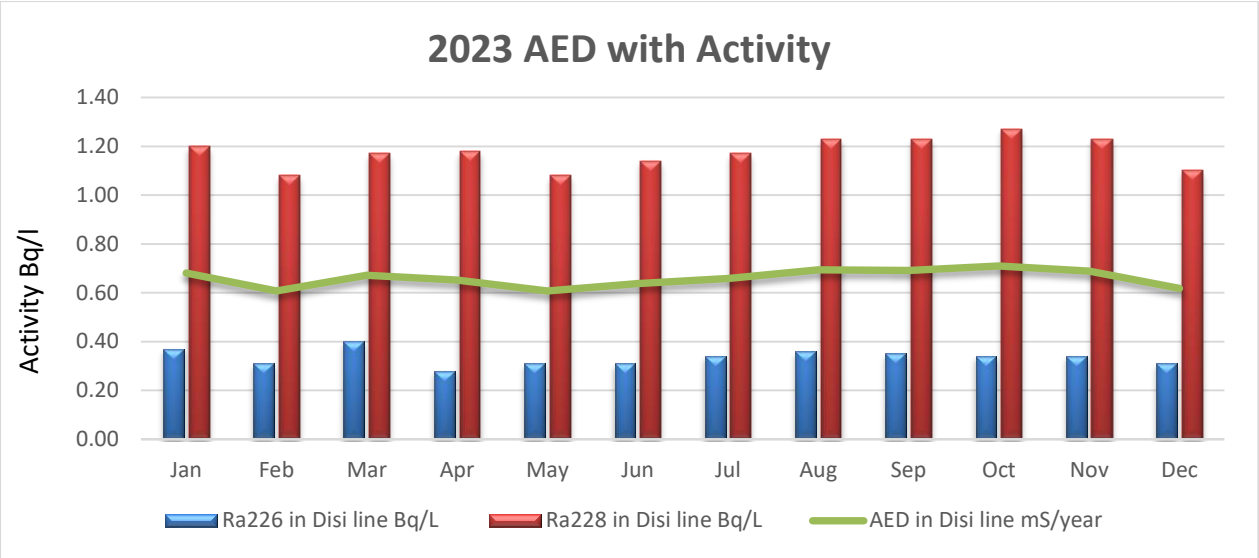
As shown from the previous Tables for the four mixing points:

1- From the table it's clearly shown that the total quantity supplied from disi in 2024 is (115424968m3) which is more than 2023(110445892m3) by 4.5%.
2- The quantity supplied from Zara to Abu Alanda was reduced in 2024 from (9339131to 8411752) by 10%.
3- The total quantity supplied from Disi to Abu Alanda increased from 45284883 to 48019208 by 6%, and the quantity supplied from Zara and Disi to Abu Alanda clearly represented in the mixing ratio, which reduced in 2024 to be 18% while it was 21% in 2023.
This makes the AED in Abu Alanda higher in 2024
4- In Dabouk Booster the quantity supplied from Zai was reduced in 2024 from 50850038 to 49870341 by 2%, And from the Disi side raised (from 63964870 in 2023 to 67405760 in 2024) by a percentage of 5%.These supplied quantity shown in the mixing ratio percent (0.75 in 2024 while it was 0.80%in 2023).The AED in Dabouk Boaster remains the same (0.45msv/y) which is expected since the mixing ratio reduced in a slight percentage (0.05%).

Comparison of the radioactive indicators for the four monitored points over years

	AED in Dabuk main Disi line	AED in Abu Alanda Res. (Al Margab)	AED in Dabuk Boster Res.
Year	mSv/y	mSv/y	mSv/y
2014	0.70	0.43	0.48
2015	0.70	0.43	0.37
2016	0.73	0.52	0.34
2017	0.68	0.54	0.33
2018	0.70	0.55	0.36
2019	0.68	0.46	0.36
2020	0.71	0.51	0.39
2021	0.64	0.58	0.40
2022	0.63	0.57	0.43
2023	0.66	0.54	0.45
2024	0.67	0.58	0.45

Table #11 comparison in AED for each point over years which evident that values over years are in consistence, (note that the Max AED permitted in Jordan is 0.50 msv/y)



Fig# 15 a

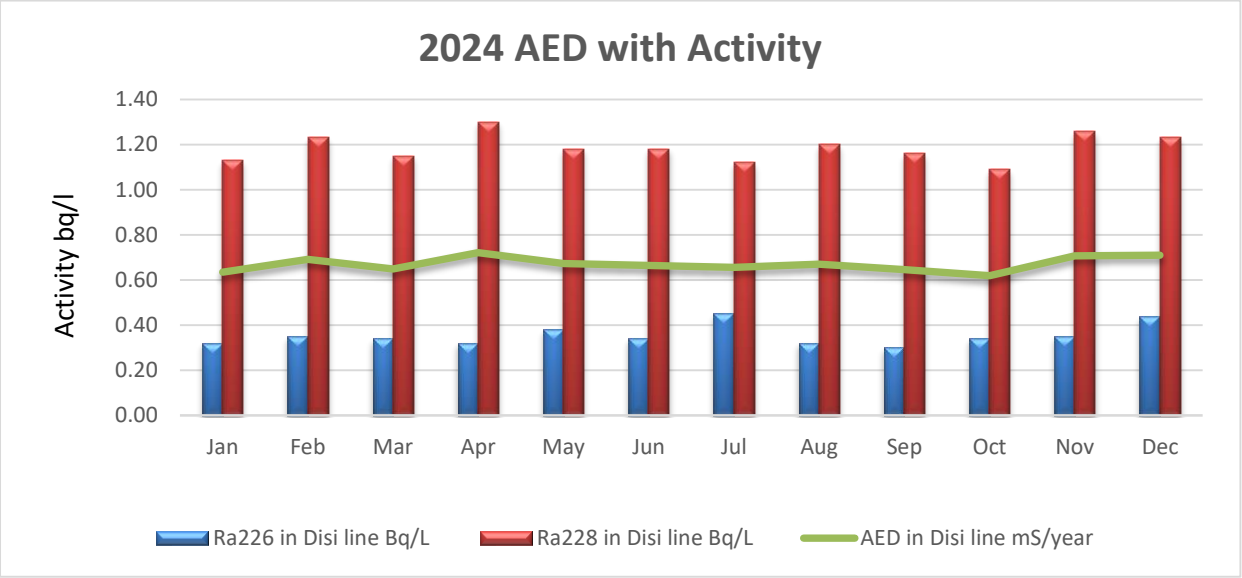


Fig # 15 b

Fig# 15a+b: shows the $Ra^{226}$and Ra^{228} activities comparing to the resulted AED through months 2023 and 2024up to Dec and clearly seen the effect of Ra228 on dose .and as seen ,the behavior of Disi wells (Rum Aquifer) its seen that Ra228is usually three times of Ra226 activity, in addition the AED equation specify the factor of Ra228 to be 0.504 with 0.204 of Ra226,

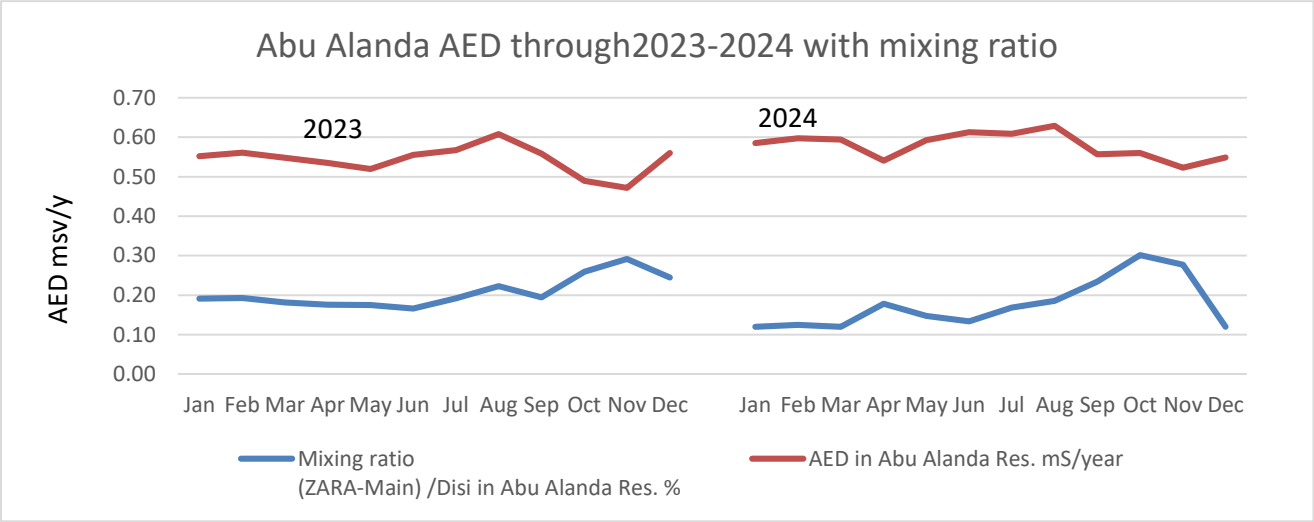


Fig # 16: shows the consistency of AED at Abu Alanda with the mixing ratios applied, increasing the mixing ratios will decrease the AED and with decreasing the mixing ratios will increase the AED.

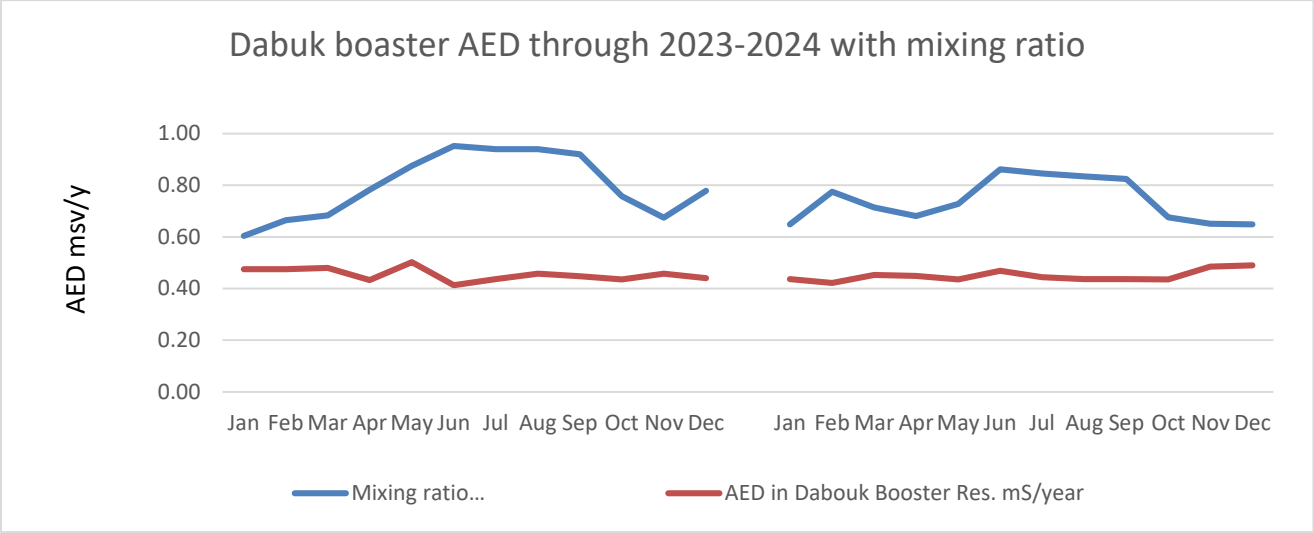


Fig # 17 shows the consistency of AED increment on mixing ratios, with the effect on AED (decreasing) as Well.

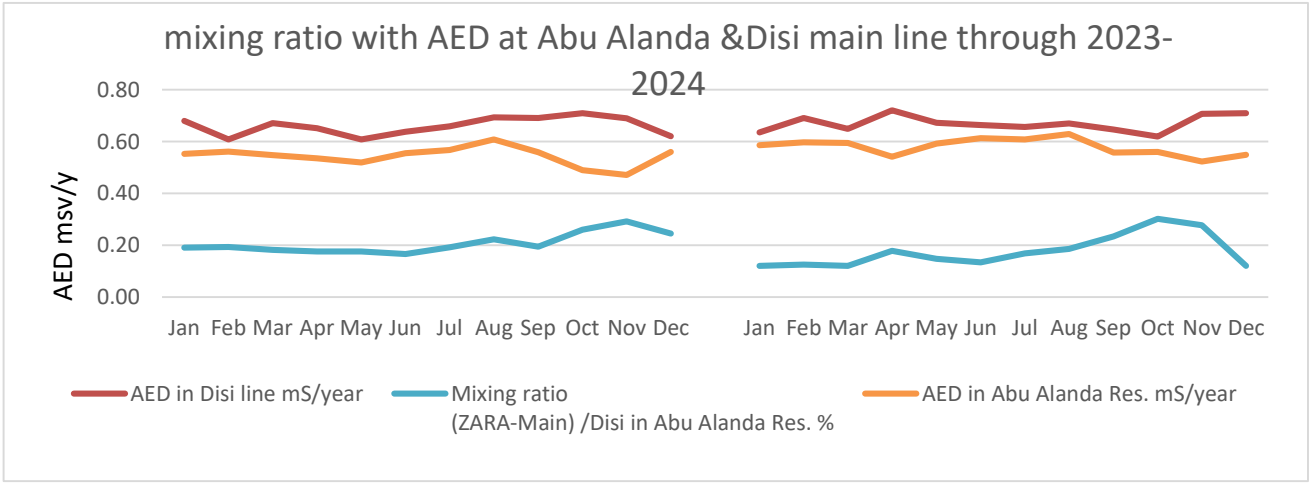


Fig # 18 shows the effect of mixing ratios on AED at Disi line and Abu Alanda

5.2Part three; Radioactivity in the Combined Wellfield

Combined wellfield Results:

Combined wellfield is a two components tank where the water from the 55 well field are collected in at Al Mudawara in order to be pumped to Amman city.

Radioactivity Results in the combined well field tank (CO) reflects radioactivity concentration of the operating wells mixture at the time of sampling.

Round no.	ID	collection date	Alpha (Bq/L)	Beta(Bq/l)	Ra226 (Bq/L)	Ra 228 (Bq/L)	Dose(mSv/y)	O18	D	T	C13	Rn222	Pb210
Jan-23	107	18/1/2023	4.05	2.28	0.43	1.23	0.71	-6.29	-36.97	<1.2	-5.3	26.45	<0.02
Mar-23	213	16/3/2023	3.38	2.51	0.34	1.18	0.66	-6.35	-38.47	<1.2	-4.96	12.23	<0.02
Jul-23	408	13/7/2023	2.23	2.64	0.33	1.17	0.66	-5.97	-36.76	1.29	-5.49	canceled	<0.02
Oct-23	634	19/10/2023	1.46	2.09	0.32	1.26	0.70	-6.6	-37.82	<1.2	-6.35	Failed	<0.02
Nov-23	754	22/11/2023	3.81	2.72	0.33	1.07	0.61	-6.64	-37.67	<1.2	-6.84	26.26	0.02
Mar-24	197	26/3/2024	2.96	2.97	0.36	1.14	0.65	-6.13	-39.25	<1.2	-3.69	15.5	0.02
Jul-24	422	18/7/2024	2.63	2.54	0.35	1.27	0.71	-6.86	-36.72	<1.2	out of work	14.8	0.02
Oct-24	578	3/10/2024	3.00	2.68	0.32	0.91	0.52	-6.62	-39.53	<1.2	out of work	12.99	0.03
Dec-24	685	12/12/2024	2.25	2.81	0.39	1.33	0.75	-6.37	-37.5	<1.2	out of work	15.87	0.03

Table #12 summarize the radiological and stable (O18&D) results of the combined well through 2023-2024.

Consider the following for the above table:

-Sample that collected for Ra222 in July 2023 has been cancelled since the sample received with cocktail contamination around the bottle ,which might affect the instrument, on the other hand the spoiling of the cocktail might include part of the sample with it , and this is will affect the actual value of Ra222 in the sample .

-Sample that collected for Ra222 in October 2023 failed in counting (samples were collected in the field and must be received to be counted not more than three hours to ensure that the following daughters will vanish short lived progenies (218Po, 214Pb, 214Bi, 214Po) but in this sample it was received in more than 3 hours which build up new short lived progenies.

-At the beginning of July 2024 **Cavity ring-down spectroscopy** that used to measure carbon 13 has been considered to be out of service.

Round no.	ID	collection date	Alpha (Bq/L)	Beta(Bq/l)	Ra226 (Bq/L)	Ra 228 (Bq/L)	Dose(mSv/y)
Jan-23	107	18/1/2023	4.05	2.28	0.43	1.23	0.71
Mar-23	213	16/3/2023	3.38	2.51	0.34	1.18	0.66
Jul-23	408	13/7/2023	2.23	2.64	0.33	1.17	0.66
Oct-23	634	19/10/2023	1.46	2.09	0.32	1.26	0.70
Nov-23	754	**22/11/2023**	3.81	2.72	0.33	1.07	0.61
Mar-24	197	**26/3/2024**	2.96	2.97	0.36	1.14	0.65
Jul-24	422	**18/7/2024**	2.63	2.54	0.35	1.27	0.71
Oct-24	578	3/10/2024	3.00	2.68	0.32	0.91	0.52
Dec-24	685	12/12/2024	2.25	2.81	0.39	1.33	0.75
		AVG	2.86	2.58	0.35	1.17	0.66

Table #13 shows the consistency in AED for the CO well through 2023and 2024.

The combined well field reservoir is sampled quarterly to obtain total alpha, total beta, Ra^{226} concentration, Ra^{228} concentration, Pb^{210} concentration, and radon concentration Rn^{222}. It is noted that the averages of any single indicator are similar over the years.

	2023		
	Ra226 (Bq/L)	Ra 228 (Bq/L)	Dose(mSv/y)
combined wellfield	0.35	1.18	0.67
	2024		
combined wellfield	0.36	1.16	0.66

Table #14 shows the radioactivity of Radium ^{226}and ^{228} and the AED as well through 2023, 2024 for the combined well it's clearly shown that there is no obvious deviation in AED.

6. CONCLUSIONS

6.1 The highest values of AED for the sampled wells are for the wells in line A on the Disi wellfield map then getting down as we go from E up to M,C,K,H,G,B,D,L,J,F)

The above results is an indication for the 55 wells that have been sampled through 2023 &2024(Table #3)
Fig # 9, 10&11 shows clearly the highest and lowest AED due to the measured ones in 2023 and 2024 which shows that the highest AED is for P2 (line A), while the lowest one is for W33 (line F) as shown in Table #6
Knowing the highest and lowest AED for the wells can help in pumping issues (to select the appropriate well for pumping amounts especially due to the season)

6.2 No significant variation in the radioactivity results of the 55wellfield over years.

The radioactive results for the measured wells as shown in the tables and the charts shows a consistency of data , that there is a wells with high activity and wells with low activity in which there is a slight deviation through years .as shown in Table #5 (a comparison for the measured wells through 2023&2024).

The majority of the AED in well and post-transfer is due to the contribution of Ra^{228}, which is a member of the thorium decay chain. $Radium^{226}$ was also noted but did not constitute the main component in terms of AED.

6.3 Dabuk network has fully complied with Jordanian standards over the years while still Abu Aland face a slight raise in AED in some months.

Samples that have been collected in monthly basis (composite samples) for Dabuk which receive a supplying amount of water from Disi main line and blended by a supplying amount from Zara –main shows a the success of keeping the AED to be <0.50msv/y (JS of AED), with an average of 0.45msv/y in both 2023&2024 , as well as Al Shmesani Reservoir that achieve AED of 0.27msv/y as an average for both two years.

On the other hand, the AED for Abu Alanda still exceeds slightly the JS with an average of 0.56 msv/y

6.4 The results of the combined tank are consistent with the results of the 55 wellfields and the results of Dabuk (main line of Disi)

As described in section 5.3 and clarified through Table # 12 and 13 the combined well field through 2023up to the end of 2024 keep it's AED values with an average of 0.66msv/y which slightly lower than the AED for the previous year (0.69msv/y) but within the range over the previous years also.

7 Recommendation

7.1 Commissioning an additional automatic sampling device at Abu Alanda reservoir,

To collect a composite sample to flow into the tank, which facilitates comparison of the radiological results entering, with the results of the mixed water from Al Margab.

7.2 To arrange "if applicable "to increase the pumping from wells in line F&J and reduce the pumping amount from line A

As shown from the results that line A has the max values of AED and by reducing the pumping from such wells , we can reduce the activity resulted from mixing those water amounts with Al-Zara maen stream , which will lead to minimize the AED at Abu Alanda

7.3 Increase amount of blending from Al-Zara maen if the recommendation in point 7.2 is not applicable for blending with Abu Alanda water.

For certain months Al Margab AED was more than the acceptable Jordanian limit, it is Recommended to **increase the proportion of Zara main water free of radioactivity to reduce AED to meet Jordanian standards or to find another sources** which are appropriate in quality for blending

7.4 Provide the Water Authority with the schedule with the time and date of cleaning the three tanks

Abu Alanda,Al Margab and Boster Dabuk for examining the radioactivity of sediments and estimating its effect on radiological results trying to explain the illogical increase of radioactivity results in Al Margab than that of Dabuk reservoir.

8. Appendices

8.1 Appendix-1 shows radioactive results of the 55 wells of Disi through 2023-2024

Table # 15 Results of Alpha, Beta, Ra226, Ra228 and Does Coefficient, of all operating boreholes (BH) (the 55 wells in the Disi well field)

WELL NAME	Alpha (Bq/L)	Beta(Bq/l)	Ra226 (Bq/L)	Ra 228 (Bq/L)	Dose(mSv/y)	decision
ISO-P1	4.65	3.19	0.64	1.69	0.98	exceed the limit
ISO-P2	5.84	4.69	0.78	2.50	1.42	exceed the limit
ISO-P3	4.46	3.65	0.58	1.90	1.08	exceed the limit
ISO-P4	4.03	3.7	0.58	1.86	1.06	exceed the limit
ISO-P5	3.28	3.2	0.54	1.86	1.05	exceed the limit
ISO-P6	1.13	3.52	0.78	2.24	1.29	exceed the limit
ISO-P7	1.91	3.87	0.61	2.22	1.25	exceed the limit
ISO-P8	1.85	3.17	0.66	2.09	1.19	exceed the limit
ISO-W1	4.5	3.08	0.87	1.61	0.99	exceed the limit
ISO-W4	2.99	2.53	0.31	1.04	0.59	exceed the limit
ISO-W1	3.39	3.24	0.71	1.68	0.99	exceed the limit
ISO-W2	3.64	3.76	0.68	1.87	1.08	exceed the limit
ISO-W3	1.35	1.57	0.22	0.63	0.36	accepted
ISO-W4	2.99	2.53	0.31	1.04	0.59	exceed the limit
ISO-W5	3.16	2.68	<0.15	0.83	0.45	accepted
ISO-W6	3.04	2.33	0.18	0.96	0.52	exceed the limit
ISO-W7	2.34	1.94	<0.15	0.60	0.33	accepted
ISO-W8	2.16	3.41	0.55	2.71	1.40	exceed the limit
ISO-W9	6.63	5.06	0.73	2.35	1.34	exceed the limit
ISO-W10	6.18	5.24	0.53	2.04	1.14	exceed the limit
ISO-W11	3.35	2.31	0.27	1.46	0.79	exceed the limit
ISO-W12	4.9	3.97	0.14	0.86	0.46	accepted
ISO-W21	2.53	1.71	0.35	0.90	0.53	exceed the limit
ISO-W22	2.06	2.21	0.26	1.03	0.57	exceed the limit
ISO-W23	3.37	2.8	0.59	1.50	0.88	exceed the limit
ISO-W24	3.01	2.76	0.59	1.50	0.88	exceed the limit
ISO-W25	3.27	2.84	0.52	1.53	0.88	exceed the limit
ISO-W26	3.19	2.62	0.41	1.40	0.79	exceed the limit
ISO-W27	2.1	2.04	0.24	0.81	0.46	accepted
ISO-W28	0.88	1.28	0.22	0.85	0.47	accepted
ISO-W29	0.98	1.5	0.20	1.04	0.57	exceed the limit
ISO-W30	0.74	0.9	0.20	0.64	0.36	accepted
ISO-W31	0.98	1.82	0.24	1.16	0.63	exceed the limit
ISO-W32	0.89	0.75	<0.12	0.26	0.16	accepted

ISO-W33	0.33	0.59	<0.12	0.19	0.12	accepted
ISO-W34	1.57	1.39	<0.12	0.62	0.34	accepted
ISO-W35	0.78	0.51	<0.12	0.21	0.13	accepted
ISO-W36	1.81	2.26	0.22	0.84	0.47	accepted
ISO-W37	1.70	1.36	<0.12	0.60	0.33	accepted
ISO-W38	3.03	3.04	0.35	1.38	0.77	exceed the limit
ISO-W39	0.88	0.69	<0.12	0.36	0.21	accepted
ISO-W40	1.79	2.47	0.31	1.12	0.63	exceed the limit
ISO-W41	3.62	2.92	0.22	1.16	0.63	exceed the limit
ISO-W42	2.29	2.1	0.24	0.95	0.53	exceed the limit
ISO-W43	4.62	4.09	0.42	1.42	0.80	exceed the limit
ISO-W44	1.9	1.18	<0.13	0.33	0.19	accepted
ISO-W45	4.14	2.98	0.21	0.40	0.24	accepted
ISO-W46	1.38	0.97	<0.12	0.45	0.25	accepted
ISO-W47	2.65	2.27	0.24	1.07	0.59	exceed the limit
ISO-W48	4.08	3.22	0.36	1.28	0.72	exceed the limit
ISO-W49	3.54	3.31	0.36	1.25	0.70	exceed the limit
ISO-W50	3.84	2.78	0.36	1.08	0.62	exceed the limit
ISO-W51	1.28	0.69	0.13	0.30	0.18	accepted
ISO-W52	2.43	2.17	0.45	1.22	0.71	exceed the limit
ISO-W53	3.18	2.54	0.33	1.13	0.64	exceed the limit
ISO-W54	2.96	2.61	0.50	1.38	0.80	exceed the limit
ISO-W55	3.06	2.83	0.64	1.70	0.99	exceed the limit

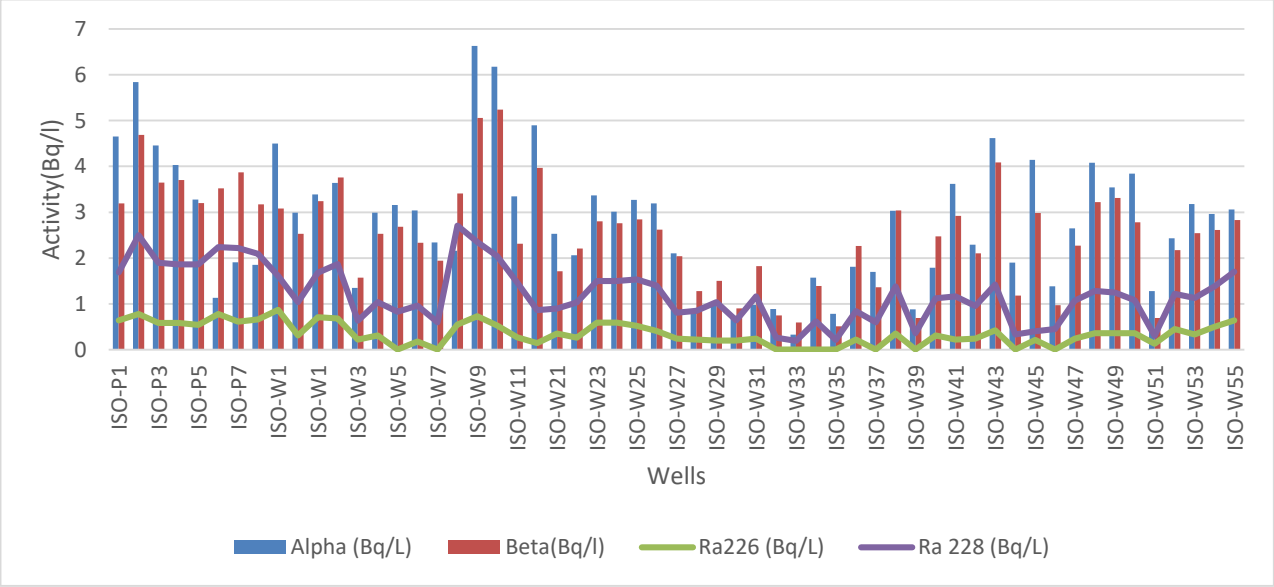


Fig #5 Comparison between radioactive indices through 2023-2024

LINE A	LINE D	LINE E	LINE G	LINE F	LINE C	LINE B	LINE H	LINE J	LINE K	LINE L	LINE M
P1	W28	W7	W38	W32	W21	W3	W41	W44	W48	W51	W53
P2	W29	W8	W39	W33	W22	W4	W42	W45	W49	W52	W54
P3	W30	W9	W40	W34	W23	W5	W43	W46	W50		W55
P4	W31	W10		W35	W24	W6		W47			
P5		W11		W36	W25						
P6		W12		W37	W26						
P7					W27						
P8											
W1											
W2											

Table # 3 analyzed wells names through 2023-2024

	Alpha (Bq/L)	Beta(Bq/l)	Ra226 (Bq/L)	Ra 228 (Bq/L)	DOSE
LINE A	3.53	3.58	0.67	1.98	1.14
LINE D	1.92	2.40	0.22	0.92	0.51
LINE E	4.26	3.66	0.44	1.67	0.93
LINE G	3.75	3.21	0.33	0.95	0.55
LINE F	1.85	1.98	0.22	0.55	0.32
LINE C	2.75	2.42	0.45	1.31	0.75
LINE B	3.06	2.51	0.25	0.94	0.52
LINE H	3.51	3.04	0.29	1.18	0.65
LINE J	2.52	1.85	0.23	0.56	0.33
LINE K	3.82	3.10	0.36	1.20	0.68
LINE L	1.86	1.43	0.29	0.76	0.44
LINE M	3.07	2.66	0.49	1.40	0.81

Table #4 indicates the higher dose achieved through the Disi wells (Line A) and the lowest dose (LineF&J)

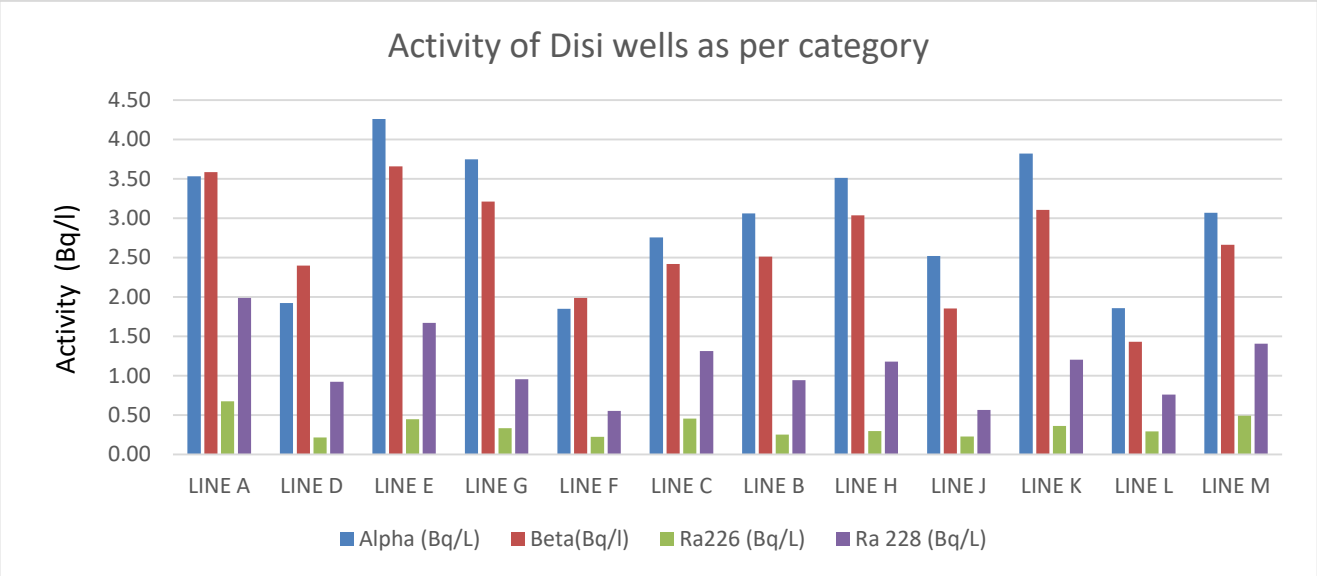


Fig.10 shows the Avg of the activity for Radium in the Disi wells asper categories

WELL NAME	Dose(msv/y)2023-2024	Dose(msv/y)2021-2022
ISO-P2	1.42	1.67
ISO-W33	0.12	0.18

Table #16 Max and Min AED for the measured well comparing with cycle 2021-2022 and 2023-2024

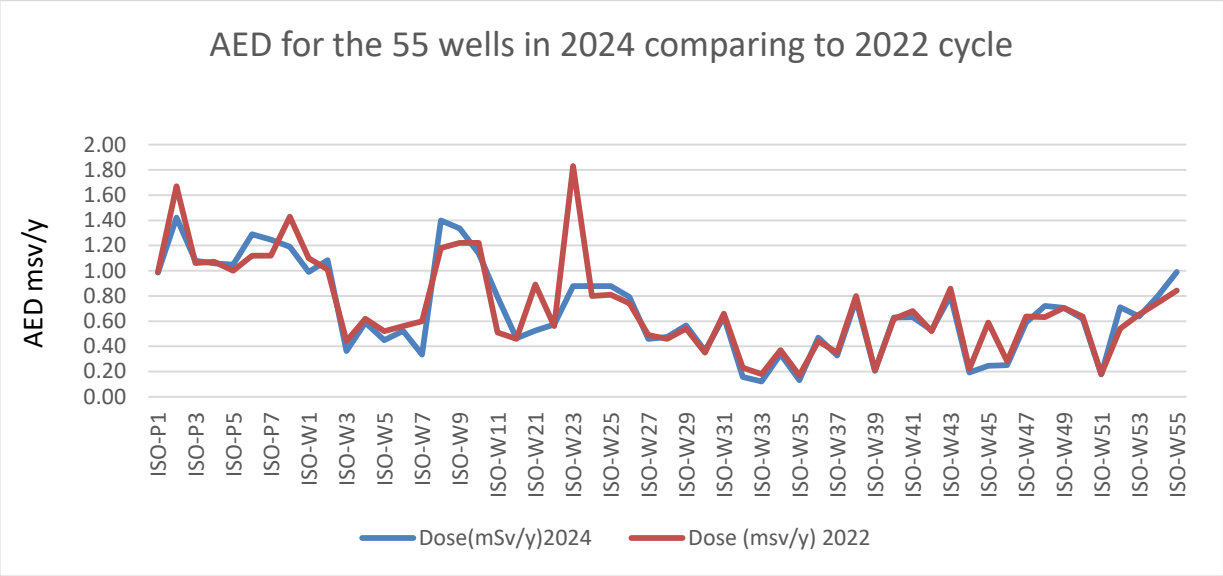


Fig #12 shows that there is consistency between AED through cycle 2022 and 2024 .

WELL NAME	Dose(mSv/y) 2024	Dose (msv/y) 2022
ISO-P1	0.98	0.99
ISO-P2	1.42	1.67
ISO-P3	1.08	1.06
ISO-P4	1.06	1.07
ISO-P5	1.05	1.00
ISO-P6	1.29	1.12
ISO-P7	1.25	1.12
ISO-P8	1.19	1.43
ISO-W1	0.99	1.10
ISO-W2	1.08	1.01
ISO-W3	0.36	0.44
ISO-W4	0.59	0.62
ISO-W5	0.45	0.52
ISO-W6	0.52	0.56
ISO-W7	0.33	0.60
ISO-W8	1.40	1.18
ISO-W9	1.34	1.22
ISO-W10	1.14	1.22
ISO-W11	0.79	0.51
ISO-W12	0.46	0.46
ISO-W21	0.53	0.89
ISO-W22	0.57	0.56
ISO-W23	0.88	1.83
ISO-W24	0.88	0.80
ISO-W25	0.88	0.81
ISO-W26	0.79	0.74
ISO-W27	0.46	0.49
ISO-W28	0.47	0.46
ISO-W29	0.57	0.54
ISO-W30	0.36	0.35
ISO-W31	0.63	0.66
ISO-W32	0.16	0.23
ISO-W33	0.12	0.18
ISO-W34	0.34	0.37
ISO-W35	0.13	0.17
ISO-W36	0.47	0.44
ISO-W37	0.33	0.35
ISO-W38	0.77	0.80
ISO-W39	0.21	0.21
ISO-W40	0.63	0.62
ISO-W41	0.63	0.68
ISO-W42	0.53	0.52
ISO-W43	0.80	0.86
ISO-W44	0.19	0.22
ISO-W45	0.24	0.59
ISO-W46	0.25	0.28
ISO-W47	0.59	0.64
ISO-W48	0.72	0.63
ISO-W49	0.70	0.71
ISO-W50	0.62	0.64
ISO-W51	0.18	0.18
ISO-W52	0.71	0.54
ISO-W53	0.64	0.65
ISO-W54	0.80	0.75
ISO-W55	0.99	0.84
MAX	1.42	1.83
MIN	0.12	0.17

Table #5 a comparison for the measured wells through 2022&2024

	Ra226 in Disi line	Ra228 in Disi line	AED in Disi line	Ra226 in Abu Alanda Res.	Ra228in Abu Alanda Res.	AED in Abu Alanda Res	Ra226 in Dabouk Booster Res.	Ra228 in Dabouk Booster Res.	AED inDabouk Booster Res	Ra226 in Shamisani Res.	Ra228 in Shamisani Res.	AED in Shamisani Res	Ra226 in Zatary Res.	Ra228 in Zatary Res.	AED in Zatary Res.
Month	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year
Jan	0.37	1.20	0.68	0.26	0.99	0.55	0.23	0.85	0.48	0.17	0.45	0.26			0.00
Feb	0.31	1.08	0.61	0.28	1.00	0.56	0.25	0.84	0.47	0.14	0.52	0.29			0.00
Mar	0.40	1.17	0.67	0.29	0.97	0.55	0.25	0.85	0.48	0.23	0.39	0.24			0.00
Apr	0.28	1.18	0.65	0.25	0.96	0.53	0.17	0.79	0.43	0.14	0.33	0.19			0.00
May	0.31	1.08	0.61	0.25	0.93	0.52	0.24	0.9	0.50	0.12	0.37	0.21			0.00
Jun	0.31	1.14	0.64	0.25	1.00	0.56	0.22	0.73	0.41	0.15	0.43	0.25			0.00
Jul	0.34	1.17	0.66	0.31	1.00	0.57	0.21	0.78	0.44	0.18	0.39	0.23	<0.12	<0.13	<0.50
Aug	0.36	1.23	0.69	0.31	1.08	0.61	0.24	0.81	0.46	0.17	0.56	0.32	<0.12	0.16	<0.50
Sep	0.35	1.23	0.69	0.29	0.99	0.56	0.27	0.78	0.45	0.17	0.47	0.27	<0.12	0.14	<0.50
Oct	0.34	1.27	0.71	0.25	0.87	0.49	0.23	0.77	0.44	0.21	0.46	0.27	<0.12	0.14	<0.50
Nov	0.34	1.23	0.69	0.26	0.83	0.47	0.24	0.81	0.46	0.21	0.52	0.30	<0.12	<0.13	<0.50
Dec	0.31	1.10	0.62	0.26	1.01	0.56	0.22	0.79	0.44	0.19	0.52	0.30			0.00
Avg	0.34	1.17	0.66	0.27	0.97	0.54	0.23	0.81	0.45	0.17	0.45	0.26	<0.12	0.15	<0.50

Table 8.a shows monthly radioactive indicators of the four delivery/blending points through 2023

	Ra226 in Disi line	**Ra228 in Disi line**	AED in Disi line	**Ra226 in Abu Alanda Res.**	**Ra228in Abu Alanda Res.**	Equivalent Dose in Abu Alanda Res	**Ra226 in Dabouk Booster Res.**	**Ra228 in Dabouk Booster Res.**	Equivalent Dose inDabouk Booster Res	**Ra226 in Shamisani Res.**	**Ra228 in Shamisani Res.**	Equivalent Dose in Shamisani Res
Month	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year	Bq/L	Bq/L	mS/year
Jan	0.32	1.13	**0.63**	0.30	1.04	**0.59**	0.21	0.78	**0.44**	0.16	0.38	**0.22**
Feb	0.35	1.23	**0.69**	0.26	1.08	**0.60**	0.19	0.76	**0.42**	0.20	0.46	**0.27**
Mar	**0.34**	**1.15**	**0.65**	**0.27**	**1.07**	**0.59**	**0.22**	**0.81**	**0.45**	**0.18**	**0.50**	**0.29**
Apr	0.32	1.30	**0.72**	0.23	0.98	**0.54**	0.20	0.81	**0.45**	0.16	0.43	**0.25**
May	0.38	1.18	**0.67**	0.31	1.05	**0.59**	0.23	0.77	**0.44**	0.16	0.34	**0.20**
Jun	0.34	1.18	**0.66**	0.26	1.11	**0.61**	0.22	0.84	**0.47**	0.18	0.60	**0.34**
Jul	0.45	1.12	**0.66**	0.34	1.07	**0.61**	0.25	0.78	**0.44**	0.17	0.45	**0.26**
Aug	0.32	1.20	**0.67**	0.29	1.13	**0.63**	0.24	0.77	**0.44**	0.15	0.43	**0.25**
Sep	0.30	1.16	**0.65**	0.26	1.00	**0.56**	0.21	0.78	**0.44**	0.16	0.57	**0.32**
Oct	0.34	1.09	**0.62**	0.25	1.01	**0.56**	0.23	0.77	**0.44**	0.16	0.51	**0.29**
Nov	0.35	1.26	**0.71**	0.24	0.94	**0.52**	0.23	0.87	**0.49**	0.2	0.53	**0.31**
Dec	0.44	1.23	**0.71**	0.27	0.98	**0.55**	0.35	0.83	**0.49**	0.26	0.54	**0.33**
Avg			0.67			**0.58**			**0.45**			0.28

Table 8.b shows monthly radioactive indicators of the four delivery/blending points through 2024

8 References

1. DISI-MUDAWARRA TO AMMAN WATER CONVEYANCE SYSTEM ENVIRONMENTAL & SOCIAL MANAGEMENT PLAN PART 2 (ESMP 2)
   August 2017
2. Environment and Social Management Plan (ESMP) DISI-MUDAWARRA TO AMMAN WATER CONVEYANCE SYSTEM ENVIRONMENTAL & SOCIAL MANAGEMENT PLAN PART 2 (ESMP 2) July 2009

3. Annual round of 2022-2023Evaluation of Radioactivity in Dubaydib well field Disi Raw Water, Combined wellfield, and Blended Water (Dabuk, and Abu Alanda)

4. Radioactivity in drinking water from Southern Jordan and its treatment Journal of Water and Health|14.3|2016Downloaded from http://iwaponline.com/jwh/article-pdf/14/3/528/394378/jwh0140528.pdfby gueston 03 July 2022

5. Blending as the best compliance option for the management of radioactivity in drinking water supplied from the deep sandstone aquifer in Southern Jordan February 2016Journal of Water and Health 14)3(DOI:10.2166/wh.2016.265

6. UNSCEAR, Effects of Ionizing Radiation: Report to the General Assembly, with Scientific Annexes, vol. 2, 2000.
7. Beretka J, Matthew PJ. Natural radioactivity of Australian building materials, industrial wastes and by-products. Health Phys. 1985;48(1):87-95. doi:10.1097/00004032- 198501000-00007
8. OECD (1979), OECD Observer, Volume 1979 Issue 4, OECD Publishing, Paris,
9. Determination of naturally occurring radionuclides in Disi aquifer water of Jordan M B H Al-Bedri1 , T A J Younis2 , I J Abdulghani2 and W O H