Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Chapter 6: Environmental Description

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6 Environmental Description

6.1 Introduction

This chapter summarises the baseline environmental conditions, both terrestrial and marine, within the ESIA Study Area (Figure 3-1, Chapter 3) to support the assessment of potential impacts, as presented in Chapter 9. It also describes the sensitivity of identified receptors, taking into account their current state and any protected status they may have.

The Project is currently in the early stages of design, with the EPC Contractors undertaking field surveys, including geotechnical, LIDAR, and Ground Penetrating Radar (GPR) and supporting route mapping surveys to inform the meteorological, hydrological, structural, and seismic aspects of the design. The information presented in this Chapter is not intended to inform the design directly.

The following process has been applied to characterise the terrestrial and marine environment:

- Desktop study of available primary and secondary data (see Section 6.2.1 and 6.3.1) to identify key receptors and their sensitivities
- Rapid Field Assessment and stakeholder engagement
- Baseline terrestrial and marine biodiversity surveys, including a bird survey, a study of benthic habitats and seabed sediment and seawater sampling
- Provisional Terrestrial and marine critical habitat assessments (CHAs)

The socio-economic baseline is addressed separately in Chapter 7 due to its specific methodologies and stakeholder considerations.

6.2 Terrestrial Environment

6.2.1 Data Sources

Considering the early stages of the Project design and its extensive linear nature, combined with remote access limitations, the environmental baseline has been characterised through desktop studies of primary and secondary data, supplemented by field surveys conducted within the limited time available, as presented in Table 6-1.

Table 6-1: Terrestrial Environment Data Sources

Chapter 6 Topic	Primary Data Source	Secondary Data Source
Seismicity	-	Various published literature Global Facility for Disaster Reduction and Recovery (GFDRR) / World Bank Group ThinkHazard Database
Topography	-	2022 AAWDC Project ESIA 2025 Renewable Energy Component ESIA
Geology and Soils	-	Various published literature
Landscape	-	2022 AAWDC Project ESIA

Chapter 6 Topic	Primary Data Source	Secondary Data Source
		2025 Renewable Energy Component ESIA
Hydrology	-	2022 AAWDC Project ESIA 2025 Renewable Energy Component ESIA Official reports published by the Ministry of Water and Irrigation (MWI) Various published literature
Meteorology and Climate	-	Various published literature World Bank Group Climate Change Knowledge Portal Meteoblue Database
Air Quality	-	Ambient air quality reports for 2020-2024 published by the Ministry of Environment (MoEnv) Individual air monitoring campaign reports by MoEnv for 2019, 2022 and 2025 Various published literature
Noise and Light	-	2022 AAWDC Project ESIA ESIAs for other developments in the vicinity of the Project ASEZ Master Plan Update Environmental Baseline Study Various published literature
Biodiversity	2025 AAWDCP Terrestrial Ecological Survey Report 2025 AAWDCP Terrestrial Critical Habitat Assessment 2025 AAWDCP Avifauna Survey Report Engagement with the following biodiversity experts: • Dr Zuhair Amr, Professor of Zoology, Department of Biology, Jordan University of Science and Technology) • Dr Hatem Taifour, Director of Conservation, Royal Botanic Garden, Jordan • Mr Yaseen Ananbeh, head of botanical research at the Royal Society for the Conservation of Nature (RSCN) in Jordan	2022 AAWDC Project ESIA 2025 Renewable Energy Component ESIA The Global Biodiversity Information Facility (GBIF) eBird Database BirdLife Data Zone Jordan BirdWatch (JBW) database Various published literature

Chapter 6 Topic	Primary Data Source	Secondary Data Source
	• Mr Sameh Khatatbeh, botanical researcher at (RSCN) in Jordan • Mr Tareq Qaneer, an Avifauna Expert (ECO Consult)	

6.2.2 Desktop Study

Reviews of published literature and databases were carried out to support the planning of the baseline survey (Appendix 6-3) and to screen available information as part of the Critical Habitat Assessment (Appendix 6-1).

The review of available literature was conducted with the assistance of stakeholders consulted during the survey planning process.

The following documents were consulted during the desk study:

- Abu Baker, M. & Amr, Z. 2004. The rodents (Mammalia: Rodentia) of Wadi Ramm, southern Jordan: New records and notes on distribution. Arab Gulf Journal of Scientific Research, 22:9-20
- Abu Baker, M., Al Omari, K., Qarqaz, M., Khaled, Y., Ahmad, Q. & Amr, Z. 2004. On the current status and distribution of Blanford's Fox, Vulpes cana Blanford, 1877, in Jordan (Mammalia: Carnivora: Canidae). Turkish Journal of Zoology 28:1-6
- Amr, Z.S., Abu Baker, M.A., Qumsiyeh, M.B., & Eid, E. (2018). Systematics, distribution and ecological analysis of rodents in Jordan. Zootaxa, 4397(1), 1–94
- Amr, Z. S. & Disi, A. 2011. Systematics, distribution and ecology of the snakes of Jordan. Vertebrate Zoology, 61:179-266
- Amr, Z.S. & Saliba, E.K. 1986. Ecological observations on the Fat Jird, Psammomys obesus dianae, in the Mowaqqar area of Jordan. Dirasat, 13:155-161
- BATES P.I. & D. HARRISON (1989): New records of small mammals from Jordan. — Bonner Zoologische Beiträge 40: 223-226
- Benda *et al*. 2010. First record of the Egyptian Slit-faced Bat, Nycteris thebaica , from Jordan. Zoology in the Middle East 21(1):5-7
- BirdLife International (2025). Site factsheet: Aqaba coast and mountains. Downloaded from https://datazone.birdlife.org/site/factsheet/aqaba-coast-and-mountains on 25/09/2025
- Catullo, G., Ciucci, P., Disi, A.M. & Boitani, L. 1996. Nubian Ibex in southwestern Jordan (Dana Nature Reserve). Oryx, 30:222-224
- Disi, A. M., Modry, D., Nečas, P. & Rifai, L. 2001. Amphibians and Reptiles of the Hashemite Kingdom of Jordan: An Atlas and Field Guide. Chimaira, Frankfurt
- Eid, E., Abu Baker, M., and Amr, Z. (2020). National Red data book of mammals in Jordan. Amman, Jordan: IUCN Regional Office for West Asia Amman
- Hays, C. & Bandak, N. 1997. Jordan. In: Shackleton, D.M. (ed.) and the IUCN/SSC Caprinae Specialist Group. 1997. Wild Sheep and Goats and their Relatives. Status Survey and Conservation Action Plan for Caprinae. IUCN, Gland, Switzerland and Cambridge, UK. 390 + vii pp

- Hemmer, H. 1978. Nachweis der sandkatze (Felis margaita harrisoni) Hemmer, Grubb and Groves, 1976) in Jordanien. Ergebnisse der Reisen von R. Kinzelbach in lander des Hahen und Mittleren Ostens. Nr. 1. Zeitschrift für Säugetierkunde, 43:62-64
- Melnikov, D., Nazarov, R., Ananjeva, N. & Disi, A. 2012. A new species of Pseudotrapelus (Agamidae, Sauria) from Aqaba, southern Jordan. Russian Journal of Herpetology, 19:143-154
- Mountfort, G. 1965. Portrait of a Desert, London, Collins
- Obuch, J. 2018. On the diet of owls (Strigiformes) in Jordan. Slovak Raptor Journal, 12: 9–40
- Qarqaz, M. & Abu Baker, M. 2006. The leopard in Jordan. Cat News,1: 9–10
- Qumsiyeh *et al*., 1993. Status and conservation of carnivores in Jordan. Mammalia. 57(1):55-62
- Werner, Y. L. 2004. A new species of the Acanthodactylus pardalis group (Reptilia: Lacertidae) from Jordan. Zoology in the Middle East, 32: 39–46

The Integrated Biodiversity Assessment Tool (IBAT) was accessed during the Critical Habitat Assessment, along with several internationally and nationally relevant datasets as follows:

- The IUCN Red List of Threatened Species (IUCN Red List of Threatened Species)
- National Red data book of mammals in Jordan (Eid *et al.* 2020) (https://portals.iucn.org/library/sites/library/files/documents/RL-569.5-001-En.pdf)
- IUCN Red List of Ecosystems (IUCN Ecosystems)
- The Global Biodiversity Information Facility (GBIF) (https://www.gbif.org/)
- eBird (http://www.ebird.org)
- BirdLife data zone (http://datazone.birdlife.org/home)
- Movebank (Movebank)
- POWO – Plants of the world online, Royal Botanic Gardens, Kew (https://powo.science.kew.org)
- WFO – The World Flora Online (http://wfoplantlist.org)
- Jordan BirdWatch (JBW) (https://www.jordanbirdwatch.com/)

6.2.3 Protected and Designated Sites

There are five Protected, Designated or Proposed Protected Areas in Jordan that are within 10km of the Project (see Table 6-2).

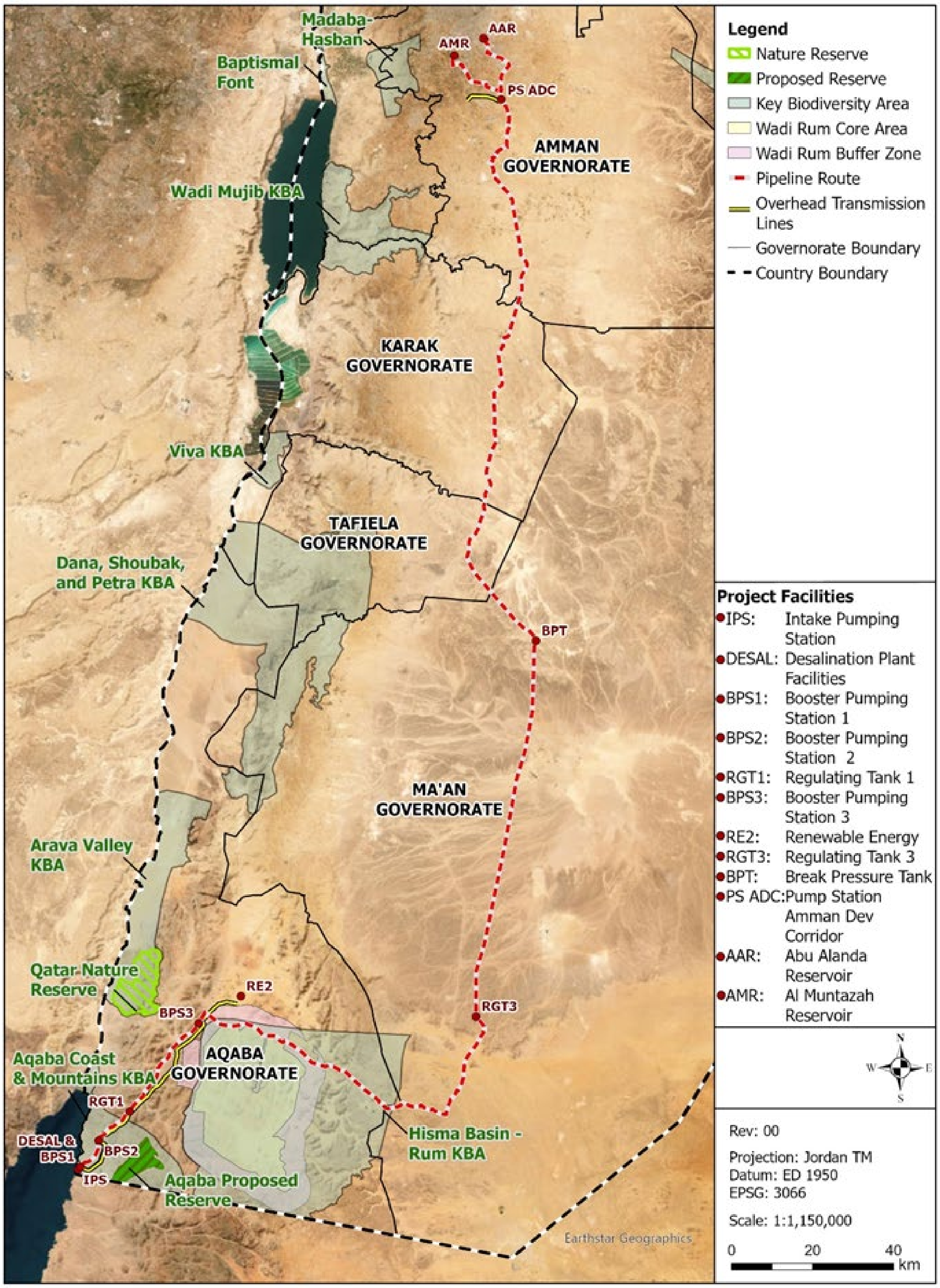
The Aqaba Proposed Reserve, the Qatar Nature Reserve, the Wadi Rum Protected Area and the Aqaba Coast and Mountains Key Biodiversity Area (KBA) are all located in the south of Jordan, while the Madaba Hisban KBA is located in the north of Jordan (see Figure 6-1).

Table 6-2: Protected Areas, Designated Areas and Proposed Reserves within 10km

Name	Type	Area (sq km)	Distance from Project Facilities and Pipeline	Project Facilities and Pipeline Within the Area
Aqaba Coast & Mountains KBA	KBA (0.6% covered by OECM)	382.5	Within KBA	Sea water reverse osmosis

Name	Type	Area (sq km)	Distance from Project Facilities and Pipeline	Project Facilities and Pipeline Within the Area
				Booster pumping station 1 Booster pumping station 2 Approximately 16.9km of the Pipeline
Aqaba Proposed Reserve	Proposed Protected Area	Unknown	6.4km	No facilities or Pipeline within the area
Hisma Basin – Rum KBA	KBA (34.7% covered by OECM)	2000	Within KBA	Approximately 49km of the Pipeline
Wadi Rum Protected Area	Protected Area	740.0	The Project is immediately adjacent to the northern boundary	Approximately 24km of the Pipeline is within the Wadi Rum buffer area
Qatar Nature Reserve	Nature Reserve	109.94	8.9km	No facilities or Pipeline within the area
Madaba Hisban KBA	KBA (0.0% covered by OECM)	247	8.4	No facilities or Pipeline within the area

Figure 6-1: Map Showing Location of Protected Areas, Designated Areas and Proposed Reserves



6.2.3.1 Aqaba Coast and Mountains KBA

The Aqaba Coast and Mountains KBA covers approximately 382.5 km^2 of southeastern Jordan, including all of its coastline (Figure 6-1), and encompasses an elevation gradient of 1,592m from the GoA coast into the Aqaba Mountains.

Most habitats in the area have been substantially altered, particularly around Aqaba, though some natural scrub vegetation survives near the Palestine border along with some undisturbed desert to the south of the area. This site represents a migratory bottleneck site for birds and also holds a breeding bird community representative of the Rift Valley. The enormous spring passage of raptors across the border at Eilat occasionally passes over Aqaba (with maximum daily counts of Buteo buteo (105, April) and Accipiter brevipes (75, September)), but spring passage at Aqaba exceeds 50,000 raptors per season nevertheless. The Levant Sparrowhawk (*Accipiter brevipes*) triggered KBA and IBA criteria in this site, with 3,000 individuals recorded in 2000. Another six bird species triggered IBA criteria in 2000, including the VU Sooty Falcon (BirdLife International 2025b; Key Biodiversity Areas Partnership 2025b).

The Project Desalination Plant site, BPS1 and BPS2, and approximately 16.9km of the Pipeline are located within the KBA. However, only 0.6% of the KBA area is covered by protected areas or Other Effective Area-Based Conservation Measures (OECM). Eight species qualify the area as a KBA (Table 6-3) (BirdLife International, 2025).

Table 6-3: Bird Populations in Aqaba Coast and Mountains KBA Meeting IBA/KBA Criteria

Scientific Name	Common Name	Red List category	Season	Year(s) of Population Estimate	Population	Units
Species group – soaring birds/cranes	A4iv	-	Passage	1993	50000-99999	Individuals
Accipter brevipes	Levant Sparrowhawk	Least Concern	Passage	1995 - 2000	3000	Individuals
Falco concolor	Sooty Falcon	Vulnerable	Breeding	1993	present	-
Curraca leucomelaena	Arabian Warbler	Least Concern	Resident	1993	present	-
Araya squamiceps	Arabian Babbler	Least Concern	Resident	1993	present	-
Onychognathus tristamii	Tristram's Starling	Least Concern	Resident	1993	present	-
Oeanthe monacha	Hooded Wheatear	Least Concern	Resident	1993	present	-
Capodacus synoicus	-	-	Winter	1993	present	-

6.2.3.2 Aqaba Proposed Reserve

The Aqaba Proposed Reserve (Aqaba Mountains Reserve) falls entirely within the footprint of the Aqaba Coast and Mountains KBA, and lies to the east of the Project facilities. The proposed reserve covers an area of 57.7km^2 and is entirely within the Aqaba Mountains, approximately 6.4km distant from the

Project at its closest point. The elevated location of the proposed reserve relative to the Project, the intervening mountains, and its distance make it unlikely that construction activities on the Project will have an impact on its protected resources.

6.2.3.3 Hisma Basin – Rum KBA

This KBA, which has an area of 2,099 km^2, consists primarily of a desert ecosystem (97%), approximately 2% shrubland, and 1% artificial (e.g., constructed) land. It comprises an isolated tract of large sandstone and granite mountains, ranging up to 1,754 m (Jabal Rum, the highest point in Jordan), separated from each other by flat, sandy 'corridor'-wadis, and surrounded by a desert of siltflats and mobile dunes. The predominant desert vegetation is a scanty shrub-steppe bushes. The site is known to support an unusually varied assemblage of desert and mountain birds. There are 22 bird species that triggered IBA criteria for the site in 2000, including the VU Sooty Falcon (*Falco concolor*), the EN Egyptian Vulture (*Neophron percnopterus*), the Red-rumped Wheatear (*Oenanthe moesta*). Other species in the KBA include the VU Egyptian Spiny–tailed Lizard (*Uromastyx aegyptia*), the VU Nubian Ibex (*Capra nubiana*), and several plant species (BirdLife International 2025a; Key Biodiversity Areas Partnership 2025a). Approximately 35% of this KBA is covered by the Wadi Rum Protected Area (see below).

The Pipeline will transit through the northern extent of the KBA for approximately 49km as it traverses from west to east.

6.2.3.4 Wadi Rum Protected Area

The Wadi Rum Protected Area (PA) covers an extent of approximately 742km^2 and lies entirely within the Hisma Basin – Rum KBA. It is a mixed site of natural and cultural outstanding values. It is the largest protected area in Jordan, covering almost one per cent of the country's total surface area. It is a major part of the Hisma desert positioned to the east of the Jordan Rift Valley and south of the steep escarpment of the central Jordanian plateau.

Wadi Rum encompasses a diverse desert landscape featuring sandstone mountains, gorges, arches, cliffs, landslides, and cavernous weathering forms. These landforms result from fluvial incision, salt and biological weathering and erosion, forming globally significant honeycomb weathering networks. The site lies within the Sudanian Biogeographical Region. The high mountains in the site (over 1,700 m above sea level) enable some unusual elements of the Mediterranean Bioregion to persist here, e.g. Juniper trees and Mediterranean reptiles. The site is known to support 183 flora species (including at least two endemics), 26 mammals, 34 reptiles and 119 birds, including a number of globally threatened species. The level of bird species diversity is considered exceptional for a habitat within the Sudanian Biogeographical Region of Jordan. Notable fauna include the Arabian Oryx (*Oryx leucoryx*), currently being reintroduced after becoming nationally extinct, and the Nubian Ibex (*Capra nubiana*), threatened with becoming nationally extinct (IUCN 2025b; UNESCO World Heritage Centre 2025).

The Pipeline extends from east to west along the northern perimeter of Wadi Rum, remaining outside the boundary of the PA; however, approximately 24km of its route traverses the Wadi Rum Buffer Zone that encircles the PA.

6.2.3.5 Qatar Nature Reserve

The Qatar Nature Reserve of Jordan is a Terrestrial and Inland Waters Protected Area with an area of approximately 110km^2, located in the southeast of Jordan, north of Aqaba. The western edge of the protected area is 8.9km from the Pipeline; its position on the western side of the mountain highlands effectively isolates it from potential impacts of the Project construction and operation.

6.2.3.6 Madaba Hisban KBA

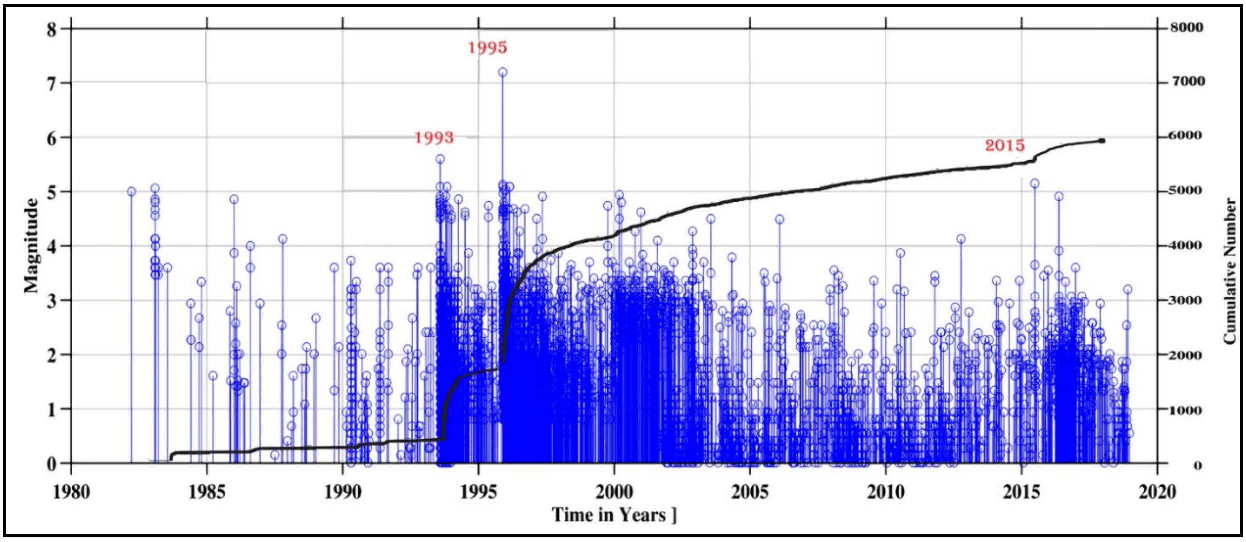
The Madaba Hisban Key Biodiversity Area spans approximately 259 km² at an elevation of around 900 meters and is recognised for its ecological significance, particularly for birds and rare plants. The landscape is primarily former steppe land, now converted to dry cereal cultivation, with areas of irrigated farmland and pasture. It supports notable species, such as the Eastern Imperial Eagle (*Aquila heliaca*), a qualifying species for its designation, as well as rare and endemic plants, including *Colchicum tunicatum*, *Romulea bulbocodium*, and *Globularia arabica*. The site is under pressure from agricultural expansion, groundwater depletion, and urban development. Despite its designation as a KBA, it currently lacks formal protection.

6.2.4 Seismicity

The Gulf of Aqaba (GoA) is considered one of the most seismically active regions in the Middle East (Abdelazim *et al.,* 2023) (Figure 6-2). The area has a long historical seismic record and has experienced historical earthquakes, whether occurring in its vicinity or affecting it.

Jordan lies along the eastern edge of the Dead Sea Transform (DST) fault system, a major strike-slip plate boundary between the Arabian Plate and the African Plate (more precisely, the Sinai subplate of the African Plate). This left-lateral transform fault extends from the Red Sea (via the GoA) northwards through the Wadi Araba, the Dead Sea, the Jordan Valley, and into Lebanon and western Syria. This area constitutes a segment of an extensive plate boundary zone that facilitates the northward movement of the Arabian Plate relative to the African Plate.

Figure 6-2: Cumulative number of earthquakes in the Gulf of Aqaba 1983 - 2018[1]



The Conveyance Pipeline crosses various geological structures, including the south-eastern extension of the Ras en Naqab Fault, the Al-Hisa Fault, the Siwaqa Fault, and the Zarqa Ma'in Fault (Figure 6-3). Although sections along the Conveyance Pipeline route exhibit moderate vertical displacements, they all display lateral strike-slip movements, which could impact any man-made structures situated across or alongside them.

[1] The numbers in red identify the three largest earthquakes

Monitoring by the Jordan Seismological Observatory (JSO) confirms that seismic activity in Jordan is most prevalent along the DST. In 2023, the Observatory recorded 1,126 seismic events, with notable clusters occurring in the Dead Sea region, Wadi Araba, the GoA, the Jordan Valley, and border zones. These events ranged from low-magnitude microseisms to moderate earthquakes.

The earthquake hazard in Aqaba is classified as medium (Think Hazard, 2021). This means that there is a 10% chance of a potentially damaging earthquake occurring in the area in the next 50 years.

6.2.5 Topography

Jordan is located about 80km to the east of the Mediterranean Sea with an area of 8,929 m^2. The country has a unique topographic nature. The western part of the country is the world's lowest valley that runs north – south between two mountain ranges. The Jordan valley has a length of about 400km, a width varying from 10km in the north to 30km in the south, and elevation between 170 – 400m below Mean Sea Level (MSL). The Jordan river passes through this valley from north to south down to the Dead Sea. Just to the east of the Jordan Valley the mountain range reaches about 1,150m above Mean Sea Level in the north and about 1,500m above Mean Sea level in the southern parts of the Kingdom. To the east of this mountain range a semi-desert plateau extends to cover approximately 80% of the total area of the country. Most of Jordan (90%) is an arid and semi-arid area characterised by remarkable rainfall variation with total annual rainfall averages less than 200mm (Abdulla, 2020).

The topography from Aqaba to Amman transitions from low-lying coastal and rift valley terrain to rugged escarpments, high plateaus, hills and mountain highlands. In the southern region near Aqaba, steep terrain is characteristic of granite and basement-rock mountains that drop sharply toward the Gulf of Aqaba, with extensive alluvial fans, eroded slopes, and broad valley bottoms in between (Aqubuqu *et al.,* 2016). To the north, toward the highlands around Amman, the relief becomes more moderate but still substantial, characterised by ridge-valley systems, dissected plateaus, and slope instability in places (Al-hamoud *et al.,* 1995). There are also extensive wadis (ephemeral channels), alluvial plains, terraces, and sometimes karst features (sinkholes, solution cavities) in the limestone-dominated areas (Odeh *et al.,* 2017).

Figure 6-4 presents the topographic map of Jordan, which ranges in elevation from -431 to 1,842m above Mean Sea Level. The Project topography varies between different components, ranging from sea level at the Intake Pump Station (IPS) to approximately 1,000m above Mean Sea Level in Amman, where the existing Abu Alanda Reservoir (AAR) and Al Muntazah Reservoir (AMR) are located.

In Qweirah, where the RE site is located, the terrain features a combination of rocky hills and sandy plains, with an average elevation of approximately 819 meters above Mean Sea Level. The region's topography is shaped by tectonic activities, such as faulting and uplifting, resulting in steep, eroded slopes and sharp escarpments (Bazazo *et al.*, 2020; Farhan *et al.*, 2016).

Figure 6-3: Geological Structure Faults within the ESIA Study Area

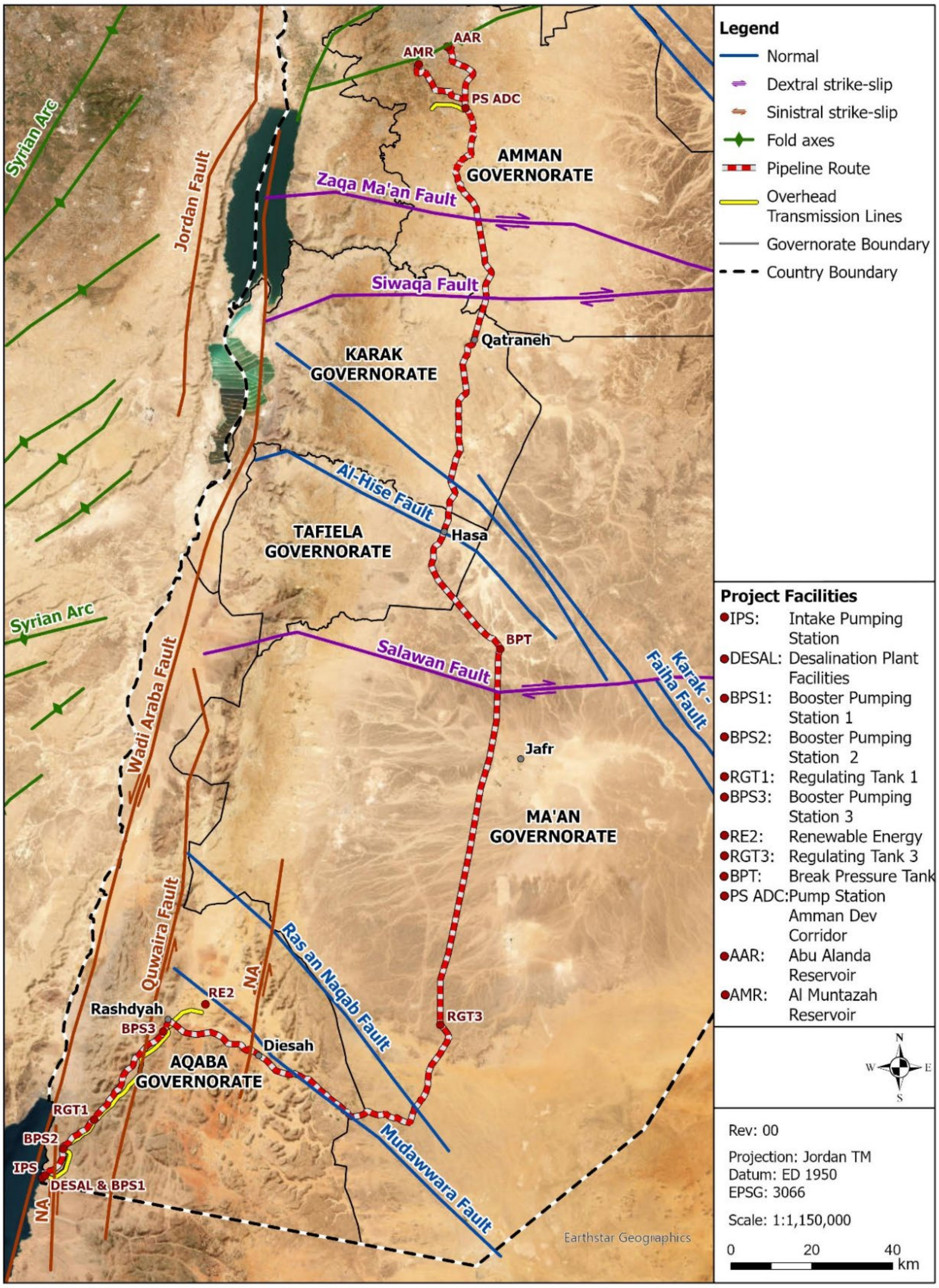
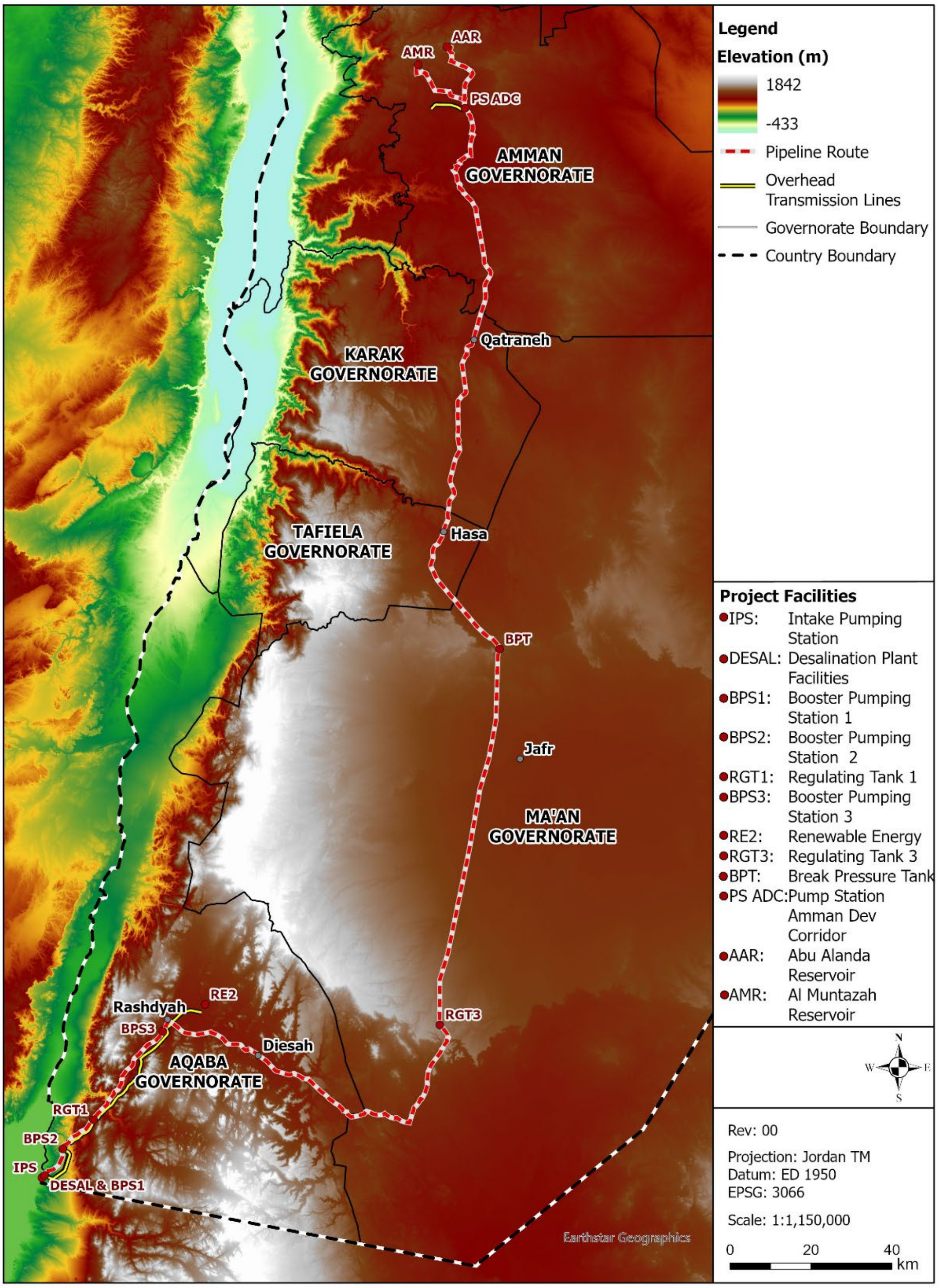


Figure 6-4: ESIA Study Area Topography



6.2.6 Geology and Soils

6.2.6.1 Geology

Jordan's geology is dominated by sedimentary formations with exposures of older crystalline basement rock in the south, especially near the Gulf of Aqaba. In the Aqaba area, the Aqaba Complex comprises granitic and metamorphic rocks, i.e., the crystalline basement rock of the Arabian-African shield, which rises in rugged mountains and steep escarpments, juxtaposed against a more recent sedimentary cover (Abuqubu *et al*., 2016). Northward, sedimentary sequences such as the Palaeozoic, Mesozoic, and especially the Upper Cretaceous limestones, marls and sandstones become more dominant. The DST plays a central structural role, with major faulting, such as the Dead Sea and Wadi Araba fault sections, influencing uplift, subsidence and relief.

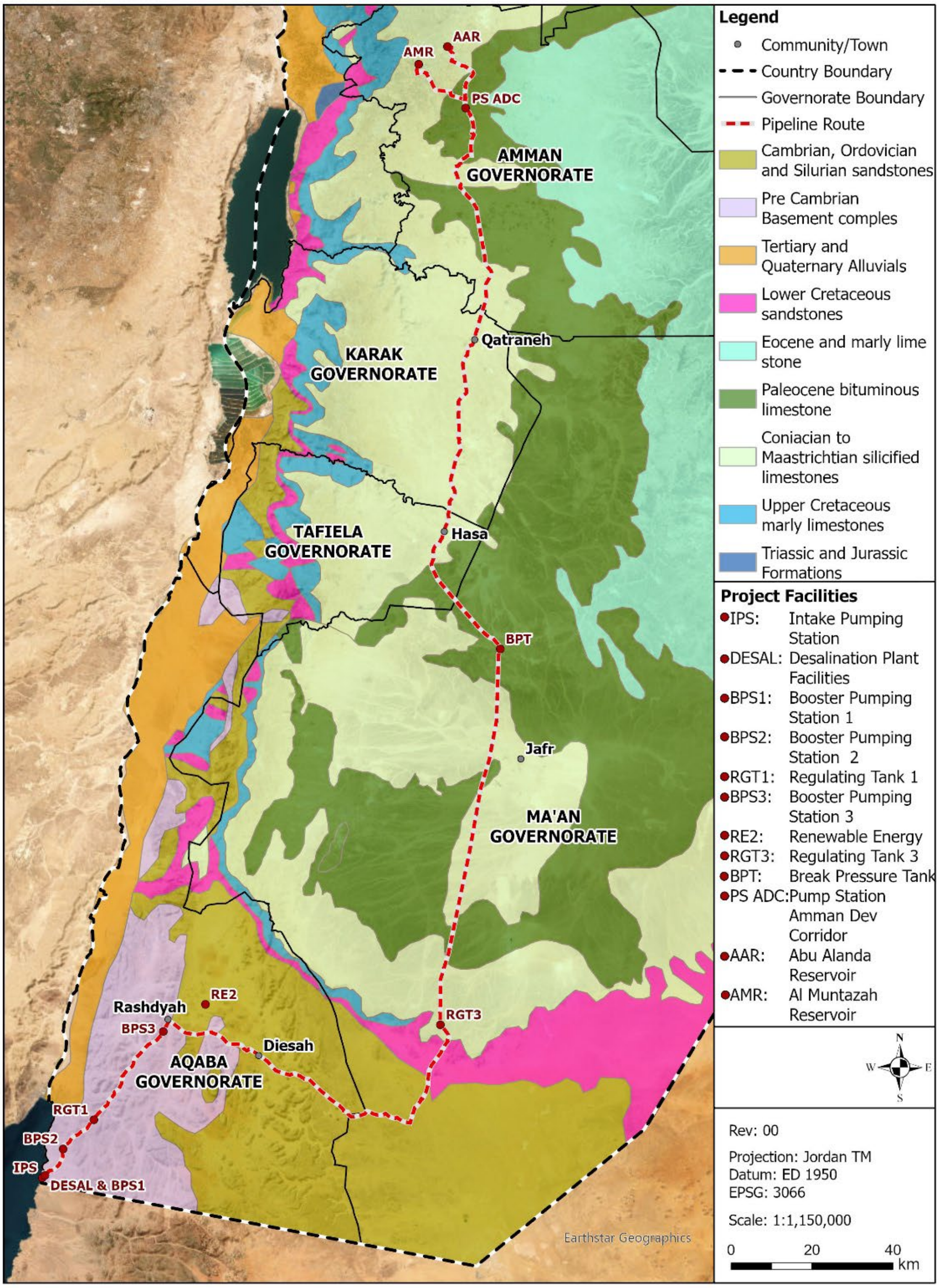
The Project area is situated to the east of the Dead Sea rift. It is dominated mostly by sedimentary rocks, with igneous rocks exposed in limited areas. Quaternary and recent deposits are also present, covering the older geologic formations. The Conveyance Pipeline route traverses very different geological formations ranging from hard granitic rocks to soft marls (Figure 6-5). The rocks are characterised according to their types, petrography, hardness and potential for settlement under overloads. The Aqaba coastal areas are characterised by clastic sedimentary rocks composed of gravels, sand, and some marls in low-lying areas.

The Aqaba mountains are composed of hard granitic rocks, except in areas with recent alluvial and colluvial deposits. The Conveyance Pipeline passes through Wadi Yutum, also characterised by alluvial sediments consisting of gravels and sands of up to 40m thick. The wadi banks consist of hard granitic rock interlaced by basic dykes. From Shakriyye to Batn El Ghul, the prevailing rocks are sandstones of various ages. In Batn El Ghul, the pipeline turns north into a terrain composed of a variety of sandstone and limestone formations of Upper Cretaceous and Tertiary age. In areas east of Maan, Tertiary and Cretaceous carbonates prevail. These rocks are composed of marls, clay, sand, and playa sediments. Further north of the Jafr depression, the route turns northward and enters a terrain composed of Silicified Limestone and Phosphate beds that continue until the Qatraneh and Damikhi areas. The areas of Jizah and Sahab are characterised by solid rock of limestone, marl, chert, and phosphate, with recent sediments of gravel, sand and silt present in some locations.

The geology of the Renewable Energy (RE) Facility is characterised by the Ram Group and the Basement Complex. Ram Group consists mainly of siliciclastic formations and a marine carbonate/siliciclastic wedge, which unconformably overlie the Neoproterozoic basement terrain (Aqaba Complex and Araba Complex). The Group shapes a rugged topography of steep-faced cliffs and mesas, interspersed with sand-filled wadis in the Southern Desert region (Powell *et al.*, 2014). The Basement Complex is categorised into two primary complexes: the older Aqaba Complex, consisting predominantly of granitoids, which is exposed near Aqaba and extends eastward and northward, and the younger Araba Complex, characterised by abundant volcanic rocks, metasedimentary rocks (mainly conglomerates), and minor granitoids.

From Aqaba to Shakriyye, the Conveyance Pipeline route traverses mainly hard granitic rocks and their weathering products. The major rocks along the route are composed of sandstone, limestone, dolomite, chert and phosphates, which are stable and easy to excavate. Along the wadis, recent gravel, sand, and marl deposits can be found in relatively thin layers that are easily excavated. Studies of highway alignment near Aqaba have shown that inadequate design of wadi crossings and underestimation of fluvial processes resulted in damage under relatively rare floods (Farhan, 2011).

Figure 6-5: ESIA Study Area Geology



6.2.6.2 Soils

A total of 41 soil types have been identified within the ESIA Study Area, divided into nine segments based on geomorphological features consistent with the approach adopted for the baseline Terrestrial Ecological Survey (see Section 6.2.12). Along its full course from Aqaba to Amman, the ESIA Study Area covers a south-north gradient of soil environments:

- Southern segments (1–3): predominantly saline, gypsiferous sandy soils with very low fertility
- Central plateau (4–6): mainly stony, calcareous and moderately saline profiles; shallow depth limits rooting and infiltration
- Northern highlands (7–9): deep, fine-textured, non-saline soils—the most productive and stable for both agriculture and engineering

Overall, the ESIA Study Area is characterised by calcareous and saline desert soils with localised fertile zones in the Madaba and Amman plains, reflecting the diverse geology and arid climate of Jordan.

Segment 1 – Southern Coastal Plain (Aqaba Area)

Along the shore and the lower Wadi Araba, the route crosses young alluvial and aeolian soil types (Figure 6-6). These are fan and dune systems with sandy–loamy, often gravelly materials that are highly calcareous, frequently gypsiferous, and widely saline—especially in flats and interdune basins where salts accumulate. Fertility is naturally low because of aridity, scarce organic matter and carbonate/gypsum dominance. The soils in this area are moderately to highly saline (especially basins and fans) and salt crusts are common. Multiple studies describe salinity as a pervasive limitation in Wadi Araba, driven by aridity and capillary rise with both soil and irrigation-water salinity risks documented in the area (Ministry of Agriculture, 1993; Al-Kharabsheh, 2013).

Segment 2 – Ras an-Naqab escarpment & Wadi Rum Piedmont

Segment 2 ascends through dissected sandstone plateaus and fan systems (Figure 6-7). This area is characterised by sandy-skeletal to loamy-skeletal soils, which are developed on sandstone and granite formations. They are arid and thermic, with very low natural fertility. Soils are moderately to highly calcareous and saline, with strong textural contrasts due to the mixture of sand dunes and gravelly fan deposits. Salinity and stoniness can be pronounced, making soils erodible and sensitive to disturbance. Fertility is constrained by coarse textures and carbonate/gypsum accumulations (Abu-Jaber and Nazim, 2016).

Segment 3 – Disi and Mudawwar Desert Plain

Across the broad interior plain the Conveyance Pipeline route intersects aeolian sands with weak structure (Figure 6-8). The soils are characterised by braided fans, gypsiferous mudflats and saline hummocks. The Disi sandstone plateau is covered with sandy to fine-loamy, calcareous soils that can be moderately saline and locally weakly cemented. Overall fertility remains low, with salinity and gypsum common in closed or low-relief basins. These segment soils have moderate–high salinity and gypsum in mudflats. The Disi sandstone aquifer area is well documented for its sandy substrates and aridity-driven salinity issues in soils and waters (Ministry of Agriculture, 1993; Abu-Jaber and Nazim, 2016).

Segment 4 – Southern Limestone Plateau (Ma’an to Jurf al-Darwish)

Crossing the southern plateau, Segment 4 is characterised by stony, strongly calcareous gravel plain on Belqa/Mowaqqar rocks and pediments and hills on Mowaqqar Chalk–Marl (Figure 6-9). These are gravelly and loamy-skeletal plateau soils developed on limestone and marl formations. They are strongly calcareous, often gypsiferous, and show moderate salinity in lower-lying terraces and pediments. Soils have low permeability (key constraint for agriculture) and moderate fertility potential, with gypsum and lime being the dominant components. Shallow profiles limit plant rooting depth, particularly near escarpment slopes. The Mowaqqar Chalk–Marl Formation is a soft, carbonate-rich unit; studies emphasise its mineralogy, oil-shale content and hydrological behaviour, which explains salinity/alkalinity and low structural strength in associated soils.

Segment 5 – Wadi Hasa and Karak Plateau Edge

In Segment 5, terrain transitions from saline alluvial fans and lacustrine deposits to limestone plateaus, characterised by fine to loamy soil textures (Figure 6-10). Fertility is moderate, and soil contains fine-textured, clayey portions of phosphorite formations. Across this Segment, soils are alkaline, with carbonate and gypsum accumulations limiting moisture retention and root growth. A study of Jordan's highlands and plateaus highlights widespread calcareous soils, localised salinity on alluvial fans, and loessic mantles that increase clay content and shrink–swell risk (Al-Qudah, 2001).

Segment 6 – Wadi Mujib to Madaba Highlands

Segment 6 runs along steep limestone escarpments and uplands with soils that are loamy to skeletal, calcareous, and range from non-saline to saline (Figure 6-11 and Figure 6-12). Parts of the Segment are particularly saline due to their marl-rich substrates. Fertility remains low to moderate, constrained by stoniness and shallow depth on slopes. The soils near Madaba are among the more productive in this region, being fine-textured, calcareous, and non-saline (Al-Qudah, 2001).

Segment 7 – Madaba Plains

The Madaba Plain is characterised by the predominance of gently undulating plains that have deep, fine-textured, calcareous soils with no salinity problems (Figure 6-13 and Figure 6-14). They show weak vertical characteristics (shrink-swell behaviour) and are relatively more fertile than southern and desert soils. Compared to southern segments, these landscapes offer higher agricultural potential, provided irrigation and drainage are well managed in the clayey subsoils. These are productive agricultural zones, though still alkaline and carbonate-rich, requiring careful water management for sustainable cultivation. Overviews of Jordan's central highlands (Madaba region) point to calcareous, fine-textured soils supporting long-standing agriculture on the plains and interfluves (Al-Qudah, 2001).

Segment 8 – Outer Amman Plateau

As the Conveyance Pipeline route enters the northern plateau, it passes through loamy to silty, calcareous, and weakly saline soils (Figure 6-15). They are deep and moderately fertile but highly stony in places. Soils located near the Wala–Azraq watershed exhibit better water retention and are utilised for mixed agriculture, whereas soils on limestone slopes are shallower, stonier, and less productive due to rockiness and carbonate accumulation. Salinity is present but generally less severe than in the south and is patchy, tied to drainage and relief.

Segment 9 – Amman Urban Area

The final Segment crosses chalk and marl uplands near Amman (Figure 6-15). These are fine-textured, highly calcareous, and non-saline, showing good structure and moderate fertility. The soils support mixed agricultural and urban land uses, characterised by deep subsoils and high lime content. Despite being alkaline, their structure makes them suitable for engineering foundations and limited cultivation if irrigated properly. Urban-area studies and national overviews confirm calcareous fine-textured soils across the Amman highlands, with salinity problems more localised than in the south and Jordan Valley.

Figure 6-6: Soil Units within ESIA Study Area, Segment 1

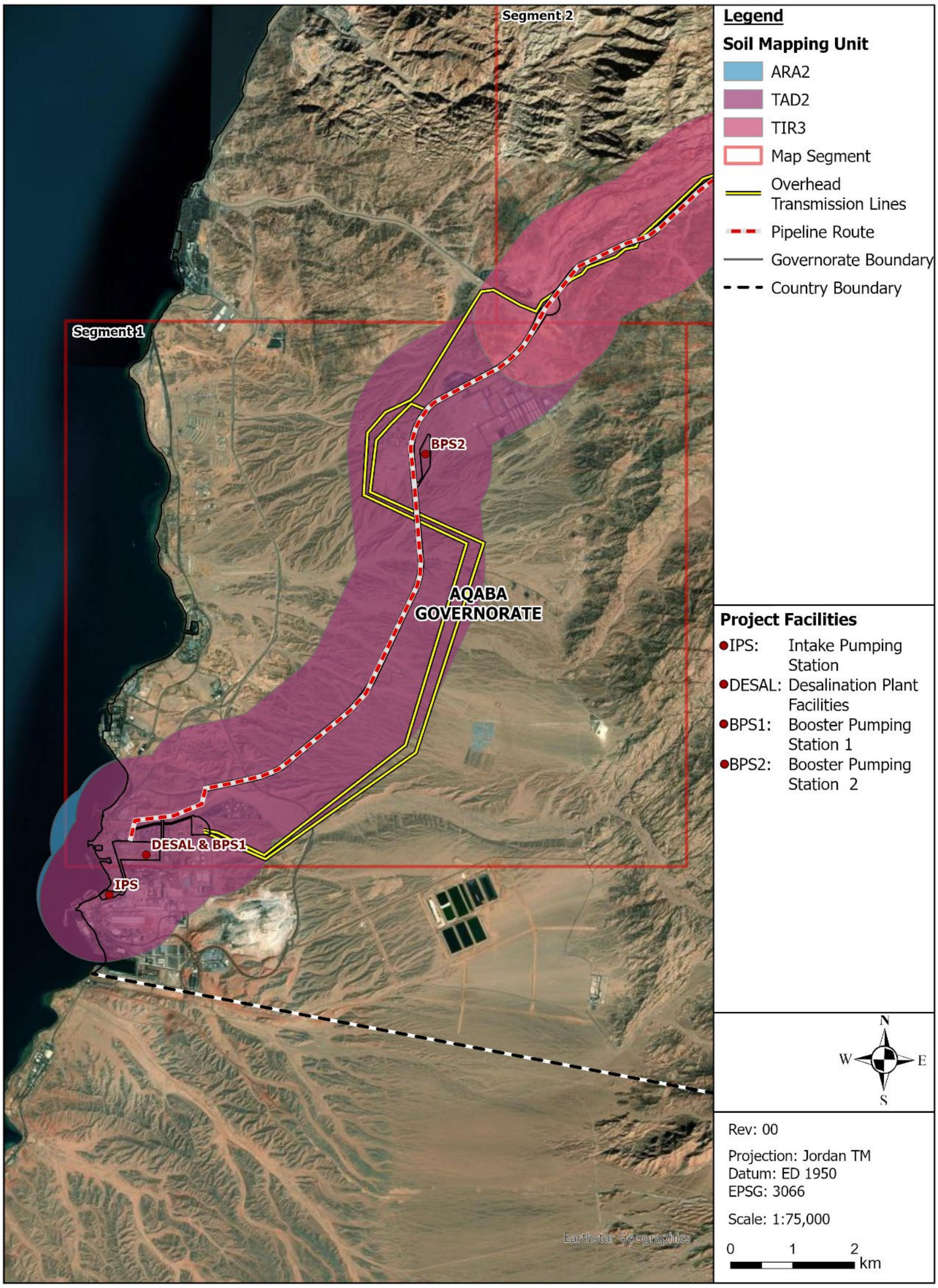


Figure 6-7: Soil Units within ESIA Study Area, Segment 2

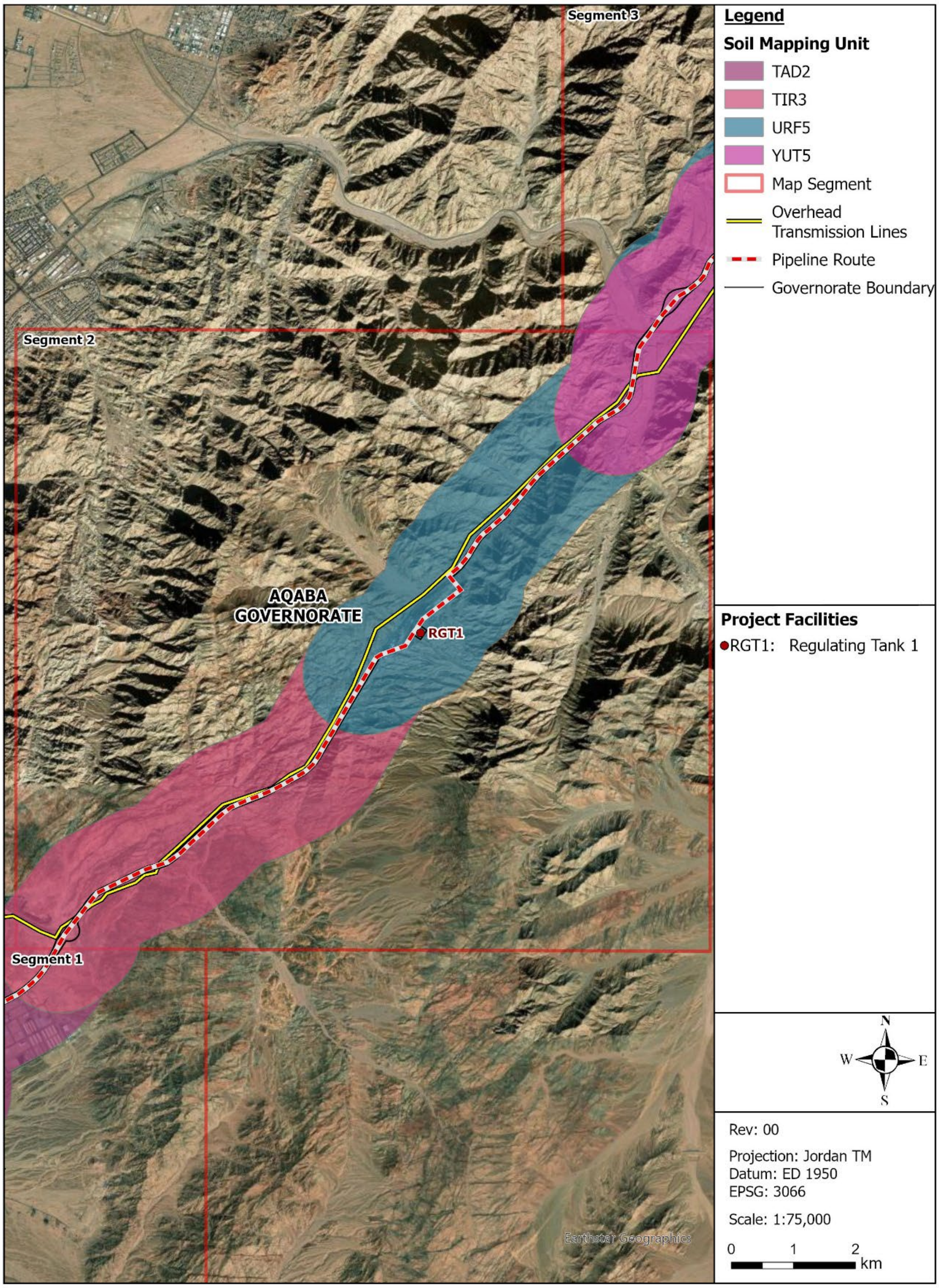


Figure 6-8: Soil Units within ESIA Study Area, Segment 3

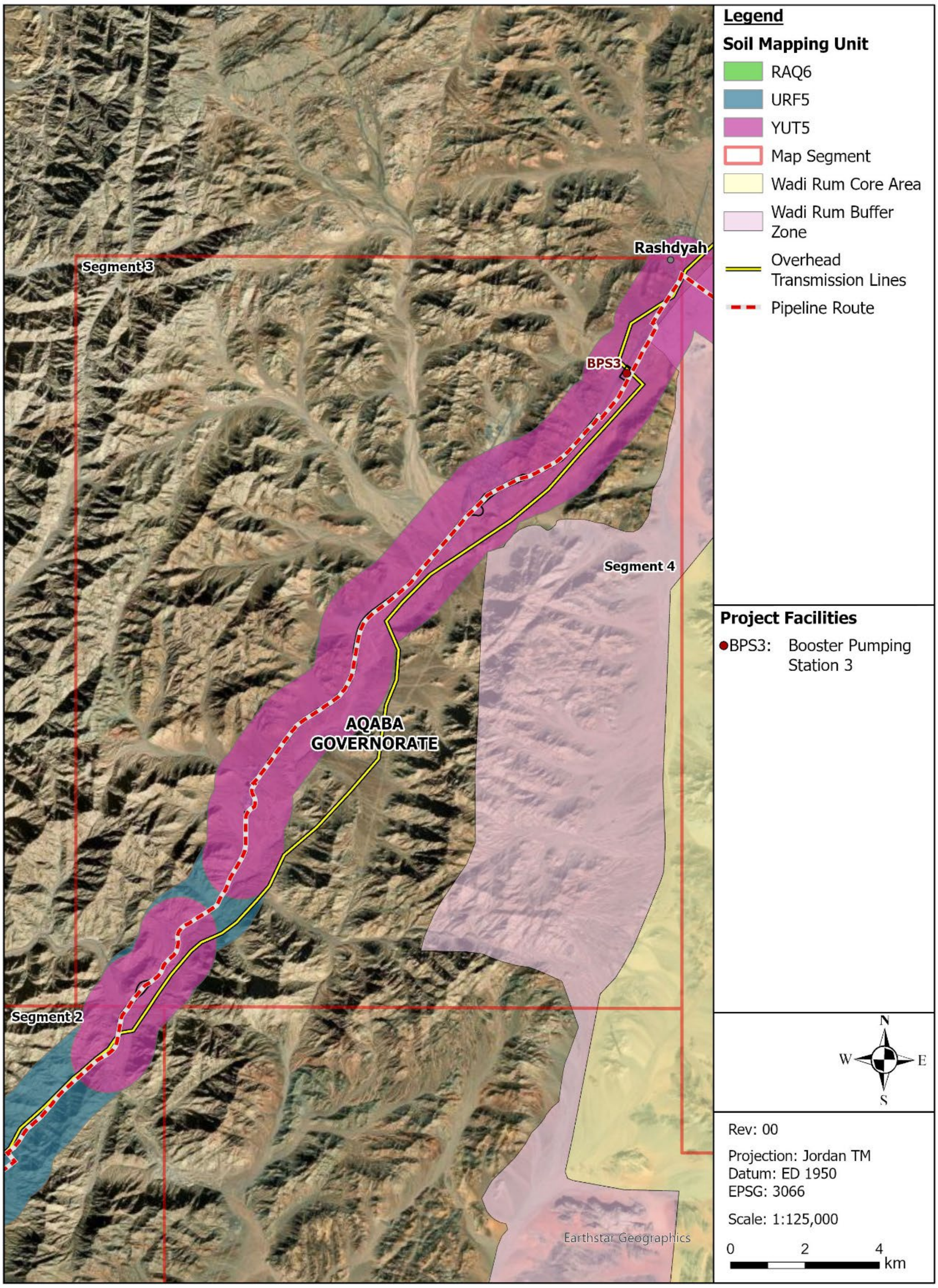


Figure 6-9: Soil Units within ESIA Study Area, Segment 4

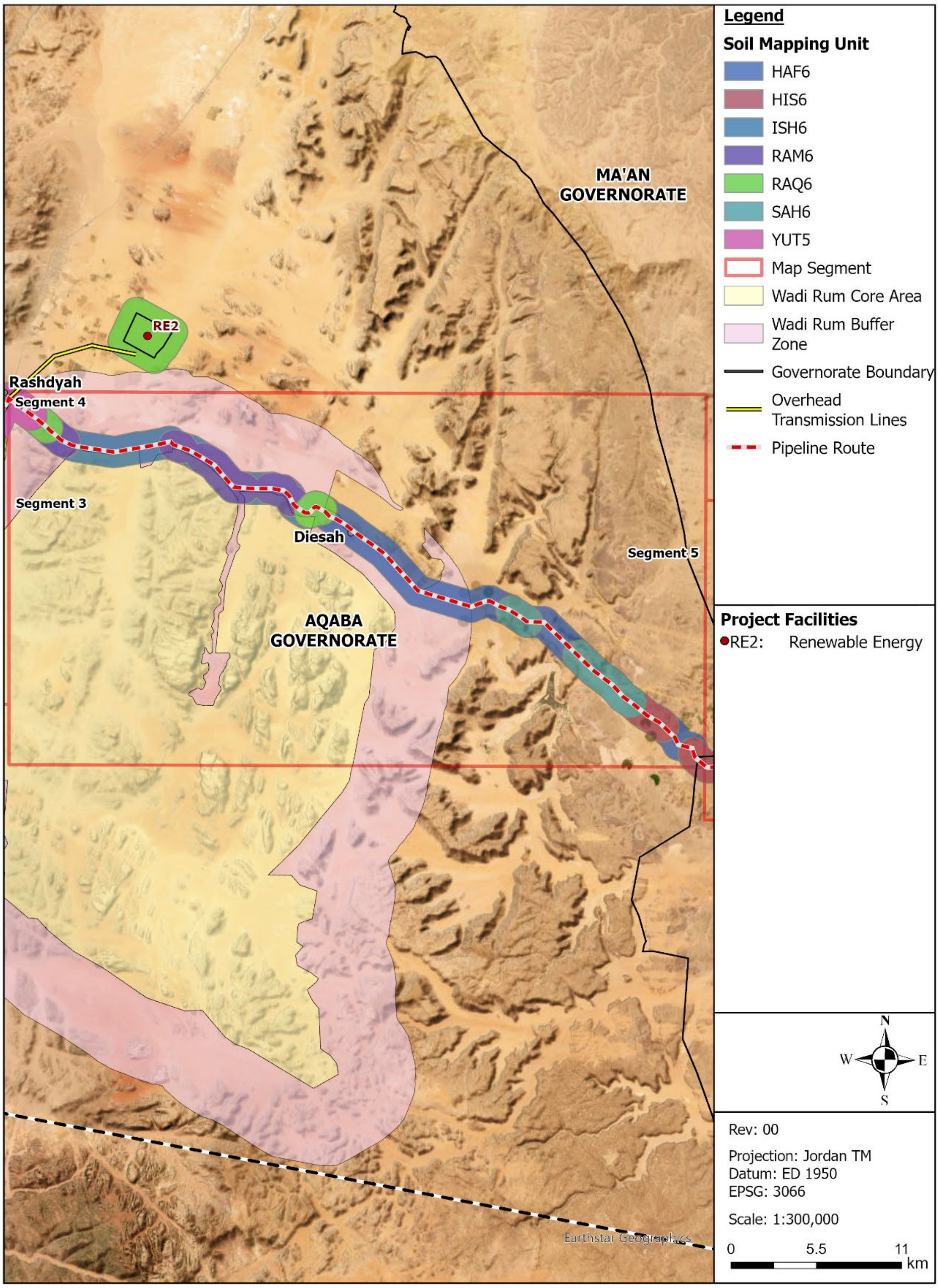


Figure 6-10: Soil Units within ESIA Study Area, Segment 5

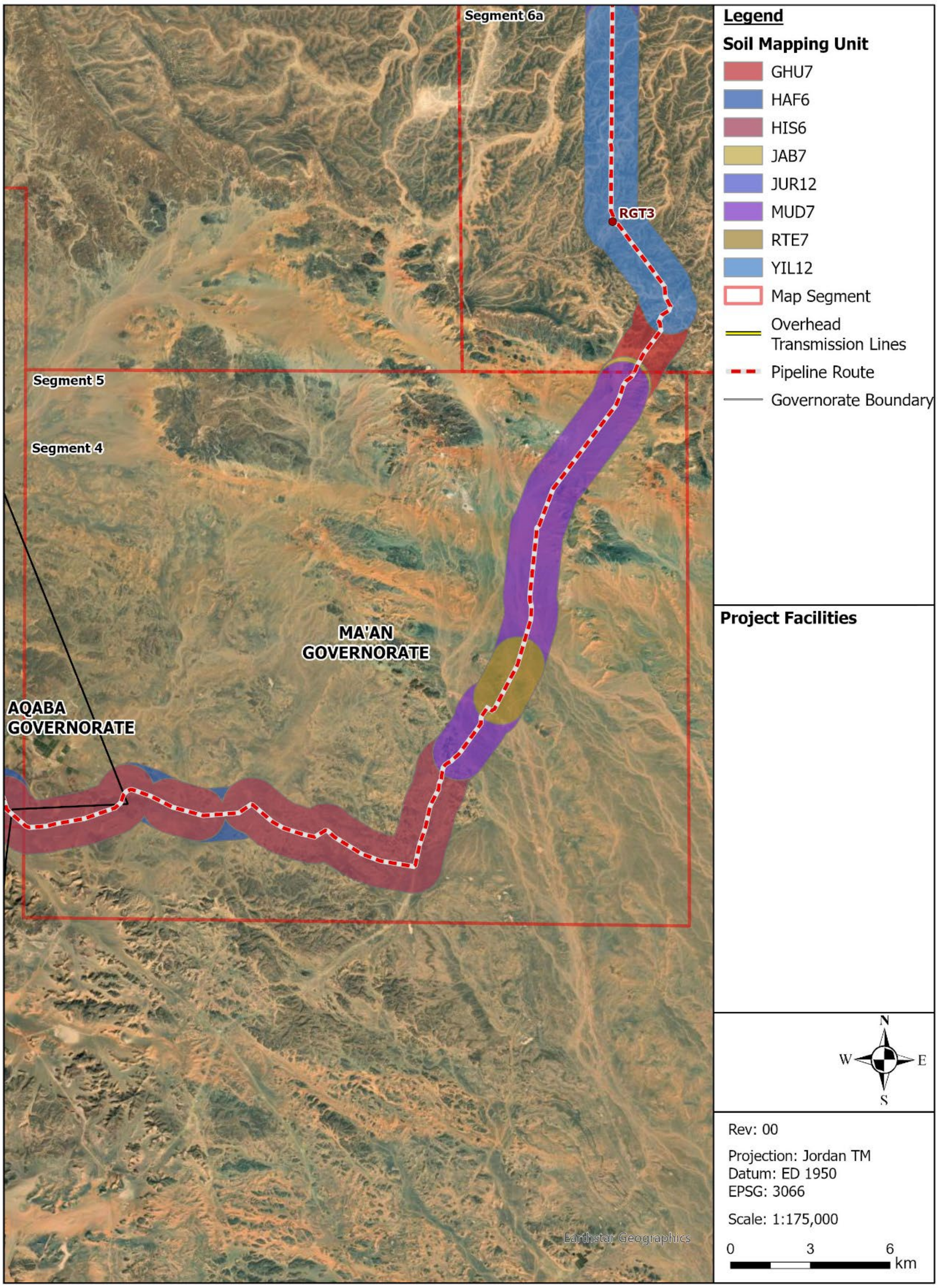


Figure 6-11: Soil Units within ESIA Study Area, Segment 6a

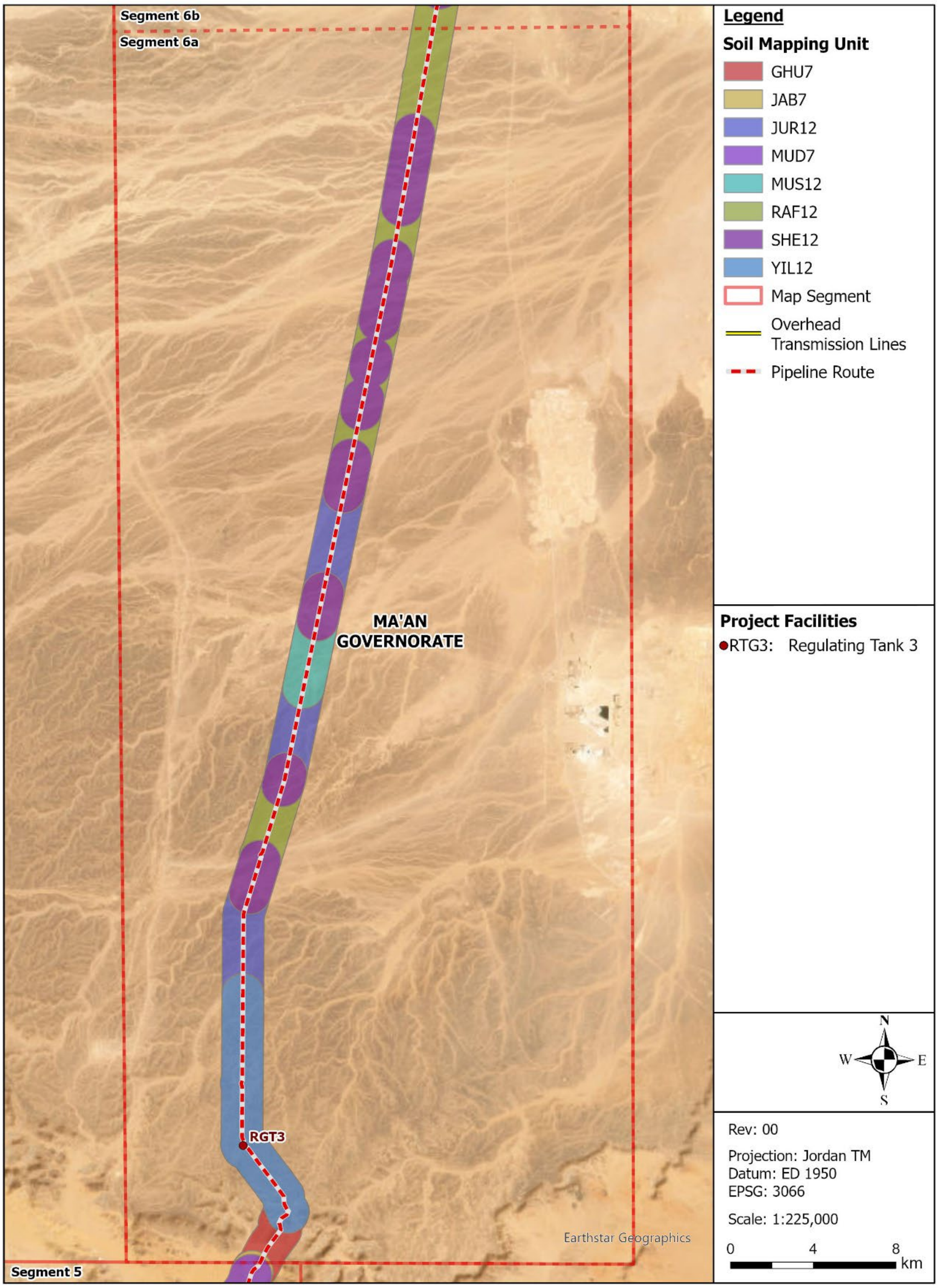


Figure 6-12: Soil Units within ESIA Study Area, Segment 6b

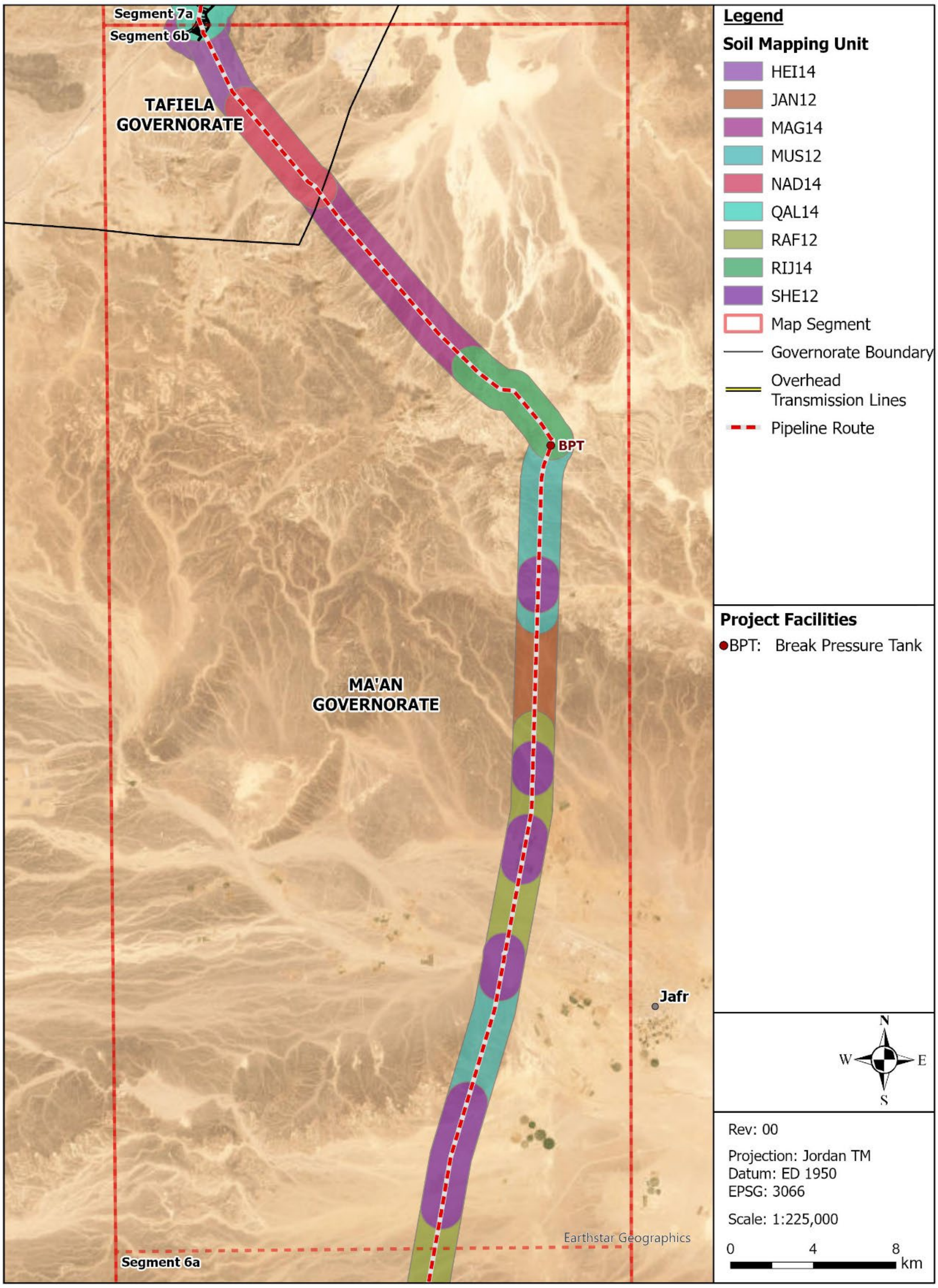


Figure 6-13: Soil Units within ESIA Study Area, Segment 7a

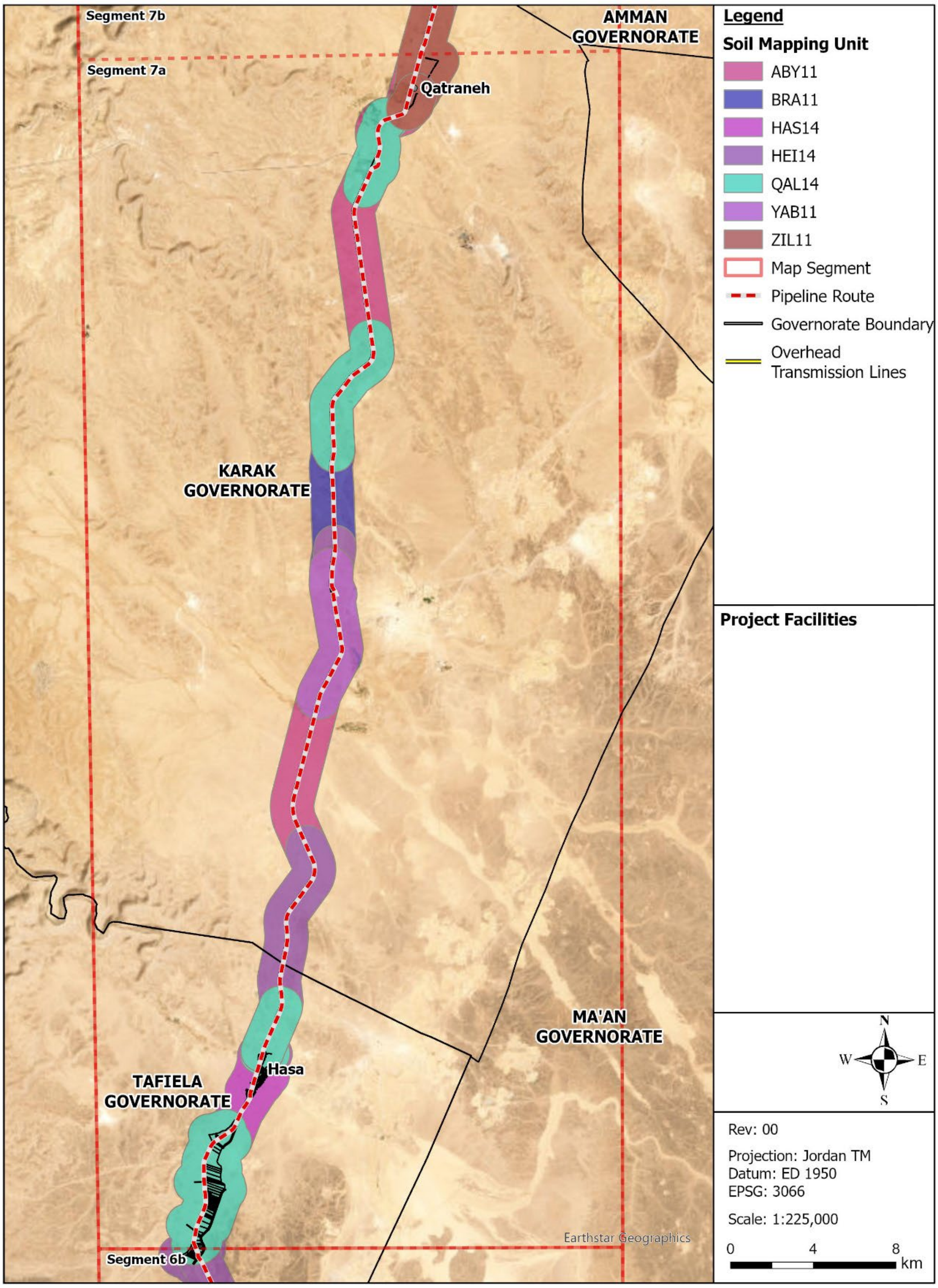


Figure 6-14: Soil Units within ESIA Study Area, Segment 7b

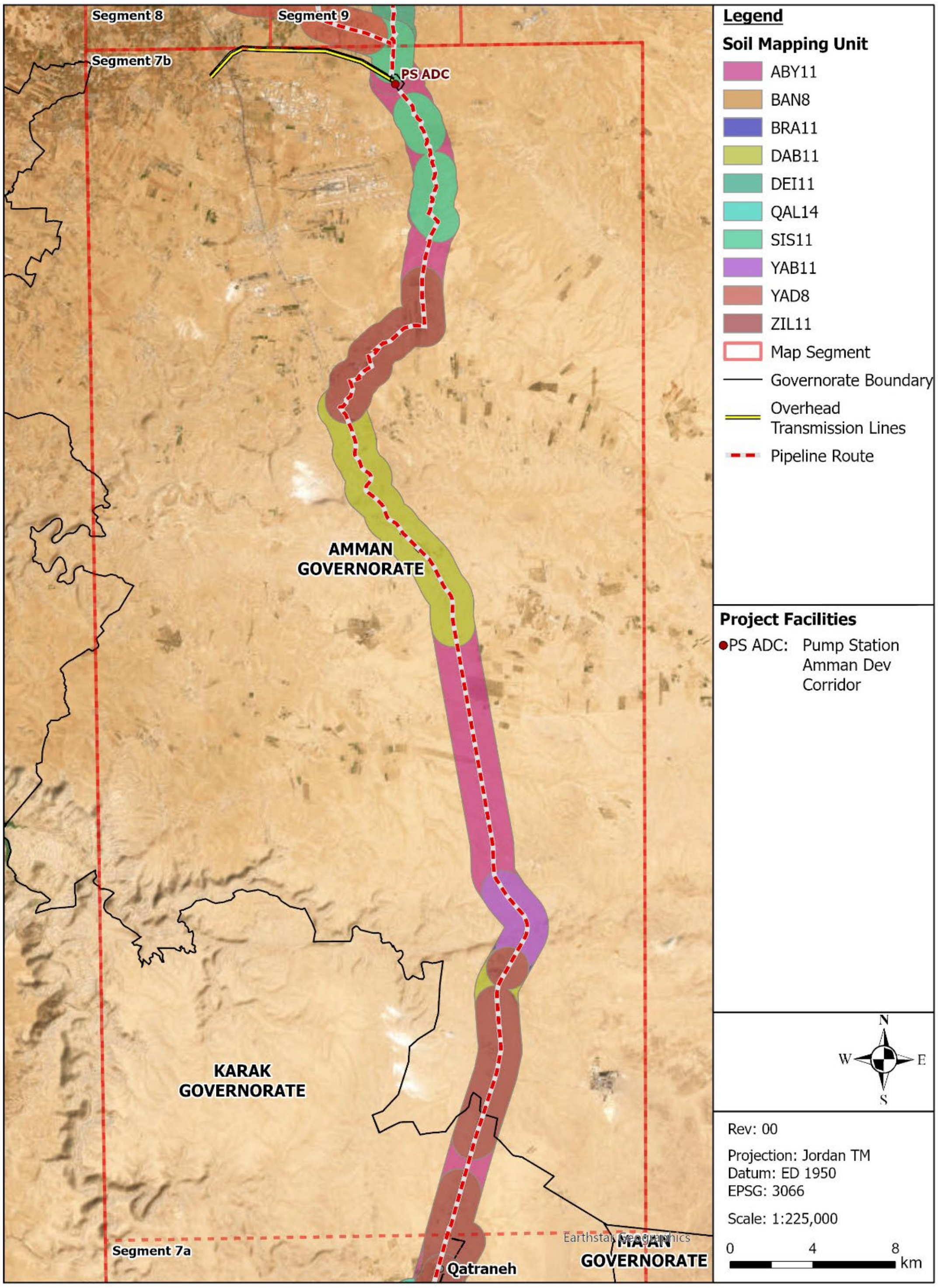
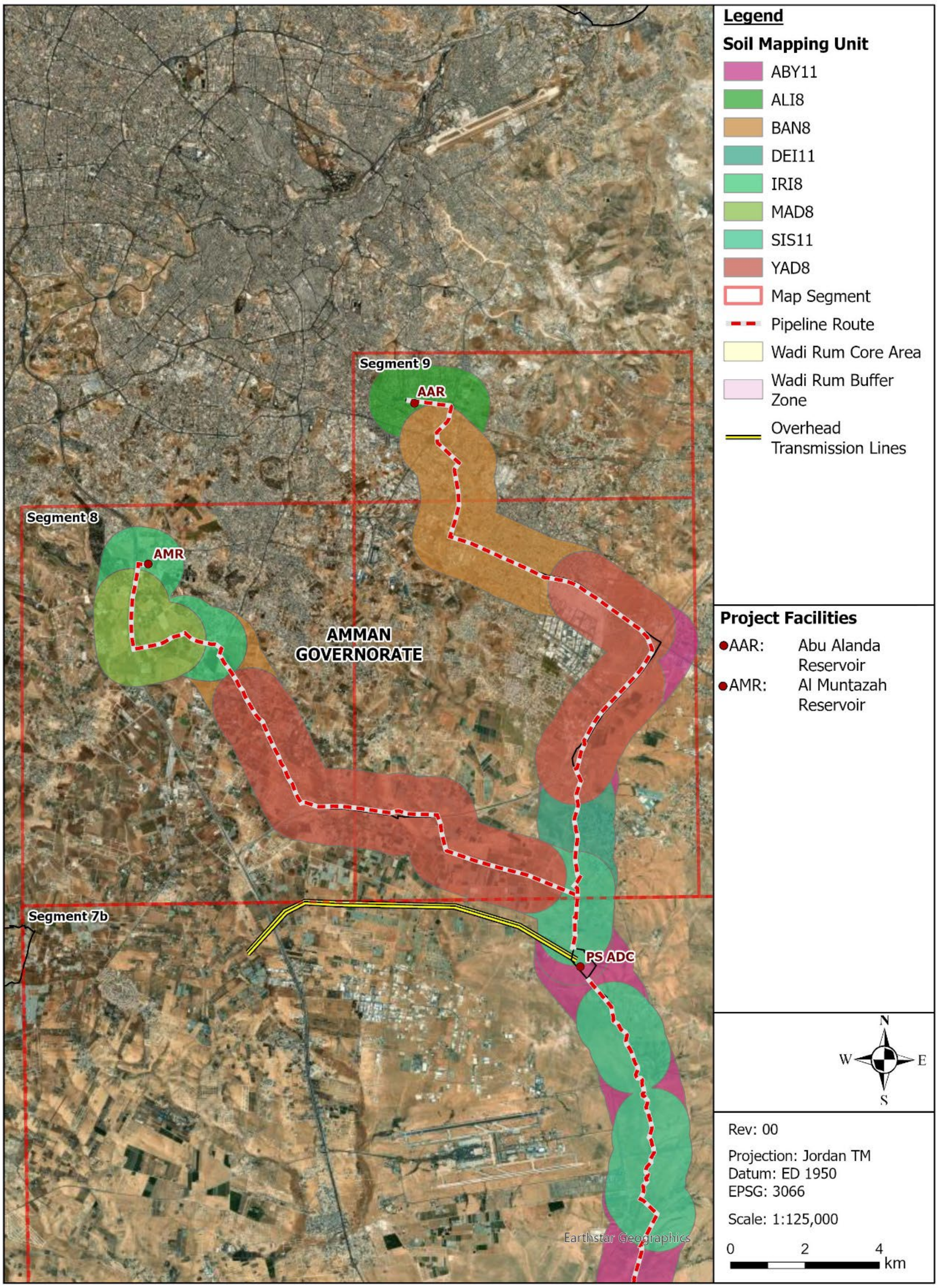


Figure 6-15: Soil Units within ESIA Study Area, Segment 8 and 9



6.2.7 Landscape

The landscape character across Jordan is heavily shaped by its geology. The type of rock (limestone, sandstone, marl, and crystalline basement rock) not only determines the topography and slope profiles but also influences soil formation, vegetation cover, land use, and, consequently, settlement patterns.

The Conveyance Pipeline route from the Intake Pumping Station (IPS) to Booster Pump Station 3 (BPS3) is surrounded by the granite mountains of Aqaba. Its northern part is covered by wind-blown sand, whereas the mid-to-southern portion has a hard substrate covered with coarse granite soil and rocks. The area has several narrow wadi systems, and scattered vegetation. Solid granite mountains with various altitudes are common. The substrate in the area is mostly gravelly and hard, especially in the southern half. Grazing is high, and many settlers can be observed with sheep and camels throughout the area. Vehicle traffic is relatively high, as the area is used as a shortcut to reach Aqaba.

Figure 6-16: Desalination Plant, BPS2, BP3 and RTG1 Locations

The Desalination Plant area is mostly barren, hard soil, consisting of a firm upper crust in most areas, with the remnants of previous industrial buildings and structures that have been demolished still in-situ. Only a few scattered Acacia trees are located to the east, close to the road leading to the site. A sharp mountain ridge, known as the Aqaba Mountains, is located approximately 2km east of the site. The four pumping stations sites are heavily disturbed and exhibit no biodiversity elements and pose no threat to the local diversity.

The area from BPS3 to Regulating Tank 3 (RGT3) runs in the vicinity of the Wadi Rum, is characterised by a unique landscape of scenic sandstone mountains divided by extensive open sandy valleys. The soil is predominantly alluvial (being transported by water and wind) and of sandy, saline, and/or granite nature. According to soil maps of Jordan, the Wadi Rum Protected Area encompasses two main soil types that differ in their properties. Both types are shallow and contain moderate to high levels of soluble salts, requiring high leaching to practice irrigated agriculture. Most of the area to the east is characterised by steep slopes and eroded lands that include Tropopsamment and some camborthids soil types, whereas the western and southwestern regions are located on a land region known as Wadi Araba Escarpment with aridic Torriorthent soil. This area is dominated by coarse-textured soils with a very stony nature and calcic horizons. The area between Qweirah and the villages of Sallheiah, Shakriyye and Disi is a tourism zone. This particular area represents an open, sandy desert and large sandstone mountains that currently host minimal biodiversity.

Figure 6-17: Wadi Rum Protected Area and RGT3 Location

Part of the Conveyance Pipeline route is within an agricultural area that extends southeast from the village of Disi to the wellfields and 'crop circles' of large-scale agricultural farms. The landscape is mostly open Hamada of gravely substrate. This area lies to the east of the Wadi Rum area, east of the villages of Disi, Twaiseh and Mnaishir. Irrigated agriculture in this area has developed over the last 15-20 years on the silt plains between Disi, Sahl as Suwwan, and Al Mudawwara, which lie along the northern and eastern boundaries of the Wadi Rum Protected Area.

The eastern desert area, from the RGT3 to the crosspoint of the alignment with the Desert Highway (between Jurf Al-Darwish and Hasa) is a highly diversified geomorphic area with different types of habitats that offer shelter and space for various assemblages of communities preferring open land. The landscape ranges from basaltic fields and boulders (lava or harra desert), flat low-land areas (marab), saline dunes (sabkhaht), sandy sheets, to wadi beds and flat deserts (gravel Hamada).

The area between Jurf Al-Darwish and Qatraneh lies within the southeastern desert region of Jordan, along the Desert Highway. The area is mostly flat deserts (gravel Hamada), often interrupted by lowlands (marab) and wadi beds. This area is already situated along a heavily disturbed highway where the biodiversity elements are at their minimum.

The Qatraneh to Dhab'a area lies within a semi-desert area that represents the transition zone between the desert and the Mediterranean region of Jordan. The area is mostly flat semi-desert that is often interrupted by lowlands (marab) and wadi beds.

In the Amman governorate, the ESIA Study Area extends from Jizah to Abu Alanda and Al Muntazah reservoirs comprising of a transition zone between the desert and the Mediterranean region of Jordan. The area is mostly semi desert that is often interrupted by lowlands (marab) and wadi beds, the area also has some small townships and villages, several small-scale olive farms and vegetable farms.

The area of Abu Alanda Reservoir is a heavily urbanised area and perhaps one of the densest in the area southeast of Amman. The landscape of Al Muntazah reservoir resembles an interwoven mosaic of farms, urban areas, and forest fragments. This area lies fully within the Mediterranean biogeographical region of Jordan. It contains farmlands of olives, various fruit trees, and crops.

The RE Facility can be generally described as four landscape units:

- Unit 1: Unsettled undulating bare land hills
- Unit 2: Rocky rangeland wadis
- Unit 3: Cultivated flat open areas
- Unit 4: Uncultivated flat sandy clay area

Unit 1 (unsettled undulating bare land hills) is an area considered to have a difficult, mountainous, undulating terrain cut by a group of long wadis from east to west, most of which are formed by seasonal water flow and vary in width and depth. The soil is gravelly, sandy, rocky with a low organic content and therefore the vegetation cover is very weak and sparse (Figure 6-18).

Unit 2 (rocky, sandy rangeland wadis) consists of relatively narrow, north-south wadis mainly of gravel, sand and rocks that vary in size according to the strength of the seasonal flow. The vegetation cover is generally weak and scattered (Figure 6-18).

Figure 6-18: Landscape Unit 1 and Unit 2 Areas

Unit 3 (cultivated flat open areas) generally consist of open flat areas with mostly clay soil and some sandy patches. The vegetation cover is low due to high agricultural activity, allowing vegetable farms to spread throughout the terrain. This is evident in the ploughing of the land and its remaining agricultural mulch in the soil. There are also some simple citrus trees, which are cultivated by small farms. Some roads are closed due to agricultural activities, as farmers erect fences or rock barriers to prevent cars from entering their cultivated lands. This pattern extends to the northern area of the ESIA Study Area, reaching the end of the corridor to the RE Facility (Figure 6-19).

Unit 4 (uncultivated flat sandy clay area) is an open, flat area, slightly undulating to the west of the RE Facility. The soil is mostly sandy, mixed with clay soil in the form of transverse corridors from the north to the south, which were transported by seasonal floods. The vegetation is sparse in the sandy area and becomes denser in the areas mixed with clay soil. Many animal and bird species have been recorded at the site, and the grazing activity of livestock and camels is evident (Figure 6-19).

Figure 6-19: Landscape Unit 3 and Unit 4 Areas

6.2.8 Hydrology

6.2.8.1 Groundwater

The ESIA Study Area encompasses several groundwater basins that serve as sources of irrigation and potable water through wells (Figure 6-21). In the coastal areas of Aqaba, groundwater is fed by the discharge from the eastern mountains into the Gulf of Aqaba. The groundwater in these areas has received, during the last four decades, increasing amounts of fresh water leaking from the water supply network and untreated wastewater leaking from the sewerage system and cesspools. In the Aqaba City area, groundwater quality varies depending on well depth, distance from the shore, and surrounding land use.

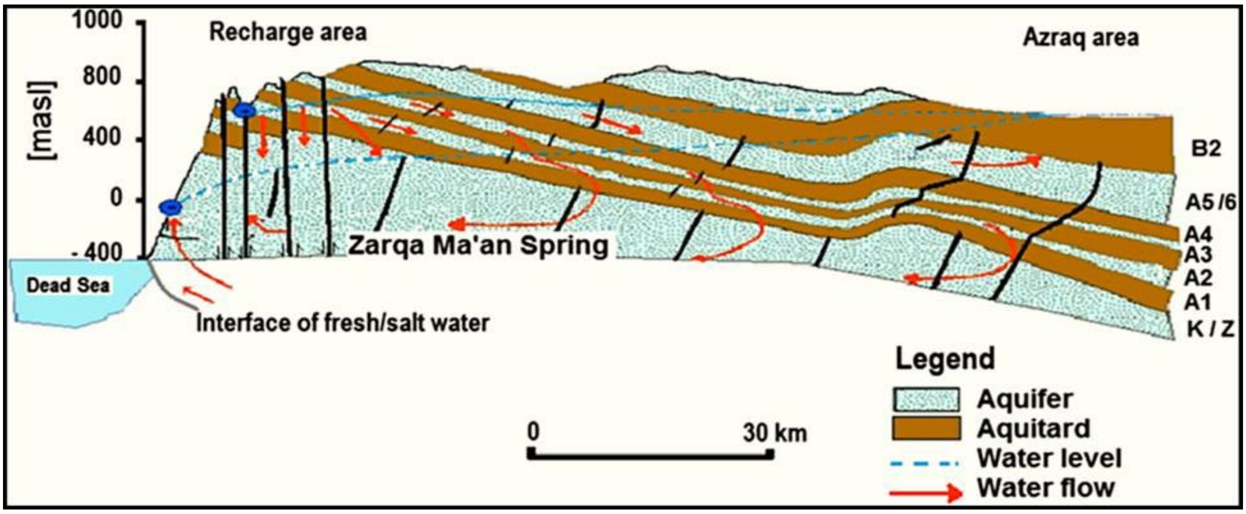
Along the Wadi Yutum, the groundwater can be intercepted at depths of 20-40m. It flows towards the GoA through sediments of the wadi, composed of alluvial and colluvial rocks. The aquifer has been used for more than 50 years as a source of freshwater supply to Aqaba City (Wadi Yutum well 4 has a TDS of 670mg/l, used for drinking purposes following chlorination).

From Shakriyye to Batn El-Ghul, the only available water source is the Disi aquifer, which spans approximately 4,234 km² in southern Jordan. It is a non-renewable aquifer with an annual extraction estimated at 144.95 MCM. The Jordanian portion of the aquifer is estimated to hold approximately 100,000 MCM of water in storage (Al-Addous *et al.,* 2023). The groundwater is primarily used for domestic and agricultural purposes, making it a vital resource for the Mudawwar Region and one of the most permeable and productive sandstone aquifers in Jordan. This aquifer water quality is considered good and acceptable for drinking purposes according to national and EU standards (Mahasneh, 2017). Due to intensive extraction, the water levels have dropped and are currently at approximately 30m below the ground surface. Whilst the salinity of the water increases gradually from Disi in the west to Batn El-Ghul due to natural water-rock interaction, the groundwater remains free of pollutants and can be used directly for drinking, except in the eastern parts of the proposed Pipeline route, where it requires aeration.

To the north, from Batn El-Ghul to Al-Husayneyah, Upper Cretaceous calcareous rocks overlie the sandstone aquifer. Generally, to the east of the Amman-Aqaba Highway, the Bituminous Marl Unit confines the aquifer, increasing its flow pressure. The recharge area lies in the west along the highlands extending from Ras-en-Naqb to Tafiela. The groundwater table in this area lies tens of meters below the ground surface. The water is of drinking quality and free of pollution. To the north of Al-Husayneyah through Qatraneh, and from Jizah to south Amman, the upper calcareous aquifer is of relevance, as the depth of the Disi Aquifer in this area is >1000 m, well below the proposed route of the Project pipeline, feeding the thermal springs of Ibn Hammad, Zara and Zarqa Main.

The upper aquifer receives recharge along the western high mountains overlooking the Dead Sea and flows east, along the Amman-Aqaba Highway, where it becomes confined by the Bituminous Marls, similar to the Al-Husayneyah – Qatraneh section of the pipeline. In this section, the aquifer is subject to heavy extraction for irrigation, and the water levels, 50-150m below the ground surface, continue to drop. In this area, the groundwater is generally free of pollution. The unconfined groundwater to the west of the Amman-Aqaba Highway is used for drinking purposes, although minor agricultural activities also depend on it.

Figure 6-20: East-west Groundwater Flow within Qatraneh - South Amman Area



Groundwater is the main source of water in Jordan, accounting for 60% of all uses and 76% of sources for drinking water (MWI, 2019). To meet the high-water demand, wells have been drilled intensively. According to the MWI (MWI, 2021), there were 3,208 legal private and governmental wells, as well as 5,160 pumping wells, primarily located in the highly populated northern and central governorates. However, many illegally operated wells are also discovered and backfilled every year. Between 2007 and 2020, the MWI closed approximately 1,548 illegal wells.

The current state of groundwater remains critical, with an estimated 200 MCM (MWI, 2021) of over-pumping, and most basins have been extracted above their safe yields. This has led to a significant decline in the water table within major aquifers. The rate of decline is rapid, averaging about 2m per year, and in severely affected areas, the decline reaches 20m per year. The decline in groundwater levels is affecting its quality, causing it to exceed the allowable limits set by Jordanian Standard for Drinking Water Quality No. 286/2015.

In areas from Shakriyye to Jafr and from Al-Husayneyah northward towards Amman, the ESIA Study Area includes a large number of groundwater wells located within 10km on either side of the Conveyance pipeline. Wells are also present in the Conveyance pipeline section from Al-Ghal to Batn El-Ghul (alternatively, water has to be transported either from the Al-Ghal area or from Mudawwar from a distance of 35km and 20km, respectively). In the Jafr area, groundwater wells are located within a 10km distance of the Conveyance Pipeline route. From Jafr to Al-Husayneyah, groundwater wells are scarce, and water can be transported alternatively from sources located 18km away.

6.2.8.2 Surface Water

The surface water resources of Jordan are very limited, highly seasonal and unevenly distributed. Overall, surface water contributes less to the country's water balance than groundwater. Approximately 37% of the total surface water supply originates from 16 basins, and the Yarmouk River is the primary tributary of the Jordan River, with a historical flow of 450 MCM/yr. While the Zarqa River is the only major river completely within Jordan's jurisdiction, about 50% of the river's flow originates from the Al-Samra wastewater treatment plant.

Climate change has led to a decline in precipitation, resulting in a corresponding decrease in surface water flows. Naturally low water availability in Jordan is further reduced by the overconsumption of shared surface water resources by upstream and neighbouring countries. Both the Jordan River and the Yarmouk River have been depleted due to upstream overconsumption in Palestine and Syria (Alqadi and Kumar, 2014). The prevailing semi-arid conditions in Jordan govern not only precipitation amounts but also potential evaporation, which ranges from approximately 1,800 mm/yr in the Amman highlands to more than 4,000 mm/yr in the southern desert areas of the ESIA Study Area (Figure 6-22). The potential evaporation in the Plateau area and in the South-Eastern Desert areas is 12 to 100 times the amount of precipitation received in these areas (Salameh and Al-Alami, 2021).

The ESIA Study Area does not include any perennial watercourses. All wadis are intermittent and flow only as a result of precipitation that falls over their catchment areas during the rainy season (Figure 6-23). The major wadis include Yutum, Disi, Mneishir, El-Ghal, Ram, Abu-Elhamam, Rweishdat, Mahatta, Jurf, Jardan, Breka, Qaa' Jinz, Hasa upper catchment, Qatraneh, Seeda, Nukheila, and Swaqa, among others.

Wadi Yutum presents a challenging terrain during and immediately after intense rainfall, because of its slope and the resulting violent floods and sediment loads, which include partly rock boulders, as well as gravel, sand, silt, and clay. From Shakriyye to Batn El-Ghul, the wadis are shallow, draining small catchment areas of a few tens of square kilometres composed mainly of friable sand and sandstone. Rainfall in the area is scarce, and most of it infiltrates directly into the soil where it falls, resulting in only very moderate flooding. Mudflats in this same area are also underlain by a sand deposit, allowing floodwater to collect and rapidly infiltrate. From Batn El-Ghul to Jafr and Al-Husseiniyya, the ESIA Study Area encompasses a terrain characterised by flat wadis, primarily draining intermediate catchment areas that flow into a playa topography towards the Jafr Depression in the east. These west-to-east flowing wadis are flat. The nature of rain events in the upstream areas of these wadis in Ras en-Naqab, extending to the Shoubak area, is characterised by concentrated storm rainfall in a few hours, producing large, shallow floods due to the flatness of the wadi courses. From Jafr to Amman, the ESIA Study Area passes through or within water divides between wadis that drain eastwards to Wadi Sirhan at the borders with Saudi Arabia and wadis that drain westwards towards the Jordan Rift Valley. The areas of these water divides are generally of low to very low topography (slopes), or they consist of flat playas or mudflats between catchment areas draining east and west. Naturally, such playas and mudflats are shallow and collect floodwater in wintertime, directly during and after rain events. The collected floodwater gradually discharges to neighbouring wadis, infiltrates into the soil, or evaporates.

Figure 6-21: Groundwater Aquifers within the ESIA Study Area

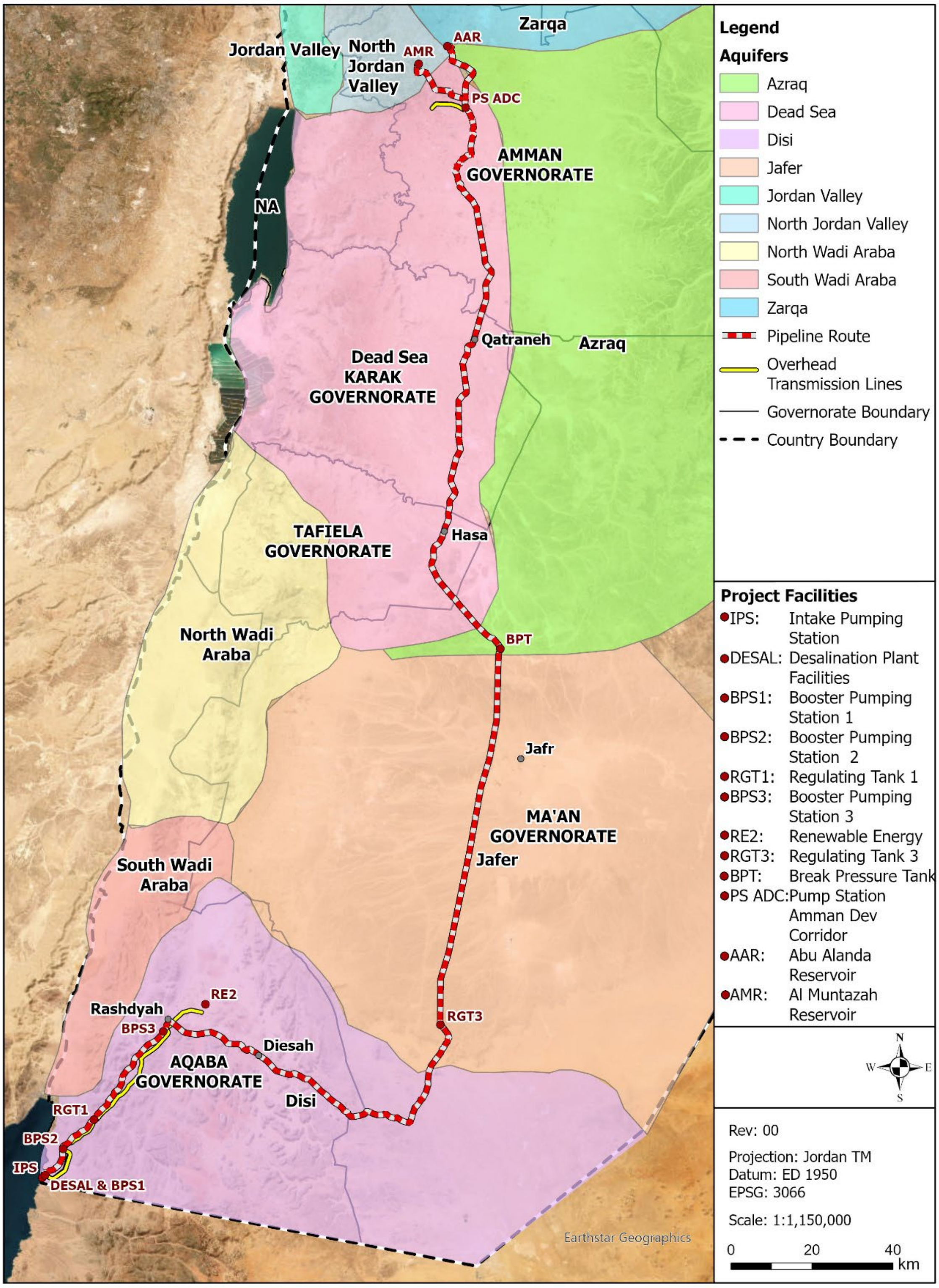


Figure 6-22: Distribution of Potential Evaporation Rates within ESIA Study Area (mm/yr)

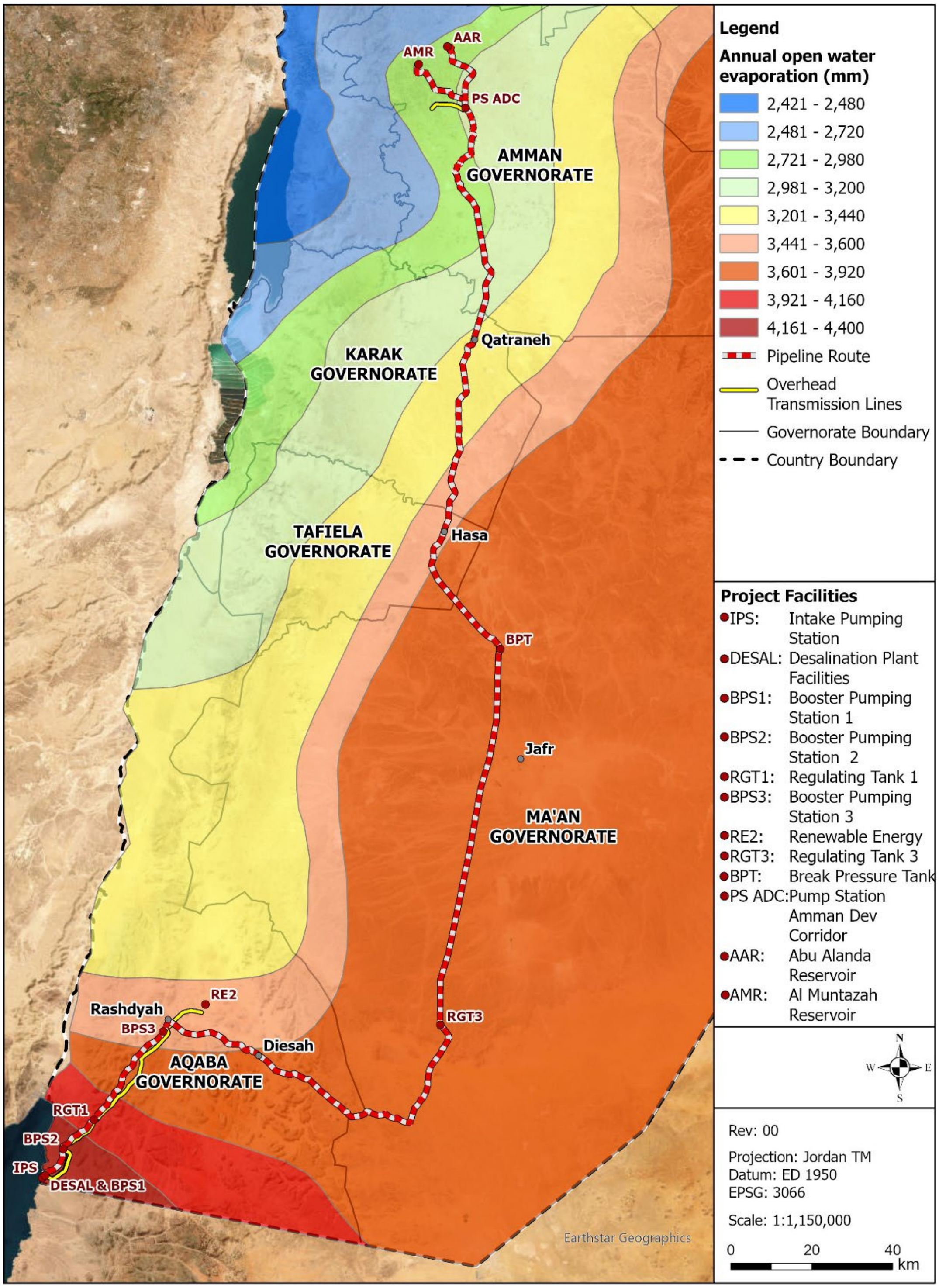
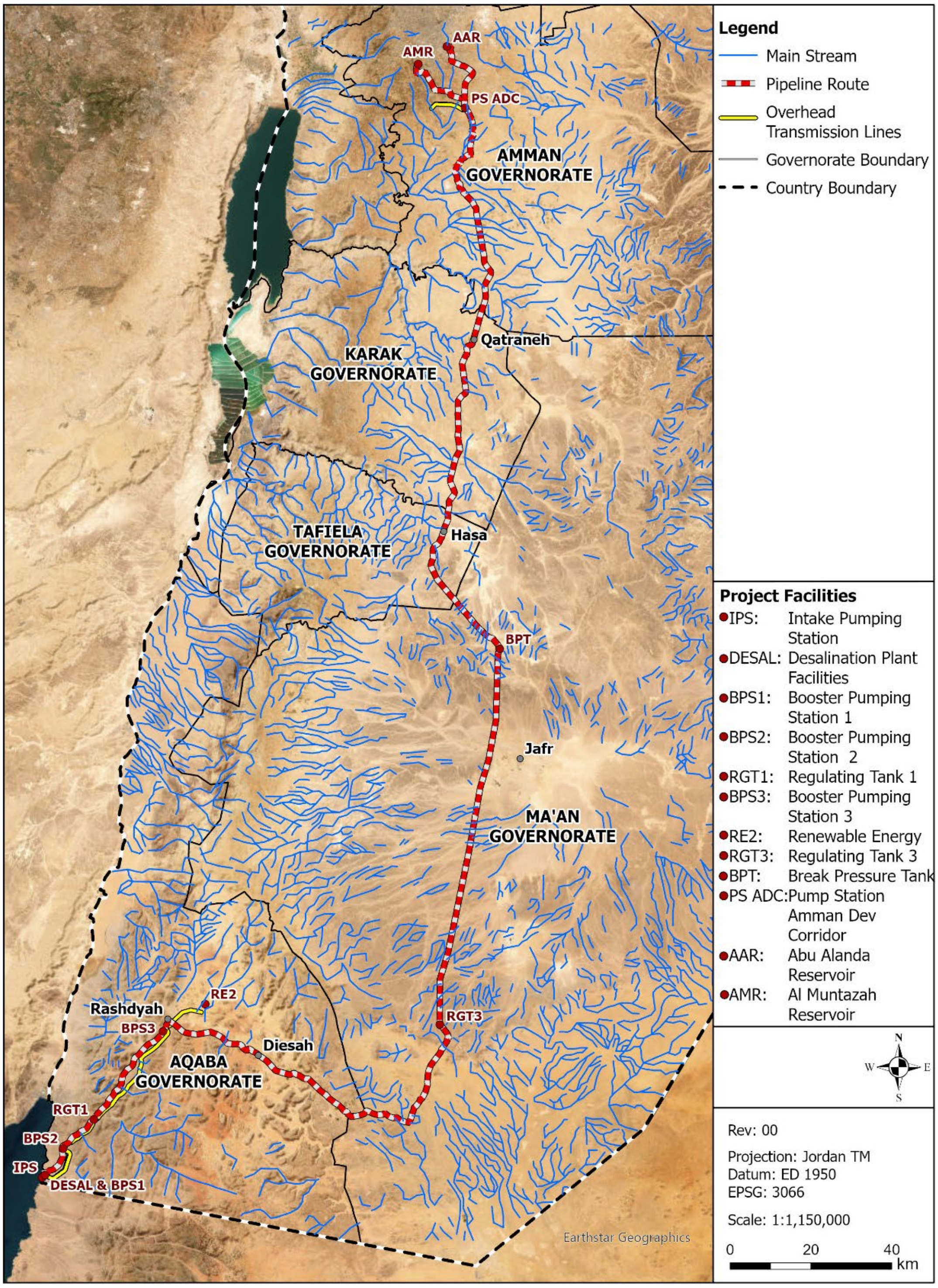


Figure 6-23: Main Surface Water Streams within the ESIA Study Area



6.2.9 Meteorology and Climate

Jordan's climate ranges from desert to arid to Mediterranean climate. The climate variation across the country is influenced by topography and proximity to the Mediterranean Sea. Summers are long and hot, particularly in low-lying areas (Jordan Valley, desert). Winters are short and cooler, especially in higher elevations (Figure 6-24).

At a country level, Jordan has three distinct climatic regions (Red Cross Red Crescent Climate Centre, 2024):

- Jordan valley, which forms a narrow strip located below the Mean Sea Level, and has warm winters (19°-22°C) and hot summers (38°–39°C), with average annual rainfall ranging between 100–300 mm
- the Western Highlands, where temperatures range from 9°C–13°C in the winter to 26°C–29°C in the summer and rainfall is relatively high (300–600 mm per year)
- the Badia, an arid and semiarid inland area to the east, where temperatures range from 14°C to 16°C in winter to 35°C to 37°C in summer, and the annual rainfall is below 50 mm

The rainy season lasts from October to May, with the heaviest seasonal rainfall occurring between December and March, peaking at a maximum average in January. The annual total precipitation varies sharply across different climatic areas, ranging from less than 50mm in the southern Badia region to as much as 600mm in the Upper Northern Highlands (Figure 6-25).

The prevailing winds throughout the country are westerly to south-westerly, but spells of hot, dry, dusty winds blowing from the southeast off the Arabian Peninsula frequently occur, bringing the country its most uncomfortable weather. Known locally as the 'khamsin', these winds blow most often in the early and late summer and can last for several days at a time, before terminating abruptly as the wind direction changes and much cooler air follows.

Climate within the ESIA Study Area varies by location. The Aqaba governorate has a hot desert climate characterised by very low rainfall, abundant sunshine, and large seasonal and daily temperature ranges. Because the governorate borders the GoA and has a desert terrain, conditions are arid, with clear skies and strong solar radiation, especially in summer. The average mean temperature in Aqaba is 20.2°C with maximum monthly means of 36°C. August is the hottest month of the year with an average temperature of 28.5°C, while January, the coldest month, has an average temperature of 10.4°C. Precipitation patterns are the inverse of the temperature curve (Figure 6-26) with minimal levels in June to September, before gradually increasing towards the end of the year (World Bank Climate Knowledge Centre, 2025). The average annual rainfall in Aqaba is 38.45mm. The modelled wind rose for Aqaba (Meteoblue, 2025), indicates that wind in Aqaba mostly blows from the north and north-northwest.

The Ma'an governorate has a largely arid, desert climate, with extremely low rainfall. Due to its elevation (~850m above sea level) and inland location, the temperature regime exhibits both hot summers and cool winters. The average mean annual temperature is 19.9°C, ranging from 28.8°C in August to 8.9°C in January (Figure 6-27). The average mean precipitation is 50.19mm, with rain mostly falling in January and summer months having virtually no rain. Winds blowing in the Ma'an governorate are predominantly from the northwest and west-northwest directions.

The Tafiela governorate is situated at a relatively high elevation (~1,000 m) compared to many parts of Jordan, which influences its climate to be cooler than that of lower desert areas. The climate is arid to semi-arid, characterised by hot, dry summers and cool, wetter winters , but with overall limited precipitation. The terrain is rugged, and variations in elevation result in local microclimates, leading to conditions that can differ across the governorate. The mean annual temperature in Tafiela is 19.8°C, with daily high averages from about 13°C in January to about 30-33°C in July (Figure 6-28). Rainfall is limited with an annual mean precipitation of 50.19mm. Snow is occasionally possible in the winter months at the elevated parts of the governorate, although it is not heavy or prolonged. Seasonal variation in winds exists, with prevailing north-west and west-northwest directions.

Climate in Karak is similar to that of Tafiela and Ma'an governorates, with an annual mean temperature of 18.8°C and most of the precipitation in the cooler months of November to March (Figure 6-29). Wind rose of Karak is similar to that of Tafiela, dominated by westerly winds.

The Amman governorate is situated on the East Bank Plateau of Jordan, at elevations ranging from ~700 to 1100 meters above sea level, which moderates temperatures compared to the lowland desert areas. The climate is semi-arid to steppe in many parts of the governorate, with some western/northern areas closer to a hot-summer Mediterranean type. Precipitation is modest and concentrated in the cooler months, whilst summers are very dry. The seasonal distribution is a major feature (Figure 6-30). The average mean annual temperature in Amman is 18.2 °C, and the annual average precipitation is around 137 mm. Winds are predominantly from the west-northwest direction with occasional winds from the west-southwest.

Figure 6-24: Climatic Zones within ESIA Study Area

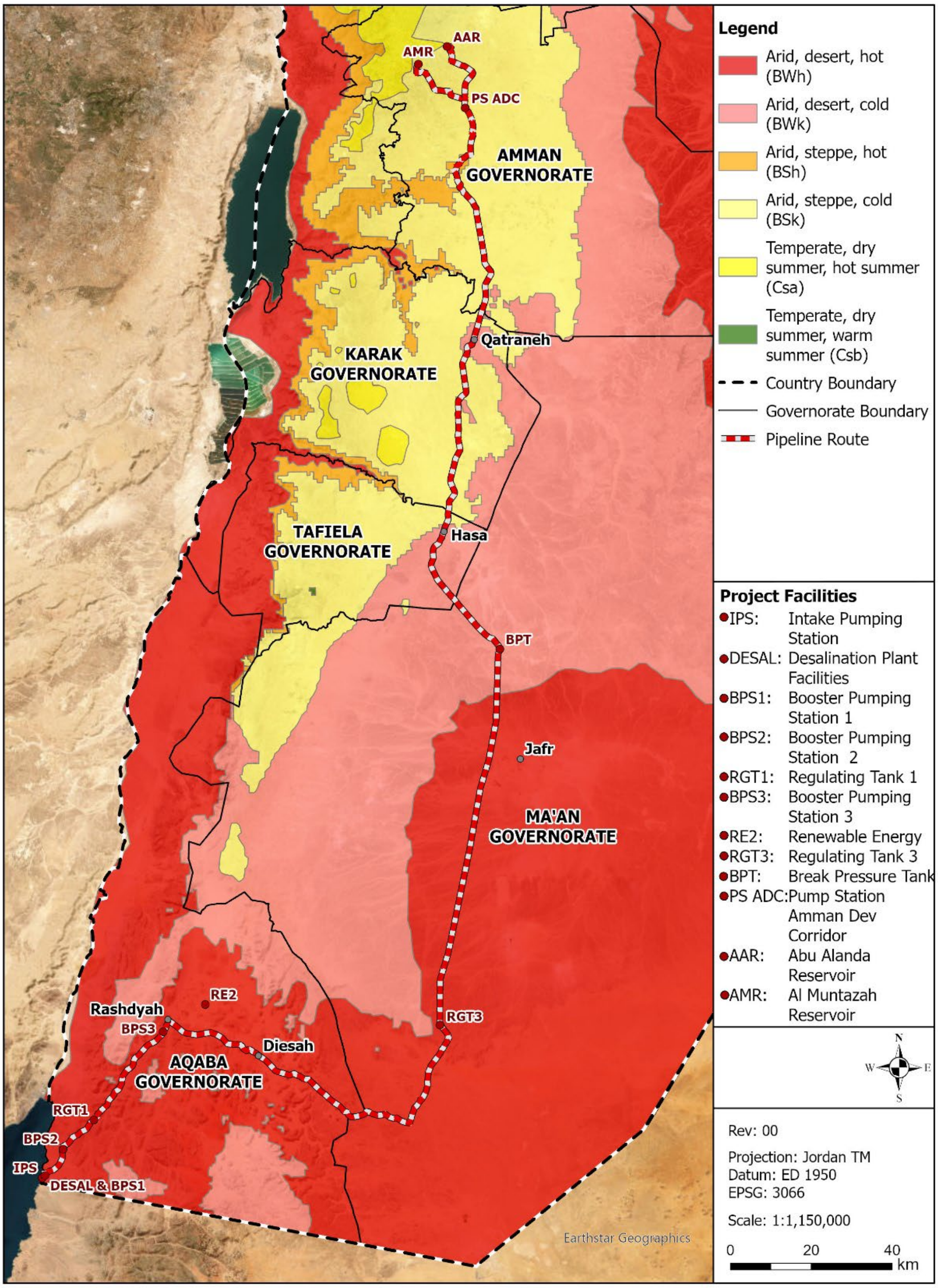


Figure 6-25: Annual Precipitation within ESIA Study Area

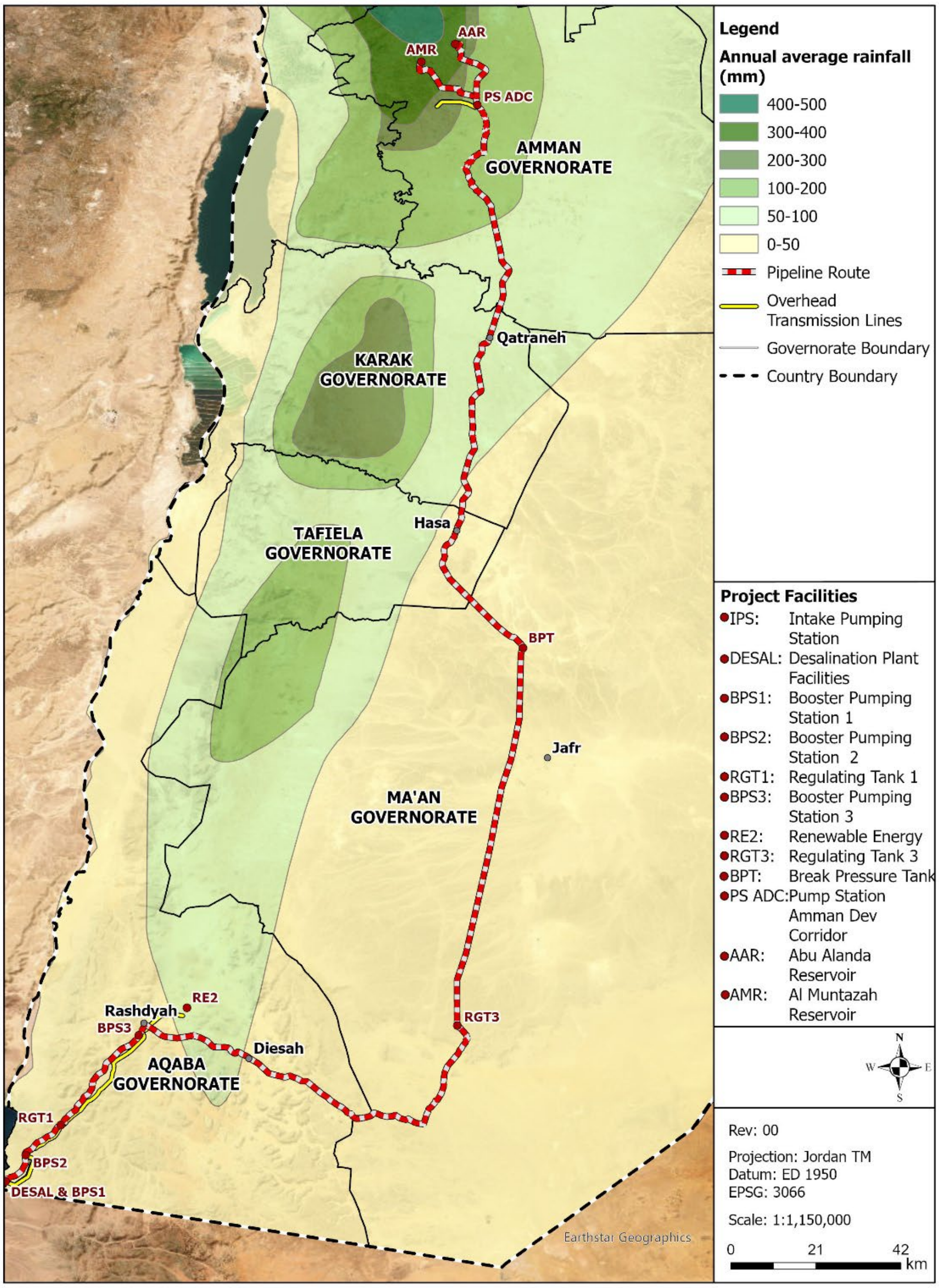


Figure 6-26: Monthly Climatology for Aqaba 1991-2020

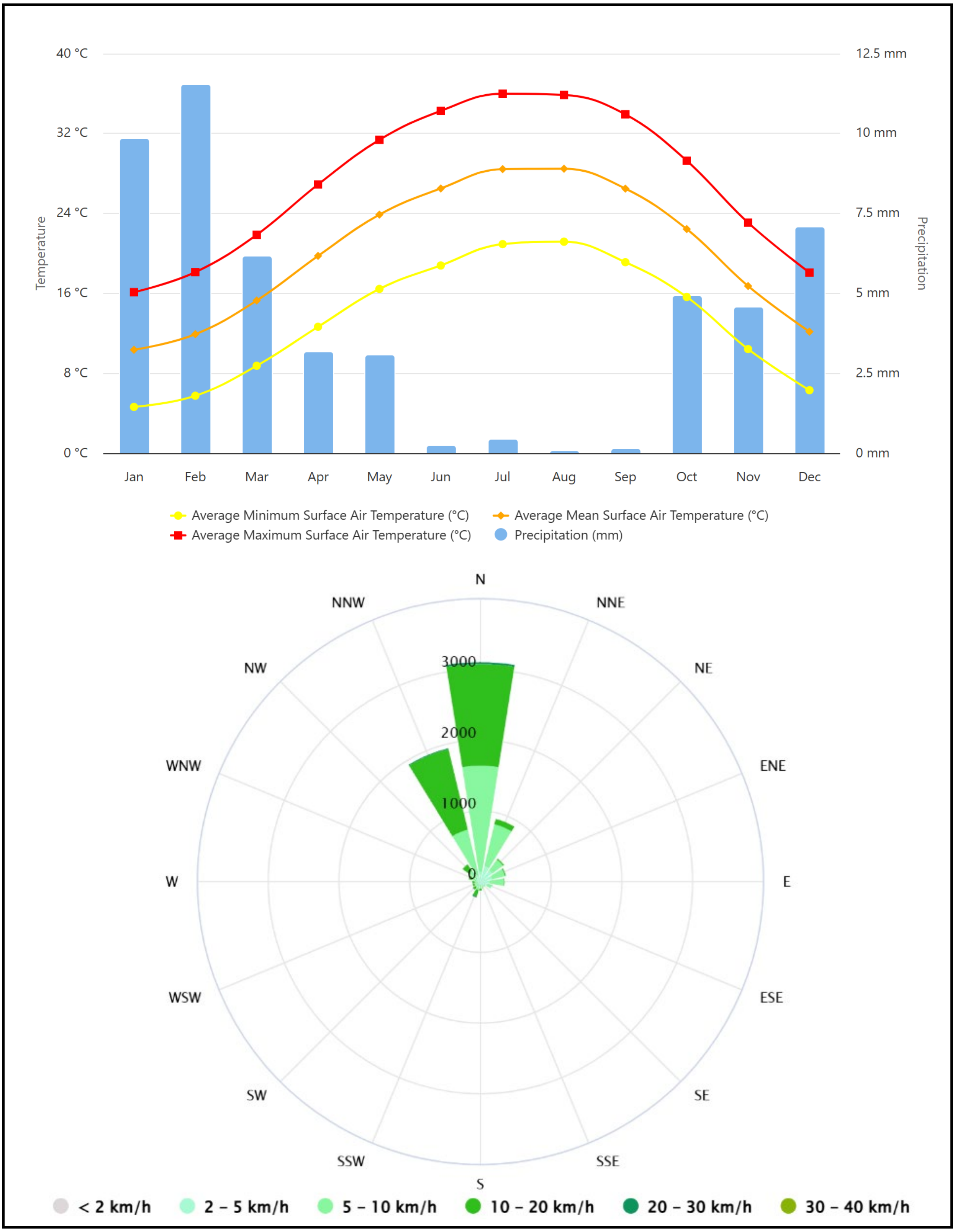


Figure 6-27: Monthly Climatology for Ma'an 1991-2020

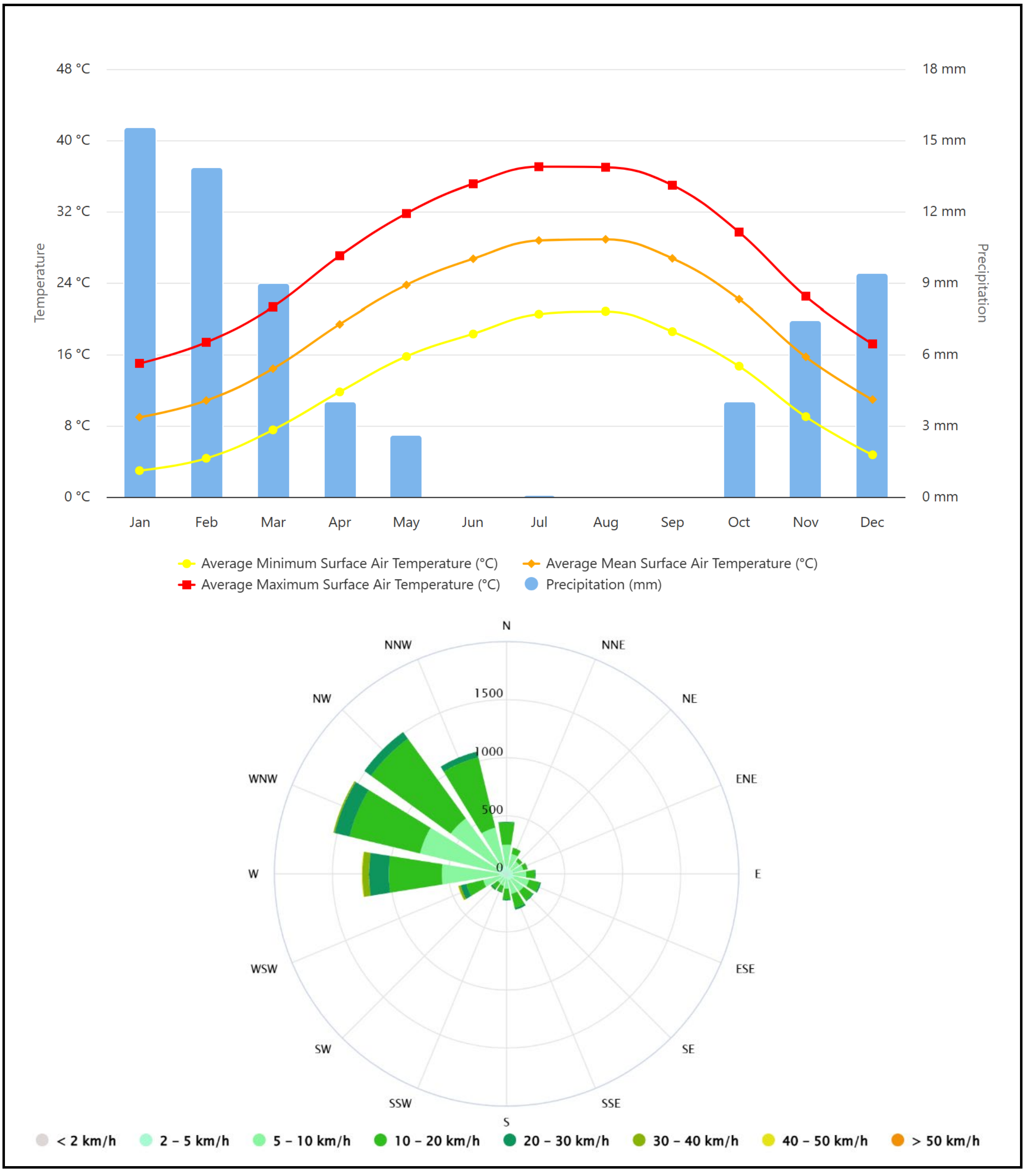


Figure 6-28: Monthly Climatology for Tafiela 1991-2020

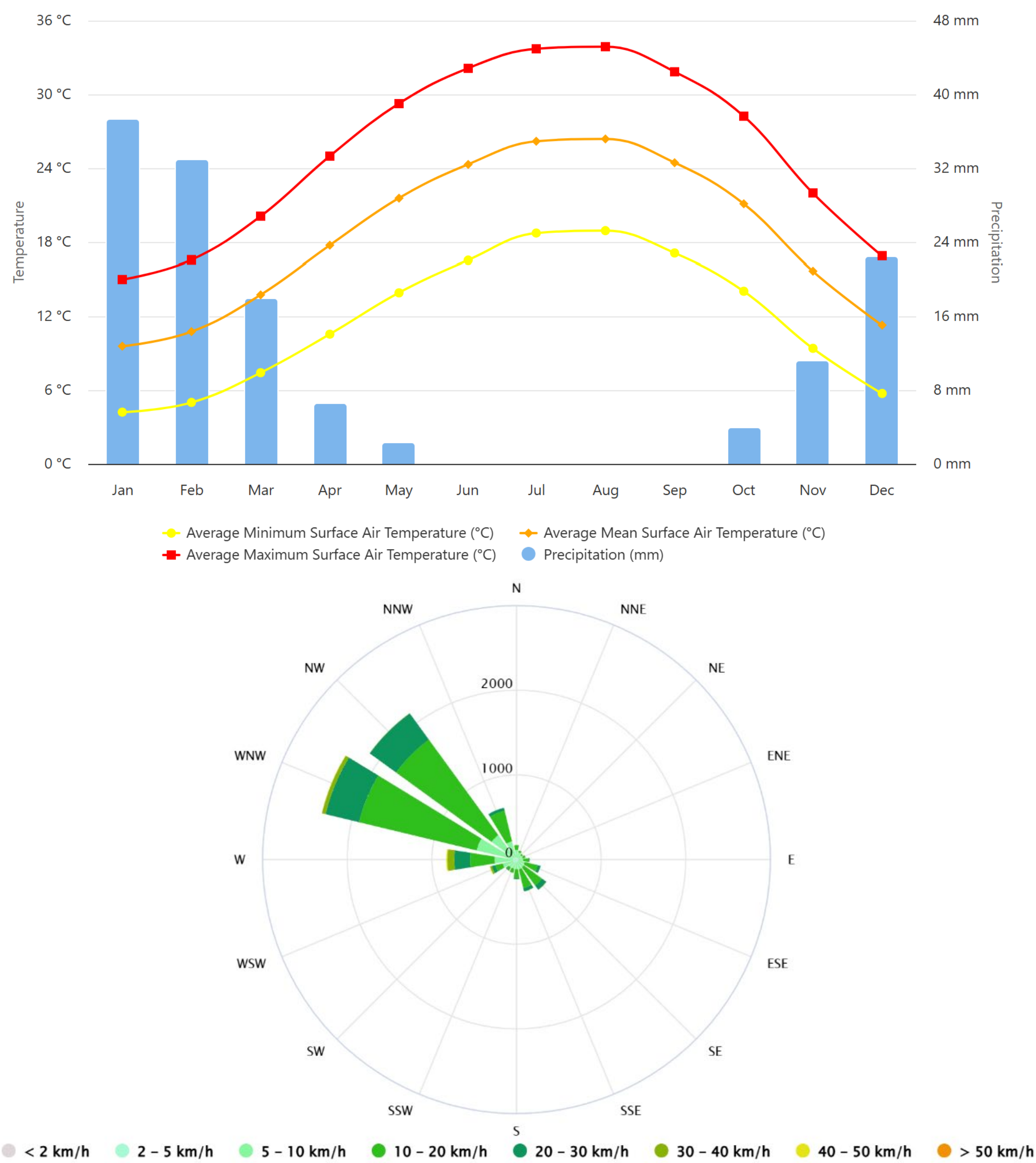


Figure 6-29: Monthly Climatology for Karak 1991-2020

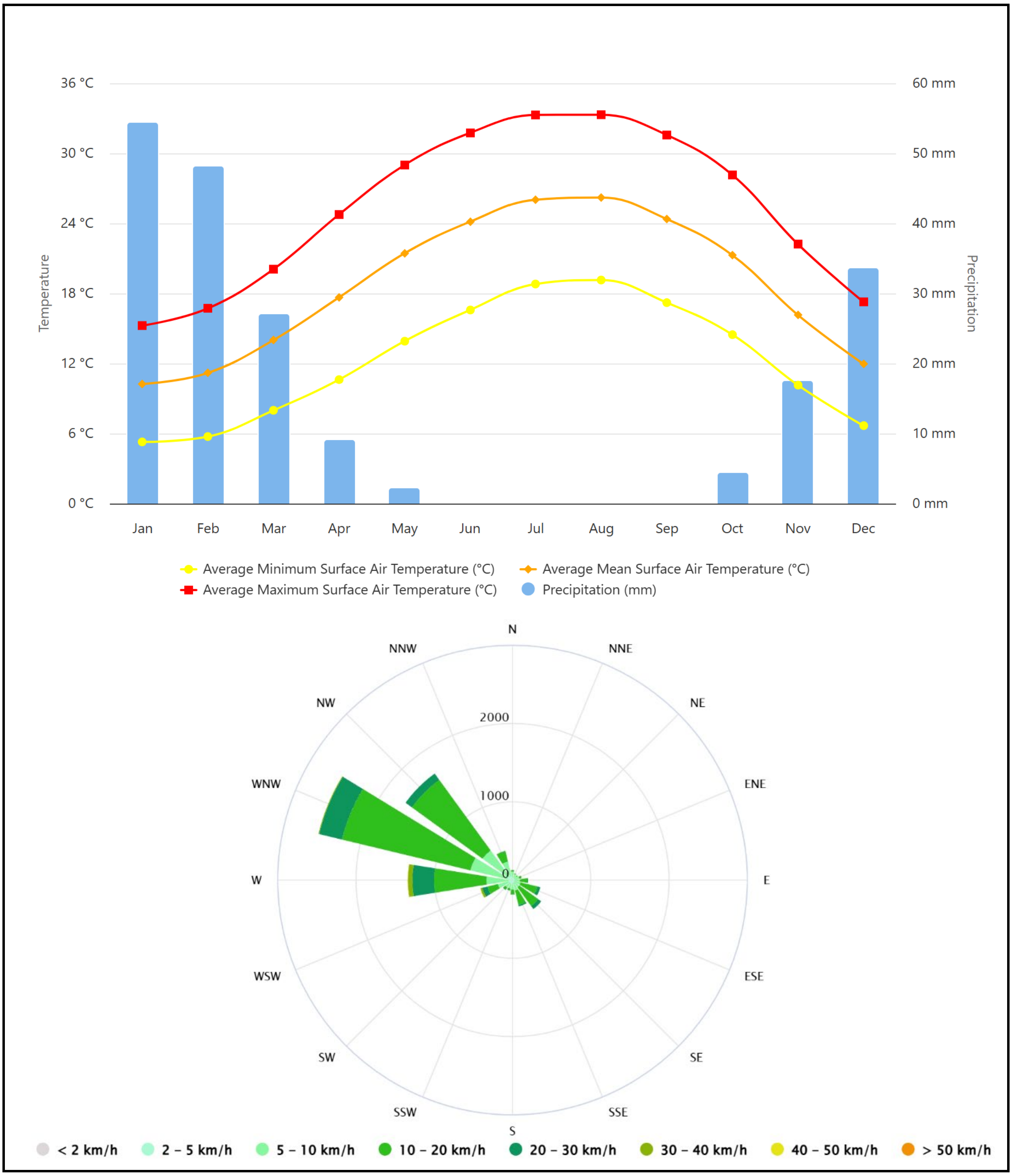
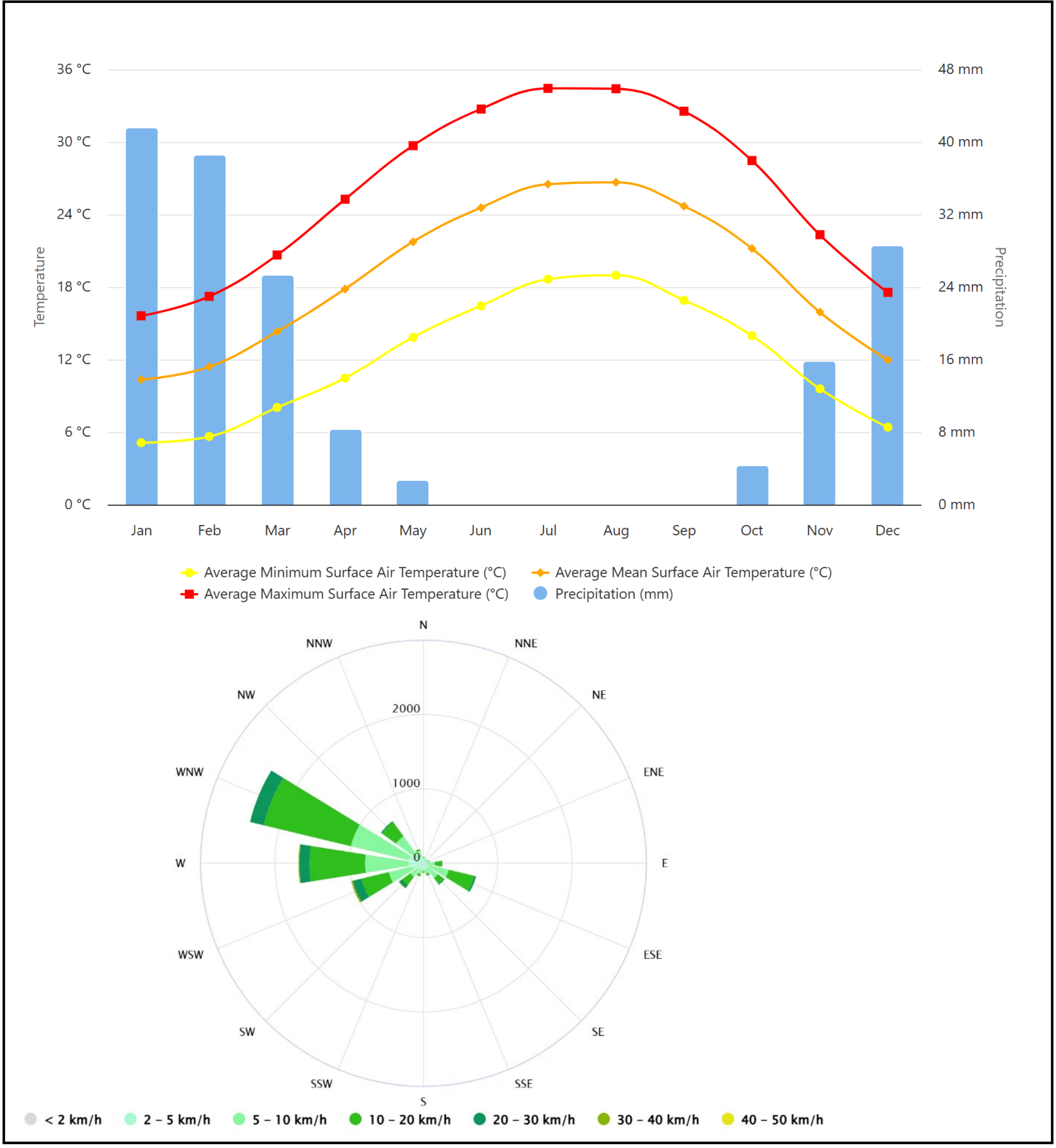


Figure 6-30: Monthly Climatology for Amman 1991-2020



6.2.10 Air Quality

Air quality within the ESIA Study Area has been characterised from the ambient air quality reports published by the Ministry of Environment (MoEnv) and supplemented by other published literature, such as studies for other developments, at the following key locations (Figure 6-31):

- Sahab, Muaqqar and Jizah districts in Amman governorate
- Qatraneh and Al-Sultani in Karak governorate
- Hasa and Al-Rashadiyah in Tafiela governorate
- Ma'an city and Al-Husayneyah village in Ma'an governorate
- Aqaba city in Aqaba governorate

Much of the ESIA Study Area is formed of predominantly desert-like habitats, characterised by sparse vegetation and minimal human activity. As such, these regions do not typically host significant sources of air pollution, which is often associated with urban or industrial settings. The primary air quality concern in these areas arises from particulate matter, which is naturally generated due to the desert conditions and can be exacerbated by frequent dust storms.

6.2.10.1 Amman Governorate

The results for ambient air quality monitoring have been compiled from the MoEnv reports for three stations in the Amman governorate, namely Sahab (located within the King Abdullah II Industrial City), Mowaqqar, and Jizah. These results are compared to the Jordanian Standard on Ambient Air Quality JS: 1140/2024. Since there is no annual permissible limit for SO_2 in JS 1140/2024, the sulphur dioxide results were compared to the annual limit specified in JS 1140/2006.

Table 6-4 presents the latest air quality monitoring results as published by the MoEnv (MoEnv, 2024) for monitoring conducted at Sahab from January to December 2024. The exceedance of $PM_{2.5}$ and NO_2 concentrations can be attributed to the station's location within a highly industrialised zone. The King Abdullah II Industrial City encompasses approximately 435 factories engaged in various industrial and manufacturing activities. These facilities, together with the associated heavy transport and logistical operations, are significant sources of both fine particulate matter and nitrogen oxides.

Previous MoEnv reports (2020 – 2023) indicate annual fine particulate levels were moderate in 2021 (~20µg/m³) but spiked in 2022–2023, reaching 30.1µg/m³ in 2022 and 35.0µg/m³ in 2023. Despite improvement in 2024, the annual $PM_{2.5}$ levels consistently exceeded Jordan's recommended annual average (15 µg/m³), indicating persistent particulate challenges.

Overall, Sahab's air quality results indicate frequent moderate pollution. Based on the Air Quality Index (AQI)[2], the King Abdullah II Industrial City experienced a substantial number of days with 'Moderate' air quality (249 days), which, while generally acceptable, may still pose mild health risks to vulnerable groups. Additionally, 59 days were classified as 'Unhealthy for Sensitive Groups', and two days reached the 'Unhealthy' level, showing that elevated pollution levels occur regularly throughout the year. Air quality was rated as 'Good' on only 35 days, with no days classified as 'Very Unhealthy' or 'Hazardous'.

[2] The AQI, developed by the US EPA, is a numerical scale that communicates air pollution levels and associated health risks. AQI values are divided into six categories: 0–50 (Good), 51–100 (Moderate), 101–150 (Unhealthy for sensitive groups), 151–200 (Unhealthy), 201–300 (Very Unhealthy), and 301–500 (Hazardous).

Table 6-4: Air Quality Monitoring Results at Sahab Station

Parameters	2024 Result (Annual Average)	JS: 1140/2024 (Annual Permissible Limit)
SO_2 (ppb)	2	40[1]
NO_2 (ppb)	31	21
$PM_{2.5}$ (µg/m^3)	25	15
[1] The SO_2 annual limit applied in this table is derived from JS 1140/2006, as JS 1140/2024 does not stipulate an annual value		

Table 6-5 presents the results of air quality monitoring at Mowaqqar station as published by MoEnv for 2024. The results indicate exceedance in $PM_{2.5}$ levels, whilst SO_2 and NO_2 levels remained within the applicable thresholds throughout the monitoring period from January 2024 to December 2024.

In accordance with MoEnv reports for previous years, in 2020, the Mowaqqar station's annual average PM_{10} concentration was 48.8µg/m^3, below the annual limit of 70µg/m^3. However, short-term dust events caused multiple spikes above the 24-hour standard. There were 10 days in 2020 when the 24-hour PM_{10} average exceeded 120µg/m^3, well beyond the allowed three exceedances per year, indicating frequent dust episodes. Notably, these PM_{10} exceedances occurred across all stations in Jordan that year due to natural dust storms. After 2020, no PM_{10} data are reported for Mowaqqar in official MoEnv summaries, as the network shifted focus to $PM_{2.5}$ monitoring.

The fine particulate levels ($PM_{2.5}$) have consistently exceeded the annual permissible limit of 15µg/m^3 every year since 2021, with the first result of 20.1µg/m^3 surpassing the limit by ~34%. In 2022, the annual average rose to 30.1 µg/m^3, nearly double the standard, reflecting a deterioration in air quality (likely due to increased dust and emissions following 2020). 2023 saw the highest fine particulate levels, with an average of around 35 µg/m^3, more than twice the allowable annual limit. By 2024, the annual $PM_{2.5}$ mean declined to 26.1 µg/m^3 but remained well above the 15µg/m^3 standard.

Air quality at the Mowaqqar district was mostly 'Good' (313 days) based on the AQI, indicating generally clean air throughout the year, with occasional days that may have caused mild health effects for vulnerable individuals. . Similar to the results at the Sahab station, there were no days classified as 'Very Unhealthy' or 'Hazardous' recorded.

Table 6-5: Air Quality Monitoring Results at Mowaqqar Station

Parameters	2024 Result (Annual Average)	JS: 1140/2024 (Annual Permissible Limit)
SO_2 (ppb)	2	40[1]
NO_2 (ppb)	0	21
$PM_{2.5}$ (µg/m^3)	26.1	15
[1] The SO_2 annual limit applied in this table is derived from JS 1140/2006, as JS 1140/2024 does not stipulate an annual value		

Table 6-6 presents the MoEnv 2024 monitoring results at the Jizah air quality monitoring station. The annual average of PM_{10} exceeded the permissible limit, whilst NO_2 and SO_2 concentrations remained compliant with the national standard. The Jizah AQI was 'Moderate' for 251 days in 2024, 'Good' on 86 days, 'Unhealthy for Sensitive Groups' on 25 days, with 1 day when the AQI reached the 'Hazardous' level.

Table 6-6: Air Quality Monitoring Results at Jizah Station

Parameters	2024 Result (Annual Average)	JS: 1140/2024 (Annual Permissible Limit)
SO_2 (ppb)	2	40[1]
NO_2 (ppb)	13	21
PM_{10} (μg/m^3)	93	70
[1] **The SO_2 annual limit applied in this table is derived from JS 1140/2006, as JS 1140/2024 does not stipulate an annual value**		

6.2.10.2 Karak Governorate

The Qatraneh station became operational in 2022 under a joint program between the MoEnv and the Royal Scientific Society (RSS), focusing on air quality in industrial cities. Prior to 2022, no continuous ambient monitoring existed at Qatraneh. Baseline measurements taken during a six-day monitoring campaign by MoEnv in 2019 indicated that criteria pollutants were within permissible limits at this location, except for slight exceedances of H_2S and SO_2 levels on one day of the monitoring period.

Data collected by MoEnv/RSS from January to December 2022 revealed that particulate levels spiked periodically due to dust events. $PM_{2.5}$ was the primary concern: the annual average $PM_{2.5}$ exceeded the 15 μg/m^3 standard, and 5 days surpassed the 24-hour limit (65μg/m^3). Intense spring sandstorms (notably in April) caused extreme PM peaks, such as, for example, a late-April storm pushed hourly $PM_{2.5}$ into hazardous ranges (~458μg/m^3 daily peak) (MoEnv, 2022). PM_{10} likewise surged during such events (exceeding the 120 μg/m^3 daily standard on storm days). Concentrations of NO_2, SO_2, and CO stayed within the permissible limits.

Table 6-7 presents the MoEnv monitoring results at the Qatraneh air quality monitoring station in 2023. The annual average of $PM_{2.5}$ exceeded the permissible limit, whilst NO_2 and SO_2 concentrations remained compliant with the national standard. The 2023 data followed the 2022 pattern: $PM_{2.5}$ remained elevated due to two intense sandstorm periods (May and September 2023), which led to multiple "Unhealthy" AQI days. The station recorded around 9 days where $PM_{2.5}$ exceeded the daily standard and consequently, the annual mean $PM_{2.5}$ again surpassed the permissible limit.

The Qatraneh station remained operational through 2024, though official results have not yet been published. No significant changes in emission sources or station status were reported. It is expected that air-quality patterns in 2024 will mirror those of 2022-2023, predominantly characterised by good-to-moderate air quality with occasional high-PM events during regional dust storms. Notably, other rural monitoring stations (e.g., Hasa and Al-Rashadiyah in 2024) continued to record PM levels below permissible limits, suggesting that Qatraneh likely also saw few or no standard exceedances in 2024, aside from any extreme weather episodes.

Table 6-7: Air Quality Monitoring Results at Qatraneh Station

Parameters	2023 Result (Annual Average)	JS: 1140/2024 (Annual Permissible Limit)
SO_2 (ppb)	4.5	40[1]
NO_2 (ppb)	6.2	21
$PM_{2.5}$ (μg/m^3)	18.3	15

Parameters	2023 Result (Annual Average)	JS: 1140/2024 (Annual Permissible Limit)
[1] **The SO_2 annual limit applied in this table is derived from JS 1140/2006, as JS 1140/2024 does not stipulate an annual value**		

Al-Sultani is a monitoring site along the Desert Highway representing a rural desert environment. It has not previously been part of the main real-time urban air quality network. As a result, continuous data from Al-Sultani is limited. The collected data at Al-Sultani station is available from specific studies by MoEnv, such as the 2020 nationwide ambient air quality assessment and a 2024 study on industrial areas.

Al-Sultani's air quality profile has been characterised by high particulate levels ($PM_{2.5}$ and PM_{10}) driven by natural dust and low concentrations of gaseous pollutants. The official data do not indicate any dramatic trend of improvement or deterioration at this remote site; instead, year-to-year fluctuations were observed, mainly tied to weather patterns (e.g. the frequency and severity of dust storms). There are hints of a slight reduction in average PM_{10} in 2024 compared to 2020, but this change is modest and could be due to a less dust storms. $PM_{2.5}$ remained persistently around the standard limit in most years, underscoring a continuing fine-particle issue nationally. In contrast, NO_2, SO_2, CO, and O_3 exhibited steady and compliant levels with no notable changes.

6.2.10.3 Tafiela Governorate

Table 6-8 and Table 6-9 present results of air quality monitoring at Hasa and Al-Rashadiyah stations as published by MoEnv for 2024. The results indicate that both $PM_{2.5}$ and PM_{10} levels remained below the permissible limits.

The Hasa monitoring station became operational in 2021 to continuously collect PM_{10} and $PM_{2.5}$ measurements, filling an essential gap in the national monitoring network and providing insight into rural dust conditions, which differ from urban pollution profiles.

According to earlier MoEnv reports for 2021-2023, the Hasa station has revealed a persistent challenge to air quality driven by dust. Year by year, PM_{10} levels have been high, exceeding the permissible limits in 2023, while $PM_{2.5}$ levels have stayed near the threshold but are compliant. The station data highlights the impact of natural events (dust storms) on air quality in the region. Exceedances of the 24-hour PM_{10} standard occur regularly at Hasa. Between 2021 and 2023, multiple dust episodes occurred, resulting in exceedances of the daily permissible limits.

Table 6-8: Air Quality Monitoring Results at Hasa Station

Parameters	2024 Result (Annual Average)	JS: 1140/2024 (Annual Permissible Limit)
PM_{10} ($\mu g/m^3$)	64.1	70
$PM_{2.5}$ ($\mu g/m^3$)	13.1	15

The Al-Rashadiyah station is located near the Lafarge cement plant and is categorised as an industrial-area station. It was integrated into the national air quality monitoring network in 2023, in collaboration with Lafarge, as part of the MoEnv air quality monitoring network expansion. No data is available before the integration. The station primarily monitors fine particle matter ($PM_{2.5}$).

Table 6-9 presents the results of air quality monitoring at Al-Rashadiyah station as published by MoEnv for 2024. The results indicate that the $PM_{2.5}$ level remained below the permissible limits during the monitoring period from January to December 2024.

For 2023, the station recorded an annual average $PM_{2.5}$ of 13µg/m³, below the permissible limit of 15 µg/m³. This made it one of the cleaner stations in the network for fine particles. In fact, the only stations meeting the annual $PM_{2.5}$ standard in 2023 were in Tafiela governorate (Al-Rashadiyah and Hasa), whilst all other monitored urban stations recorded exceedances of the permissible limits.

The relatively low $PM_{2.5}$ at Al-Rashadiyah reflects its rural/industrial setting, with fewer combustion sources; however, dust from the nearby cement operations and desert likely contributes to coarse particles (PM_{10}) more than to fine $PM_{2.5}$.

Table 6-9: Air Quality Monitoring Results at Al-Rashadiyah Station

Parameters	2024 Result (Annual Average)	JS: 1140/2024 (Annual Permissible Limit)
$PM_{2.5}$ (µg/m³)	12	15

6.2.10.4 Ma'an Governorate

Ma'an is a smaller city with few local pollution sources, and its air quality has been classified as predominantly 'good' to 'moderate' AQI. However, windblown dust is a significant factor in Ma'an, leading to short-term increases in particulate matter levels. The national monitoring network did not actively report data from a Ma'an station for much of 2020–2023, indicating a data gap. By 2024, the network had begun expanding to southern governorates, but Ma'an still lacked a dedicated automatic station, as noted in the official reports.

The ambient air quality data for Ma'an are available from a six-day campaign conducted by the MoEnv in 2019 at two locations, Ma'an City and Al-Husayneyah village. The collected data for both locations, summarised in Table 6-10 and Table 6-11 below, indicate that all measured parameters were within the permissible limits established by the Jordanian Standard JS: 2024/1140, except for H_2S, which was slightly above the allowable threshold.

Table 6-10: Air Quality Monitoring Results for Ma'an City

Date	Parameters					
	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (ppb)	NO_2 (ppb)	H_2S (ppb)	NH_3 (µg/m³)
	JS 2024/1140					
	70	50	48	64	10	270
20 Sep 2019	62	23	9.13	4.98	11.50	3.73
21 Sep 2019	52	18	7.62	4.25	11.70	4.70
22 Sep 2019	36	12	8.27	6.68	11.43	2.42
23 Sep 2019	49	17	8.59	8.58	11.87	2.14
24 Sep 2019	41	12	8.02	9.35	11.70	1.33
25 Sep 2019	41	13	9.56	9.49	11.25	1.17

Table 6-11: Air Quality Monitoring Results for Al-Husayneyah

Date	Parameters					
	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (ppb)	NO_2 (ppb)	H_2S (ppb)	NH_3 (µg/m³)
	JS 2024/1140					
	70	50	48	64	10	270
13 Sep 2019	33	9	11.91	2.55	10.7	5.68
14 Sep 2019	53	19	8.44	2.40	11.2	7.31
15 Sep 2019	49	18	7.10	1.87	11.6	5.94
16 Sep 2019	40	17	8.48	2.98	11.4	5.44
17 Sep 2019	44	15	10.43	4.90	11	5.04
18 Sep 2019	51	14	8.47	4.92	11.3	4.14

6.2.10.5 Aqaba Governorate

The Aqaba ambient air quality monitoring station was integrated into Jordan’s national monitoring network in 2022 as part of the MoEnv air quality monitoring network expansion, in cooperation with ASEZA. The 2020–2021 data for Aqaba is not published, and after integration into the MoEnv network in 2022, the Aqaba station’s data were omitted from the 2023 and 2024 official reports.

For Aqaba City, hourly air quality measurements were obtained from the MoEnv for the period of one month between 27 August 2025 and 27 September 2025 (Table 6-12). The results reflect daily variations in key pollutants with 24-hour averages for SO_2, NO_2, and PM_{10}, and an 8-hour average for O_3. Air quality parameters remained consistently within the permissible limits except for ozone (O_3), which slightly exceeded the limit on 5 days during the 30-day monitoring period.

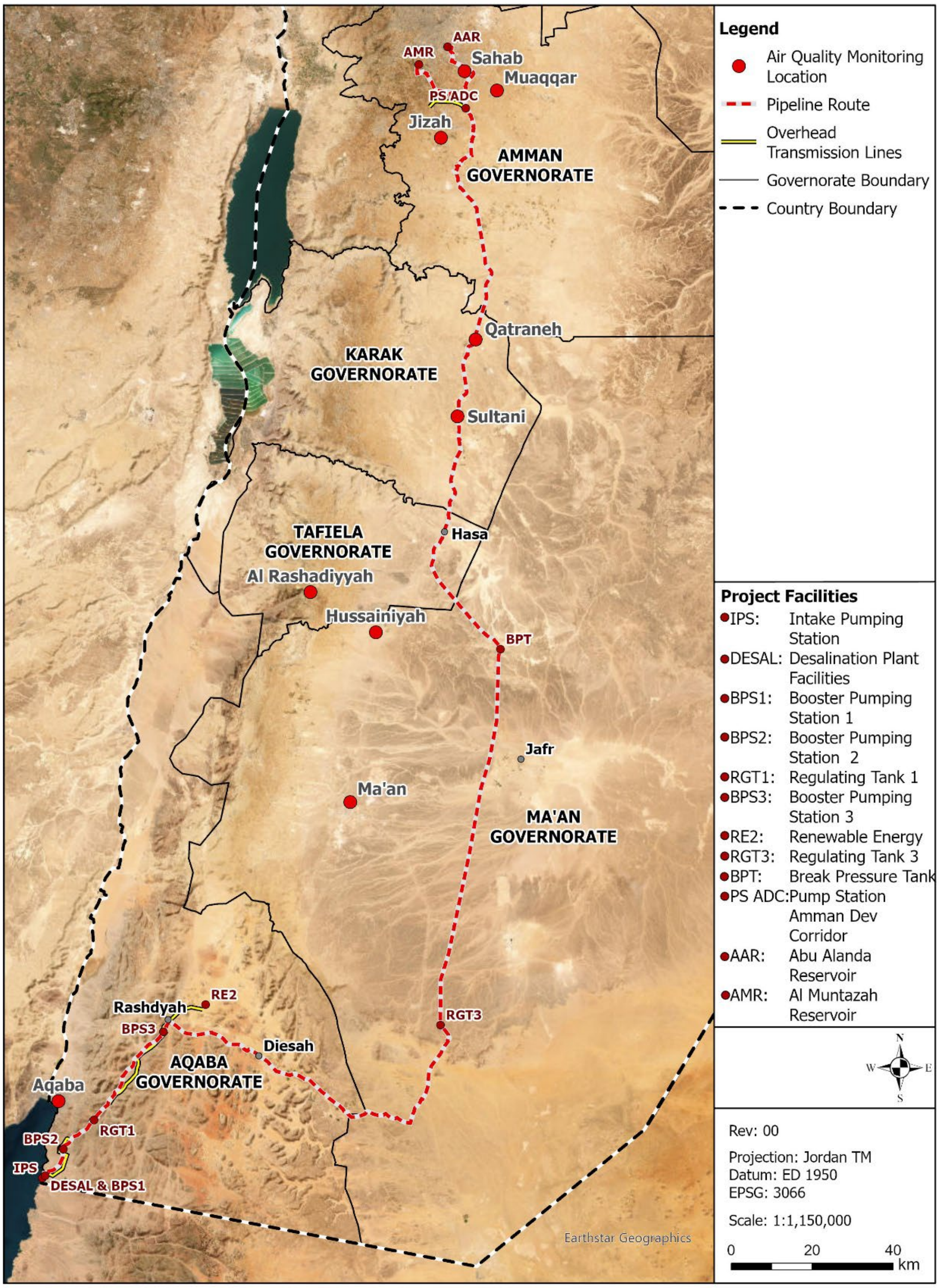
Due to limited data availability, it is challenging to quantify clear trends at the Aqaba station. Available 2022 and 2025 data suggest the city’s air pollution profile remains characterised by low urban-industrial emissions and periodic natural dust incursions. Overall air quality in Aqaba ranges between ‘Good’ and ‘Moderate’ AQI, with pollutant levels generally low.

Table 6-12: Ambient Air Quality Measurements for Aqaba City

Date	Parameters			
	SO_2 (ppb)	NO_2 (ppb)	PM_{10} (µg/m3)	O_3 (ppb)
	JS 1140/2024			
	48	64	70	61
27 Sep 2025	3.17	10.1	24.1	51.87
26 Sep 2025	2.99	8.58	20.5	57.51
25 Sep 2025	2.82	10.3	22.7	61.16
24 Sep 2025	2.94	8.97	31.6	60.87
23 Sep 2025	2.58	11.2	33.2	52.56

Date	Parameters			
	SO_2 (ppb)	NO_2 (ppb)	PM_{10} (µg/m3)	O_3 (ppb)
	JS 1140/2024			
	48	64	70	61
22 Sep 2025	2.32	11.6	29.6	60.57
21 Sep 2025	2.8	11.3	30.3	63.42
20 Sep 2025	2.93	8.75	24.9	55.67
19 Sep 2025	2.88	8.75	15.5	55.63
18 Sep 2025	2.83	12.0	20.0	48.33
17 Sep 2025	2.93	11.3	17.7	49.81
16 Sep 2025	2.38	9.54	23.0	44.97
15 Sep 2025	2.61	11.3	23.5	51.00
14 Sep 2025	3.2	12.6	22.1	57.12
13 Sep 2025	2.75	10.6	19.9	59.85
12 Sep 2025	2.88	10.5	22.1	55.61
11 Sep 2025	2.88	10.6	25.4	55.97
10 Sep 2025	2.77	9.39	18.7	48.85
9 Sep 2025	2.61	8.85	19.8	50.27
8 Sep 2025	2.85	10.2	17.4	52.23
7 Sep 2025	2.56	8.19	19.4	49.38
6 Sep 2025	2.55	8.85	29.5	56.61
5 Sep 2025	2.52	11.7	24.8	62.83
4 Sep 2025	2.66	13.8	19.9	72.04
3 Sep 2025	2.67	10.8	15.9	47.94
2 Sep 2025	3.02	11.8	18.0	47.68
1 Sep 2025	2.82	11.7	21.5	52.10
31 Aug 2025	2.79	8.96	29.6	50.33
30 Aug 2025	2.54	12.8	22.4	60.34
29 Aug 2025	2.73	10.7	17.2	50.97
28 Aug 2025	2.26	10.1	20.3	52.47
27 Aug 2025	0.96	9.96	26.6	61.53
Average	2.69	10.49	22.72	54.9

Figure 6-31: Air Quality Monitoring Stations within the ESIA Study Area



6.2.11 Noise

Various published data sources have been used to characterise the baseline acoustic environment at the following key locations, which are representative of areas within the ESIA Study Area (Figure 6-32):

- Sahab district and Ras Al-Ain Area in Amman governorate
- Al-Husayneyah and Jaya villages in Ma'an governorate
- Aqaba City and Wadi Rum in Aqaba governorate

All results were compared against the permissible limits set in the Instructions for Reduction and Prevention of Noise, 2003.

6.2.11.1 Amman Governorate

Noise monitoring was conducted in September 2021 in the Sahab district as part of the baseline study for the 2022 AAWDC Project ESIA. The measurements were performed over a 72-hour monitoring period, with data recorded at 1-hour intervals in accordance with the ANSI S1.13 standard test method.

The measured noise levels surpassed the permitted daytime thresholds, which can be attributed to the influence of nearby activities at King Abdullah II Industrial City, located around 1.2km from the monitoring point. Despite this, the average noise levels were observed to remain largely within the acceptable limits established under the national noise Instructions (Table 6-13).

This monitoring point is situated in a predominantly residential area that includes some commercial facilities. Consequently, it can be considered representative of the other regions along the proposed pipeline route, such as Rajm Al-Shami Suburb in Mowaqqar district. Although Rajm Al-Shami is not a major urban centre like Sahab, it shares similar residential characteristics and is located closer to the King Abdullah II Industrial City.

Table 6-13: Noise Measurements Results for Sahab District

Timeframe	2021 Results									Permissible Limit[1]
	Daily Min. reading			Daily Max. reading			Daily average			
	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	
Daytime dB(A)	37.7	36.8	37.4	77.8	77.8	78.6	55.0	55.1	52.6	65dB(A)
Nighttime dB(A)	37.9	37.6	36.8	36.8	36.8	36.8	36.8	46.3	46.3	55dB(A)

[1] Permissible Limit for Residential Areas with Small Workshops, Crafts or Commercial Activities (Instructions for Reduction and Prevention of Noise, 2003)

Noise data for the Ras Al Ain area was collected during a 2017 monitoring campaign at the Greater Amman Municipality (GAM) building as part of the ESIA for the Amman and Amman-Zarqa Bus Rapid Transit (BRT) Systems (Engicon, 2017). Measurements were taken with a handheld sound level metre, positioned opposite the wind direction, using a windshield-equipped microphone, for 15 minutes each session, conducted four times during both day and night.

The survey recorded elevated ambient noise, with average daytime and nighttime levels of 76.1dB(A) and 58.7dB(A), respectively, which exceeded the permissible limits of 65dB(A) daytime and 55dB(A) nighttime prescribed for residential areas with small workshops, crafts, or commercial activities.

The elevated noise levels can be attributed to the measuring point being located within a densely populated residential area and in proximity to major roads, which significantly contributed to the background noise.

These survey results from the Ras Al Ain area may also be representative of sensitive receptors located along the Conveyance Pipeline route, such as the Abu Alanda area, which shares similar conditions of dense residential development and proximity to major roads.

6.2.11.2 Ma'an Governorate

Noise data is available from a baseline survey conducted in August 2018 in Al-Husayneyah village for the 50MW Solar Power Project ESIA (ECO Consult, 2018) (Table 6-14). The results exceeded the permissible limits for residential areas in villages.

The monitoring point was situated more than 20 km from the Conveyance pipeline route. The surrounding area is generally quiet and free of major noise sources, aside from nearby agricultural activities close to the monitoring point, which likely contributed to noise level exceedances. Noise data from Al-Husayneyah village can be regarded as representative of multiple locations along the proposed Project pipeline route within Ma'an governorate, where the route passes mainly through vacant lands with some agricultural use activities.

Table 6-14: Noise Measurement Results for Al-Husayneyah Village

Timeframe	2018 Results (Daily Average)	Permissible Limit[1]
Daytime dB(A)	61.37	50dB(A)
Nighttime dB(A)	51.07	40dB(A)
1 Permissible Limit for Residential Areas in Villages (Instructions for Reduction and Prevention of Noise, 2003)		

Another source of noise data for Ma'an governorate is the 2017 baseline survey for the Shobak 45 MW Wind Power Project ESIA (ECO Consult, 2017) near the Jaya Village. The survey was conducted over a 24-hour period at each monitoring site using a dB 307 Noise Meter to measure ambient noise levels and assess existing acoustic conditions in the project area.

The results of the survey are presented in Table 6-15 indicate compliance with the permissible limits for residential areas in villages.

The noise monitoring point is situated approximately 50 km from the Conveyance pipeline route. The area can be characterised as a rural residential–agricultural area, consisting of a village with a typical concentration of residential buildings alongside surrounding agricultural land. Similar to the monitoring location at Al-Husayneyah village, the Jaya village monitoring point can be regarded as representative of several locations along the proposed Project pipeline route, such as Jafr and Hasa, due to their similar characteristics in terms of land use, residential and agricultural mix, and absence of major noise sources.

Table 6-15: Noise Measurement Results for Jaya Village

Timeframe	2017 Results (Daily Average)	Permissible Limit[1]
Daytime dB(A)	44.6	50dB(A)

Timeframe	2017 Results (Daily Average)	Permissible Limit[1]
Nighttime dB(A)	42.9	40dB(A)
1 Permissible Limit for Residential Areas in Villages (Instructions for Reduction and Prevention of Noise, 2003)		

6.2.11.3 Aqaba Governorate

Within the Aqaba governorate, noise monitoring was conducted in September 2021 in Wadi Rum as part of the baseline surveys for the 2022 AAWDC Project ESIA. The survey lasted 72 hours, with measurements recorded every hour in accordance with the ANSI S1.13 test method.

When compared with the permissible limits for residential villages (Table 6-16), exceedances for permissible daytime thresholds are noted, likely due to the proximity of the monitoring site to the Rum Agriculture Company workshops. However, the overall average noise levels were found to be generally in compliance with the permissible limits.

The area around the monitoring location consists of several farms with scattered residential houses, except for the Rum Agriculture Company workshops and vehicle movement on a nearby secondary road, which are the primary sources of noise. The monitoring point is considered a suitable representation of the typical baseline noise conditions in the surrounding villages of Wadi Rum, such as Shakriyye Village.

Table 6-16: Noise Measurement Results for Wadi Rum

Timeframe	2021 Results									Permissible Limit[1]
	Daily Min. reading			Daily Max. reading			Daily average			
	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	
Daytime dB(A)	32.1	32.1	31.3	73.2	66.9	71.3	43.3	40.3	41.9	50dB(A)
Nighttime dB(A)	31.6	31.4	32.6	71.4	71.4	68.1	40.2	38.0	38.6	40dB(A)
[1] Permissible Limit for Residential Areas in Villages (Instructions for Reduction and Prevention of Noise, 2003)										

Noise data for Aqaba city and surrounding areas is available from the baseline environmental assessment carried out by Japan International Cooperation Agency (JICA) in collaboration with ASEZA in January 2024 as part of the ASEZ Urban Development Master Plan Update Study, aimed to assess existing environmental conditions within the zone and to provide reference data for sustainable urban and industrial planning. As part of this baseline assessment, ambient noise measurements were conducted at four representative locations in Aqaba, including residential areas, main roads, and resort zones.

Table 6-17 presents the results of the noise measurements. Results for densely populated locations with high commercial activities in Aqaba city and locations near the main road exceed the permissible daytime and nighttime limits, influenced by industrial activities and traffic.

Table 6-17: Noise Measurement Results for Aqaba

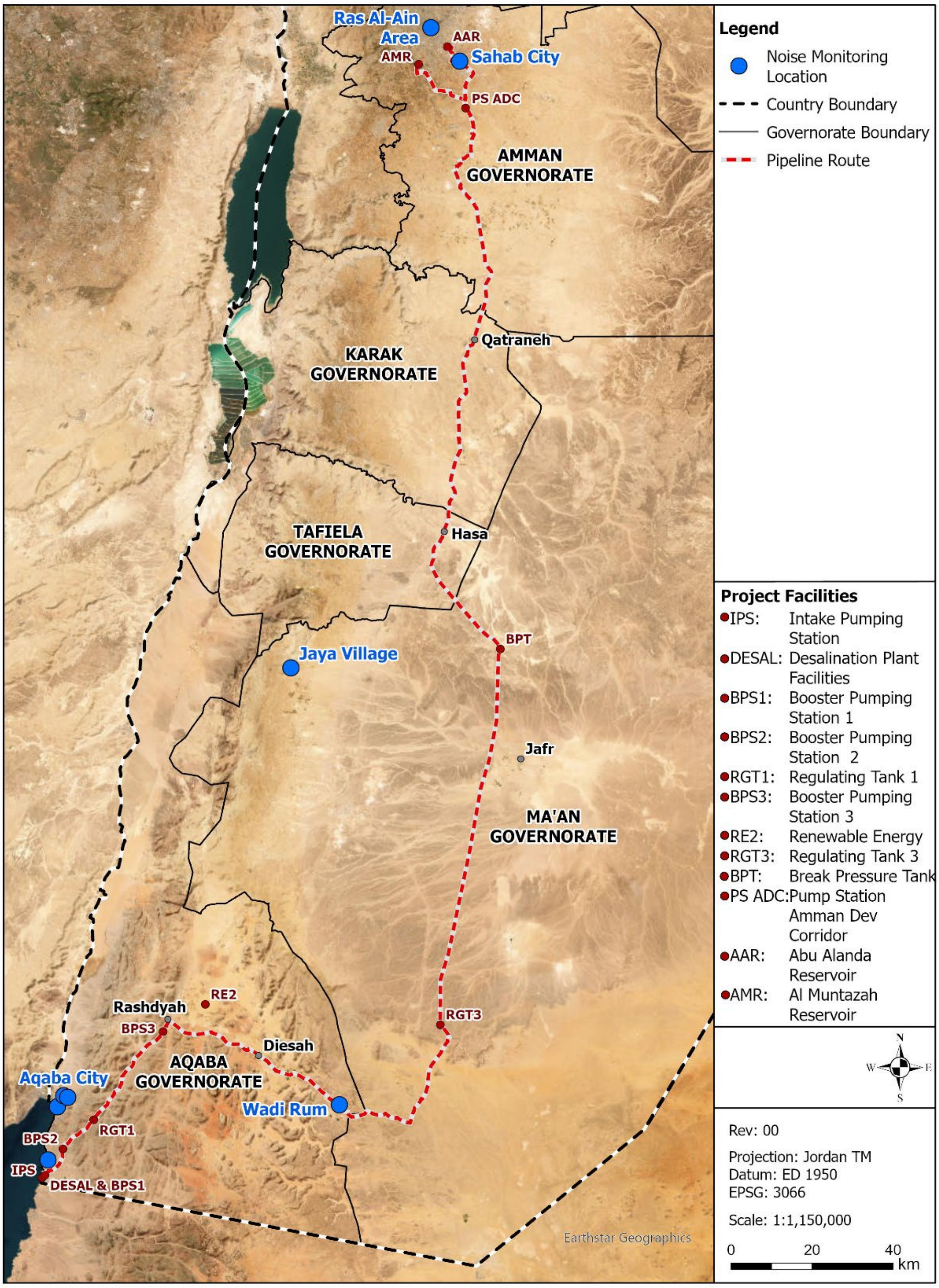
Monitoring Point	Area Type	Distance from Project Pipeline (Km)	Timeframe	2024 Results	Permissible Limit
1 Aqaba City		8.4	Daytime dB(A)	66.6	65db(A)[1]

Monitoring Point	Area Type	Distance from Project Pipeline (Km)	Timeframe	2024 Results	Permissible Limit
	Mixed commercial and tourism area		Nighttime dB(A)	56.4	55db(A)[1]
2 Aqaba City	Residential area	9.2	Daytime dB(A)	65.8	60db(A)[2]
			Nighttime dB(A)	50.8	50db(A)[2]
3 Main Road	Mixed commercial and residential area	8.1	Daytime dB(A)	73.5	65db(A)[1]
			Nighttime dB(A)	69.6	55db(A)[1]
4 Tala Bay	Tourism and recreational Area	2.4	Daytime dB(A)	50.3	65db(A)[1]
			Nighttime dB(A)	48.7	55db(A)[1]

[1] Permissible Limit for Residential Areas with Small Workshops, Crafts or Commercial Activities, and Commercial / Administrative Downtown Areas (Instructions for Reduction and Prevention of Noise, 2003)

[2] Permissible Limit for Residential Areas in Cities (Instructions for Reduction and Prevention of Noise, 2003)

Figure 6-32: Noise Monitoring Locations within the ESIA Study Area



6.2.12 Infrastructure Adjacent to the Conveyance Pipeline

Figure 6-33 provides an overview of the infrastructure adjacent to the Conveyance Pipeline, focusing on greenfield, existing roads and the Disi water pipeline. The greenfield category was defined as areas lacking both road and Disi pipeline infrastructure.

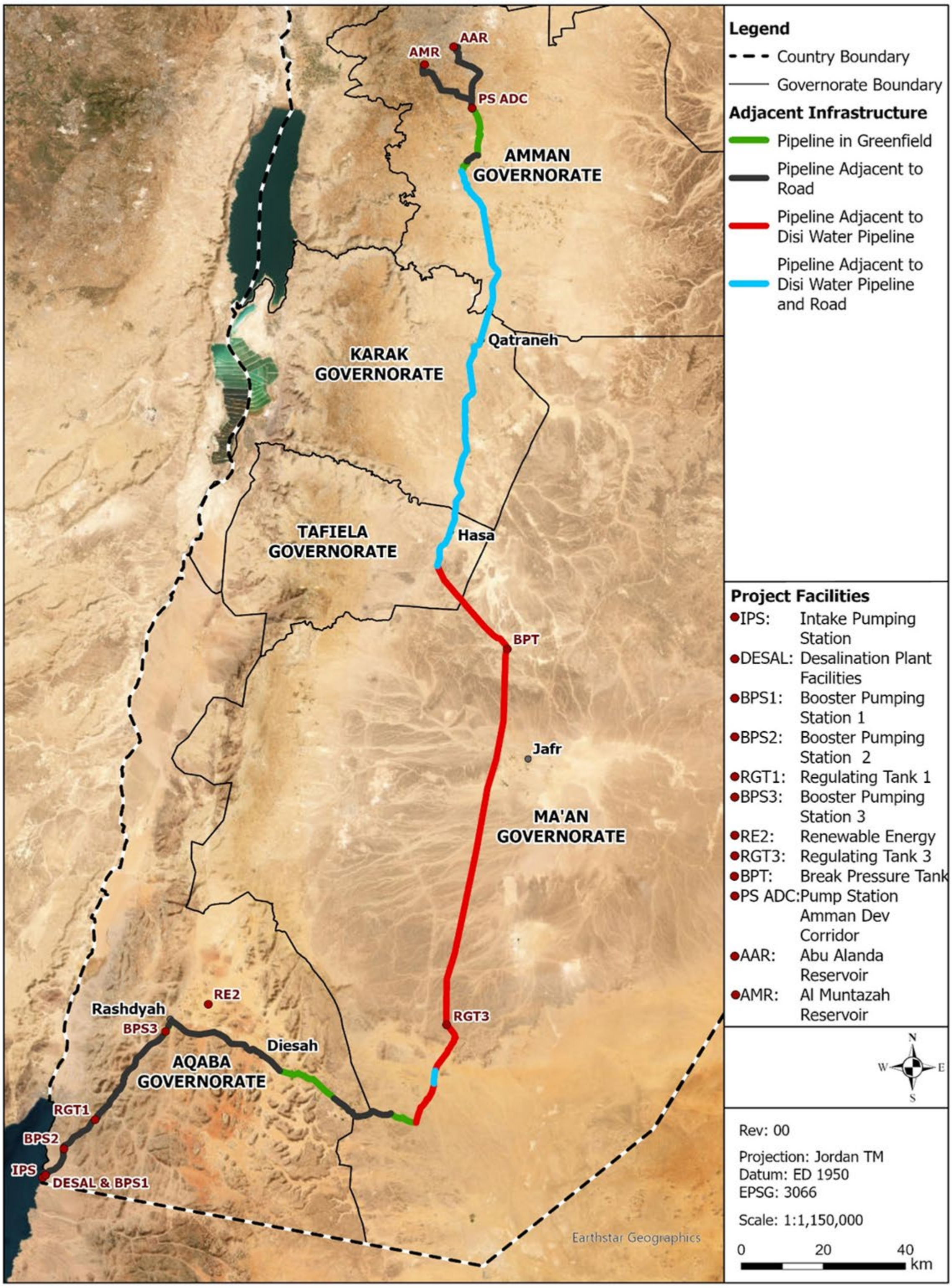
The Conveyance Pipeline is adjacent to the following infrastructure within each governorate:

- Within the Aqaba governorate, the Conveyance Pipeline is not adjacent to the Disi pipeline; however, it is adjacent to 18.8km (17.7%) of greenfield and 87.3km (82.3%) of road
- Within the Ma'an governorate, the Conveyance Pipeline is adjacent to 6.9km (4.4%) of greenfield, 10.0km (6.4%) of road, 136.3km (87.2%) of Disi pipeline and 3.1km (2.0%) of Disi pipeline and road
- Within the Tafiela governorate, the Conveyance Pipeline is not adjacent to either the greenfield or road categories; however, it is adjacent to 10.5km (42.0%) of Disi pipeline and 14.7km (58.0%) of Disi pipeline and road combined
- Within the Karak governorate, the Conveyance Pipeline is not adjacent to either the greenfield, road or Disi pipeline categories; however, it is adjacent to 53.5km (100%) of Disi pipeline and road combined
- Within the Amman governorate, the Pipeline is not adjacent to the Disi pipeline category; however, it is adjacent to 16.2 (16.6%) of greenfield, 43.8km (44.9%) of road and 37.6 (38.5%) of Disi pipeline and road combined

Table 6-18: Adjacent Infrastructure to the Conveyance Pipeline

Governorate	Greenfield	Road	Disi pipeline	Disi pipeline/Road	Total Pipeline Length in Each Governorate (km)
Aqaba	18.8	87.3	0	0	106.1
Ma'an	6.9	10	136.3	3.1	156.3
Tafiela	0	0	10.5	14.7	25.2
Karak	0	0	0	53.5	53.5
Amman	16.2	43.8	0	37.6	97.6
Adjacent Infrastructure Totals (km,%)	41.9 (9.5%)	141.1 (32.2%)	146.8 (33.5%)	108.9 (24.8%)	-
Total Pipeline (km)					438.7

Figure 6-33: Infrastructure Adjacent to the Conveyance Pipeline



6.2.13 Waste Management Facilities

This section provides an overview of waste management in Jordan, including municipal, hazardous, and construction and demolition (C&D) waste, and outlines the roles of national and local institutions in managing these streams. It also highlights the main disposal practices and facilities, such as landfills, dumpsites, the licensed hazardous waste facility, and recycling activities.

6.2.13.1 Solid Municipal Waste

Jordan generates an estimated 2.7 million tons of municipal solid waste annually (SoWas, 2024), with the largest quantities produced in the governorates of Amman, Zarqa, Irbid, and Aqaba due to population density and concentration of economic activity. The solid waste sector is governed through a combination of national and local entities, each with distinct roles.

At the national level, the Ministry of Local Administration (MoLA) provides policy direction, financial oversight, and institutional support to municipalities and the Joint Services Councils (JSCs). MoLA is responsible for budget allocations, approving waste management plans, setting service performance standards, and coordinating the development of regional waste infrastructure in collaboration with the Ministry of Environment (MoEnv).

At the local level, service delivery responsibilities differ by governorate:

- In the Amman Governorate, the Greater Amman Municipality (GAM) independently manages waste collection, transportation, and disposal, including the operation of the Ghabawi Landfill
- In the Aqaba Governorate, solid waste management is centrally overseen by the Aqaba Special Economic Zone Authority (ASEZA), with operational duties delegated to the Aqaba Development Corporation (ADC)

In all other governorates, the Joint Services Councils (JSCs) have been established under the Waste Management Framework Law No. 16 of 2020 to coordinate solid waste management among groups of municipalities. These councils work closely with municipalities to plan, operate, and manage waste services in alignment with national waste-management policies and in coordination with MoLA and the MoEnv. Across Jordan, the majority of the solid municipal wase is disposed of through a range of facilities, which vary in their level of engineering and environmental control. Disposal sites include fully engineered sanitary landfills, controlled tipping sites, and uncontrolled open dumpsites, depending on the governorate and available resources.

Sanitary landfills, such as Ghabawi in Amman, are defined as an engineered disposal facility equipped with a protective liner, leachate-collection and treatment systems, controlled compaction, daily soil cover, and, where available, landfill-gas control and environmental monitoring systems (MoEnv, 2020).

A controlled tipping site refers to a disposal location where waste is placed in organised cells or trenches and periodically covered, but where essential sanitary features, such as composite liners, complete leachate systems, and landfill-gas controls are not in place.

Open dumpsites are un-engineered disposal areas lacking environmental protection systems, operational controls, and monitoring, typically representing older municipal dumping practices now being phased out or rehabilitated under national programs (Green Building Council, 2016).

The main landfill sites in Jordan are presented in Figure 6-34 and following sub-sections provide an outline on the solid-waste management facilities within the ESIA Study Area with details on their locations, areas served, and waste types received.

Amman Governorate

Amman, Jordan's largest governorate and home to over 4.9 million residents (DoS, 2024), generates the highest volume of solid waste in the country, producing an estimated 4,000 - 4,400 tons of MSW per day (AVTR, 2025).

Waste management in the capital is overseen by GAM through an integrated system that includes one major sanitary landfill, two transfer and sorting facilities, and several private and informal recycling operations for metals, wood, and vehicle parts.

The Al Ghabawi Landfill, located approximately 40 km east of the city, is the only engineered sanitary landfill in operation within the governorate and serves as the main disposal site for all municipal waste collected from Amman and surrounding areas (GAM, 2019).

Table 6-19: Waste Management Facilities in Amman Governorate

Name of Waste Disposal Facility	Facility Type	Area (Donum)	Location	Waste type Received	Amount of Received Waste
Al Ghabawi Sanitary	Sanitary Landfill	2000	Uhud District around 23 km from Amman in the Eastern semi-arid desert	MSW (mainly 50% organic waste, 16% plastics, 15% paper and cardboard, 8% textiles and napkins, 4% glass and metals, 1% compost material, 1% hazardous waste, and 5% unclassified combustibles)	4,000 and 4,300 tons/day
Al-Shaer Transfer & Sorting Facility	Transfer Station	NA	Al Shaer area, East Amman	MSW	3,500 tons/day

Karak Governorate

Solid waste management in the governorate is overseen by the Karak JSC under the supervision of MoLA. The governorate generates an estimated 250 - 300 tons of municipal solid waste per day, collected from Karak city and surrounding districts. The waste is primarily disposed of at the Al-Lajjun (Allajoun) Landfill, which serves as the main disposal site for Karak Governorate and parts of neighbouring areas. The site was established in the mid-1990s and has been partially upgraded with controlled tipping and basic environmental controls, but it does not fully meet the design standards of a modern sanitary landfill (Sarayrah and Alsarayreh, 2021).

Recycling and waste sorting operations remain limited in Karak, with small-scale recovery of plastics and metals occurring informally or through donor-supported pilot projects near the landfill.

Table 6-20: Waste Management Facilities in Karak Governorate

Name of Waste Disposal Facility	Facility Type	Area (Donum)	Location	Waste type Received	Amount of Received Waste
Al Bareka	Dumpsite	Not publicly reported	Gore Al-Mazraa District in Al-Aghwwar Al-Janoobieh	MSW	Not publicly reported
Al-Lajjun (Allajoun)	Controlled Tipping Site	1980	10 km east of Karak, along Karak–Qatraneh road	MSW	250–300 tons/day

Tafiela Governorate

Solid waste generated in Tafiela Governorate is primarily disposed of at the Tafiela Landfill, commonly referred to as Jorf Al-Daraweesh. In addition, there is a smaller, unofficial dumpsite known as the Sammar dumpsite in Ghor Al-Safi, which receives municipal solid waste and, at times, illegally dumped wastewater.

Table 6-21: Waste Management Facilities in Tafiela Governorate

Name of Waste Disposal Facility	Facility Type	Area (Donum)	Location	Waste type Received	Amount of Received Waste
Tafilah/Jorf Al Daraweesh	Controlled Tipping Site	450 (of which only 20% is utilized, enough to last for about the next 20 years).	35 km southeast of the Tafilah city center.	MSW	200 tons/day.
Sammar	Dumpsite	153	Ghor Al-Safi Area	MSW and wastewater	20 tons/day.

Ma'an Governorate

In Ma'an, municipal solid waste is managed through three main dumpsites, which serve the surrounding communities. These are the Central Ma'an dumpsite, the Ail dumpsite, and the Muhammadiyah dumpsite (Aljaradin, 2014).

Alongside the aforementioned waste disposal facilities, Ma'an Governorate also has two transfer stations, Al-Husayneyah and Beir-Khaddad, though their area and the quantity of waste received are not specified.

Table 6-22: Waste Management Facilities in Ma'an Governorate

Name of Waste Disposal Facility	Facility Type	Area (donum)	Location	Waste type Received	Amount of Received Waste
Central Ma'an	Controlled Tipping Site	502	~20 km from the Ma'an City Center	MSW	The daily waste intake is estimated at around 80 tons. There is no specific number on the total capacity which the landfill can handle, however it is expected to remain operational till the year 2045 taking into account the population growth and various developments within the Ma'an area.
Ail	Controlled Tipping Site	280	A few kilometers to the east of Al-Basta Village	MSW	20 – 30 tons/day. There is no specific number on the total capacity which the landfill can handle.
Muhammadiyah	Dumpsite	100	Near Muhammadiyah Village	MSW	15 tons/day. There is no specific number on the total capacity which the landfill can handle.

Aqaba Governorate

Waste management in Aqaba Governorate is administered under two systems depending on jurisdiction. Within the Aqaba Special Economic Zone (ASEZ), the Aqaba Special Economic Zone Authority (ASEZA), through the Aqaba Development Corporation (ADC) and contracted service providers, is responsible for municipal solid waste collection, transportation, and disposal.

Areas located outside the ASEZ boundary, including settlements such as Qweirah, Rahma, and Disi, fall under the responsibility of the respective local municipalities operating under the Ministry of Local Administration (MoLA). Municipal solid waste generated in the governorate is primarily disposed of at two landfills: the Aqaba Landfill, which serves ASEZ, and the Qweirah Dumpsite, which serves communities outside ASEZ (Al-Bawwat *et. al.,* 2023).

Table 6-23: Waste Management Facilities in Aqaba Governorate

Name of Waste Disposal Facility	Facility Type	Area (Donum)	Location	Waste type Received	Amount of Received Waste
Aqaba	Controlled Tipping Site	120	~20 km from the city centre	MSW	80–120 tons/day.
Qweirah	Controlled Tipping Site	270	Al-Qweirah district	MSW	Estimated 20 tons/day

6.2.13.2 Hazardous Waste

Hazardous waste in Jordan is disposed of at the Swaqa Hazardous Waste Treatment and Disposal Facility, which is the country's only licensed central facility for hazardous waste storage, treatment, and secure disposal.

The facility is located approximately 125km southeast of Amman in the village of Swaqa, Ma'an Governorate. It occupies roughly 8,000 dunums (8 km²), of which about 1,200 dunums are currently in active use for hazardous-waste storage and disposal operations. Swaqa receives an estimated 3,000–5,000m³/year of hazardous waste, including industrial chemical wastes and medical-waste streams (MoEnv, 2021; Green Growth National Action Plan; JICA, 2016). As the main hub for hazardous waste management, the facility forms a core component of the national hazardous-waste management system under the responsibility of the Ministry of Environment (MoEnv, 2022).

6.2.13.3 Construction and Demolition Waste

Construction and demolition (C&D) waste in Jordan has been increasing due to the expansion of the construction sector and associated urban development. The main sources of C&D waste include inefficient design and procurement practices, inadequate material handling and storage on construction sites, and demolition or renovation activities. A large portion of generated C&D waste remains underutilized, with limited recycling or reuse of materials (Alshdiefat et al., 2023).

Current disposal practices rely heavily on landfills, open dumping sites, and informal roadside dumping. Approximately half of the total C&D waste generated is disposed of in an uncontrolled manner, often without environmental safeguards. Existing facilities for proper sorting, recycling, or dedicated C&D waste management are limited, and much of the waste is mixed with municipal solid waste when sent to landfills (Alshdiefat et al., 2023).

In Amman, C&D waste has historically been directed to the Al-Bayda disposal site, located south of Amman along the Airport Road/Desert Highway corridor, which has served as the primary official dumping location for C&D materials. The facility receives large volumes of excavation waste, concrete debris, broken blocks, asphalt fragments, and soil generated by construction activities. The Al-Bayda site received approximately 1.7 million cubic meters of C&D waste, placing significant pressure on its operational capacity (Gerasa News, n.d.).

Due to the increasing pressure on Al-Bayda, GAM established two additional designated C&D disposal sites outside its administrative boundaries: one located to the north in Safut and another to the south in Al-Adasiyah. In parallel, GAM initiated a study to identify five to six additional small-scale C&D transfer sites intended specifically for waste generated from household renovation and minor construction activities. These transfer sites will operate as regulated unloading and reloading points, with GAM-provided equipment transporting collected materials to final disposal locations. Their use will be limited to small vehicles with capacities of 2–3 m^3, and the municipality will charge nominal service fees for unloading.

In areas where no designated C&D dumping sites exist, contractors typically coordinate directly with local municipalities to identify suitable locations for disposal, which are often informal and lack environmental controls.

6.2.13.4 Recycling

Recycling in Jordan remains limited in scale and primarily driven by private-sector operators and informal collection networks. National recycling rates are estimated at 7–10% of total waste generated, reflecting limited infrastructure, low market incentives, and the absence of a mandatory source-separation system (GIZ SoWas, 2024). Most formal municipal systems do not include dedicated recycling operations, and a significant portion of material recovery occurs outside the government-managed waste stream.

In Amman, recycling activity is concentrated around the Al-Shaer Transfer and Sorting Facility and Al-Ghabawi Landfill, where small- to medium-scale sorting lines recover plastics, metals, cardboard, and paper before disposal. These operations are managed under GAM’s wider solid-waste system but remain limited relative to the overall intake at both facilities (GAM, 2019). In addition, private operators such as Amman Vision Treatment & Recycling (AVTR), located in Sahab, operate material recovery facilities that process plastics, cardboard, and scrap metals for resale and export (AVTR, 2025).

Outside Amman, small- and medium-scale recycling and scrap-handling activities exist primarily in industrial areas, including Sahab Industrial Zone, Al-Russayfa, and Zarqa Free Zone, where private scrap dealers and baling facilities process ferrous and non-ferrous metals, cardboard, and selected plastics (JICA, 2017; UNDP, 2019). These facilities form the backbone of Jordan’s recycling economy, with operations ranging from baling and sorting to shredding and processing for export.

Despite these interventions, national recycling capacity remains constrained by weak regulatory enforcement, contamination of recyclables due to mixing with municipal waste, and insufficient financial incentives for municipalities to implement sustainable recycling systems (GIZ SoWas, 2024; UNDP, 2019).

Figure 6-34: Main Landfill Sites in Jordan

6.2.14 Terrestrial Baseline Survey and Habitat Summary

6.2.14.1 Survey Methodology

Habitat Mapping

To determine habitat type, the entire length of the Conveyance Pipeline route from the Port of Aqaba up to the two existing reservoirs in Amman was surveyed. Both sides of the Conveyance Pipeline route for approximately 100m were assessed, with a light visual search up to 1 km on both sides of the Conveyance Pipeline route. The team selected locations where it appeared that a habitat feature of interest (a habitat that appeared different from the preceding habitat) was present, for more detailed study during the Terrestrial Baseline Survey.

In areas that were inaccessible due to safety concerns (e.g. cliffsides), natural areas that were composed of salt pan (no vegetation), and some sites that were off-route (due to the inaccessibility of the Conveyance Pipeline route) were not selected for survey. These areas included:

- The currently selected location for the Desalination Plant
- A 7 km long part of the Conveyance Pipeline route in Segment 5 that is not traversed by a road. Satellite imagery indicates that this area is natural habitat consisting mainly of flat salt pans (Playa)
- A 7.5 km part of the Conveyance Pipeline route in Segment 4 that is inaccessible due 1.5 – 2m tall soil berms, presumably used to demarcate areas with agricultural activities. The un-accessed area was conclusively identified as agricultural land using satellite imagery

Site observation waypoints included stops to verify assessment of areas, particularly in urban and agricultural areas, and stops to gain a landscape overview and stops to investigate areas set back from the travel route to identify species or other features of interest (e.g. “green” areas that appeared anomalous relative to the overall landscape).

The decision to include locations in the baseline survey was based on several criteria (see Table 6-24), including species present, the extent of habitat, uniqueness of habitat, and likely importance of habitat, suitability of habitat for red-listed species, and physical features such as soil/surface material properties.

Soil stability was very low throughout the natural habitat areas of the conveyance; therefore, this was not a factor in determining whether or not to include a site in the upcoming Terrestrial Baseline Survey. Similarly, the pH was alkaline, ranging from 7.01 to 7.98 for the soil and between 7.14 and 8.00 for the standing water (leakage from the Disi Pipeline), with no significant effect on the selection of sites for the Terrestrial Biodiversity Survey. Full results of the soil stability findings are provided in Appendix 12.

Table 6-24: Criteria and Parameters Used to Decide Inclusion of Sites for the Full Survey

Criteria	Site Inclusion Parameter	Optional Inclusion Parameter	Site Inclusion Modifier
Soil pH	Acid range (pH<7)		Selectively exclude if very common
Water pH	Acid range (pH<7)		Selectively exclude if very common
Water	Standing or flowing water present	Mandatory inclusion if from a natural source	Selectively exclude if very common or if water is

Criteria	Site Inclusion Parameter	Optional Inclusion Parameter	Site Inclusion Modifier
			from a non-natural source
Soil stability	Medium – High stability class (>4)		Selectively exclude if very common
Habitat Class	Natural Habitat	Semi-Natural/Degraded Habitat	
Substrate	Deep caves or large abandoned buildings	Evidence of bats (e.g. Guano)	
	Footprints, scat, etc. of animals		
	Active burrows/ middens of small mammals		
	Presence of substrate associated with (habitat for) red-listed animal species		
Red-list species (plants and animals)	Presence of IUCN Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered,		Selectively exclude only if very common
Plant species & composition	Unique species or High species richness or species different from the adjacent community/ feature		Selectively exclude only if very common
	Presence of species associated with (habitat for) red-listed animal species		
Plant density/canopy cover	High density/cover	Under-canopy plants present	

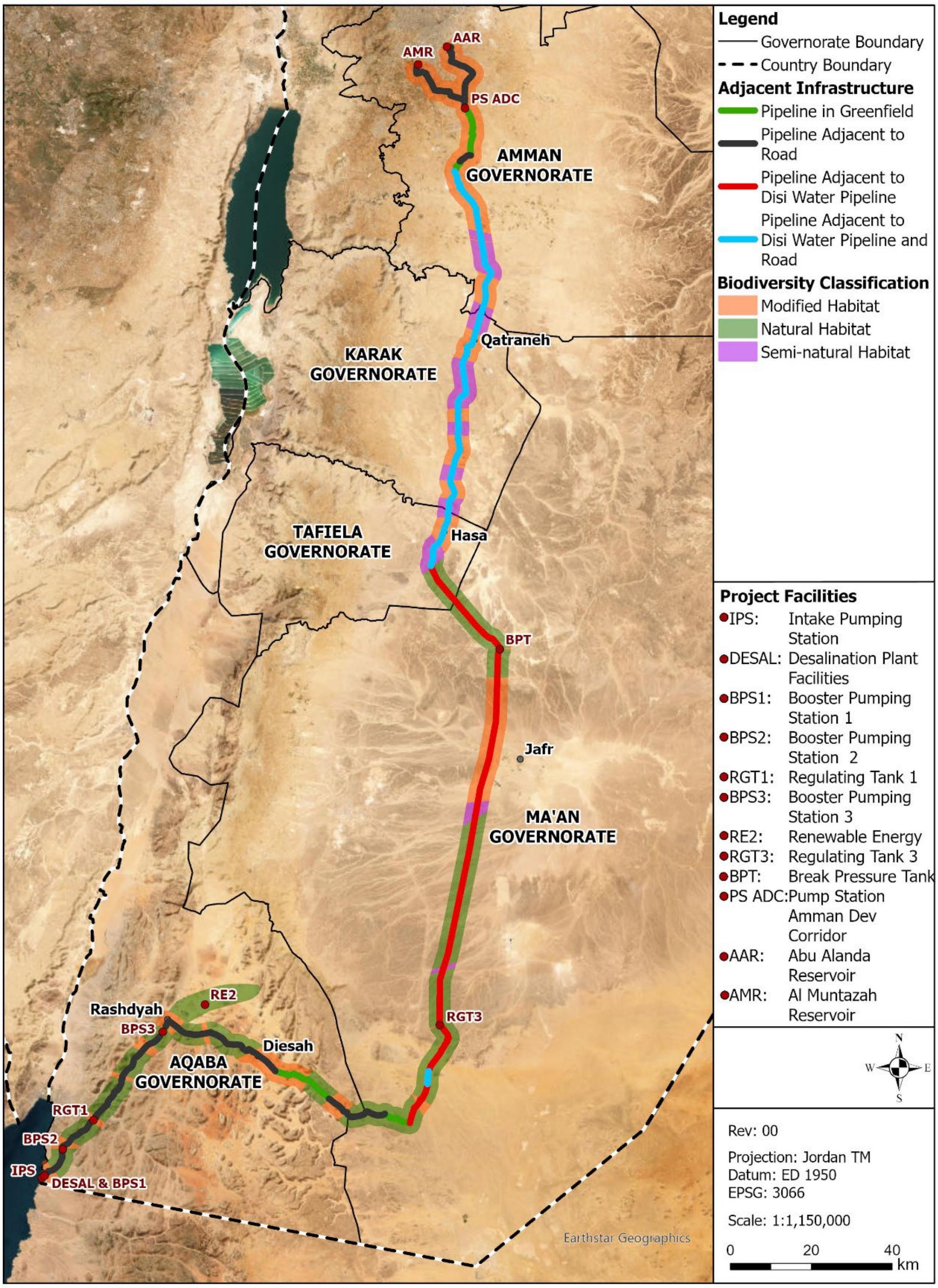
The habitats encountered were categorised as shown in Table 6-25 and Figure 6-35.

Table 6-25: Habitat Classifications

Main Habitat Class	Secondary	Tertiary	Description
Modified Habitat	Urban	Residential	Mainly residential area
		Commercial/Industrial	Mainly commercial/industrial
		Mixed	Mixed residential with commercial/industrial
	Agricultural	Active	Agricultural fields/orchards actively cultivated
		Mixed	Agricultural fields both active and fallow / abandoned
Natural Habitat	Natural	Low value*	No observable changes to naturally occurring habitat
	Semi-Natural/Degraded		Limited change to habitat considered to be >75% natural

*In terms of land use, the designation of Natural Habitat as Low Value relates to the low level of commercial/economic activity associated with it. It does not relate to biodiversity value or ability to support significant fauna and flora.

Figure 6-35: Habitat Classifications



Baseline Survey

The Terrestrial Baseline Survey included the following:

- Line transects (three 100m transects parallel with the pipeline route, on both sides where possible)
- Walking transects (plants, birds, animals & night surveys for terrestrial fauna)
- Quadrats (plants, only in some plots)
- Small mammal traps (select plots)
- Camera traps (select plots)
- Bat roost surveys (select areas)
- Water body counts (birds)
- Carcass Surveys (birds)
- Avifauna survey

Detailed methodologies for the baseline surveys are included in the Terrestrial Baseline Survey Report, which is provided as Appendix 6-3 to this Chapter.

6.2.14.2 Desalination Plant

The site of the proposed desalination plant is located within the Port of Aqaba, near the waterfront and was inaccessible at the time of the survey. Observations from outside the fence revealed a site that was almost completely paved with concrete, with occasional plants (*Prosopis juliflora* and *Salsola baryosma*) growing through cracks and along the unpaved edges of the plot. There were no signs of mammals or lizards occupying the area. Various waste materials including plastic and rubble were scattered throughout the site. The site has clearly been heavily impacted by anthropogenic activities and there is no evidence of attempted rehabilitation

6.2.14.3 Segment 1

Segment 1 Habitat Summary

The Segment begins at the seaport in the south, where water is abstracted from the GoA, piped to the Desalination Plant for treatment, and thereafter pumped northward. The Conveyance Pipeline initially climbs rapidly for approximately 12km toward the southern edge of the Aqaba Mountains, then runs parallel to the Aqaba Truck Road, which carries freight entering and leaving the Port of Aqaba.

This Segment is characterised by wadi systems that cross from east to west and is composed of a sand-and-gravel surface over a limestone bedrock. The Proposed Aqaba Reserve lies to the south-east of the Pipeline route and at its closest point is approximately 6km distant.

The central part of the Segment is considered to be “Natural Habitat” while the southern end and the northern end of the Segment were classified as Modified Habitat, Urban (Commercial/industrial) due to the Port and an industrial facility, respectively (Figure 6-37). Natural Habitat is very sparsely vegetated, with most vegetation occurring along the physically disturbed roadsides and in the Wadis. A summary of the habitat classification is provided below:

Table 6-26: Habitat Classification Summary, Segment 1

Main Habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	5.6	49.5
Natural	Natural	Low Value	No observable changes to naturally occurring habitat	5.7	50.5
Total Segment Length				11.3km	

Segment 1 Baseline Summary

Four locations were selected within this segment for detailed vegetation sampling, which were representative of the overall floristic characteristics of the segment as a whole. The habitats within the segment demonstrate a sparse and fragmented vegetation distribution.

Table 6-27: Segment 1 Summary of Results

Site ID	Plant Cover (%)	No. of Plant Species	No. of Individuals	Animal Species	Animal “Signs”
FA1	0.40	1	1	-	-
FA2	1.03	4	7	-	-
FA3	6.85	3	17	-	-
FA-PS1	0.27	1	1	1	1

The Terrestrial Baseline Survey recorded six plant species within the sample locations: The small tree *Vachellia tortilis*, the annual herb *Aizoon canariense* and the perennial shrubs, *Cleome droserifolia*, *Ochradenus baccatus, Polycarpaea repens*, and *Salsola baryosma*.

Additional records of plant species within this segment, but outside of the transects were made. These were: the low shrubs *Hammada salicornica* and *Iphiona scabra*, the perennial herbs *Morettia canescens* and *Zilla spinosa*, together with the grasses *Panicum turgidum* and *Stipagrostis spp*. These species were recorded along a narrow, scattered band immediately adjacent to the roadside

Plant density within this segment was universally sparse, from 0.27 to 6.85% vegetation cover. The highest density was recorded at location FA3, which supported a relatively large proportion of the shrub *Salsola barysoma.*

A single specimen of *Cleome droserifolia*, which is listed as locally Endangered in Jordan, was encountered at site FA2. The relative abundance of this species can be expressed as an encounter rate of 3.8% of all the plants recorded within this segment (Number of records of this species divided by the total number of plant records in the segment, expressed as a percentage)

Vachellia tortilis (the Umbrella Thorn Accacia) that is listed as locally Vulnerable (globally “Least Concern”) occurred in three sites (FA1, FA2, and FA-PS1), with one specimen recorded at each location, giving an encounter rate of 11.5% for the segment as a whole.

One reptile species was observed in the segment, at the FA-PS1 site, an Aqaba Agama *Pseudotrapelus aqabensis* (not protected). In addition, this site FA-PS1 also supported a possible burrow (Figure 6-36) of the IUCN listed (Vulnerable) Egyptian Spiny–tailed Lizard *Uromastyx aegyipticus.*

Figure 6-36: Likely Burrow of an Egyptian Spiny–tailed Lizard (Left) and an Aqaba Agama (Right) Observed at Site FA-PS1

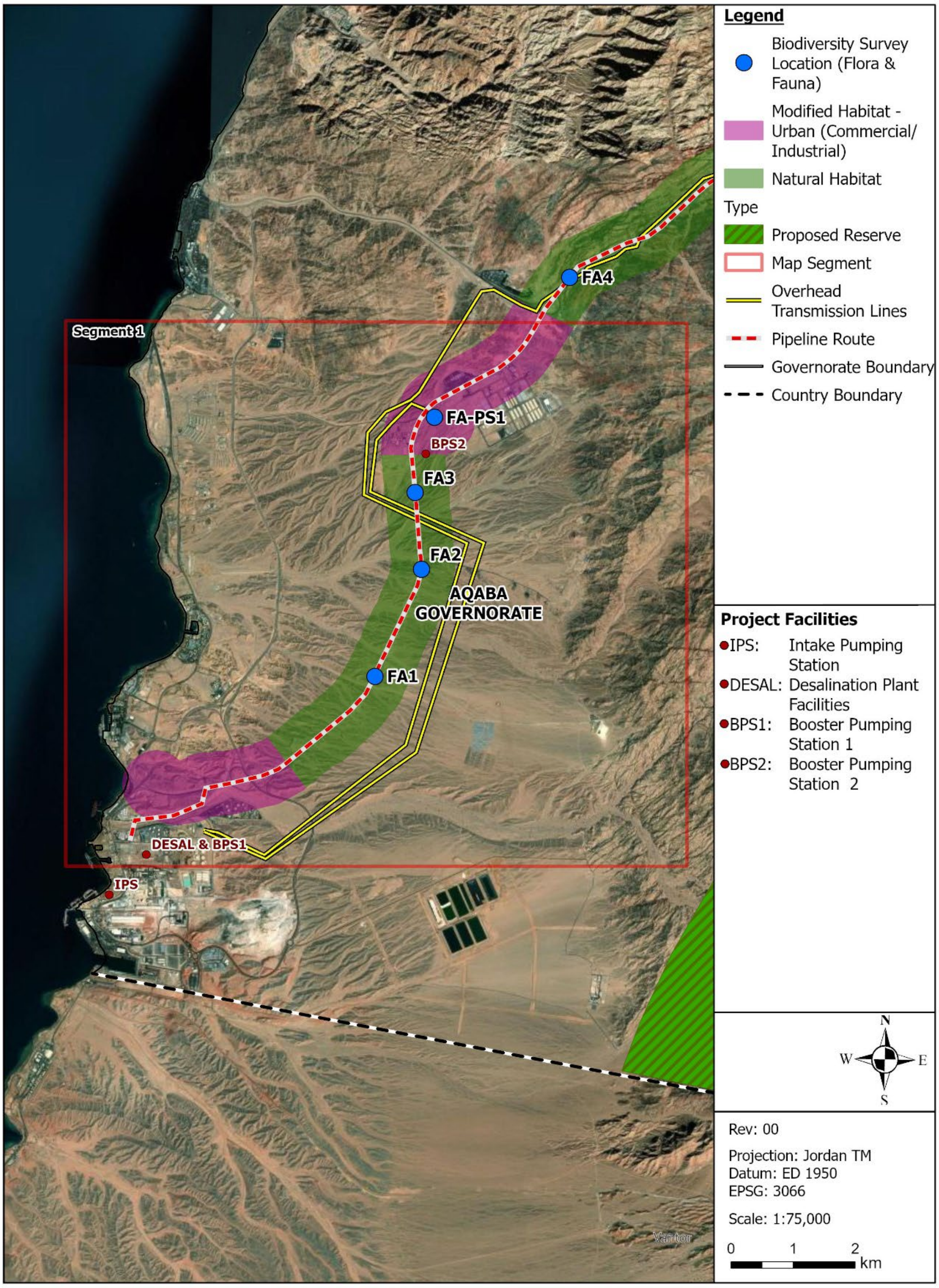
Segment 1 Key Sensitivities

This segment supported examples of the plants *Cleome droserifolia* which is listed as locally Endangered in Jordan and *Vachellia tortilis* (the Umbrella Thorn Accacia) that is listed as locally Vulnerable.

A single reptile species was observed in the Segment, *Pseudotrapelus aqabensis* Aqaba Agama, recorded in an area of low vegetation cover.

In addition, a potential burrow of the IUCN listed (Vulnerable) lizard *Uromastyx aegyptia* Egyptian Spiny–tailed Lizard was recorded in this Segment.

Figure 6-37: Segment 1 Map



6.2.14.4 Segment 2

Segment 2 Habitat Summary

Segment 2 extends for approximately 15km through the Aqaba Mountains, gaining altitude as it travels northward parallel to the Aqaba Port Truck Road (Figure 6-38). Granite mountains dominate the landscape, with wadi systems that cross the route and sometimes run parallel to the Pipeline route. For much of the proposed Pipeline route in this Segment, the road is bordered by steep granite cliffs. There are occasional industrial and commercial businesses along the route, as well as other infrastructure for transport trucks and other vehicles. Vegetation is mostly limited to disturbed areas (e.g., roadsides) and Wadi environments (Table 6-28).

Table 6-28: Habitat Classification Summary, Segment 2

Main Habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	2.6	18
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	11.9	82
Total Segment 2 Length				14.5km	

Segment 2 Baseline Summary

Three locations were selected within this segment for detailed vegetation sampling, which were representative of the overall floristic characteristics of the segment as a whole. The habitats within the segment demonstrate a sparse and fragmented vegetation distribution. (Table 6-29).

Table 6-29: Segment 2 Summary of Results

Site ID	Plant Cover (%)	No. of Plant Species	No. of Individuals	Animal Species	Animal "Signs"
FA4	2.28	4	9	-	-
FA5	2.61	6	13	-	-
FA6-PS2	0.00	0	0	-	-

The Terrestrial Baseline Survey recorded nine plant species within the sample locations: the small tree, *Vachellia tortilis*, the herbs/sub shrubs *Anabasis setifera* and *Zilla spinosa* and the shrubs *Cleome droserifolia*, *Crotalaria aegyptiaca*, *Haloxylon scoparium*, *Lavandula coronopifolia*, *Ochradenus baccatus* and *Salsola baryosma*.

Additional records of plant species within this segment, but outside of the transects were made. These were: the shrubs *Arthrocnemum macrostachyum*, *Capparis cartilaginea*, *Hammada salicornica and Retama raetam,* together with the herbs/sub shrubs, *Citrullus colocynthis*, *Fagonia mollis*, *Forsskaolea tenacissima*, *Heliotropium bacciferum*, *Launaea spinosa* and *Pergularia tomentosa.* These species were recorded along a narrow, scattered band immediately adjacent to the roadside.

A single specimen of *Cleome droserifolia*, which is listed as locally Endangered in Jordan, was encountered at site FA4. The relative abundance of this species can be expressed as an encounter rate of 4.5% of all the plants recorded within this segment (Number of records of this species divided by the total number of plant records in the segment, expressed as a percentage).

One specimen of *Vachellia tortilis* (the Umbrella Thorn Acacia) that is listed as locally Vulnerable (globally "Least Concern") was recorded at site FA5, giving an encounter rate of 4.5% for the segment as a whole.

Two specimens of *Lavandula coronopifolia* (Near Threatened in the RDB for Jordan) were recoded at sites FA4 and FA5, with one specimen at each location. This gives an encounter rate of 9% for the segment as a whole.

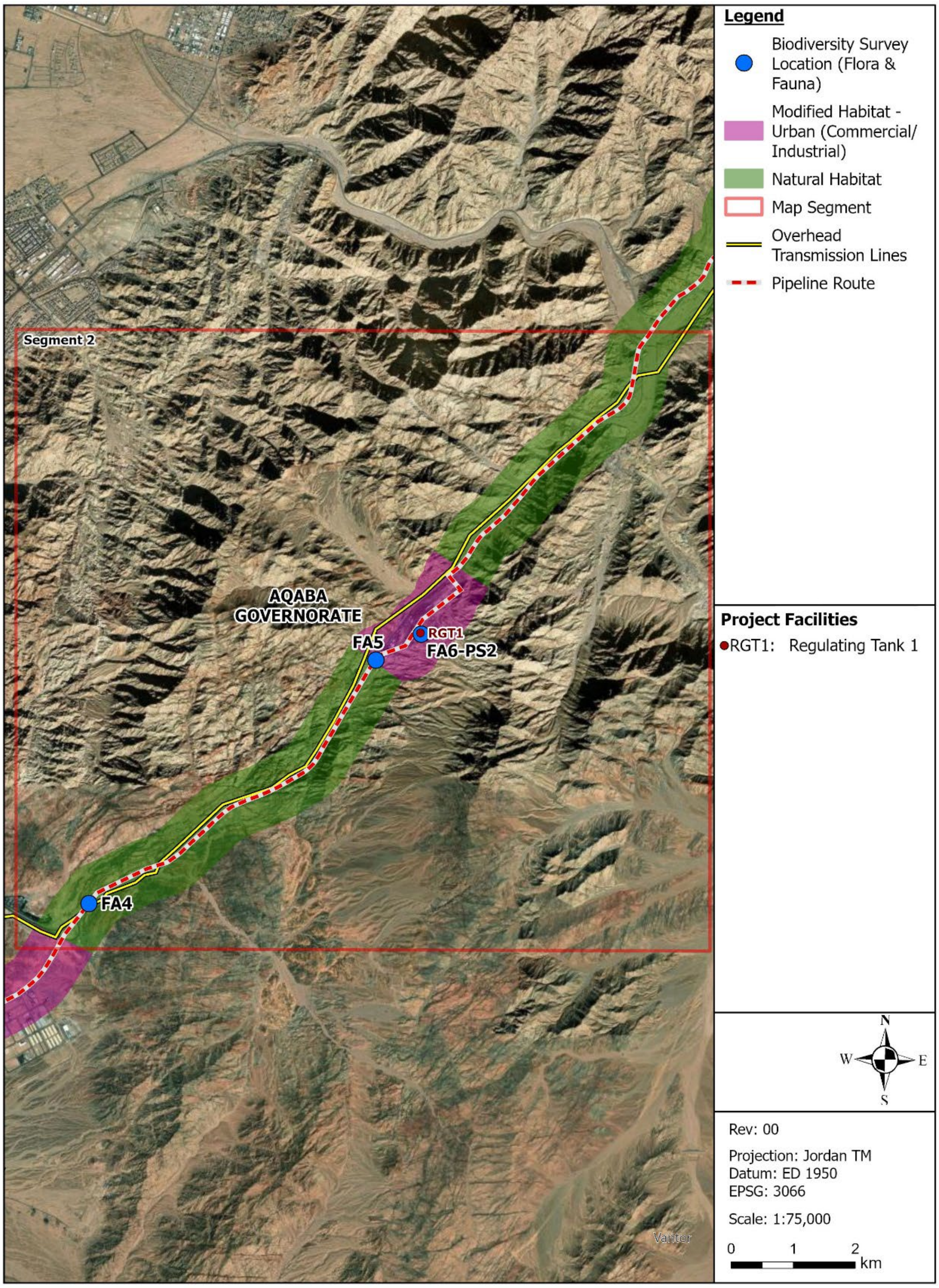
The proposed location for the BPS2 pump station (FA6-PS2) did not contain any measurable plant material and appeared to have been used as a site for disposing of waste materials and trash.

No animal species or signs were observed at any of the three sites in this Segment.

Segment 2 Key Sensitivities

Nine plant species were recorded in Segment 2. Of these *Vachellia tortilis, Cleome droserifolia*, and *Lavandula coronopifolia* are red-listed in Jordan.

Figure 6-38: Segment 2 Map



6.2.14.5 Segment 3

Segment 3 Habitat Summary

In this segment the topography begins to level off, especially along the northern parts of the route, where a large (wide) wadi system crosses the route on the western side. This is part of a wadi that runs parallel to the route for much of its length on the eastern side of the highway.

There is sparse, relatively widely distributed development in the area, including customs checkpoints, residential developments, and agriculture, which increases as the route progresses northward. While there are some trees in the wadis, vegetation is widely spaced, and it is still very much a desert ecosystem with no riparian species evident. At some locations, larger wadis have been slightly modified by human intervention, such as dams, to slow water flow and temporarily collect water (Figure 6-39).

The Buffer Zone of the Wadi Rum Protected Area (PA) is immediately adjacent to the eastern edge of the Conveyance Pipeline route at the end of the segment. In the same area, the Wadi Rum PA Core Area is 4km to the east of the Project.

Table 6-30: Habitat Classification Summary, Segment 3

Main Habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	3.8	14.5
Modified	Urban	Residential	Mainly a residential area	3.5	13.5
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	18.6	72
Total Segment 3 Length				25.9km	

Segment 3 Baseline Summary

Roadside disturbance is less than the previous segments (but not absent). This may be because it is less enclosed by steep cliffs, and the road is wider (additional traffic lanes) due to the Port Highway joining with the Desert Highway.

Vegetation in this segment is sparse and fragmented. The sample sites are representative of the overall floristic characteristics of this Segment. Vegetation was quantitatively surveyed at three sites within the Segment. Vegetation cover ranged from 0.08 to 4.48% (Table 6-31).

Table 6-31: Segment 3 Summary of Results

Site ID	Plant Cover (%)	No. of Plant Species	No. of Individuals	Animal Species	Animal "Signs"
FA7-EX	No flora measurements, new site based on fauna observation			1*	-
FA8	4.48	8	31	-	-
FA9	0.08	1	2	-	-

Site ID	Plant Cover (%)	No. of Plant Species	No. of Individuals	Animal Species	Animal "Signs"
PS3	2.67	2	12	-	-
***Capra nubiana* (Nubian Ibex) IUCN Red List Vulnerable**					

Nine plant species were recorded at the sample locations: the herbs/sub shrubs Aizoon canariense, Artemisia sieberi, Fagonia mollis, Launaea spinosa and Zilla spinosa and the shrubs Haloxylon salicornicum, Ochradenus baccatus, Retama raetam and Salsola baryosma. No plant species occurring in this Segment were listed for conservation globally or locally.

Additional plant species within this segment, recorded outside of the sampling locations were: the small tree *Acacia radiana*, the herb/sub shrubs *Anabasis setifera* and *Pergularia tomentosa* together with the shrub *Hammada salicornica*. All are native to arid and semi-arid ecosystems. These typically occurred with a low abundance throughout the Segment and were associated with the roadside verge areas.

One new (previously unidentified during the Rapid Assessment) site (FA7-EX) for fauna observations was added to the survey based on a recent sighting of an IUCN listed (Vulnerable) species, *Capra nubiana*, the Nubian Ibex, by a member of the survey team in March 2025 (four months before the baseline survey).

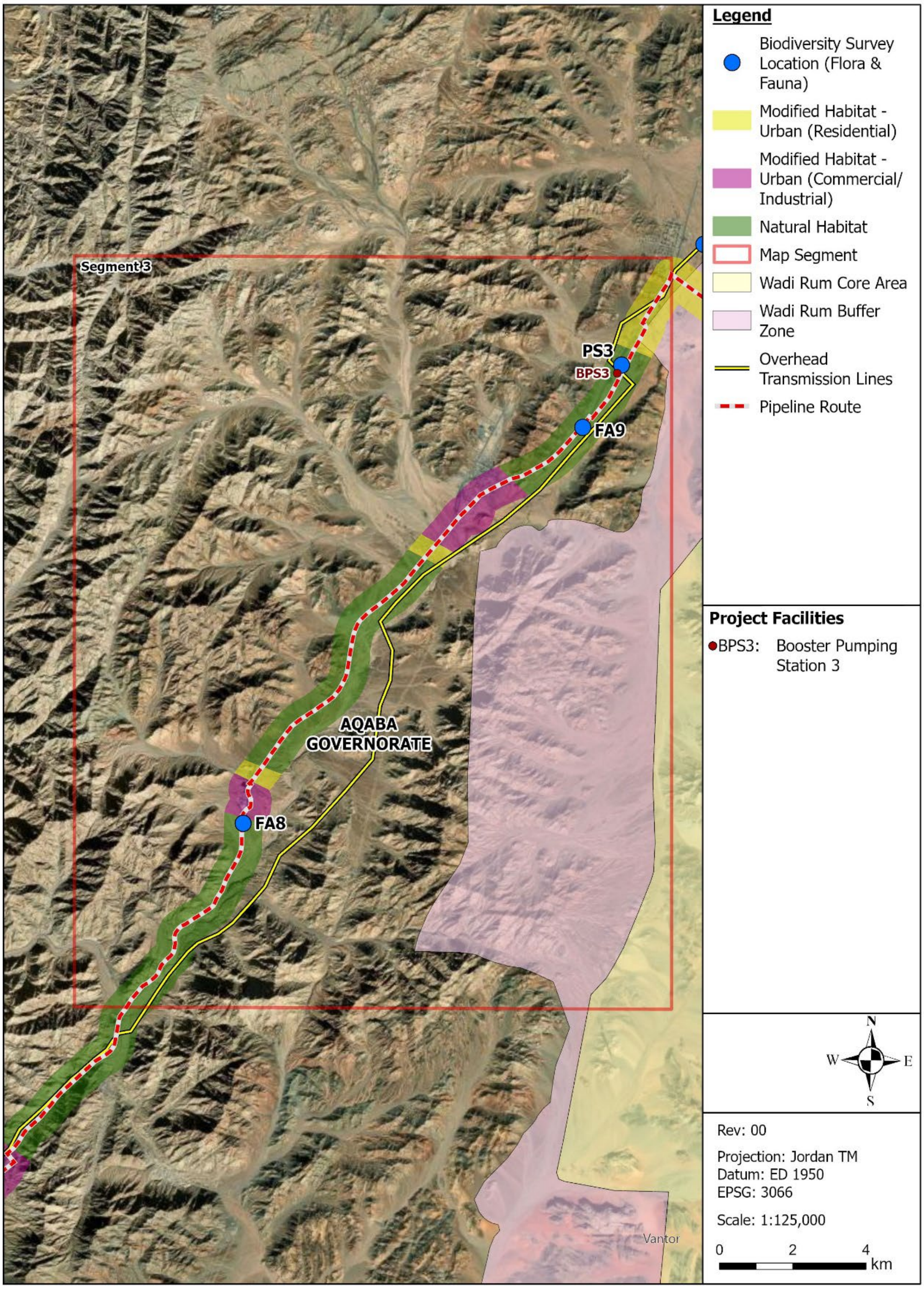
No other animal species or signs (including potential bat roosting sites) were observed at the sites in this Segment.

Segment 3 Key Sensitivities

No plant species occurring in this Segment were listed for conservation globally or locally.

A recent sighting of an IUCN listed (Vulnerable) species, *Capra nubiana*, the Nubian Ibex, by a member of the survey team in March 2025 (four months before the baseline survey) was made in this Segment.

Figure 6-39: Segment 3 Map



6.2.14.6 Segment 4

Segment 4 Habitat Summary

This segment begins where the Pipeline route diverges from the Desert Highway at Rashadiyah Junction. The Segment is approximately 55km in length, and is oriented from east to west, with the Wadi Rum PA lying to its south. The eastern 2/3 of the length of the Conveyance Pipeline route lies within the Buffer Zone for Wadi Rum PA, as does the proposed site for the Renewable Energy Facility, which is located near the western end of the route on its north side.

The western end of the route is agricultural (with both active and inactive/abandoned fields throughout the area) although the RE Facility itself may not have been farmed. However, because these agricultural areas are set back and away from the Conveyance Pipeline route, the route itself was mostly designated as “Natural Habitat”. As the route progresses eastward agricultural activity tapers off. At the town of Diesah agricultural activity resumes and is most dense outside the Wadi Rum Buffer Zone. The intervening area along the Pipeline route is largely Natural Habitat although there are areas of light “Modified habitat – Urban (Residential) and the Wadi Rum Railway, the small township of Shakaria, and some small tourist camping businesses (Figure 6-40). From Diesah westward there are agricultural fields, and salt flats. The Conveyance Pipeline route is inaccessible in some of the eastern areas but satellite imagery clearly shows that these areas are/were agricultural and represent modified habitat.

Table 6-32: Habitat Classification Summary, Segment 4

Main Habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Residential	Mainly a residential area	8.9	16.5
Modified	Agricultural	Active	Agricultural fields/orchards actively cultivated	18.1	33.5
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	27	50
Total Segment 4 Length				54km	

Segment 4 Baseline Summary

For this Segment, the Terrestrial Baseline Survey results have been separated into the Conveyance Pipeline route and RE Facility & OHTL areas.

Pipeline Route

Nine sites were surveyed for biodiversity along the Pipeline route, of which site FA15A was only surveyed for Fauna. The low species richness in this area likely reflects the undisturbed natural habitats present, indicating dominance by drought, heat, and salt resilient species. These characterise undisturbed warm arid desert ecosystems, further supported by the Protected Area status of Wadi Rum and the Protected Area Buffer Zone that much of the Segment falls within. The surveyed sites are representative of the overall floristic characteristics of this Segment (Table 6-33).

Table 6-33: Segment 4 Summary of Results

Site ID	Plant Cover (%)	No. of Plant Species	No. of Individuals	Animal Species	Animal "Signs"
FA10	3.07	1	14	2	-
FA11	1.42	2	10	-	-
FA12	0.20	2	3	1	1
FA13A	2.91	1	12	1	-
FA13-B	0.00	0	0	-	-
FA14A	1.17	4	9	-	-
FA14B	1.45	4	5	-	-
FA15	0.00	0	0	-	-
FA15A	Fauna only survey location			12	-

Eight plant species were recorded within the survey sites: the trees Vachellia gerrardi and Tamarix nilotica, the shrubs Haloxylon persicum, Haloxylon salicornicum, Retama raetam and Salsola baryosma, and the herb/sub shrubs Salsola tragus and Zilla spinosa.

Additional plant species recorded in this Segment were: the herb/sub shrubs Citrullus colocynthis, and Pulicaria crispa, the shrub *Haloxylon scoparia*, and the perennial wetland plant Typha spp.

Vachellia gerrardii and *Haloxylon persicum* are both red-listed (Vulnerable) species for conservation in Jordan.

H. persicum dominated survey site FA13A and occurred as a single record at site FA14B. This species had an overall encounter rate of 24.5% within the segment as a whole

A single plant of V. gerrardii was recorded at site FA14B. This gives an encounter rate of 1.9% within the segment.

Survey location FA10 hosted two species of animals, *Acanthodactylus boskianus* (Bosc's Fringe-toed lizard; 2 individuals), and a single record of *Gerbillus dasyurus* (Wagner's Gerbil).

A Red fox (Vulpes vulpesl) and signs of a bushy-tailed Jird (*Sekeetamys calurus*) were observed at site FA12, and a Schmidt's Fringe Fingered lizard (*Acanthodactylus schmidti*) was observed at site FA13A.

Eleven species of bird were observed at survey site FA15A (Columba livia, Ammomanes deserti, Galerida cristata, Ptyonoprogne fuligula, Oenanthe deserti, Oenanthe lugens, Onychognathus tristramii, Passer domesticus, Carpodacus synoicus, Vanellus spinosus, Acrocephalus scirpaceus, Streptopelia decaocta). This site is an artificial wetland, fed by water from adjacent farms and the ponded water also supported individuals of the variable green toad Bufotes sitibundus.

None of the fauna recorded are considered to be of conservation importance.

Renewable Energy Facility & OHTL

The proposed Renewable Energy Facility lies approximately 8.5km to the north-east of the Conveyance Pipeline route at Rashadiyah Junction in the western end of Segment 4, from where the OHTL will transmit electricity to various Project components.

The Renewable Energy Facility is approximately 2km x 2.3km and consists of three distinct habitats. Therefore, three sets transects were used to survey plants, and two additional sets of transects were used to quantify biota at locations along the proposed OHTL (Table 6-34).

Table 6-34: Renewable Energy Facility & OHTL Summary Results

Site ID	Plant Cover (%)	No. of Plant Species	No. of Individuals	Animal Species	Animal "Signs"
S4-SPV1	11.92	1	48	-	3
S4-SPV2	0.93	1	4	-	3
S4-SPV3	4.90	1	13	-	3
S4-OHTL-4	8.00	1	35	1	1
S4-OHTL-5	4.25	1	26	-	-

The area of the Renewable Energy Facility and OHTL are dominated by *Haloxylon salicornicum* (Saxaul). No other plant species was recorded in any of the five sites in this area. Most of this area appears to have been farmed in the past, but now appearing abandoned.

One individual of *Acanthodactylus boskianus* (Bosc's fringe-fingered lizard) was detected at site S4-OHTL-4, and signs of its presence were found at all other sites in the Renewable Energy Facility + OHTL group sites. Additionally, there were signs of the presence of *Meriones crassus* (Sundeval's Jird) at S4-OHTL-4.

At the other sites of the Renewable Energy Facility OHTL group, signs were also found of the presence of *Psammomys obesus* (Fat Sand Rat) and *Meriones crassus* although live specimens were not observed.

No globally listed or Jordan red-listed species were encountered in this area.

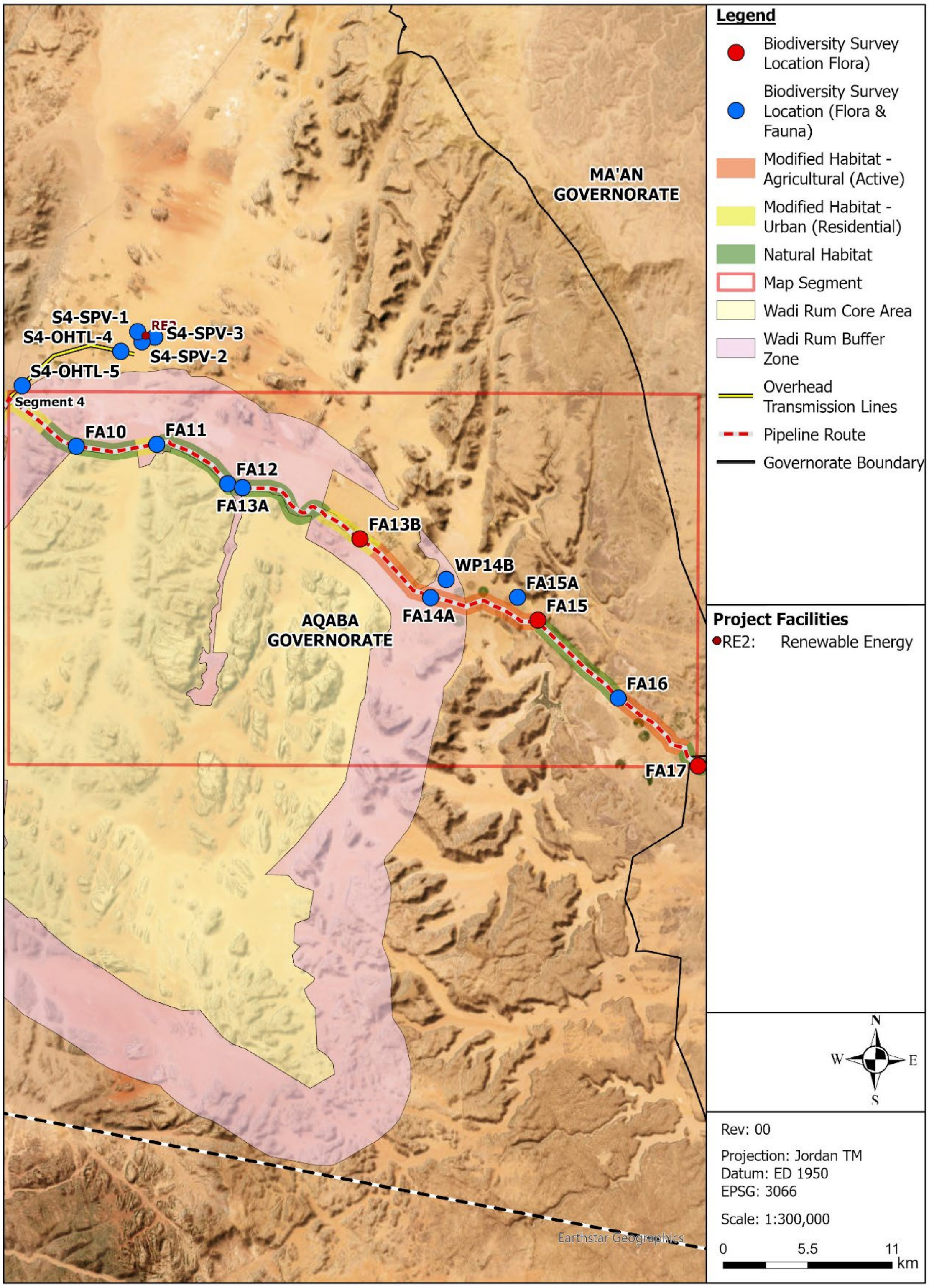
Segment 4 Key Sensitivities

Eight plant species were recorded in the eight survey sites of this segment, two of which, *Vachellia gerrardii* and *Haloxylon persicum* are red-listed (Vulnerable) for conservation in Jordan.

Eleven species of bird were observed at an artificial wetland, fed by water from adjacent farms and the ponded water. This also supported individuals of the amphibian *Bufotes sitibundus* Variable Green Toad. Although not directly on the Pipeline route, due to its potential to attract and support wildlife near the Pipeline route, a faunal survey was conducted at this location.

The area of the Renewable Energy Facility and OHTL are dominated by *Haloxylon salicornicum* (Saxaul) on what appears to be abandoned farmland. A few common reptiles and mammal signs (tracks) were recorded within the area, but no globally listed or Jordan red-listed species were encountered in this area.

Figure 6-40: Segment 4 Map



6.2.14.7 Segment 5

Segment 5 Habitat Summary

This is the only Segment that consists of a section of the Conveyance Pipeline route that is oriented west to east, and another section that is oriented south to north. It also features a significant gain in altitude in its northernmost reaches, where it crosses and runs parallel to some sizeable wadi systems. The summary of the habitat classification for this section is presented below.

Table 6-35: Habitat Classification Summary, Segment 5

Main Habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	2.4	6
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	35	94
Total Segment 5 Length (km)				37.4km	

This geographic diversity is also reflected by the Segment having the greatest plant species richness of all the Segments. It is primarily Natural Habitat. The south-easternmost corner of the Conveyance Pipeline route is inaccessible (no road or track). However, satellite imagery shows this area consist of salt flats (Playa) and desert pavement which, typically in this environment, has a very low density of flora.

At the eastern end, the route aligns with the Disi pipeline. It turns northward, passing a large Solar PV facility and associated infrastructure, classified as “Modified Habitat – Urban (Commercial/Industrial)”. Also, the Disi pipeline integrates a series of wells, likely designed for pressure management and operational efficiency (Figure 6-41).

Many of these wells are leaking water to the surface environment, creating artificial mini-wetlands that support a greater diversity and density of plants than are typically found year-round in this desert environment. These areas attract fauna and flora species that would otherwise not occur in these areas.

Segment 5 Baseline Summary

Eight locations were surveyed in this segment, of which one (FA24) was surveyed for fauna only.

This Segment displayed a higher plant species richness than previous Segments, with 13 plant species recorded: the herbs/sub shrubs *Artemisia monosperma, Citrullus colocynthis, Fagonia mollis, Hyoscyamus muticus, Pulicaria undulata and Zilla spinosa,* the shrubs, *Artemisia judaica, Haloxylon salicornicum, Heliotropum rotundifolium, Calligonum comosum* and *Retama raetam* and the grasses/reeds *Cynodon dactylon* and *Phragmites australis*.

Additional plant species recorded within this segment were: Vachellia gerrardii, Anabasis articulata, Anvillea garcinii, Calotropis procera, Conyza canadensis, Haloxylon persica, Hammada scoparia, Hyoscyamus desertorum, Launaea spinosa, Ononis spinosa, Pergularia tomentosa, Pulicaria crispa, Ricinus communis, Salsola baryosma, Tamarix spp. and Traganum nudatum.

Five plant species recorded at sample locations are red-listed for Jordan:

- *Artemisia judaica* (Vulnerable), a total of 37 plants were recorded at four sample sites, giving an encounter rate of 34.6% for this segment
- *Calligonum comosum* (Endangered) was recorded as a single specimen, giving an encounter rate of 0.9% for the segment
- *Artemisia monosperma* (Near Threatened), eighteen individuals of this plant were recorded over three sample sites, giving an encounter rate of 16.8% for the segment
- *Heliotropum rotundifolium* (Near Threatened) was recorded as a single specimen, giving an encounter rate of 0.9% for the segment
- *Hyoscyamus muticus* (Critically Endangered) was recorded as a single specimen, giving an encounter rate of 0.9% for the segment

Table 6-36: Segment 5 Summary of Results

Site ID	Plant Cover (%)	No. of Plant Species	No. of Individuals	Animal Species	Animal "Signs"
FA16	0.00	0	0	1	-
FA17	1.13	3	19	0	-
FA20-1	1.28	3	8	0	-
FA21	6.08	6	36	2	-
FA22	5.50	8	23	1	-
FA23	1.43	2	5	1	-
FA24	-	-	-	2	-
FA25	9.27	3	16	0	-

On the West-East Segment of the Conveyance Pipeline was a mud/salt flat with no recorded vegetation, but it included an observation of a Sinai Agama lizard (P*seudotrapelus sinaitus*), which appears to prefer unvegetated areas and consolidated (non-sandy) soils.

Two reptile species were recorded at site FA21: *Acanthodactylus boskianus* and *Acanthodactylus opheodurus* (Arnold's Fringe-Fingered Lizard). One reptile species, the Fan-footed Gecko (*Ptyodactylus hasselquistii*), was recorded at FA22. At the same site, abandoned structures (bridges) with potential to be bat roosting sites were investigated, but there was no evidence of them ever having been used for roosting. One reptile species, *Acanthodactylus boskianus* (Bosc's Fringe-Toed lizard), was recorded at site FA23.

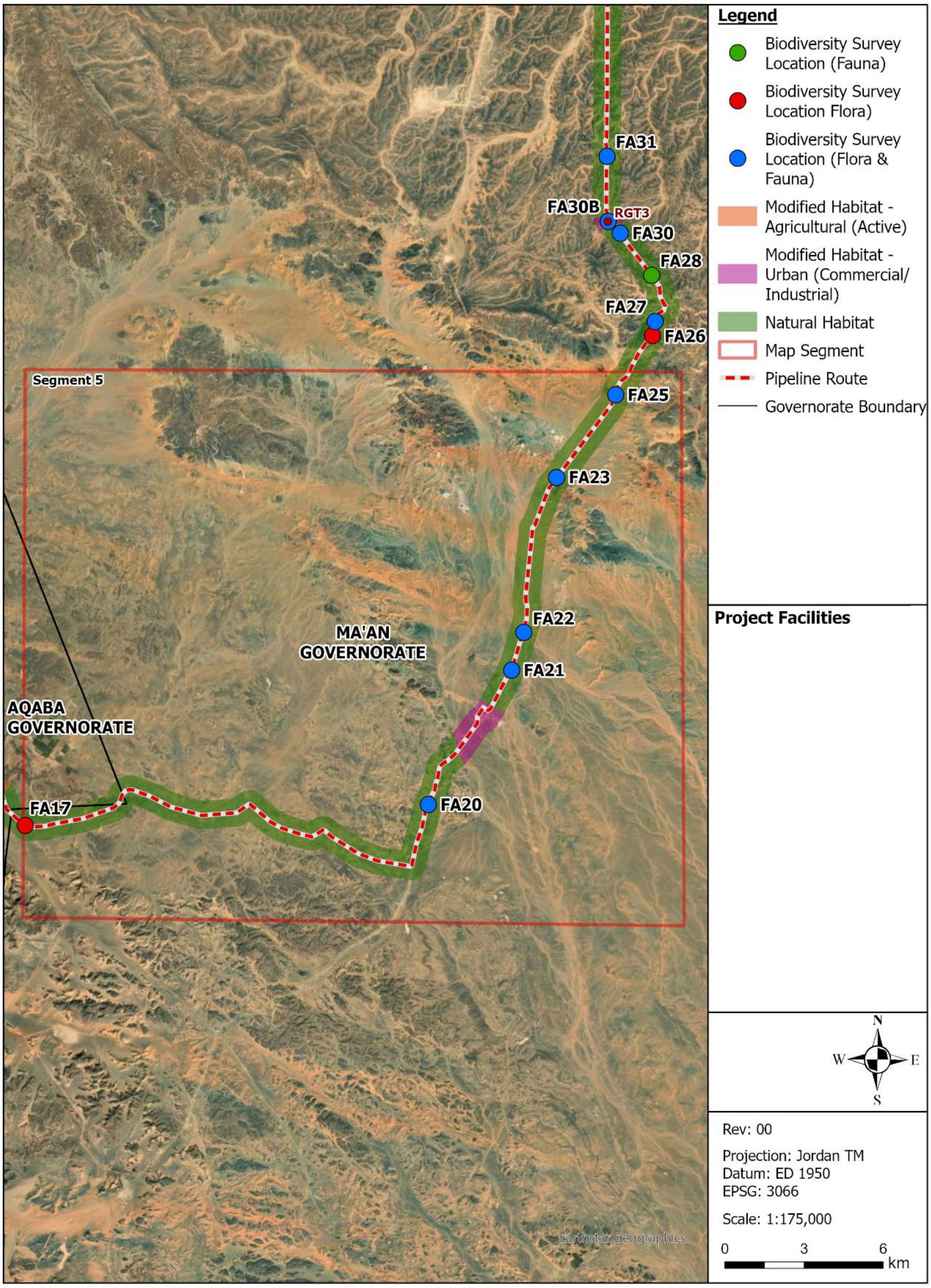
The Terrestrial Baseline Survey site FA24 was used solely as a camera trap location for larger mammals, capturing nighttime images of two red foxes (*Vulpes vulpes*) and one desert hedgehog (*Paraechinus aethiopicus*).

No globally listed or Jordan red-listed mammal or reptile species were encountered in this area.

Segment 5 Key Sensitivities

This survey Segment supported 13 plant species, of which five are red-listed for Jordan: *Artemisia judaica* (VU), *Calligonum comosum* (EN), *Artemisia monosperma* (NT), *Haloxylon rotundifolium* (NT), and *Hyoscyamus muticus* (CR). Occasional records of common reptiles and mammals were made in this Segment.

Figure 6-41: Segment 5 Map



6.2.14.8 Segment 6

Segment 6 Habitat Summary

Segment 6 is oriented north-south, and is approximately 130+ km long, beginning at the intersection of the unpaved track paralleling the Disi Pipeline and the Jordan– India Phosphoric Acid Plant access road The segment ends at the intersection with the Desert Highway in the North.

Most of the route in this Segment passes through “Natural Habitat”. Towards the centre of the Segment, there is an area with a significant Modified Habitat classified as “Modified Habitat – Agricultural (Active)” (Figure 6-42 and Figure 6-43). The effects of the Disi pipeline leakage are most visible in the central and southern areas. While there is little development in the southernmost section of the Segment, agricultural activities can be observed near (but not adjacent to) the Conveyance Pipeline route further to the north.

Table 6-37: Habitat Classification Summary, Segment 6

Main Habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	0.8	0.6
Modified	Agricultural	Active	Agricultural fields/orchards actively cultivated	32	25
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	91	70.8
Natural	Semi-Natural/Degraded	Low Value	Limited change to habitat considered to be >75% natural	4.7	3.6
Total Segment 6 Length				128.5km	

Segment 6 Baseline Summary

A total of 39 sites were surveyed in the Segment with a total of 23 plant species recorded.

Table 6-38: Segment 6 Summary of Results

Site ID	Plant Cover (%)	No. of Plant Species	No. of Individuals	Animal Species	Animal “Signs”
FA26	0.00	0	0	-	-
FA27[1]	5.23	4	6	3	-
FA29	Fauna survey only			2	
FA30	3.80	4	21	-	-
FA30B	0.00	0	0	-	-
FA31[2]	8.67	6	50	-	-

Site ID	Plant Cover (%)	No. of Plant Species	No. of Individuals	Animal Species	Animal "Signs"
FA32[2]	2.81	3	10	1	-
FA33[2]	Fauna survey only			1	
FA35[2]	1.80	4	9	-	-
FA36[2]	11.28	4	19	-	-
FA37[2]	2.20	8	19	-	1
FA38[2]	2.88	6	32	1	-
FA39[2]	2.15	5	17	-	-
FA40[2]	5.76	6	43	1	-
FA41[2]	7.91	6	22	2	1
FA42[2]	7.73	9	52	5	-
FA43	4.03	3	33	-	2
FA44[2]	3.68	5	47	1	-
FA45	0.00	0	0	-	-
FA46	0.12	1	5	1	-
FA46A	2.92	4	31	1	-
FA47	Fauna survey only			1	1
FA48	0.45	2	10	1	-
FA50	Fauna survey only			3	
FA51A	4.29	1	29	Flora survey only	-
FA51B	0.03	1	1	Flora survey only	-
FA52	Fauna survey only				2
FA53	0.62	5	25	3	1
FA54	Fauna survey only			1	-
FA55	0.85	2	-	1	
FA56	Fauna survey only			2	-
FA57	Fauna survey only			-	-
FA58	Fauna survey only			2	-
FA59	Fauna survey only			-	-
FA60	Fauna survey only			1	-
FA-PS4	Fauna survey only			-	-
FA61	0.92	3	6	Flora survey only	
FA62	0.28	2	2	Flora survey only	

Site ID	Plant Cover (%)	No. of Plant Species	No. of Individuals	Animal Species	Animal "Signs"
FA63	0.05	1	1	Flora survey only	
[1] Site with water leakage from the Disi pipeline					
[2] Wadi site with trees of *Vachellia gerrardii*					

The area between Terrestrial Baseline Survey sites FA31 and FA44 features frequent Wadis (and intervening desert), including the locally red-listed (Vulnerable) species *Vachellia gerrardii*. Species richness was highest at FA42, where nine species were recorded (*Phragmites australis*, *Astragalus spinosus*, *Pulicaria undulata*, *Zilla spinosa*, *Vachellia gerrardi*, *Fagonia bruguieri, Achillea fragrantissima*, *Haloxylon scoparium*, and *Cynodon dactylon*).

Further north along the Pipeline route, species richness decreases, and there is no measurable vegetation between survey sites FA54 and FA PS4.

Vachellia gerrardi (Vulnerable in Jordan) was the only plant species of conservation importance recorded in this segment. Thirty-four specimens were recorded at eleven of the sample locations in this segment. This gives an encounter rate of 6.8% for the segment as a whole. Although it should be noted that this species is more associated with wadis.

The IUCN red-listed Egyptian Spiny–tailed Lizard *Uromastyx aegyptia* was recorded at one survey location, with a burrow recorded at another.

Other reptile species recorded included Aqaba Agama *Pseudotrapelus aqabensis*, Bosk's Fringe-toed Lizard *Acanthodactylus boskianus*, Sinai Agama *Pseudotrapelus sinaitus*, Hasselquist's Fan-footed Gecko *Ptyodactylus hasselquistii*, Jordan short-fingered Gecko *Stenodactylus grandiceps and* Northern Arabian Plain Agama *Trapelus agnetae.* Signs of the Desert Monitor *Varanus griseus* were also recorded at two locations.

Mammal species were less common with "signs" (burrows) of Libyan Jird (*Meriones crassus)* observed at four survey sites and Red Fox (*Vulpes vulpes*) observed during a night transect survey; a desert hedgehog (*Paraechinus aethiopicus*) observed at one location and signs of a Gerbil species at another.

Birds were observed at one survey site in Segment 6, at site FA42 (*Galerida cristata, Carpodacus synoicus, Acrocephalus scirpaceus*, and *Streptopelia decaocta*), which is a plant species-rich wadi site.

Variable Green Toad (*Bufotes sitibundus*) were present in standing water from a Disi pipeline leakage.

Segment 6 Key Sensitivities

This Segment is notable for the many wadis that flow from east to west, intersecting with the south–north oriented Pipeline route. A characteristic of the larger wadis is the presence of *Vachellia gerrardii* trees, a Jordan red-listed species (Vulnerable).

Faunal species in this Segment included a number of common reptile species, together with the presence of IUCN red-listed *Uromastyx aegyptia* Egyptian Spiny–tailed Lizard, which appeared to be particularly attracted to the low/unvegetated areas.

Mammal species were less common with indications of common and widespread species only.

Birds were observed at one survey location in this Segment 6, at a plant species-rich wadi site.

In addition, amphibians *Bufotes sitibundus* Variable Green Toad were present in standing water from a Disi pipeline leakage.

Figure 6-42: Segment 6a Map

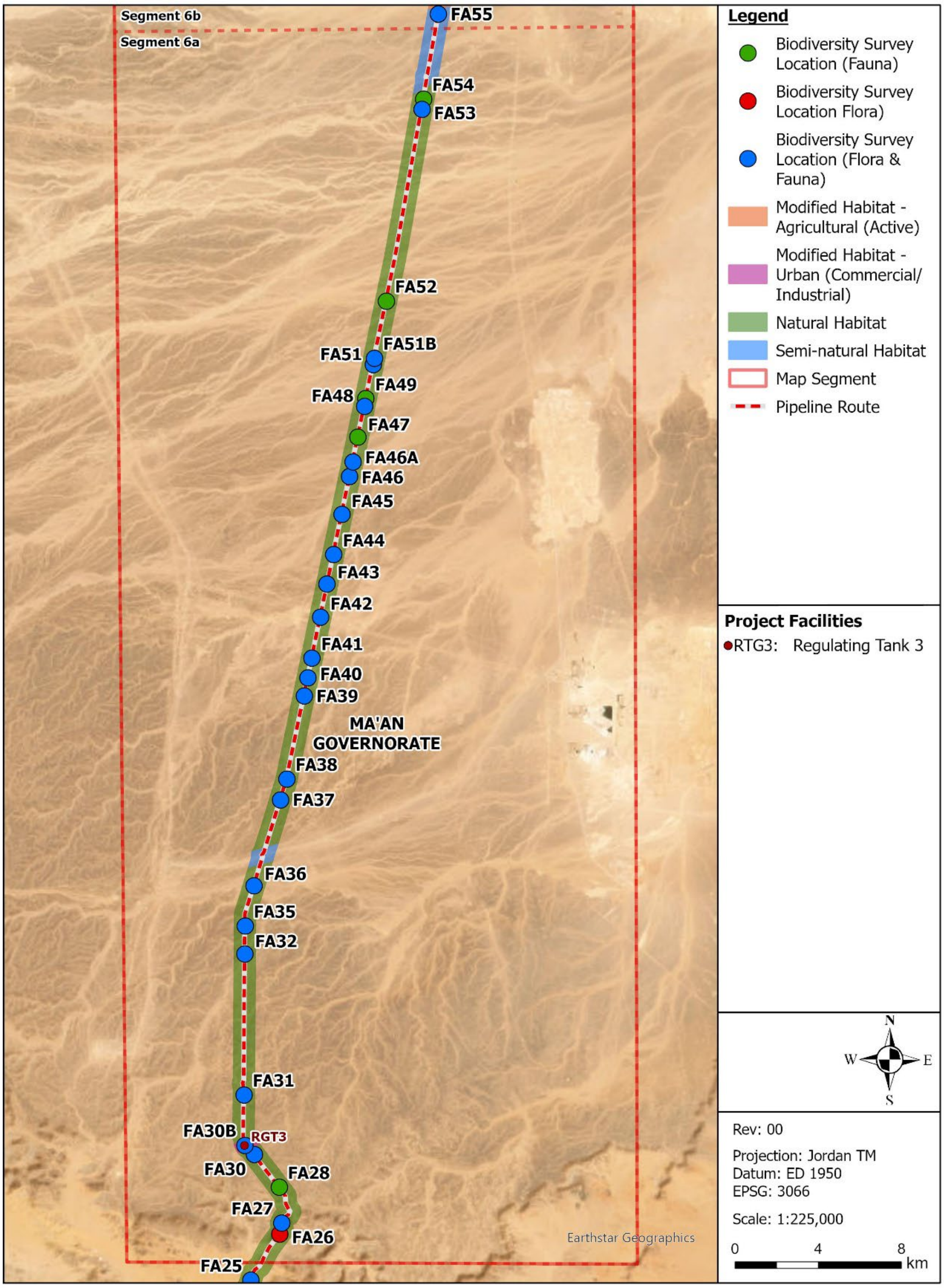
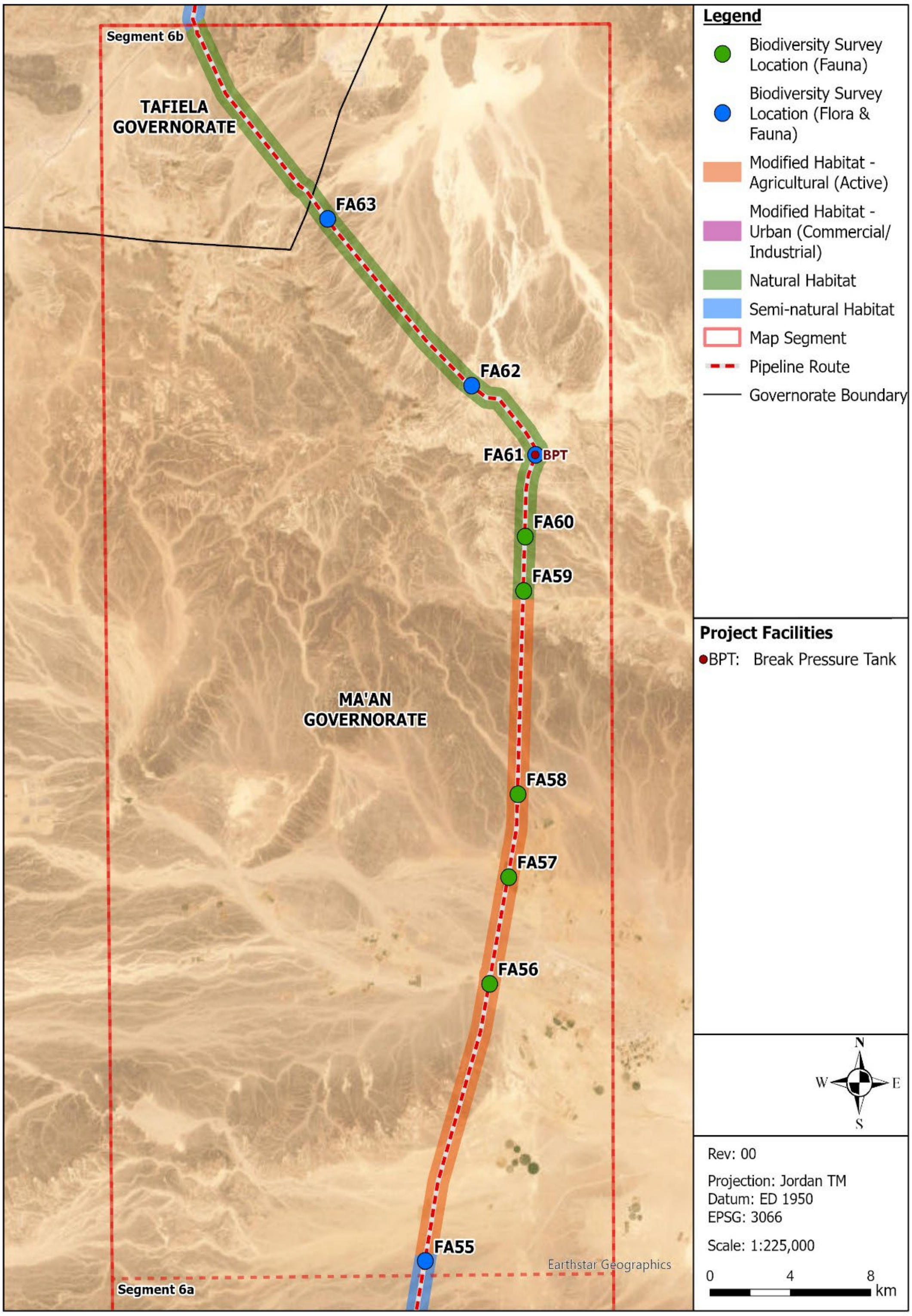


Figure 6-43: Segment 6b Map



6.2.14.9 Segment 7

Segment 7 Habitat Summary

Segment 7 is another long Segment of approximately 128+ km length, stretching along the Desert Highway until it reaches the outer limits of Amman. This Segment is the most heterogeneous of all the Segments, with a range of degraded and modified habitat types. There was no significant stretch of the Conveyance Pipeline route that could be classified as "Natural Habitat" in this Segment.

In the south, the route passes through areas of seemingly natural habitats but frequently interspersed with urban areas (residential, commercial and industrial) and areas of farmland. Further north, the Conveyance Pipeline route continues to parallel the Desert Highway for much of its length. It diverges permanently from the Desert Highway and the Disi pipeline at 31°37'30.22"N / 35°59'40.75"E when the Project Pipeline route takes a more easterly route around the Queen Alia International Airport (Figure 6-44 and Figure 6-45).

The highway and other infrastructure appears to have had a significant impact on the habitat, through interrupting the natural east to west surface water flow and the disturbance associated with the road itself, and through encouraging urban and agricultural development by providing easy access to the main north-south transport corridor.

Table 6-39: Habitat Classification Summary, Segment 7

Main Habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	24	18.7
Modified	Urban	Residential	Mainly a residential area	16.7	13
Modified	Urban	Mixed	Mixed residential with commercial/industrial	10.1	7.9
Modified	Agricultural	Active	Agricultural fields/orchards actively cultivated	21.3	16.6
Modified	Agricultural	Mixed	Agricultural fields, both active and fallow/abandoned	9.6	7.4
Natural	Semi-Natural/Degraded	Low Value	Limited change to habitat considered to be >75% natural	46.8	36.4
Total Segment 7 Length				128.5km	

Segment 7 Baseline Summary

Because of the ongoing development and modification of the habitat only nine sites were selected for Terrestrial Baseline Survey.

No more than three plant species were recorded at any survey site, and only five species overall (*Achillea fragrantissima, Anabasis articulata, Peganum harmala, Tamarix nilotica* and *Atriplex leucoclada*) in Natural Habitat sites.

A notable feature of the vegetation is that *Anabasis articulata*, which is a characteristic species of the Irano-Turanian Region was present in every at every site while the remaining species were present in one survey site each.

Table 6-40: Segment 7 Summary of Results

Site ID	Plant Cover (%)	No. of Plant Species	No. of individuals	Animal Species	Animal "Signs"
FA64	0.50	1	5		
FA64B					1
FA65	12.17	3	19		
FA66	0.45	1	5	2	
FA68	15.73	3 (+2)	81	4	
FA69A	1.20	1	18		1
FA69B	1.47	1	16		
FA70	0.71	1	16	1	
PS5	0.70	1	14		

Two reptile species, the Snake-eyed Lizard, *Ophisops elegans* and a Baluch rock gecko, *Bunopus tuberculatus,* were observed at FA66 during day and night surveys, respectively.

Four species of reptiles were observed at FA68, including one snake species, most probably a Forskal sand snake (*Psammophis schokari*) and a Snake-eyed Lizard (*Ophisops elegans*), during daytime, and two geckos, a Baluch rock gecko (*Bunopus tuberculatus*) and a *Hemidactylus dawudazraqi,* during the night walking transects.

Survey site 69A was initially selected because it was located within the known range of the endemic species *Acanthodactylus ahmaddisii* (Jordanian Fringe-fingered Lizard), which was closest to the Pipeline route. Vegetation consisted of only *A. articulata* at a relatively low canopy cover and abundance. No reptiles were observed along a 300m transect.

The area surveyed lies near the entrance to Dab'ah Village (off the Desert Highway) and may have been subject to anthropogenic impacts since *A. ahmaddisii* was identified by Werner (2004). Therefore, to gain a more thorough understanding of the potential for the species to occur in the vicinity of the Pipeline, the survey team extended the survey to the Daba'a Rangeland Reserve, a fenced and protected area. A thorough survey of the area resulted in observing three species of lizard (Snake-eyed lizard *Ophisops elegans*, Schneider's Skink *Eumeces schneiderii*, and Sinai Agama *Pseudotrapelus sinaitus*), but *Acanthodactylus ahmaddisii* was not present. Of the three species present, *Ophisops elegans* was the most common, with 25 individuals recorded, while the remaining two species were represented by a single individual each.

Walking surveys of three transects at survey site FA70 for fauna revealed two individuals of Egyptian Rock Agama (*Laudakia vulgaris*).

No species of fauna or fauna of conservation significance were recorded in this segment.

Segment 7 Key Sensitivities

This Segment includes areas close to the known range of the endemic reptile species *Acanthodactylus ahmaddisii* (Jordanian Fringe-fingered Lizard). However, no reptiles were observed in this vicinity.

The area surveyed for this species lies near the entrance to Dab'ah Village (off the Desert Highway) and may have been subject to anthropogenic impacts since it was first recorded. So the survey was extended to the Dab'ah Rangeland Reserve, a fenced protected area. This resulted in observing three species of lizard, but *Acanthodactylus ahmaddisii* (Jordanian Fringe-fingered Lizard) was not present.

Figure 6-44: Segment 7a Map

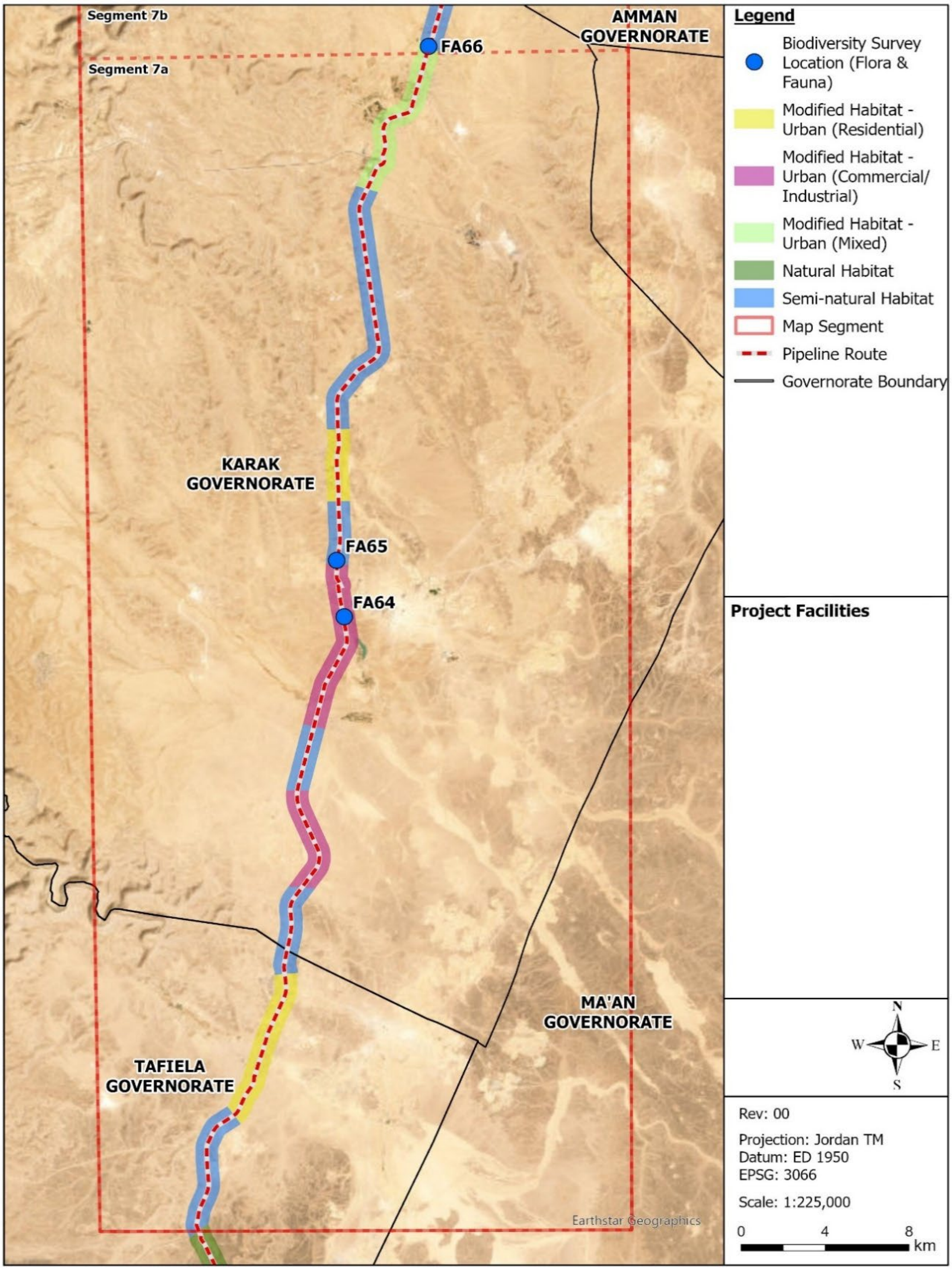
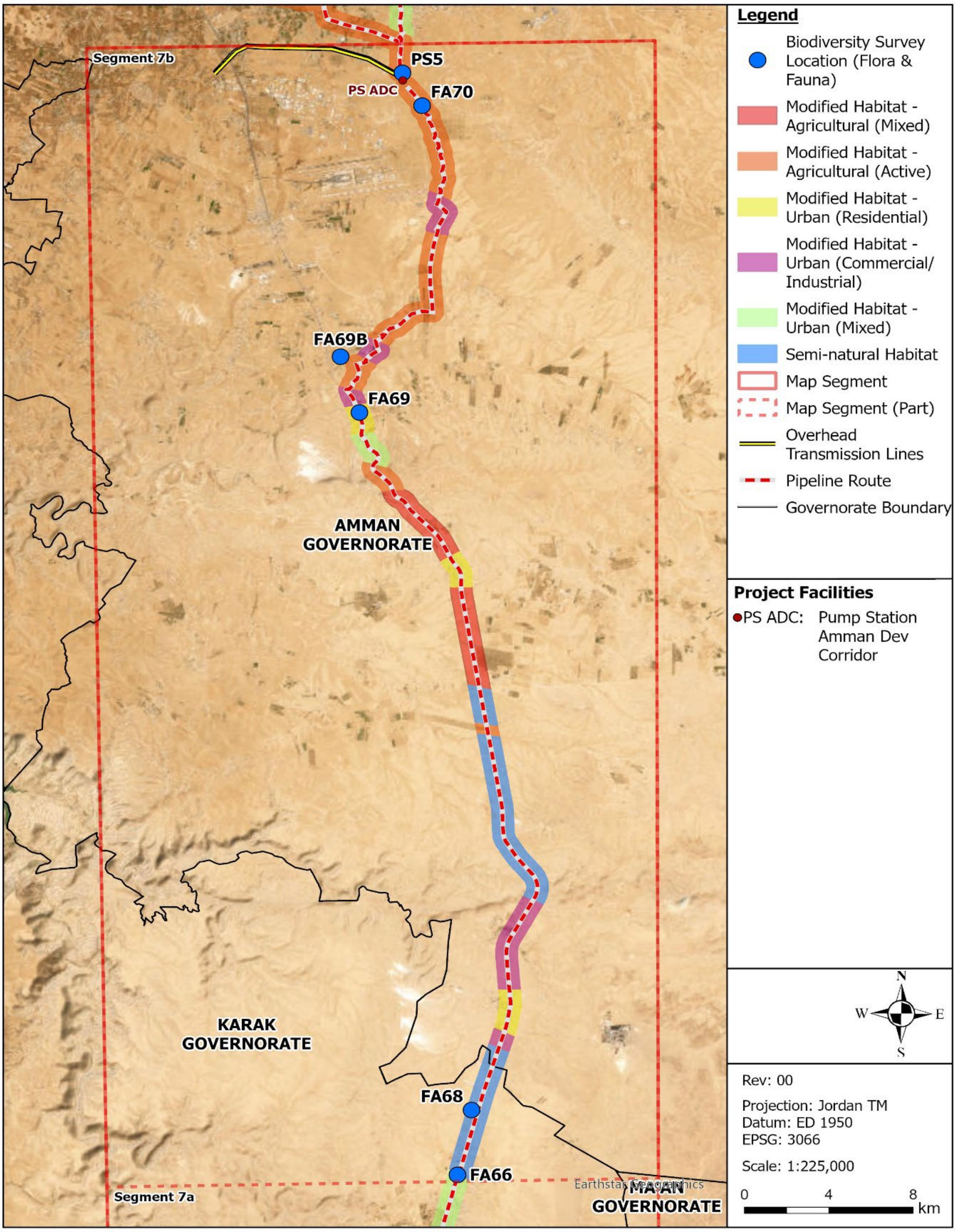


Figure 6-45: Segment 7b Map



6.2.14.10 Segment 8

Segment 8 Habitat Summary

This Segment is a relatively short Segment of approximately 19km that extends from the northern end of Segment 7 in a west and north-westerly direction, initially through abandoned farmland followed by actively cultivated farmland into a suburban setting comprising some residential and commercial areas.

The Segment was reviewed from 13 locations, but none were chosen for application of the full survey because there were no "Natural Habitat" or "Semi-Natural Habitat" within this Segment (Figure 6-46).

Table 6-41: Habitat Classification Summary, Segment 8

Main Habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Mixed	Mixed residential with commercial/industrial	0.6	3
Modified	Agricultural	Mixed	Agricultural fields both active and fallow/abandoned	9.3	49
Modified	Agricultural	Active	Agricultural fields/orchards actively cultivated	9.2	48
Total Segment 8 Length				19.1km	

Segment 8 Baseline Summary

Ten plant species were identified growing in this Segment: Achillea fragrantissima, Anabasis articulata, Capparis spinosa, Cupressus sempervirens, Eucalyptus camaldulensis, Noaea mucronata, Olea europaea, Pinus halepensis, Sarcopoterium spinosum, Verbascum sp. several of which are cultivated and/or used for landscaping. as species, and none of them are Red Listed.

No reptile or mammal species (excluding domesticated species) were observed in this Segment. The survey did not reveal any structures that could serve as roosting locations for bats.

The entire length of the pipeline in this Segment and the reservoir location were not suitable for quantitative survey methods due to busy roads, private properties lining the roads, and the extent of modified habitat.

The western part of the Pipeline including the area of the receiving reservoir (Al Muntazah) and the Ghamadan National Park is in the Mediterranean biotope. From southeast to north west, land use transitions from abandoned agriculture to active field crop agriculture to mixed field crop agriculture residential to mixed orchard agricultural-residential-commercial.

Signs (mounds) of the Middle Eastern blind mole rat (*Spalax ehrenbergi*) were observed in some fields, approximately midway along the Pipeline route in Segment 9, during the survey. Both *M. musculus* and *R. norvegicus* are known to occur in urban areas in Jordan, in close association with human habitations.

There were no natural or anthropogenic structures likely to support bat roosts in the entire area of Segment 8.

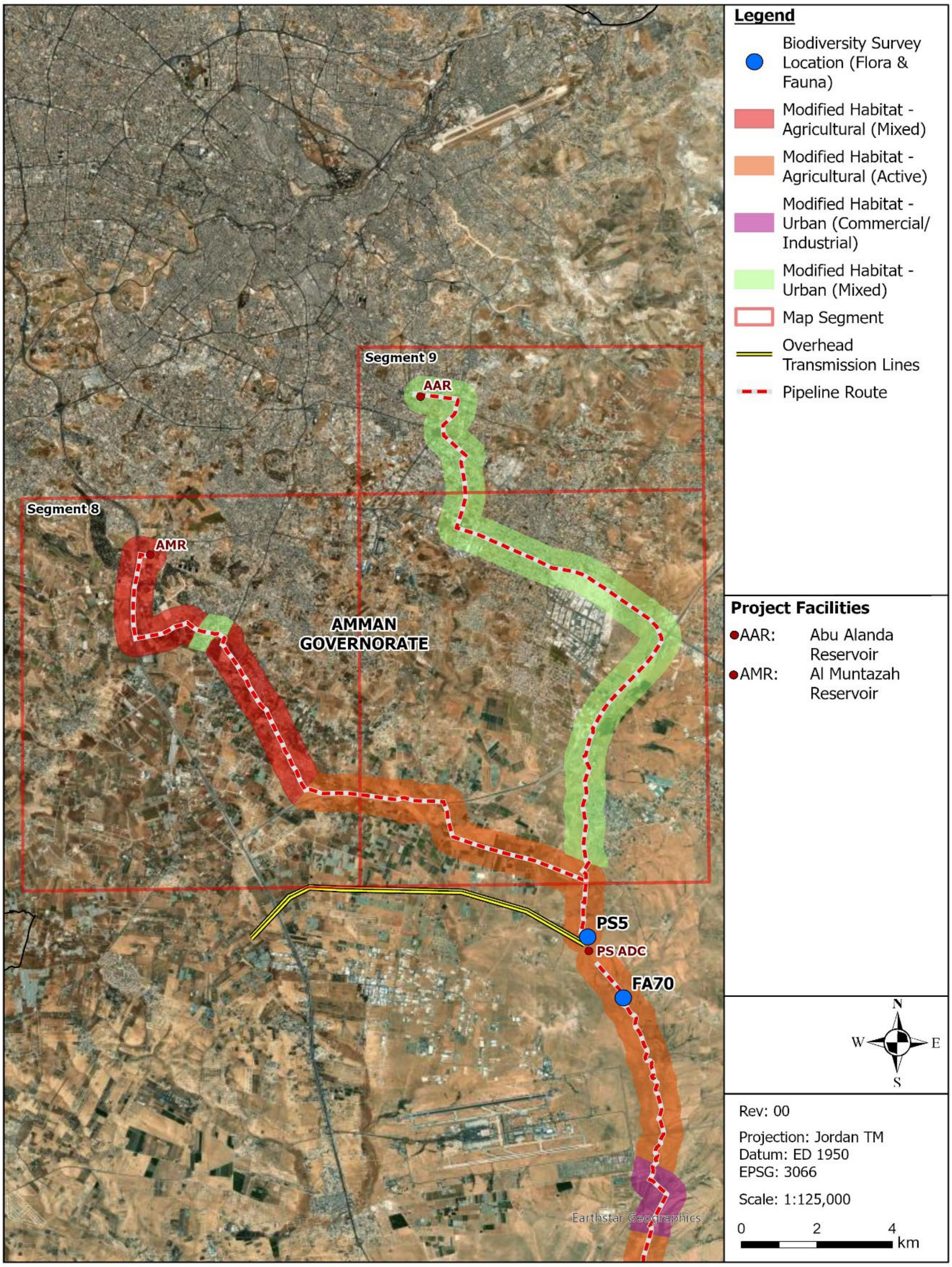
Segment 8 Key Sensitivities

This Segment comprises abandoned farmland, actively cultivated farmland and a suburban setting comprising some residential and commercial areas.

The Segment was reviewed from 13 locations, but none were chosen for application of the full survey because there were no “Natural Habitat” or “Semi-Natural Habitat” areas within this Segment.

No reptile or mammal species (excluding domesticated species) were observed in this Segment.

Figure 6-46: Segments 8 and 9 Map



6.2.14.11 Segment 9

Segment 9 Habitat Summary

Segment 9 is the most densely urbanised of all the Rapid Assessment Segments (Figure 6-46). The density of urbanisation was somewhat lower in the south, but even in areas with significant remnant agricultural fields, the area was clearly undergoing transition to urbanisation, most of which appeared to be industrial/commercial.

Table 6-42: Habitat Classification Summary, Segment 9

Main Habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Mixed	Mixed residential with commercial/ industrial	18.4	100
Total Segment 9 Length				18.4km	

Residential, commercial, and industrial areas are common in this area, which is also a major trucking corridor to the Iraqi border and the desert highway. The full extent of Segment 8 is impacted by anthropogenic activities and cannot be considered a natural habitat.

Segment 9 Baseline Summary

The plant species identified in this area included ornamental species used for landscaping (*Cupressus sempervirens*, *Eucalyptus camaldulensis*, and *Pinus halepensis*) and *Anabasis articulata* which colonizes disturbed areas including fallow fields.

No natural features or anthropogenic structures that could serve as bat roosts were observed in Segment 9.

Native species such as Aleppo pine (*Pinus halepensis*) are scattered throughout the area, as well as trees of Carob and *Ceratonia siliqua* that are planted along Highway 40.

The entire length of the pipeline and the reservoir location in this Segment was not suitable for quantitative survey methods due to busy roads, private property along them and the extent of urban developments and agricultural fields that occupied the entire route.

Regarding faunal species, invasive species such as the House Mouse (*Mus musculus*) and the Brown Rat (*Rattus norvegicus*) are known to occur in urban and commercial areas. However, in areas such as Adh Dhuhaybah and Al Sharqiyah, the Fat Sand Rat, *Psammomys obesus*, Wagner's Gerbil, *Gerbillus dasyurus*, and the Grey Hamster, *Cricetulus migratorius*, were reported from the vicinity of Al Muwaqqar (Amr & Saliba, 1986) however, recent studies, to reflect the increased extent of human activity, are lacking.

Segment 9 Key Sensitivities

The entire Segment is considered to be Modified Habitat - Urban (Mixed), no flora or fauna of significance was recorded.

6.2.14.12 Summary of Baseline Results

The following table presents a summary of the key species (Global and national RDB species) which were recorded during the baseline surveys. For plants, the encounter rate in any given section is calculated as: the number of records of the species, divided by the total number of plant records made (all species), expressed as a percentage.

A list of all species recorded during the surveys, together with desk study data from relevant areas, is presented in Appendix 6-7.

Table 6-43: Summary of Key Species

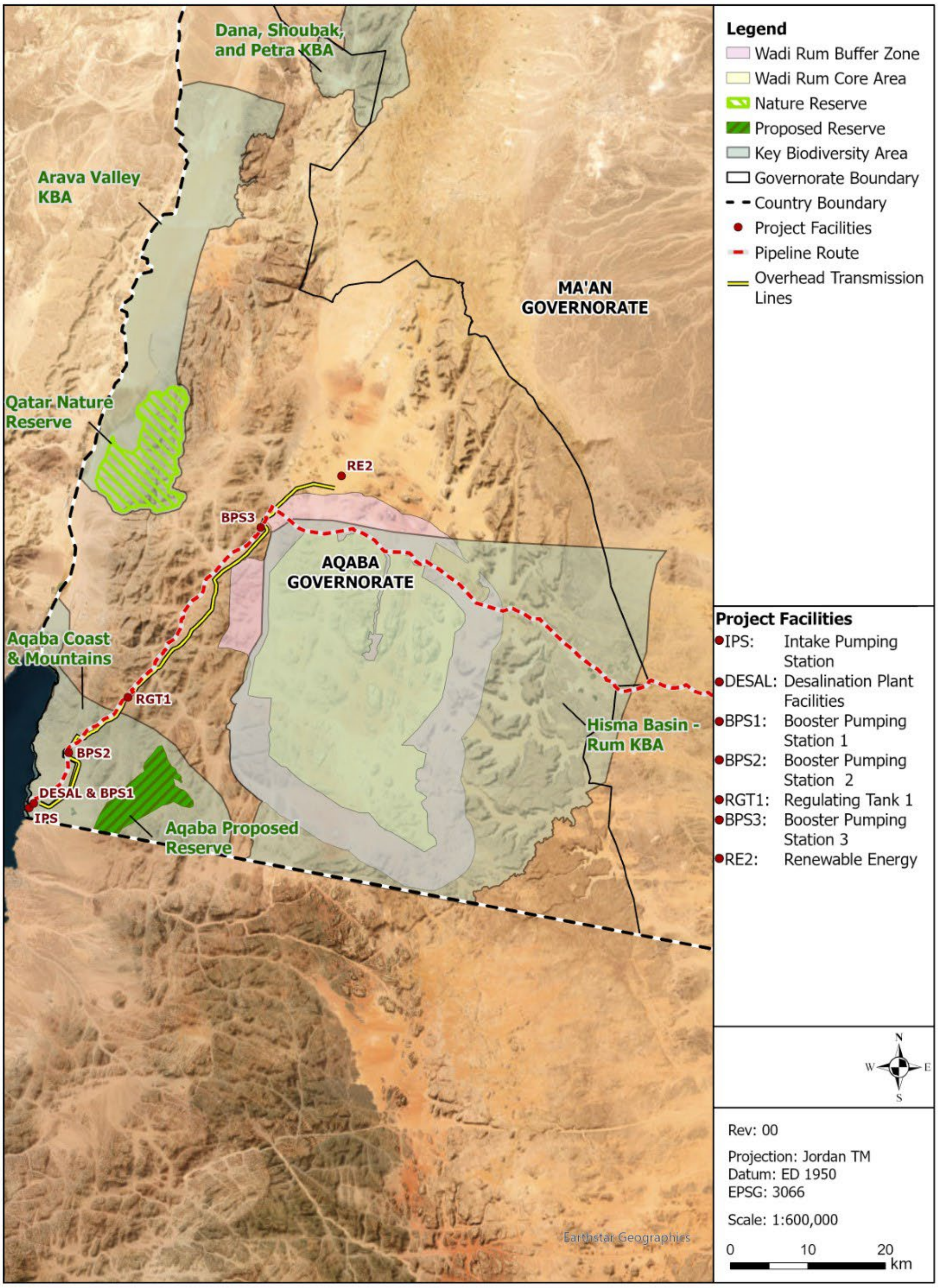
Species	Global Status	National Status	Segment	Abundance/Encounter Rate
Mammals				
***Capra nubiana* the Nubian Ibex**	VU	VU		Single record
Reptiles				
***Uromastyx aegyptia* Egyptian Spiny–tailed Lizard**	VU	NT	1,6	Suspected (Burrow), Single record
Plants				
Artemisia judaica	-	VU	5	34.6%
Artemisia monosperma	-	NT	5	16.8%
Calligonum comosum	-	EN	5	0.9%
Cleome droserifolia	-	EN	1,2	3.8%, 4.5%
Haloxylon persicum	LC	VU	4	24.5%
Heliotropum rotundifolium	-	NT	5	0.9%
Hyoscyamus muticus	-	CT	5	0.9%
Lavandula coronopifolia	-	NT	2	9%
Vachellia gerrardii	-	VU	4,6	1.9%, 6.8%
Vachellia tortilis	LC	VU	1,2	11.5%, 4.5%

6.2.15 Baseline Avifauna Summary

Because birds are generally highly mobile, the ESIA Study Area considered for the baseline assessment was a 10km buffer around the Project footprint, encompassing all Project above-ground facilities.

This baseline assessment is based on a desktop review and the results of field surveys conducted to date. The potential impacts of the Project's various infrastructure components differ, but field survey efforts focused primarily on the overhead transmission line (OHTL), which was considered to pose the greatest risk to birds (see Chapter 9), since the temporary works on the buried pipeline are not considered to have significant impacts on birds, and OHTLs are known to cause mortality through electrocution and, particularly, collisions (Prinsen *et al.* 2011; APLIC 2012; Bennun *et al.,* 2021). Additionally, part of the OHTL overlaps a Key Biodiversity Area (KBA), the Aqaba Mountains and Coast KBA (Figure 6-47), designated specifically due to the high numbers of the migratory Levant Sparrowhawk (*Accipiter brevipes*), which had also been flagged as a potential critical habitat trigger for the Project (TBC 2024).

Figure 6-47: Protected and Other Designated Areas Overlapping or in the Vicinity of the OHTL



6.2.15.1 Methodology

The Integrated Biodiversity Assessment Tool (IBAT), a source of globally authoritative biodiversity datasets, including the IUCN Red List of Threatened Species, the World Database on Protected Areas, and the World Database of Key Biodiversity Areas (including Important Bird and Biodiversity Areas), was used to identify all bird species potentially present in the ESIA Study Area.

In addition to IBAT, several internationally and nationally relevant datasets and assessments were consulted, including:

- The conservation status and distribution of the breeding birds of the Arabian Peninsula (Symes *et al.,* 2017)
- The Global Biodiversity Information Facility (GBIF)
- eBird Database
- BirdLife Data Zone
- Jordan BirdWatch (JBW) database

Field surveys were conducted across six campaigns in 2025 (each with a duration of approximately 13 days), with three carried out during the spring and three during the autumn. Results of the autumn survey are provided in Appendix 6-6. Field surveys were performed along the expected layout of the OHTL and included vantage point observations, line transects, waterbody counts and carcass surveys. For details on the survey methods refer to The Biodiversity Consultancy Reports (TBC 2025a, 2025b, 2025c).

Vantage points (VP): Vantage points comprised a series of watches from a fixed location (each with a 3-hour duration) to quantify the flight activity of birds and their distribution at the proposed development site. This method is particularly suitable for detecting and tracking the movements of soaring birds or other diurnal, medium- to large-sized birds that actively migrate or commute between foraging and/or roosting sites (Scottish Natural Heritage, 2017; BID Invest and IFC, 2019). Eleven VPs were distributed along the expected layout of the overhead transmission line, appropriately spread and located in areas of good visibility (Figure 6-48).

Line Transects: Line transects were conducted to survey the non-soaring terrestrial birds. Twenty 500m transects were defined along the expected overhead transmission line route, sufficiently spaced apart to minimise double-counting (Figure 6-49).

Waterbody counts: Waterbody counts were directed at aquatic bird species. Six observation points were established along the OHTL at waterbodies and flood barrier dams, at locations that allow the visual inspection of the water surface and 200 m of the water margin to each side (Figure 6-50). Every water bird present, either in the water or on the banks, was recorded.

Carcass surveys: Searches for carcasses were undertaken along the existing OHTL that runs nearby (parallel) to the planned OHTL, in accordance with the methodology described in Post-construction Bird and Bat Fatality Monitoring (PCFM) for Onshore Wind Energy Facilities in Emerging Market Countries: Good Practice Handbook and Decision Support Tool (IFC *et al.,* 2023). Searching the parallel line was conducted as a proxy to assess future mortality at the planned transmission line.

Within the Aqaba Coast and Mountains KBA/IBA, the existing OHTL was divided into 1 km sections. PCFM was conducted by two observers along 500 m of each 1 km segment. Outside of the IBA, the existing OHTL was divided into 5 km segments and PCFM conducted within 1 km. Carcass surveys were conducted three times in spring and three times in autumn.

Figure 6-48: Locations of Vantage Points

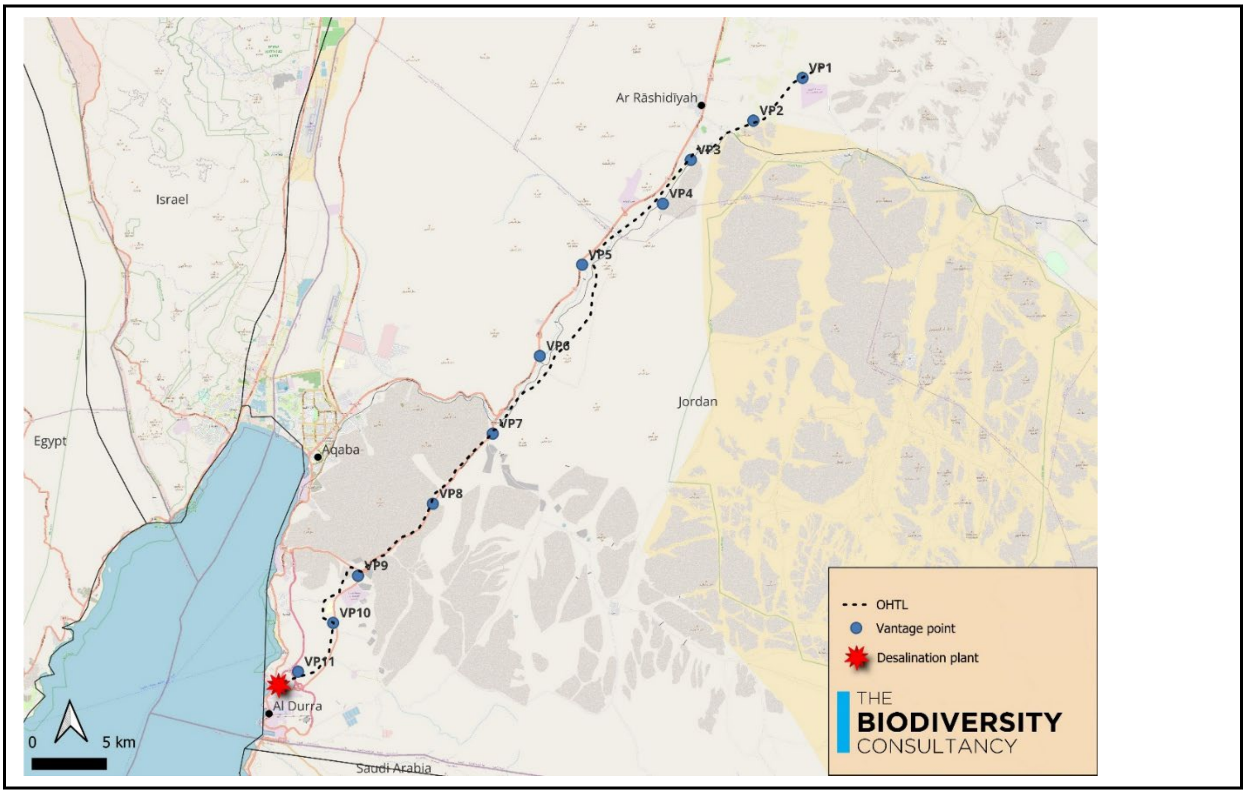


Figure 6-49: Locations of Line Transect Surveys

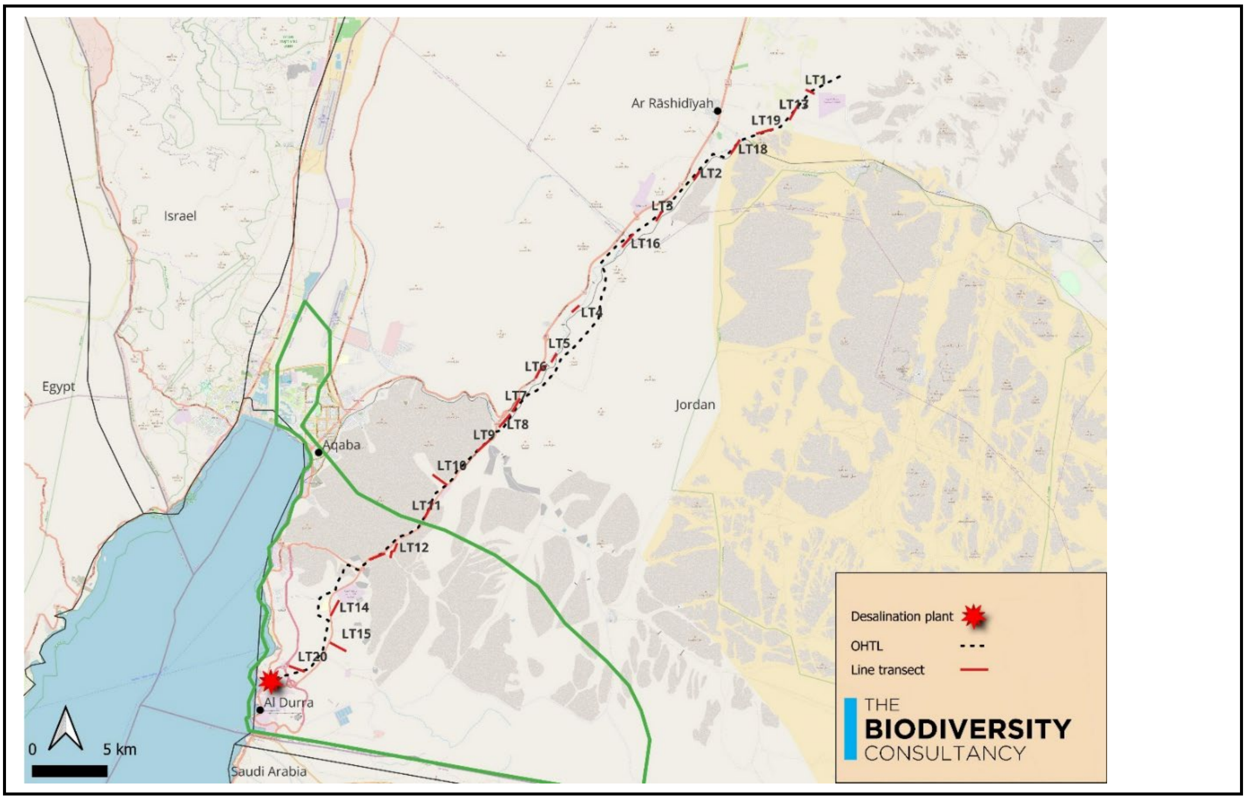
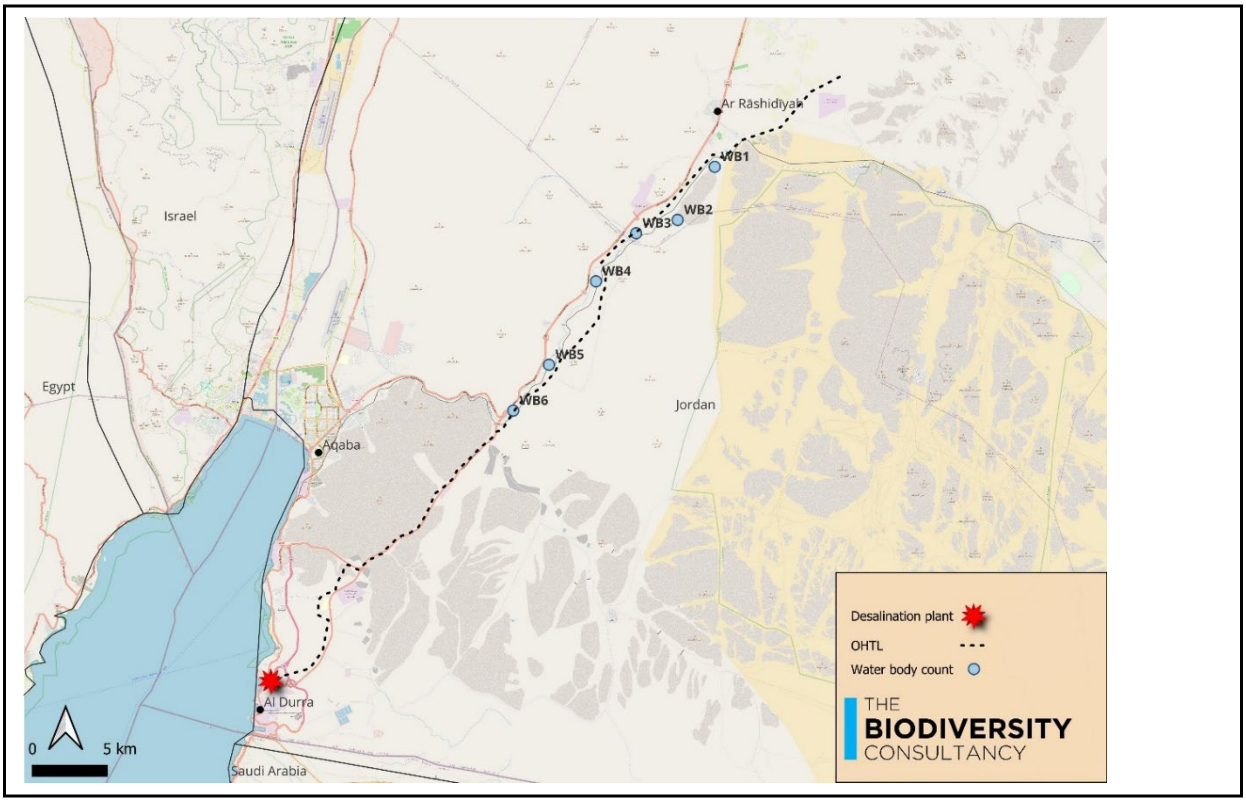


Figure 6-50: Locations of Waterbody Counts



6.2.15.2 Desktop Review and Field Survey Results

Based on the desktop review, a total of 224 bird species may potentially occur within the study area, of which 85 have been confirmed so far during the field surveys. The full list of bird species potentially present in the study area, with an indication of which ones were recorded during field surveys, their IUCN Red List and Regional Red List (Symes *et al.,* 2017) category is provided in Appendix 6-5.

It should noted, that only the southern portion of the ESIA Study Area was surveyed (along the proposed OHTL), that some of the 224 species are rare and/or localised, and that some groups of species, such as seabirds and nocturnal species, were not targeted by the surveys.

Soaring birds

Jordan is part of the Rift Valley/Red Sea migratory flyway, which is one of the most important routes in the world for migratory soaring birds (MSB), such as raptors, storks and pelicans. Each spring and autumn, 37 species of MSBs navigate this flyway, with over a million birds passing through the larger bottlenecks (Porter 2005; Jobson *et al.,* 2021). The proliferation of wind energy projects and power lines poses a major threat to these species during the spring and autumn migratory periods (Khoury, 2017).

In Jordan, soaring bird migration is more noticeable in spring when birds tend to concentrate their journey along the Rift Vally. The majority of MSBs enter the country from the Eilat (Palestine) bottleneck, in the Northern tip of the GoA, before travelling northwards. This explains why MSB counts in Eilat in spring are much higher than records along the Aqaba Mountains and Coast. Nevertheless, this area is considered as a KBA, designated for important concentrations of Levant Sparrowhawk, while some globally threatened soaring birds also occur, such as the Egyptian Vulture (*Neophron percnopterus*), the Steppe Eagle (*Aquila nipalensis*), the Saker Falcon (*Falco cherrug*), all Endangered according to the IUCN

Red List; the Eastern Imperial Eagle (*Aquila heliacal*), the Greater Spotted Eagle (*Clanga clanga*), the Sooty Falcon (*Falco concolor*) and the Red-footed Falcon (*Falco vespertinus*), all Vulnerable. In total, more than 50,000 soaring birds are expected to migrate through Aqaba each spring (BirdLife International 2025; KBA Partnership, 2025). Two raptor species are considered Critically Endangered in the Arabic Peninsula: Lanner Falcon (*Falco biarmicus*) and the Saker Falco. Both are very rare/occasional in the study area.

In autumn, soaring bird migration is less visible as birds do not tend to concentrate in one route, migrating in a broad front over the whole country (Jobson *et al.,* 2021). Table 6-44 shows the species that can potentially be found in the ESIA Study Area with an indication of the total number of individuals recorded in the vantage point surveys, and their IUCN Red List and Regional Red List (Symes *et al.,* 2017) category.

Table 6-44: Soaring Bird Species Likely To Be Present in the ESIA Study Area

Scientific name	Common name	Confirmation	Total count in spring 2025	Total count in autumn 2025	IUCN Red List Category	Regional Red List Category
Accipiter brevipes	Levant Sparrowhawk				LC	-
Accipiter nisus	Eurasian Sparrowhawk	✓		8	LC	-
Anthropoides virgo	Demoiselle Crane				LC	-
Aquila chrysaetos	Golden Eagle				LC	EN
Aquila heliaca	Eastern Imperial Eagle				VU	-
Aquila nipalensis	Steppe Eagle	✓	6	84	EN	-
Aquila verreauxii	Verreaux's Eagle	✓			LC	EN
Buteo buteo	Steppe Buzzard	✓	396	80	LC	-
Buteo rufinus	Long-legged Buzzard	✓	3	11	LC	
Ciconia ciconia	White Stork	✓			LC	-
Ciconia nigra	Black Stork	✓		5	LC	-
Circaetus gallicus	Short-toed Snake-eagle	✓		4	LC	-
Circus aeruginosus	Western Marsh-harrier			3	LC	-
Circus cyaneus	Hen Harrier				LC	-
Circus macrourus	Pallid Harrier				NT	-
Circus pygargus	Montagu's Harrier				LC	-
Clanga clanga	Greater Spotted Eagle	✓		1	VU	-
Clanga pomarina	Lesser Spotted Eagle	✓		1	LC	-
Elanus caeruleus	Black-shouldered Kite	✓		1	LC	VU
Falco biarmicus	Lanner Falcon				LC	CR
Falco cherrug	Saker Falcon				EN	CR
Falco columbarius	Merlin				LC	-
Falco concolor	Sooty Falcon				VU	EN

Scientific name	Common name	Confirmation	Total count in spring 2025	Total count in autumn 2025	IUCN Red List Category	Regional Red List Category
Falco naumanni	Lesser Kestrel				LC	-
Falco peregrinus	Peregrine Falcon	✓			LC	EN
Falco subbuteo	Eurasian Hobby				LC	-
Falco tinnunculus	Common Kestrel	✓		22	LC	-
Falco vespertinus	Red-footed Falcon				VU	-
Gyps fulvus	Griffon Vulture				LC	EN
Haliaeetus albicilla	White-tailed Sea-eagle				LC	-
Hieraaetus pennatus	Booted Eagle	✓	36	5	LC	-
Milvus migrans	Black Kite	✓	55	26	LC	-
Neophron percnopterus	Egyptian Vulture	✓	1	1	EN	-
Pandion haliaetus	Osprey	✓			LC	-
Pelecanus onocrotalus	Great-white Pelican	✓		16	LC	-
Pernis apivorus	European Honey-buzzard	✓	170		LC	-
TOTAL			667	268		

As expected, the number of MSBs recorded from vantage points in spring was much higher than the one recorded in autumn (Table 6-44), especially driven by relatively high numbers of Steppe Buzzards (*Buteo buteo*), Honey Buzzards (*Pernis apivorus*), Black Kites (*Milvus migrans*) and Booted Eagles (*Hieraaetus pennatus*), which are all common soaring bird migrants in the region.

It should be noted, that the globally Endangered Steppe Eagle was recorded in both seasons, with high numbers (84) in autumn. Other threatened species that were recorded were the Egyptian Vulture (both seasons) and the Greater Spotted Eagle (one individual in autumn).

Most of the individuals of the threatened species were observed flying at altitudes much higher than the OHTL, indicating that they were likely performing long range migratory movements. This translates into a lower risk of collision.

Verreaux's Eagle (*Aquila verreauxii*) is globally Least Concern, but Endangered in the Arabian Peninsula (Symes *et al.,* 2017). An adult bird of this species was recorded during the field surveys, and since these eagles are not migratory in the region, it is likely breeding in the Aqaba Mountains.

6.2.15.3 Waterbirds and seabirds

Several species of shore birds can be found migrating or even overwintering across the coast of Jordan (and to a lesser extent, inland) and very few of them breed in the country (eBird 2025). Three of these species are classified as Vulnerable by IUCN: Broad-billed Sandpiper (*Calidris falcinellus*), Curlew Sandpiper (*Calidris ferruginea*) and Grey Plover (*Pluvialus squatarola*). These species are rare along the coast and are not expected to occur inland. The same can also be said of seven other shore bird species that are considered Nearly Threatened by IUCN (see Appendix 6-5).

Waterbodies in the vicinity of the Project are very scarce and most of them correspond to artificial dams that were built to reduce the severity of the effects of fast floods on urban areas. Therefore, few waterbird species were found, and none of conservation concern (Table 6-45).

None of the gull and tern species that are present in the area are of conservation concern.

No specific surveys were conducted targeting pelagic seabirds, but they are quite rare in the region, and they seldom approach the coast, with the exception of the Brown Booby (*Sula leucogaster*), which is considered Least Concern by IUCN.

Some waterfowl also migrate along the coast of the Gulf of Aqaba, including the globally Endangered White-headed Duck (*Oxyura leucocephala*). However, it is considered very unlikely that this species occurs within the study area, since there are no records on eBird or GBIF of this species in Jordan, and there is no suitable habitat in the area.

Table 6-45: Water Bird Species Counted During Waterbody Surveys

Scientific name	Common name	Total count in spring	Total count in autumn	IUCN Red List Category	Regional Red List Category
Actitis hypoleucus	Common Sandpiper		1	LC	-
Anas crecca	Teal	60	2	LC	-
Ardea cinerea	Grey Heron		1	LC	NT
Calidris minuta	Little stint	5		LC	-
Egretta garzetta	Little Egret		9	LC	LC
Spatula querquedula	Garganey		3	LC	-
Tringa nebularia	Common Greenshank	2		LC	-
Tringa ochropus	Green Sandpiper		1	LC	-
Vanellus spionosus	Spur-winged Lapwing	16	20	LC	LC

6.2.15.4 Other Species of Concern

Jordan is also important concerning the migration of passerines and other small birds. One of these species, the Sociable Lapwing (*Vanellus gregarious*), is listed as Critically Endangered (CR) in the IUCN Red List. In Jordan, it occurs as a very rare passage migrant and is likely to appear only occasionally within the study area, potentially as a vagrant.

The only other globally threatened species that were not mentioned in the sections above are the MacQueens' Bustard (*Chlamydotis macqueenii*), the Syrian Serin (*Serinus syriacus*) and the European Turtle-dove (*Streptopelia turtur*), all of them classified as Vulnerable by IUCN.

MacQueen's Bustard is considered to be very rare in Jordan, with very few recent records and none of which in the vicinity of the Project (eBird, 2025).

The Syrian Serin breeds in submontane and montane open woodland and bushy slopes, usually dominated by sparse cedar (*Cedrus* spp.), pine (*Pinus* spp.), fir (*Abies* spp.) and Juniper (*Juniperus* spp.) woods, also small Palestine Oak (*Quercus calliprinos*) and orchards, at 900-1800m elevation. None of these habitats occur in the study area. During the post-breeding dispersal, it can be found at lower levels in southwestern Jordan, including the study area. It is an erratic species that can change its wintering distribution every year (Clement & de Juana, 2020).

The European Turtle-dove is a scarce passage migrant in the study area. It favours areas with some vegetation.

Some desert species are of regional concern, such as the Buff-rumped Wheatear (*Oenanthe Moesta*, globally Least Concern and regionally Endangered), which was detected during the field surveys, but is expected to be uncommon in the area. Other regionally endangered species that were not detected during the field surveys, but may be present in the study area is the Black-bellied Sandgrouse (*Pterocles orientalis*).

Carcass search along the existing parallel transmission line revealed very low mortality (only one Quail *Coturnix coturnix*).

6.2.15.5 Avifauna Key Sensitivities

The southern portion of the Project area overlaps the Aqaba Mountains and Coast KBA which is an important area for soaring bird migration, especially during spring. Some of the species that occur in the area can potentially trigger critical habitat (*sensu* IFC PS6 and EBRD PR6, see TBC 2025b). These are the Steppe Eagle, the Levant Sparrowhawk and the Sooty Falcon. Levant Sparrowhawk and Sooty Falcon are relatively small and agile birds of prey that can be considered low risk regarding transmission line impacts (Prinsen *et al.* 2011; Thaxter *et al.* 2017). They have high manoeuvrability in flight, and therefore, have lower collision probability than other species and usually fly higher than power line height during migration. Post-construction fatality monitoring being conducted in powerlines in Egypt (Red Sea coast) which is located in the same flyway as Aqaba and where the same Levant Sparrowhawks will pass (in similar numbers) as well as a proportion of the Sooty Falcons. At the time of writing, no individuals of these two species have been found as victims of power line collisions.

The Steppe Eagle however, which was detected in high numbers in the study area, is known to suffer from collisions and electrocutions (more frequently in distribution lines) (APLIC 2012; Prinsen *et al.* 2012; BirdLife International & CMS Energy Task Force 2023).

Another species that is also likely to trigger critical habitat is the Syrian Serin, but impacts on this species are unlikely to be significant.

6.3 Marine Environment

6.3.1 Data Sources

The ESIA Study Area marine baseline has been characterised through desktop studies of primary and secondary data, supplemented by field surveys conducted within the limited time available, as presented in Table 6-46.

Table 6-46: Marine Environment Data Sources

Chapter 6 Section	Primary Data Source	Secondary Data Source
Marine and Coastal Development and Industry	Engagement with ASEZA Head of Protection and Monitoring Department (T. Khodari)	ASEZA Urban Development Master Plan 2024-2040 Corporate websites of key ASEZA industrial facility and infrastructure operators Various published literature
Shipping and Navigation	Engagement with Jordan Maritime Authority Director (O. Dabbas)	Various published literature Corporate websites of key ASEZA industrial facility and infrastructure operators
Fisheries, Tourism and Other Marine Users	Focus group held on the 12th of October with the Divers Association and the Fishermen Cooperative Association	Ministry of Tourism and Antiquities Quarterly Tourism Reviews ASEZA Strategic Plan 2024-2028 Various published literature
Bathymetry and Physical Oceanography, Water and Sediment Quality, Plankton, Fish Ecology	2025 AAWDCP Marine Baseline Survey Report 2025 AAWDCP Marine Critical Habitat Assessment	ASEZA / MSS Reports on Environmental Appraisal of the Jordanian Coast 2022 AAWDC Project ESIA Various published literature
Benthic Ecology (including Shellfish)		2022 AAWDC Project ESIA Various published literature
Marine Megafauna and Turtles		IMMA E-Atlas ISRA E-Atlas Various published literature
Marine Cultural Heritage	Consultation with the Department of Antiquities (DoA) and ASEZA	Various published literature and geophysical data

6.3.2 Protected and Designated Sites

The Project is located within the Jordanian sector of the GoA, within the Red Sea region, an area known globally for its high biodiversity value, as reflected by the number of designated and protected sites within it (Figure 6-52). A desk-based review utilised a combination of different online mapping resources to identify and demarcate all relevant legally protected areas (e.g., Marine Protected Areas (MPAs), UNESCO Natural World Heritage Sites, Important Bird Areas (IBAs)), as well as internationally and nationally recognised designated sites (e.g., Important Marine Mammal Areas (MMAs), Important Shark and Ray Areas (ISRAs), etc.). Noting that both legally protected and internationally designated or recognised sites (the latter often having no legal protection) all have the potential to contain or support key biodiversity values.

Screening confirms that the Project is not located within any legally protected areas, defined as “A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values” (Dudley, 2008) or in any internationally recognised areas (e.g., UNESCO Natural World Heritage Sites).

The closest distance between the Project infrastructure (based on the current design and alternatives under consideration) and the boundary of the Aqaba Marine Reserve (AMR) is approximately 2.5km. The closest boundary of the Northern Jordan Area of Interest is approximately 9.4km from the Project infrastructure, and the ISRA boundary in Palestine at Eilat North Beach is approximately 17.8km.

There are currently three IMMAs in the Red Sea region, which are defined as “discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation”. They are designed to assist intergovernmental organisations (IGOs) and non-governmental organisations (NGOs) with identifying and prioritising conservation actions. At present, there are no IMMAs within the main body of the GoA. This means the site has been proposed as a candidate IMMA at a regional workshop with insufficient information to meet the required criteria.

There are also several ISRAs within the Red Sea region. ISRAs are defined as a “discrete, three-dimensional portion of habitat, important for one or more species of shark, ray, or chimaera species, that has the potential to be delineated and managed for conservation” based on robust scientific criteria (ISRA, 2025).

6.3.2.1 Protected, Designated and Recognised Sites within Jordan

The Aqaba Marine Reserve (AMR) spans 7km of the Jordanian coast, extending over 2.8km^2 and encompassing 3% of Jordan’s territorial waters and 26% of its coastline, approximately 1km^2 of which comprises of coral reefs running the length of the reserve out to <300m. The terrestrial boundary lies 50m west of the Mean High Water Mark (MHWM). The reserve has a buffer zone which covers a 1.5km^2 area collectively along its landward and seaward extents. The AMR supports over 150 coral and 500 fish species.

Marine ecosystems and habitats within the AMR include rocky shores and fossil coral reefs, ancient uplifted formations and Holocene beach rocks, reflecting the area’s dynamic geological and marine history. The coral reef formations comprise three distinct geological terraces, each represents a different epoch in the region’s marine history and contains fossilised marine organisms from those periods. The AMR hosts remarkably well-preserved fossil coral reefs, which hold significant scientific and cultural value as unique natural heritage features of Jordan requiring protection and conservation.

Despite being limited in spatial extent, coral reef ecosystems are the most vital component of Jordan’s marine environment, supporting exceptionally high marine biodiversity and forming part of the Red Sea biogeographic zone, recognized by the World Wide Fund for Nature (WWF) as a Global 200 Eco-Region for its outstanding ecological significance and unique coral diversity. The greatest extent of seagrass beds are found in the Al-Mamlah Bay (Tala Bay) area located at the southern edges of the AMR. The species richness and biodiversity are very high.

The boundaries of the AMR were first delineated in 1997, when it was known as the Aqaba Marine Park (AMP). In 2020 His Majesty King Abdulla II declared the AMP as a new AMR which was then included within the Jordan National Protected Areas Network (JNPA) becoming the first marine reserve in Jordan. The AMR is located approximately 2km north of the proposed Project site and is managed by the Aqaba Special Economic Zone Authority (ASEZA). Key objectives of the Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026 include maintaining and improving healthy, resilient, biodiverse reefs and seagrass habitats as both are recognised for their conservation and commercial importance.

The AMR operates under the provisions of Regulation No. 61 of 2022 on the Establishment and Management of the Aqaba Marine Reserve, issued pursuant to the Aqaba Special Economic Zone Law No. 32 of 2000, in addition to the broader Environmental Protection Regulation applicable within the zone. The remainder of Jordan's coastline falls under Regulation No. 96 of 2024 on Coastal Area Management within ASEZ, ensuring a complementary legal framework across the region.

To support implementation, several supporting instructions were issued, including:

- Instruction No. 82 (2005): Regulating scientific research and monitoring activities within AMP boundaries
- Instruction No. 83 (2005): Governing entry, tourism, and sports activities, and prohibiting fishing or removal of organisms without special permits
- Instruction No. 84 (2005): Regulating the operation of boats and diving vessels within the park
- Instruction No. 85 (2005): Managing diving activities, licensing, and restrictions related to illegal fishing
- Instruction No. 86 (2005): Establishing procedures for underwater cleanup campaigns to ensure marine life protection
- Instruction No. 161 (2014): Providing the framework for organising and licensing marine sports in Aqaba, including safety and environmental precautions

The AMR operates under an integrated technical management team led by the Reserve Manager and organized into four specialized divisions that collectively implement the Aqaba Marine Reserve Management Plan (AMRMP):

- Coastal Protection Division – responsible for shoreline integrity, beach patrols, and pollution control
- Marine Operations and Surveillance Division – oversees marine patrols, enforcement, and environmental monitoring at sea and conducts continuous monitoring of the marine environment, including water quality, sediment conditions, and reef health
- Marine Research and Studies Division – conducts scientific studies and specialised monitoring programs focusing on coral reefs, seagrasses, and marine fauna, supporting evidence-based management
- Environmental Awareness Division – implements outreach programs, educational campaigns, and stakeholder engagement initiatives as well as supporting participatory monitoring and public reporting

The AMR is characterised by distinctive and unique biodiversity, including a high degree of endemism. It is located in the North-Western Indo-Pacific biogeographic region, which contains the Wadi Rum World Heritage Site (WHS). The AMR is currently listed as an IUCN Category VI protected area, within which sustainable use of natural resources is permitted.

An IUCN Category VI this is defined as "Protected areas with sustainable use of natural resources: Areas which conserve ecosystems, together with associated cultural values and traditional natural resource management systems. Generally large, mainly in a natural condition, with a proportion under sustainable natural resource management and where low-level non-industrial natural resource use compatible with nature conservation is seen as one of the main aims".

It is intended for the conservation category of the site to be upgraded, as Jordan has a very limited marine area containing numerous conflicting activities (e.g., shipping, fishing, industrial development, tourism, conservation) (UNDP, 2023). A Zoning Plan for the AMR delineates specific zones within the reserve, identifying areas designated for various activities (e.g., diving, boating, scientific research) based on their characteristics, environmental sensitivity, and suitability for specific uses. The Zoning Plan was developed within the context of Jordan's national legal and legislative framework, which governs the management of protected areas, marine ecosystem conservation, and spatial zoning. It considers all relevant laws, bylaws, and policies regulating the protection and sustainable use of marine habitats such as coral reefs.

The reserve features four public beaches, including the Blue Beach, which holds multiple Blue Flag certifications. It was added to the IUCN Green List in 2025. With strict environmental monitoring, community outreach, marine research, and conservation programs, the reserve plays a vital role in preserving the region's ecological integrity (UNDP, 2023).

A candidate ISRA has been identified in Jordanian waters called the Northern Jordan Area of Interest. It expands from the southern Aqaba beach to Al-Ghandour Beach with a depth range of 0-450m. It has been identified for aggregations of shortfin mako (*Isurus oxyrinchus*) and potential undefined aggregations of tiger shark (*Galeocerdo cuvier*).

6.3.2.2 Protected, Designated and Recognised Sites within the GoA

There are 13 protected, designated and/or recognised sites with the GoA, spread across five countries (Figure 6-52). Of these sites, the most extensive is the Ra's Suwayhil / Ra's al-Qasbah MPA in the Kingdom of Saudi Arabia (KSA), which spans 3,705km^2 from just south of Al Humidah on the eastern coast of the GoA, through the multi-designated Straits of Tiran, along the KSA coast towards Alsourah. It is an IUCN Category VI protected area, where the primary objective is to protect natural ecosystems and utilise natural resources sustainably, when conservation and sustainable use can be mutually beneficial.

The Ras Abu Galum MPA covers an area of 400km^2 on the Egyptian coast of the GoA, north of Dahab. This MPA is designated for a variety of terrestrial habitats and species, birds, as well as some coastal/ marine features such as coral reefs and mangroves. It is also a protected area under IUCN Category VI.

The Nabq National Park, also an IUCN Category VI protected area, is a 600km^2 marine reserve located on the Egyptian coast where the GoA and the northern Red Sea meet. Protected for a variety of marine habitats, including coral reefs, mangroves, seagrass, as well as protected species such as the dugong and green turtle and numerous fish species.

The Ras Mohammed National Park (IUCN Category II) is located in the northern Red Sea at the southern tip of the Sinai Peninsula, Egypt, and is 850km^2 in size, the majority of which is an MPA. It is primarily designated for coral reef habitats, as well as for the protection of turtles and key fish species.

Tiran Island, situated at the mouth of the GoA falls within the Ra's Suwayhil / Ra's al-Qasbah MPA and the Ras Mohammed National Park in Egypt. It is also an Important Bird and Biodiversity Area (IBA) recognised for breeding waterbirds, ospreys and falcons as well as nesting green turtles (*Chelonia mydas*) and grazing dugong (*Dugong dugong*) (KBA Partnership, 2021). The Strait of Tiran is also an Area of Interest as a candidate future Important Marine Mammal Area (IMMA), and an Area of Interest as a candidate Important Shark and Ray Area (ISRA) for manta rays (*Mobula birostris*) and whale sharks (*Rhincodon typus*).

Eilat Coral Reserve measures 1.2 km^2 in size and is located at the northern end of the GoA on the coast of Palestine. The reserve is primarily designated for the protection of coral reef and associated species. Dugongs have also been observed in the reserve, indicating the distribution of this species and its functional habitats throughout the Gulf of Aqaba.

There is an ISRA in Palestine at Eilat North Beach for coach whipray (*Himantura uarnak*); reproductive areas for spotted eagle ray (*Aetobatus ocellatus*), and undefined aggregations of cowtail ray (*Pastinachus sephen*).

6.3.2.3 Qualifying Features

All protected and designated sites within an ecologically relevant distance for their specific qualifying features (i.e., receptors/ receptor groups) will be considered in the impact assessment within their respective chapters in relation to Areas of Impact(s) for each receptor/receptor group where an impact pathway exists.

Any potential impacts on the conservation and management objectives/site integrity (or equivalent) for these sites will be considered on a case-by-case basis in relation to the site, in addition to the impact assessments for qualifying features.

For example, the following is specified within the AMRMP (2022-2026), which is determined by six objectives and a series of outputs, which correspond to the objectives of ASEZA. The objectives include:

- Maintain and improve healthy, resilient, bio-diverse reefs and seagrass habitats within the AMR up to and beyond 2026
- Create and implement the necessary mechanisms to promote the AMR as a model for ecologically sustainable tourism, which complies with international principles and standards
- Effective surveillance and patrolling are being implemented to cover the entire AMR area
- Improve and strengthen the institutional/legal framework and associated management capacities
- Marine Conservation awareness and Education are improved at the International and National levels
- Sustainable financial mechanisms are established and implemented to finance future AMR-related management operations and activities

Four ecosystem assemblages represent the core focus for the AMRMP (2022-2026):

- Coral Reefs
- Seagrasses
- Terrestrial Ecosystems
- Open Sea Ecosystems.

Figure 6-51: Protected, Designated and Recognised Sites within Northern Gulf of Aqaba

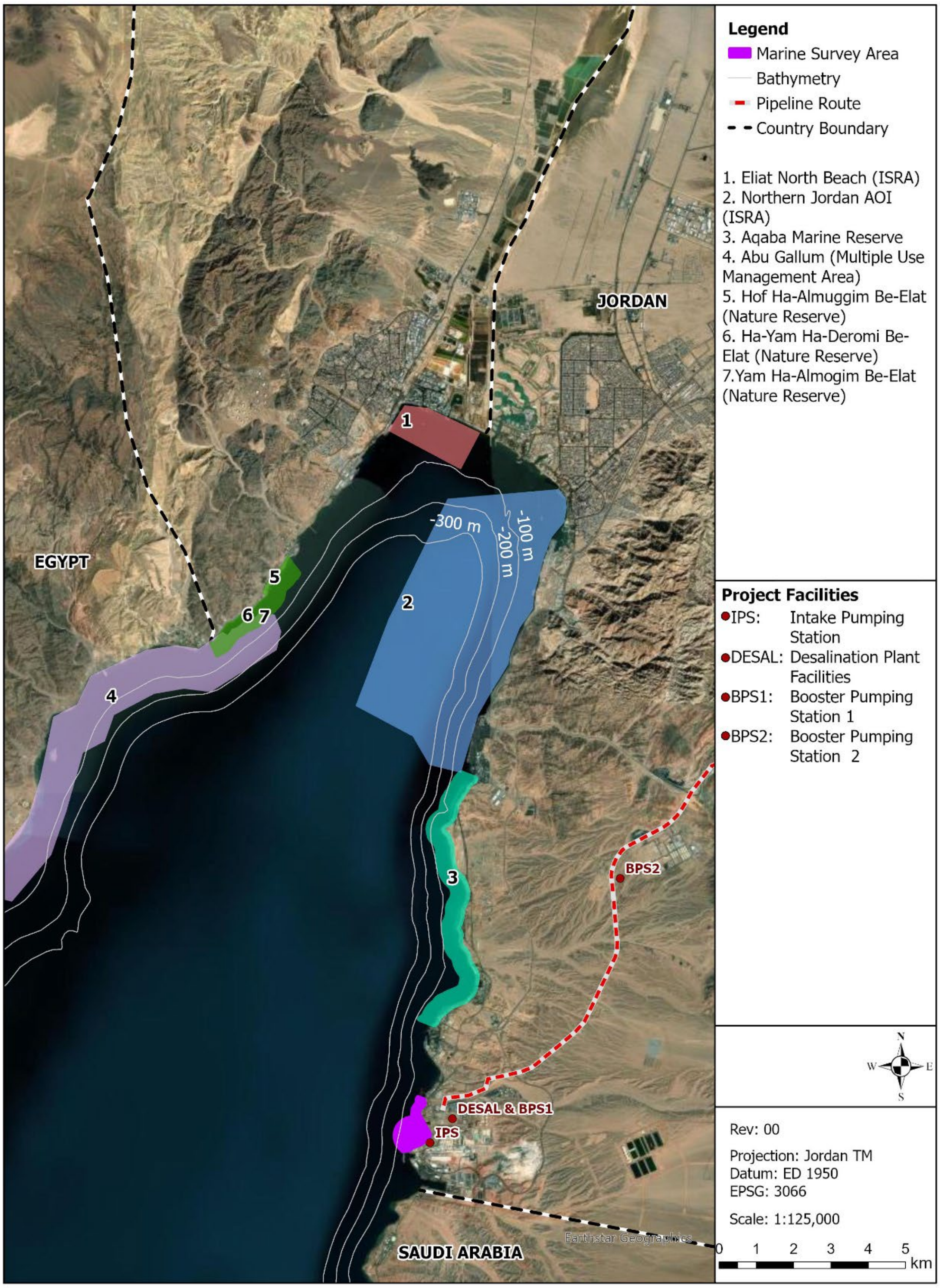
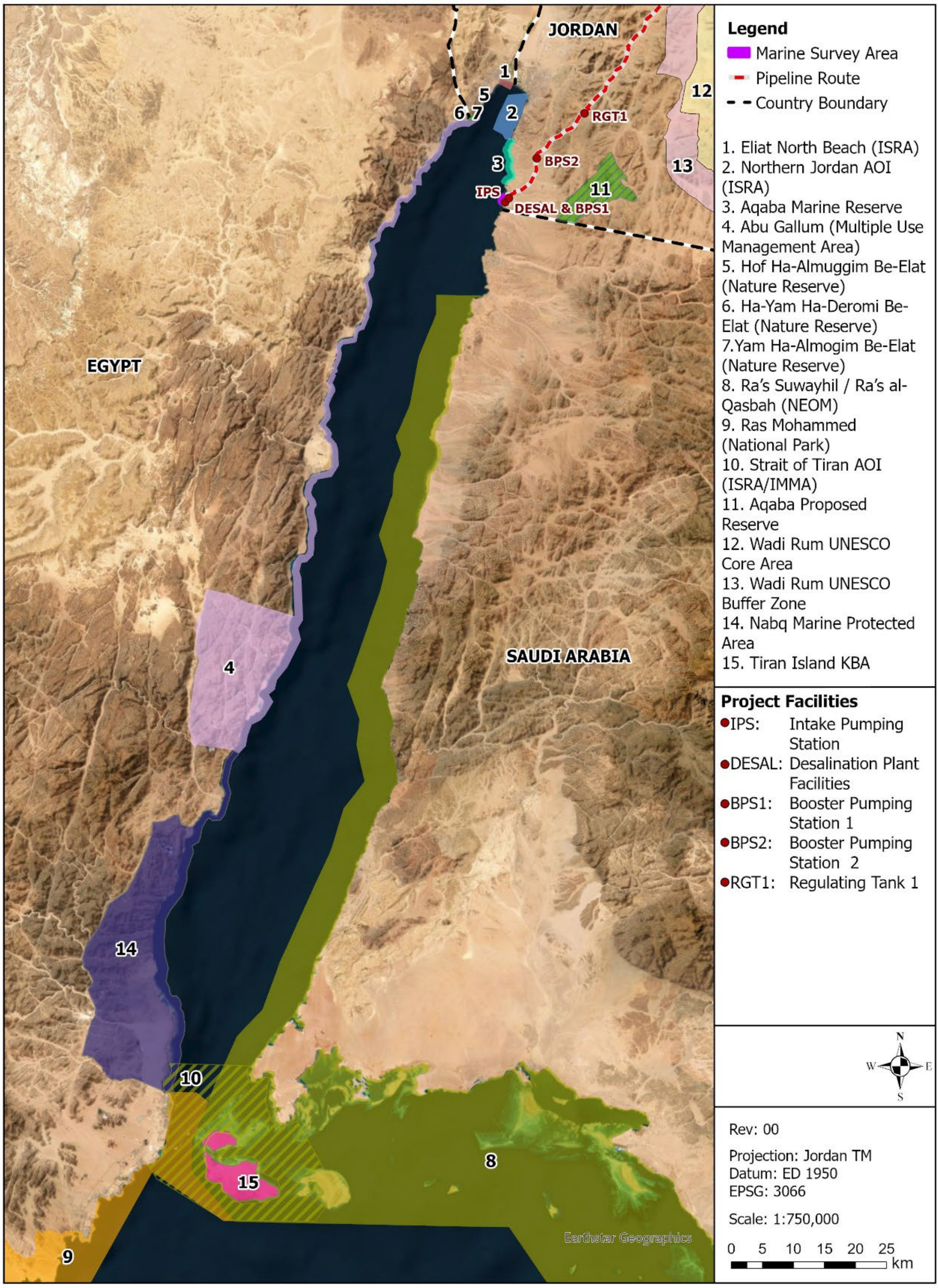


Figure 6-52: Protected, Designated and Recognised Sites within the Gulf of Aqaba



6.3.3 Marine and Coastal Development and Industry

The ESIA Study Area, including the Conveyance Pipeline route from IPS to RG3, as well as the Desalination Plant and the RE Facility, falls within the jurisdiction of Aqaba Special Economic Zone Authority (ASEZA), a financially and administratively autonomous authority responsible for managing, regulating, and developing Jordan's Aqaba Special Economic Zone (ASEZ) since its inception in 2002.

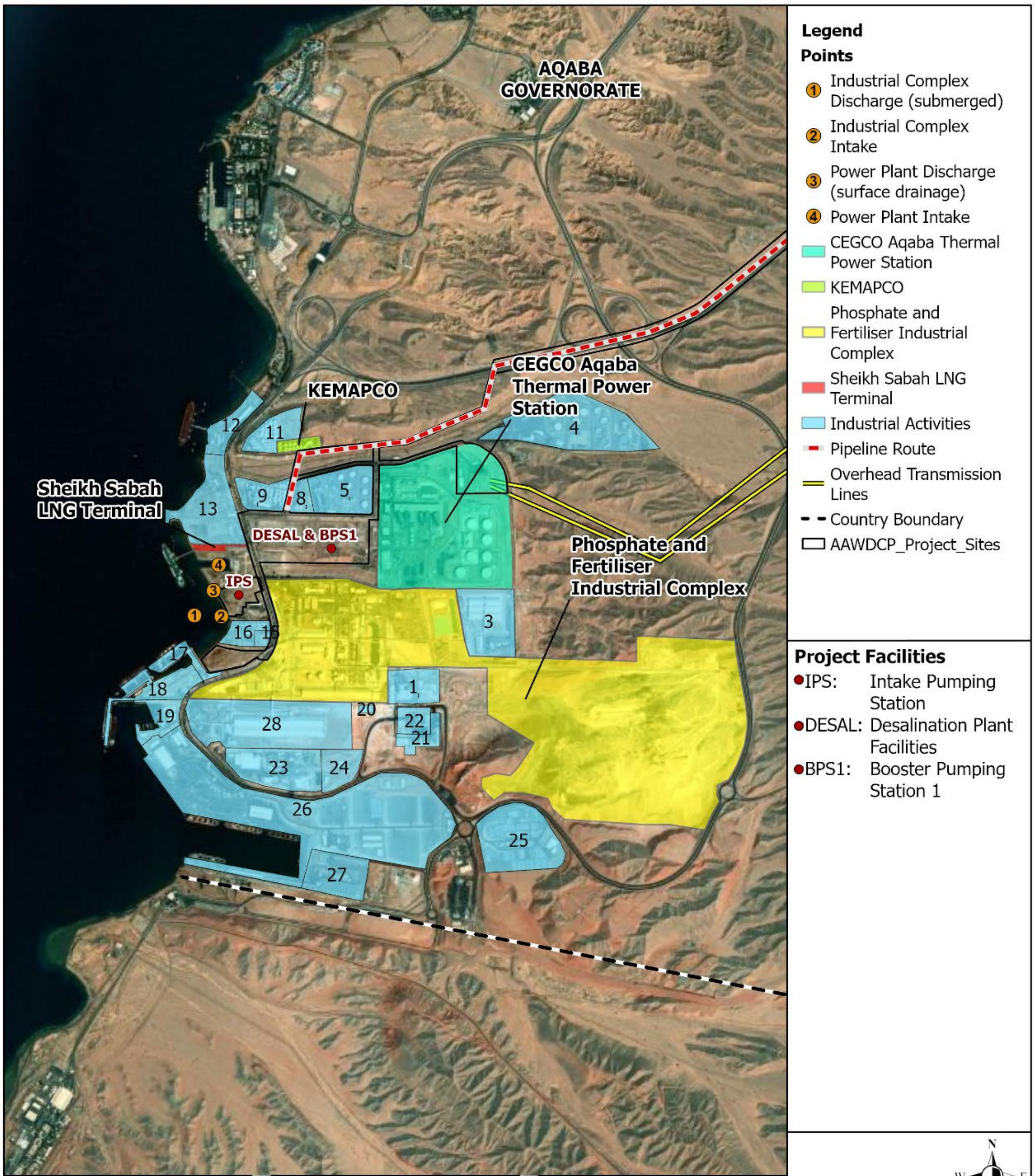
Aqaba Development Corporation (ADC), the primary development entity of the ASEZA, was founded in 2004. ADC is owned jointly by the Government of Jordan and ASEZA and is responsible for constructing new infrastructure and superstructure, expanding existing utilities, creating essential business enablers, and managing and operating key facilities within ASEZ. ADC owns the ports, the airport, and strategic parcels of land within ASEZ. It also retains development and management rights for these assets, along with important infrastructure and utilities.

In 2024, ASEZA unveiled an Urban Development Master Plan 2024-2040, defining the long-term strategy to organise and manage growth within ASEZ. The Master Plan establishes goals and policies for coordinating development, including land use, development intensity, access and circulation, utility provision and the protection of environmental, cultural and historical resources. The target area for development encompasses the entire ASEZ, covering 651.5 km², and includes the Wadi Arabia and six scattered areas that were recently added to the ASEZ jurisdiction.

The ASEZ industrial facilities and infrastructure are shown in Figure 6-53. The main facilities within ASEZ that abstract seawater for industrial purposes and subsequently discharge it in proximity to the Project intake and outfall facilities are:

- KEMAPCO Arab Fertilisers & Chemicals Industries Ltd, a subsidiary of the Arab Potash Company, which abstracts seawater for desalination processes
- Phosphate and Fertiliser Industrial Complex operated by the Jordan Phosphate Mines Company (JPMC) and Aqaba Thermal Power Station, both abstracting seawater for cooling operations with subsequent discharge of cooling water into the Gulf of Aqaba
- Sheikh Sabah Al-Ahmad Al-Jaber Al-Sabah LNG Terminal, which operates a Floating Storage Unit (FSU) that abstracts seawater, heats the natural gas, and returns the seawater to sea at reduced temperatures

Figure 6-53: Industrial Facilities and Infrastructure within the ESIA Study Area



ID	Industry Name
1	Nippon Jordan Fertilizer Co
3	Wild phosphate mine
4	Jordan Petroleum Refinery
5	Jordan Logistics Company
8	Jordan Bromine Company
9	Salvochem Netherlands
11	National Assembly Trading Company
12	Oil Terminal
13	Aqaba Port Company (Locomotives)
15	East Gas Company
16	Al Fajr Jordanian Egyptian Company
17	Phosphate Terminal
18	Industrial Terminal
19	Aqaba Port Services Company
20	The First Co for Industries
21	Jordan India Industries
22	Jordan India Industries
23	KEMAPCO
24	KEMAPCO Seawater Desalination Unit
25	Golden Triangle Company
26	Aqaba Co for Ports Operation
27	Silos and Grain Co.
28	Arab Potash Company

Rev: 01

Projection: Jordan TM
Datum: ED 1950
EPSG: 3066

Scale: 1:30,000

0 0.5 1 km

6.3.3.1 Port of Aqaba

The Port of Aqaba is Jordan’s only seaport and the backbone of Aqaba city’s economy, providing thousands of jobs and spurring related sectors, such as logistics and warehousing. Nationally, it handles over 50% of Jordan’s trade by volume and is the primary gateway for imports of consumer goods, machinery, raw materials, and exports of Jordan’s key commodities (phosphate, potash and chemicals).

The Port is operated as a multi-terminal port complex with 12 terminals. It is owned and managed by the ADC and is operated under concession agreements with different operators, each handling specific cargo types. ADC reported that the total annual cargo throughput is around 20 million tonnes in recent years.

In 2006, Jordan relocated the main port facilities southward away from Aqaba city centre. This move, completed over several years, enabled access to deeper water, accommodating larger ships, and freed up valuable waterfront land in downtown Aqaba. The old port area has been transformed into a hub of tourism and commercial development, featuring waterfront hotels, cruise piers, and business districts. The new consolidated port area, stretching along the coast toward the Saudi border, is divided into the “Main Port” and “South Port/Industrial Zone”. The main port zone houses Aqaba Container Terminal and passenger facilities, while the south industrial port zone, situated around 18–20 km south of the city, houses the phosphate and industrial terminals, oil/LNG jetties, etc. A railway is planned to connect phosphate mines directly to the port, further streamlining bulk exports.

The Port operates on a 24-hour, 7-day-a-week basis, and in recent years has invested in technology, including a centralised Operations Command Centre (opened in 2023) with CCTV and digital tracking for port activities, as well as a laser-guided truck alignment system for faster container handling. These improvements have enhanced efficiency, contributing to Aqaba’s ability to attract more shipping lines and handle growing volumes.

Aqaba Container Terminal (ACT): ACT Jordan’s sole container handling facility, operated by APM Terminals (Maersk) in a joint venture with ADC. ACT has a quay length of 1,000 m (following a major expansion in 2010–2013) and an annual throughput capacity of 1.3 million Twenty-Foot Equivalent Units (TEUs). The equipment includes seven ship-to-shore cranes and modern yard cranes, enabling it to efficiently handle large container ships (up to 400 meters in length). In 2024, Jordan extended APM’s concession to 2046, accompanied by a new $242 million investment to further expand capacity to 1.7 million TEU/year and upgrade to green, electrified operations. ACT is regarded as the second-busiest container port on the Red Sea by volume (after Jeddah), serving not only Jordan but also landlocked regional markets.

General Cargo and Ferry Terminals: Aqaba has terminals for general cargo, Ro-Ro ferries, and passengers. Prior to the pandemic, the ferry service transported ~1.3 million passengers annually between Aqaba and Egypt. However, recent figures are lower (in Jan–Aug 2025, ~235,654 ferry passengers used Aqaba, up 28% year-over-year as travel rebounds). Cruise ships also call at Aqaba (mainly in the winter cruise season), bringing tourists to Petra and Wadi Rum. The port can dock large cruise vessels at its main berths.

Vehicle Terminal: Aqaba has seen a surge in vehicle imports. Cars are offloaded either via Ro-Ro vessels at the ferry terminal or containerised units at ACT. Over 58,000 cars were imported in January – August 2025, twice the number from the same period in 2024. This over 100% increase in car imports is attributed to high demand from the reopened Syrian market and the reinstatement of direct roll-on, roll-off (Ro-Ro) shipping services to Aqaba. Aqaba acts as an entry point for cars destined for Jordan and neighbouring countries (some vehicles are transhipped overland to Syria and Iraq).

The following Bulk Cargo Terminals handle bulk commodities crucial to Jordan’s economy.

Phosphate Terminal: Jordan is a top global phosphate exporter. In 2013, a new state-of-the-art phosphate rock export terminal opened at the South Port, outside the main city. Built via a BOT agreement between ADC and Jordan Phosphate Mines Company (JPMC) in 2010, it features a 200m berth with conveyor loading arms, storage for 240,000 tons, and is capable of handling 4–6 million tonnes per year. Phosphate exports through Aqaba are now on the order of 5–6 million tonnes annually (4.36 million tonnes in the first 8 months of 2025).

Industrial Terminal: Jordan Industrial Ports Company (JIPC) operates a dedicated Industrial Terminal (about 22 km south of Aqaba city) for potash, fertilisers, and other chemicals, co-owned by Arab Potash Co. and JPMC. Originally built with a capacity of ~5 million tonnes, it underwent an expansion completed in 2022 that doubled its capacity to 10 million tonnes/year. This port has multiple berths and modern conveyor systems for potash exports (Arab Potash Company produces ~2.5 million t/year. In Jan–Aug 2025, 1.59 million tonnes of potash were exported via Aqaba, along with significant volumes of phosphate fertilisers and other industrial goods.

Grain and Miscellaneous Bulk: Aqaba Port handles Jordan's imports of essential grains and foodstuffs. A specialised grain terminal receives bulk wheat, barley, corn, and other cereals. In the first eight months of 2025, the port imported 670,253 tons of wheat, 683,936 tons of barley, and 461,974 tons of corn, all of which are vital for Jordan's food security. Bulk sugar, fertilisers, and cement are also handled. The port even loaded 448,152 t of iron ore/steel for export in early 2025.

Jordan relies on energy imports, some of which come via Aqaba's Oil and Gas Terminals.

Oil Terminal: A liquid bulk jetty for crude oil and petroleum products is managed by the Jordan Oil Terminals Company (JOTC) in coordination with the National Electric Power Company for fuel oil. This terminal receives tankers carrying refined fuels (e.g., gasoline, diesel) and occasionally crude, feeding Jordan's refineries and power plants. Exact volumes are not publicly disclosed; however, a significant portion of Jordan's fuel comes overland from neighbours, and Aqaba provides an alternative route for diversified supply.

LNG Terminal: In 2015, Jordan launched the Sheikh Sabah Al-Ahmad LNG Terminal, a Floating Storage and Regasification Unit (FSRU) off the coast of Aqaba, to import liquefied natural gas. The FSRU (replaced by a newer unit, "Energos Force," in 2025) is anchored south of the Main Port and connected to the onshore Arab Gas Pipeline. It currently supplies up to 350 million cubic feet/day for Jordan's power generation. An expansion project, currently underway in 2025, is building a permanent onshore regasification facility with a capacity of 700 million cfd and converting the setup to a floating storage unit, to be completed by 2026. LNG tankers regularly call at Aqaba as the FSRU is essentially a permanently moored ship that gets refilled by LNG carriers.

6.3.3.2 Phosphate and Fertiliser Industrial Complex

The Phosphate and Fertiliser Industrial Complex is a large facility located 18km south of Aqaba city and operated by Jordan Phosphate Mines Company (JPMC). The Industrial Complex was established to transform the rock phosphate produced at JPMC sites into finished products. In addition to Production Units, the Industrial Complex comprises a training centre, a laboratory, and a department of Environmental and Public Safety, which also provides logistical support for firefighting and first aid in the southern area bordering Saudi borders.

Currently, the Complex employs 686 people. It has undergone several developmental phases to increase the capacity and fulfil the ammonia needs of neighbouring companies. Plans are in place to further expand the complex in Aqaba, which include increasing the production capacity of the Phosphoric Acid

Plant to 1,500 tons/day and establishing an additional unit to produce compound fertilisers with a production capacity of half a million tons per year (JPMC, 2025).

In the vicinity of the Phosphate and Fertiliser Complex, JPMC also operates the Phosphate Terminal, established in its new location in 2012 (see Section 6.3.3.1).

6.3.3.3 Aqaba Thermal Power Station

The Aqaba Thermal Power Station (ATPS) is among Jordan's significant power generation assets, critical in supplying electricity, especially to the southern/coastal region and potentially for industrial zones in Aqaba. It has an installed capacity of around 650–656MW and is operated by the Central Electricity Generating Company (CEGCO). The power station comprises three steam generation units, each with a capacity of 130MW, and a hydroelectric generation unit with a total capacity of 3.6MW (CEGCO, 2025).

The ATPS utilises natural gas as the primary fuel, backed up by heavy fuel oil. As part of the diversification and modernisation of Jordan's energy sector, ATPS's ability to run on cleaner fuel (gas) is crucial for energy security, emissions targets, and environmental compatibility with tourism and marine conservation objectives.

CEGCO operates the ATPS for approximately a third of the year, based on orders from the National Electric Power Company (NEPCO), to supplement the grid. During operation, seawater is abstracted through the intake system for cooling purposes, with the same amount of water returned to the sea. Based on demand, Phase 2 water turbines are also brought into operation, engaging three out of the five pumps to generate electricity. In these cases, the discharged cooling water passes through the turbines first, prior to being returned to the sea. The cooling effluent is analysed for compliance with quality and temperature thresholds stipulated in the regulatory standards (Instructions No. 159 of 2014 – Use of Seawater for Cooling and Its Return to the Sea).

The proximity of the ATPS to the GoA places it in the interface zone between heavy infrastructure and sensitive marine ecosystems, making its operational practices, effluent controls, and thermal discharge management critical for the health of coastal reefs.

6.3.3.4 Jordan Sector of Arab Gas Pipeline

The Arab Gas Pipeline (AGP) is the main trans-regional pipeline supplying Egyptian natural gas to Jordan (and further into Syria and Lebanon). Its route includes a 15km Taba - Aqaba subsea segment, followed by a 393km Aqaba - El Rihab overland segment within Jordan, including a 1km section connection to Aqaba Thermal Power Station. Jordanian Egyptian Fajr operates the AGP under a Build-Own-Operate-Transfer (BOOT) scheme (Jordanian Egyptian Fajr, 2025). The facilities in the ESIA Study Area include the Aqaba Compressor Station and the Tie-in Site between the Floating Storage & Regasification Unit (FSRU) at the Liquified Natural Gas Terminal and the Jordanian Gas Transmission Grid.

The Fajr infrastructure in Aqaba and beyond is a key element in Jordan's energy strategy, reducing reliance on imported oil, shifting power plants to gas, lowering emissions, and supporting industrial growth. The pipeline from Aqaba is critical, as the Aqaba Thermal Power Station uses gas transported via the pipeline, along with other industries in the south (such as Qweirah), which depend on the gas.

In 2023, an agreement was signed between ADC and Fajr to establish a branch that would supply Qweirah Industrial Estate from the main gas line. It includes measuring, pressure reduction stations and a branch connection to the main pipeline, expanding Fajr's role from pure transmission into industrial supply in the region.

6.3.4 Shipping and Navigation

The GoA provides Jordan's sole maritime trade route. It serves as a transit hub, connecting Asia–Europe shipping lines via the Suez Canal, and supporting regional logistics corridors that link Jordan, Iraq, and Saudi Arabia. The Gulf also holds geopolitical sensitivity, as it borders four nations, each maintaining coastal surveillance and naval presence.

Agreements with its neighbours define Jordan's maritime boundaries. A 1996 treaty delineated their shared maritime boundary in the GoA, and a 2007 agreement with Saudi Arabia set limits to the south. Jordan claims a 12-nautical-mile territorial sea, but given the limited GoA width, its effective waters are constrained by median lines with adjacent states. In 2020, Jordan joined the Council of Red Sea and Gulf of Aden states (with Saudi Arabia, Egypt, and others) to cooperate on maritime security, anti-piracy, and anti-smuggling efforts.

6.3.4.1 Regulatory and Operational Framework

Maritime operations in Jordan are governed by national authorities and international conventions to ensure safety, security, and environmental protection:

The Jordan Maritime Authority (also referred to as the Jordan Maritime Commission) is the regulator of the maritime transport sector, established by Law No. 47 of 2002 (temporary) and subsequently by Law No. 46 of 2006, which is now permanent. Headquartered in Aqaba under the Ministry of Transport, JMA's mandate includes:

- Licensing and Regulation: It licenses all maritime activities (shipping companies, agents, port services) in Jordan. It also registers ships under the Jordanian flag (Jordan has a small flag registry, primarily for local vessels)
- Safety Oversight: JMA conducts port state control inspections on visiting ships and ensures compliance with international safety and pollution standards (SOLAS, MARPOL, etc.). It issues seafarer certifications and ship certificates for Jordan-flagged vessels
- Maritime Security & Coordination: It oversees pilotage and navigation in territorial waters, search and rescue operations, and investigation of maritime accidents in Jordan's waters. JMA coordinates closely with the Royal Jordanian Navy for SAR and maritime security
- Convention Implementation: JMA recommends and implements international maritime conventions – e.g., MARPOL, SOLAS, STCW (crew training), COLREGs (collision regulations). Jordan is a member of the International Maritime Organisation (IMO) and a party to major IMO treaties, including but not limited to:
    - SOLAS 1974 (Safety of Life at Sea), ensuring ships meet safety requirements
    - MARPOL 73/78 (Marine Pollution Prevention), enforcing discharge and emissions rules in its port and waters
    - STCW (Standards of Training, Certification, Watchkeeping for Seafarers) via JMA issuing credentials
    - Ballast Water Management Convention, aiming to prevent the spread of potentially harmful aquatic organisms and pathogens in ships' ballast water
    - International Ship & Port Facility Security (ISPS) Code, which the Port of Aqaba has complied with since the mid-2000s

- Marine Environment Protection: Along with the Ministry of Environment and ASEZA regulations, JMA helps implement laws like Environmental Law No. 52 and ASEZ Marine Protection Regulation No. 21 (2001), which guard the GoA water quality. Oil spill contingency plans are in place, with regional cooperation through the REMPEC (Regional Marine Pollution Emergency Centre)

While mainly an economic body, ASEZA has autonomous regulations for Aqaba, including environmental rules. ASEZA's Environment Department enforces the Aqaba Marine Park and coastal zone management.

Although ADC and private operators run daily port operations, government oversight ensures public interests:

- Customs and Immigration: Jordan Customs and border security handle clearance of all cargo and passengers at the port
- Harbour Master & Pilots: The harbour master's office manages vessel traffic, assigns berths, and provides pilotage (compulsory for large vessels)
- Security: Stringent port security is maintained (access controls, surveillance). The ISPS code is fully implemented, and Aqaba is considered a secure port facility. The Jordan Navy Coast Guard station is nearby for rapid response to incidents

Jordan collaborates with its neighbours on maritime issues. The 1996 agreement not only delimited boundaries but also likely included coordination on navigation, as the ports of Aqaba and Eilat are adjacent to each other. Similarly, Jordan collaborates with Egyptian authorities on ferry link safety and with Saudi Arabia and the Red Sea states on security initiatives in the Red Sea. Jordan is also actively involved in the Arab Maritime Transport Academy and regional port associations, sharing best practices.

6.3.4.2 Marine Traffic and Shipping Routes

Because Jordan's maritime trade is handled through one port complex, nearly all commercial vessels in Jordanian waters are related to the Port of Aqaba traffic. According to the JMA, an estimated 1,800 to 2,200 vessels call at Aqaba annually. Traffic composition in 2023 included container ships (~40–45%), bulk carriers (~25–30%), tankers (~10–15%), passenger/cruise ships (<5%), and government/research vessels (<5%).

Virtually all ships reach Jordan via the Red Sea route. Coming from the Indian Ocean, ships pass Bab-el-Mandeb (between Yemen and the Horn of Africa), traverse the Red Sea, then turn left into the Gulf of Aqaba at the Straits of Tiran. Coming from the Mediterranean/Atlantic, ships enter the Suez Canal, sail down the Red Sea for ~1,500 km, and then into GoA. As there is no alternate sea route, Jordan is highly reliant on the Suez Canal remaining open and Red Sea security.

The Red Sea corridor's importance grew significantly after the opening of Suez in 1869, and today it carries a significant portion of global trade (including Arabian Gulf oil shipments to Europe/Asia). Jordan's own maritime traffic is a small fraction of Red Sea traffic, but Aqaba's location at a crossroads allows it to benefit from these flows and often serves as a transhipment or relay point.

Inside the GoA, marine traffic is channelled by geography. The GoA is deep (up to 1,800m) and mostly clear of hazards, but it is relatively narrow. Jordan's sector at the northern end is only a few kilometres wide, shared with Palestine's maritime area. A vessel traffic system is in place to cooperatively manage ships entering and departing the area. Aqaba port approaches are well-marked; large vessels typically anchor outside the port when awaiting berth, in designated anchorages within Jordanian waters.

The main shipping lanes within the GoA Jordan Sector are summarised in Table 6-47. The Aqaba Marine Reserve is a no-navigation zone for large vessels, except for scientific and patrol craft.

Table 6-47: Main Shipping Routes for the GoA Jordan Sector

Route Segment	Function	Approx. Distance from Shore	Depth (m)	Notes
Main North–South Lane	Regional transit corridor	3–5 NM	> 1000	Connects to the Strait of Tiran and the Red Sea routes
Aqaba Approach Channel	Port access to ACT, Oil & Industrial Ports	1–2 NM	15–21	Buoyed, under pilotage
Turning Basin	Vessel manoeuvring area	Near Aqaba Port	20–25	Dredged and maintained
Outer Anchorage	Waiting/bunkering zone	4–7 NM	40–70	Designated area
Inner Channels	Terminal access	< 1 NM	10–15	Restricted speed, pilotage compulsory

The GoA have relatively stable navigation conditions year-round. There are no cyclones and minimal storm activity; marine traffic is continuous throughout all seasons. The GoA experiences seasonal winds (e.g., northerly winds for most of the year, occasionally southerly winds in winter) and changes in water stratification, but these seldom disrupt shipping schedules. Visibility can be reduced by dust storms (khamsin) in spring, but the impact is usually minor.

Specific trades show seasonal demand. For instance, grain imports might peak after harvest seasons when global prices are lower. Fertiliser exports can also be seasonal based on agricultural cycles in destination countries.

Tourism and passenger traffic have clear seasonal peaks: winter months (Oct–Apr) see more ferry passengers (pilgrims and tourists) and cruise calls, whereas summer (Jun–Aug), with extreme heat, sees fewer tourists but more local fishing. Religious and other holidays also slightly affect the flow of truck traffic and port working hours, but the port generally operates continuously.

Navigation within the Gulf relies on international hydrographic charts, coastal radar, and AIS-based Vessel Traffic Services (VTS), all of which are coordinated by the Aqaba Port Authority.

6.3.5 Fisheries

Jordanian fishery resources are limited due to the country's geographical position and environmental conditions. Fisheries are a low priority in Jordan’s national policy, given their limited economic significance: the fishing sector contributes less than 0.01% of Jordan's GDP. It is a relatively minor part of the economy. Due to low local marine production, 98% of the fish supply for internal consumption is imported (FAO, 2019).

Major commercial fish species (including grouper and tuna species) are considered to be over-exploited in neighbouring countries, particularly in Saudi Arabia and Egypt, with a likely effect on the stocks in Jordanian waters (Morgan, 2004). Despite the lack of comprehensive stock assessments of the major species, the generally accepted view is that the pelagic and, particularly, the demersal finfish resources in Jordanian waters are already heavily exploited. Increasing recreational fishing and environmental issues, such as growing shipping in Aqaba and the privatisation of beaches by the tourism sector, are also emerging as significant issues.

Due to the regional distribution of many key species targeted by the commercial fishery in Jordan, independent management of the fish stocks in Jordanian waters is challenging. Some regional co-operation in fisheries and marine environmental management is achieved through various multilateral programs such as the Red Sea Marine Peace Park (RSMPP). In 2024, the United Nations Development Program (UNDP) Gulf of Aqaba Resilient Reefs Programme developed Jordan's first Fisheries Management Plan for Aqaba, integrating ecological, social, economic, and cultural dimensions (UNDP, 2024).

6.3.5.1 Marine Capture Fisheries

Fishing activities along the Jordanian coast of the GoA are primarily artisanal and small-scale, representing a traditional livelihood that holds both economic and cultural significance. The fishermen community operates within ASEZA, primarily from the Fishermen's Harbour, using simple methods that have remained essentially unchanged for decades. Although modest in economic scale, this activity is vital for maintaining community identity and ensuring the sustainable use of local marine resources.

To inform the local community in Aqaba Governorate of the Project, a discussion group was organised in October 2025 in Aqaba City with the participation of representatives from the Aqaba Divers Association and the Fishermen's Cooperative Association. The section below summarises the information collated from the engagement session.

Currently, three fishing associations are operating in the area: the Aqaba Agricultural Cooperative Society for Fishermen, the Thaghr Al-Urdon Agricultural Cooperative Society and the Environmental Fishing Society. The total number of fishermen is approximately 210, all of whom are registered with the two main cooperative associations. Together, they represent approximately 210 registered fishermen. The Diving Clubs Association also plays a significant role, representing 35 licensed diving centres with around 180 members, 20 tourist boats, and nine marine tourism villages. This overlap between fishing and diving underscores the shared reliance on Aqaba's marine biodiversity.

All fishing in the area is traditional, using small fibreglass boats; there is no commercial-scale fishing activity. The fishing boats used are made of fibreglass with an average length of six meters. Fishing is conducted using handlines and hooks, targeting both demersal and pelagic species. The use of fishing nets (shawarat) has been prohibited to minimise bycatch and protect coral reefs and seagrass meadows. The most commonly caught species include Shaour, Black Faras, Sigan, and Amya (local names), while migratory species such as Tuna (Fatlah and Jambroor) and Horse Mackerel are seasonally present. No fish processing or preservation facilities exist onshore. Fish are sold directly to local markets or restaurants on the same day they are caught.

Fishing operations mainly take place north of the industrial zone, extending to the southern hotels area (Tala Bay), at depths reaching 200 meters (Figure 6-54). There are no fishing activities conducted within 3km of the Project infrastructure, and the Project is not expected to negatively affect the seasons of either migratory or resident fish species. The Project site with warmer, reused waters is seen as a new potential breeding ground, increasing fish population and expanding their spread into the areas where fishing is permitted.

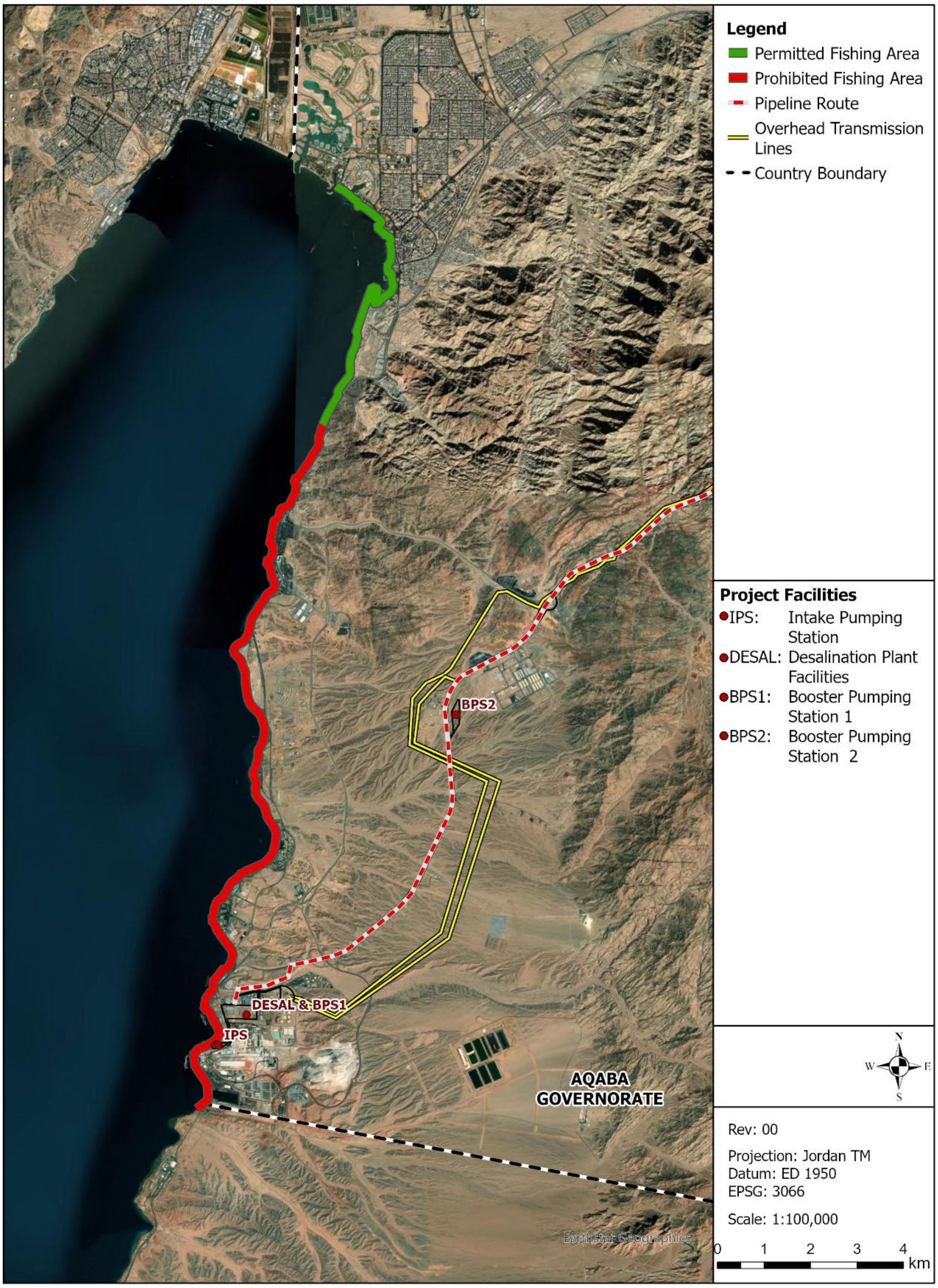
The average monthly income of a fisherman is around 700 JD. Fishing is restricted from January 1st to May 1st, with these restrictions seen as a positive impact on increasing fish stocks. During the restriction period, ASEZA provides each fisherman with a compensation of approximately 400 JD. There is no health insurance for fishermen, and the majority are not enrolled in the social security system.

6.3.5.2 Aquaculture

Aquaculture is more of a developmental target than a large existing sector in Jordan. Fish farming began in the mid-1960sand pilot projects with international assistance were launched in 1966 and 1978 to produce carp using farm dams. Currently, there are fewer than 30 active fish farms, primarily located in the Jordan Valley, with an estimated total production of 885 tonnes (FAO, 2019). The main species cultured are tilapia and common carp. The majority of fish farms are small and use traditional culture methods. Jordan Valley Fisheries (JVF) is the largest producer, utilising solar technology and a 'green water' system for algal production and heating.

Mariculture (as a subset of aquaculture) is permitted only inland, and at sea outside biodiversity-protected areas and fisheries refugia. It is subject to a license to proceed following an Environmental Impact Assessment. However, there are currently no mariculture projects in operation, and the ASEZA Commission Council has decided not to allow mariculture (Khalaf, 2015).

Figure 6-54: Permitted and Prohibited Fishing Areas



6.3.6 Tourism

Aqaba is Jordan’s sole coastal city, serving as both a port and a resort destination, with hotels and tourist accommodations located nearby. The city has been heavily promoted for tourism, especially for marine activities, beach life, coral reefs and as a base for exploring nearby desert and historical sites. Together with Wadi Rum and Petra, Aqaba forms the tourism “Golden Triangle” of Jordan's most visited destinations.

According to ASEZA, the number of visitors to Aqaba Governorate exceeded 1.9 million in 2023. It reached a record of 86,000 visitors in January 2025 alone (45% comprising foreign nationals), representing a 103% increase compared to previous periods, with an average stay of two nights (Ministry of Tourism and Antiquities (MoTA), 2025).

The tourist accommodation capacity of Aqaba city and its immediate surrounding areas is 90 hotels with 6,200 rooms (MoTA, 2024). Hotel occupancy in January 2025 is reported to have reached approximately 50%, representing an 84% increase compared to the same period in 2024. Notably, 4-star hotels experienced the highest demand.

Key tourist attractions in Aqaba include:

- Aqaba Marine Reserve offering snorkelling, diving over reefs and marine life viewing
- South Beach, Al-Hafayer Beach, Palm Beach and B12 Beach Club at Ayla
- Saraya Aqaba Waterpark, Jordan’s first large-scale waterpark
- Aqaba Castle and Mamluk Fort, a prominent historical site in the older part of the city
- Aqaba Archaeological Museum, located adjacent to the castle, in the old Sharif Hussein residence, includes Bronze Age and Islamic period ruins and artefacts
- Sharif Hussein Bin Ali Mosque
- Wadi Rum, a UNESCO World Heritage site, for which Aqaba town is used as a base for the majority of tourists

As part of its 2024-2028 Strategic Plan (ASEZA, 2024), ASEZA intends to strengthen Aqaba's position on the global tourism map as a distinctive destination for sustainable tourism on the Gulf of Aqaba in the Red Sea. Strategic objectives include:

- Attracting tourism investments and developing quality tourism products that meet the needs and interests of various segments of visitors and reflect the natural and cultural diversity of the region and Wadi Rum
- Enabling the business environment in the tourism sector and developing support services and regional accessibility
- Marketing and promoting Aqaba as a global tourist destination

6.3.7 Other Marine Users

In addition to tourism, fishing, and the port and navigational sectors, other marine interface users include science and educational institutions, as well as agencies and NGOs engaged in research, conservation, and monitoring programs.

6.3.7.1 Marine Science Station

The Marine Science Station (MSS) was established in the mid-1970s as an inter-university research institute between the University of Jordan and Yarmouk University, serving as a marine research facility for scientists and postgraduate students. MSS facilitates the research and academic roles of Jordanian universities by hosting graduate students and enabling them to conduct their research at the station through the use of its laboratories and other facilities.

The MSS conducts research projects and monitoring programs that define the environmental baseline characteristics of the Jordanian coast of the Gulf of Aqaba, as well as some applied aspects of coastal and marine research. The station features ISO 17025 accredited laboratories and maintains scientific cooperation with several international research centres, including the Leibniz Centre for Tropical Marine Research in Bremen / Germany, Mote Laboratories in Florida, US, and the Senckenberg Museum in Frankfurt, Germany.

6.3.7.2 Gulf of Aqaba Resilient Reefs Programme

The Global Fund for Coral Reefs (GFCR) is a public and private finance mechanism designed to mobilise funds and catalyse reef-positive investments, sustainable marine protected area (MPA) financing, and scalable business models that support coral conservation.

In Jordan, the GFCR supports the Gulf of Aqaba Resilient Reefs Programme, which focuses on the Jordanian marine zone of the Gulf of Aqaba, led by UNDP Jordan. ASEZA is a key national partner and implementing authority, along with the IUCN Regional Office for West Asia, which is also a co-implementer. The program runs from January 2024 to December 2030. It includes three focal areas within Jordan’s coastal marine environment: the AMR, Northern Deep Corals, and Southern Industrial Site, which span ecological variation, industrial adjacency, and reef complexity.

Some of the core interventions under the program include:

- Baseline ecological and socio-economic assessments through mapping coral reefs, identifying climate refugia, gap analysis and stakeholder mapping
- Strengthening monitoring patrolling by upgrading reef monitoring, community and citizen science involvement and enforcement of protected zones
- Seagrass surveys assessing their coverage, biodiversity role, carbon storage and relation to the blue economy
- Capacity building and training of environmental patrol and field teams, and tourism operators
- Reef-positive business incubation by establishing a Centre for Sustainable Blue Economy Innovation, which would support reef-friendly enterprises, blended finance and business models that create economic returns while conserving reefs
- Financial mechanisms and sustainability through creating sustainable funding mechanisms for operations, trust funds, payment for ecosystem services and financing to reduce donor dependency
- Knowledge and collaboration platforms, such as creating a Gulf of Aqaba Coral Reef Ecosystems Scientific Collaboration Platform
- Incident response and risk management through planning for spill events, pollution, climate stress and enforcing environmental regulations

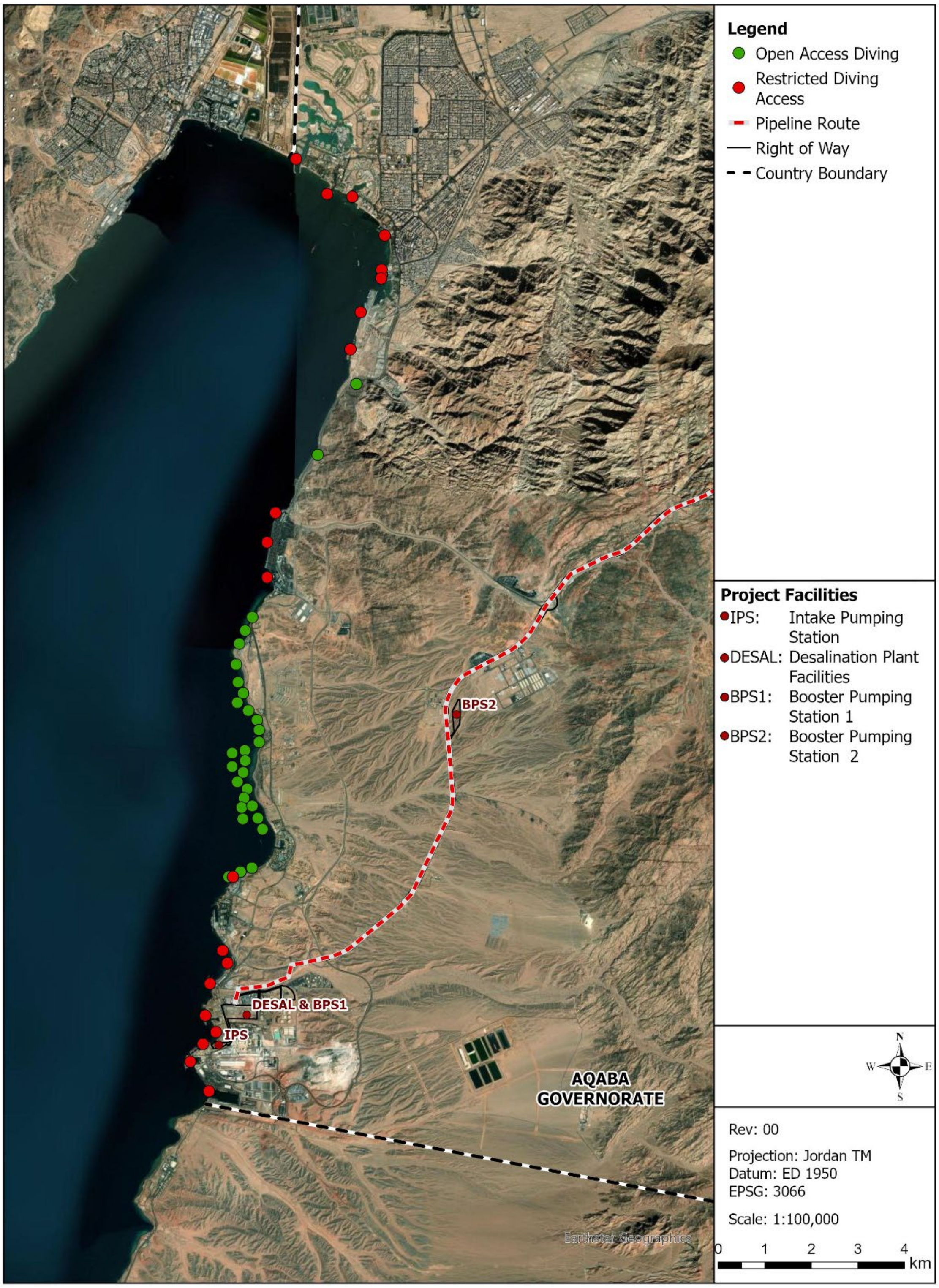
6.3.7.3 Aqaba Divers Association

The GoA offers calm seas and excellent visibility, making it an ideal destination for diving. The Jordan coastline is relatively short but packed with reefs, drop-offs, wrecks and artificial reefs, making it a rich diving destination suitable for a range of experience levels.

Dive tourism is a significant contributor to Aqaba's local economy. There are over 20 open-access diving sites along the coast, with many located within the Aqaba Marine Reserve (Figure 6-55). As a response to the ecological impacts of diving, several artificial-reef dive sites have been intentionally created (e.g., wrecks of ships, aircraft, and military hardware) to provide divers with attractions whilst reducing pressure on natural reef areas. The artificial-reef strategy is viewed both as a tourism and recreational resource and as a tool for ecosystem management.

The Aqaba Divers Association is a non-profit organisation focused on matters related to the diving industry and the marine environment. Its stated mission includes improving the quality of the diving product in Aqaba, while enhancing Aqaba’s attractiveness as a tourist destination. The Association oversees 35 licensed diving centres across nine tourist villages and has approximately 180 members with around 20 tourist boats.

Figure 6-55: Key Open Access and Restricted Diving Sites



6.3.8 Bathymetry and Physical Oceanography

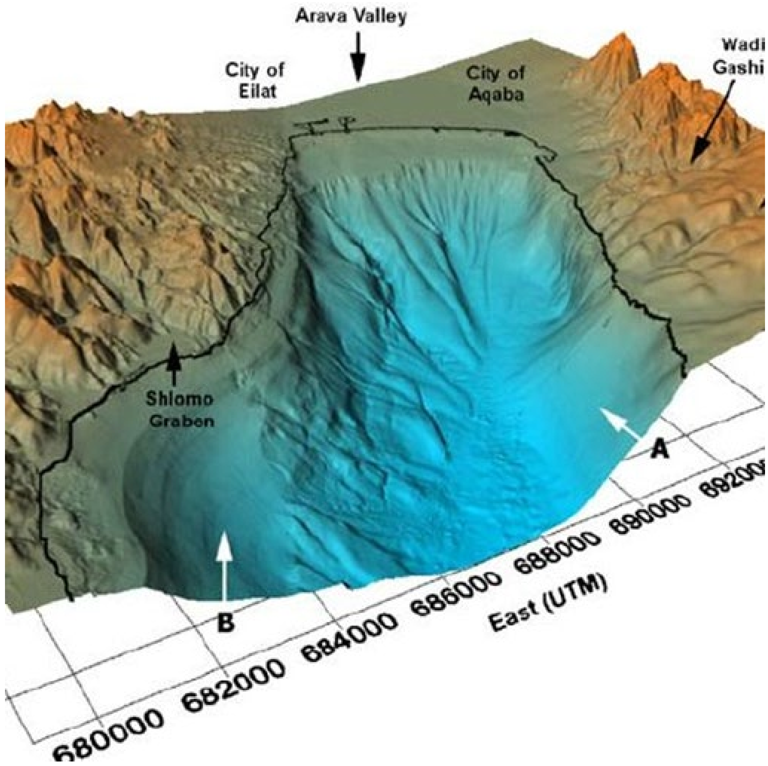
6.3.8.1 Bathymetry

The GoA is a long, narrow, deep rift basin at the northern end of the Red Sea, bounded by steep desert mountains and connected to the Red Sea through the Straits of Tiran. It is approximately 160–180km long, typically 5–25km wide, and reaches depths of up to 1,850m in its central basin (Sengupta *et al.*, 2024; “Gulf of Aqaba”, 2025). The gulf’s deep basin is hydraulically restricted by a sill at the Straits of Tiran, the southern end, with a controlling depth of ~245–290m (Berman *et al.*, 2000; Sengupta *et al.*, 2024; “Straits of Tiran”, 2025). Recent surveys have also revealed localised deep features such as small brine pools on the eastern margin, underscoring the basin’s complex seafloor (Purkis *et al.*, 2022).

Jordan’s coastline occupies the north-eastern corner of the gulf (Figure 6-56) and is only ~27–30km long, providing the country’s sole marine access via the Port of Aqaba (ASEZA, 2014; UNDP/AMR, 2023). The Jordanian nearshore is characterised by an exceptionally narrow shelf (commonly <100m) fringed by coral reefs (Hartman *et al.*, 2014; FAO, 1974).

The GoA is characterised by its steep bathymetry, which reaches depths of over 1,800m, and its connection to the Red Sea via the Strait of Tiran, with a sill depth of approximately 265m (Manasrah *et al.*, 2019). Seasonal stratification dominates the water column, with a shallow thermocline forming in summer around 40m and deeper mixing occurring in winter between 300 to 700m (Sengupta *et al.*, 2024). This cycle is influenced by regional wind patterns and density-driven exchange flows between the Gulf and the Red Sea.

Figure 6-56: Bathymetry of Northern Portion of the Gulf of Aqaba

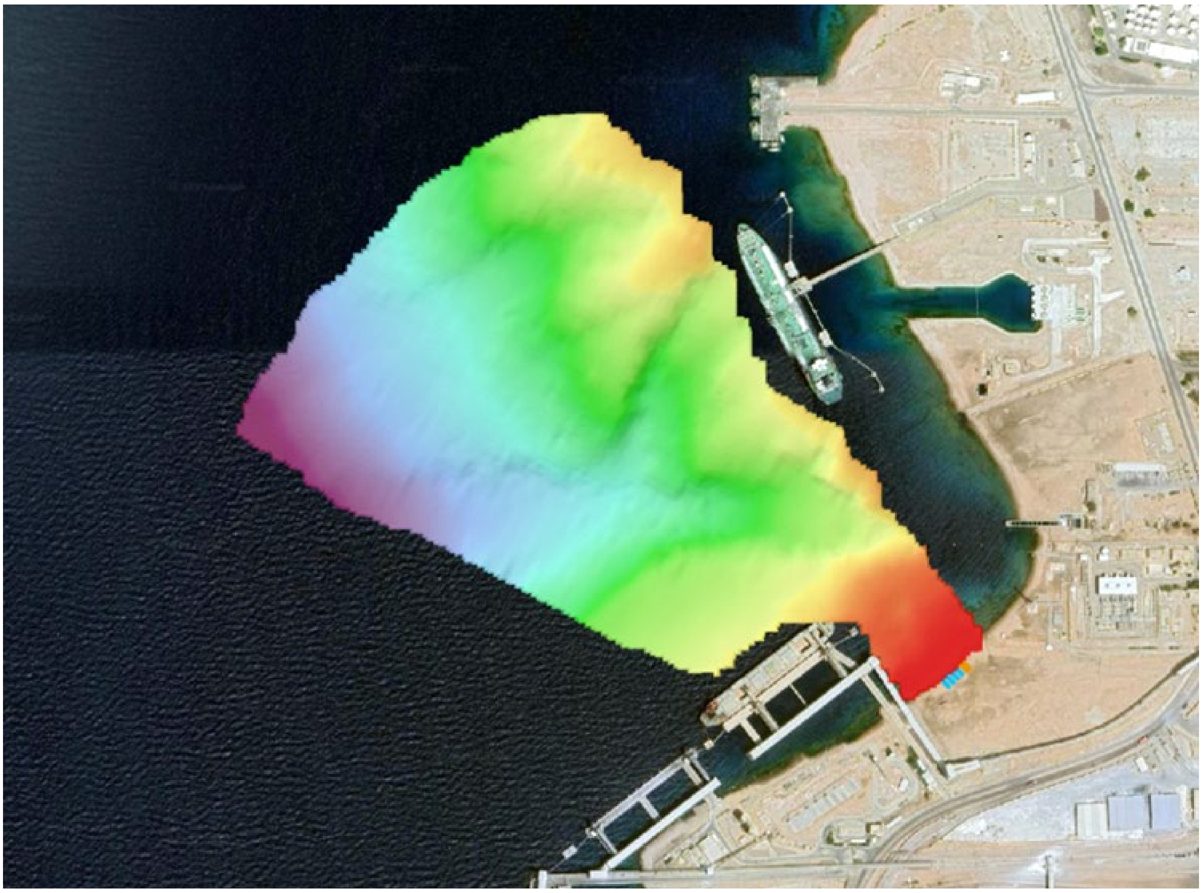


Jordan's designated marine protected areas span much of the fringing reef corridor. Reef-flat widths are typically narrow before the slope break, after which the seabed drops steeply to 20m and deeper. This configuration, combined with the proximity of steep slopes and canyons, allows coastal works to interact with both shallow- and deep-water habitats and their associated processes (ASEZA, 2014; CBD/CHM-Jordan, 2020).

ESIA Study Area

Specific details of current and circulation patterns for the ESIA Study Area have not been recorded. The 2022 AAWDC Project ESIA (TTID, 2022) noted that the coastal area of the ESIA Study Area is mainly a rocky reef structure extending to a 45m depth contour (Figure 6-57). The bottom slopes steeply from east to west and drops into deep water, with depths exceeding 900m and locally exceeding 15–20°C, and gently slopes from south to north (FAO, 1974; CBD/CHM-Jordan, 2020; TTID, 2022). The northern side accommodates a Gas Pipeline laid in a sandy valley with an average width of approximately 30m and extending beyond the 50 m contour. The southern side of the ESIA Study Area is adjacent to a Phosphate and Fertiliser Terminal, where the seabed is mostly composed of rubble from damaged corals (TTID, 2022).

Figure 6-57: Bathymetry of ESIA Study Coastal Area



6.3.8.2 Water Masses, Stratification and Seasonal Cycle

The upper Gulf exhibits a pronounced annual cycle, characterised by atmospheric cooling and strong northerly winds, which erode the pycnocline. This leads to thermal stratification during summer (May to November) and deep convective mixing and weak vertical gradients during winter (TTID, 2022). In spring and summer, surface warming and persistent evaporation re-stratify the water column, with the strongest thermocline typically in late summer to early autumn that confines biological production and many tracers to the upper ~100–150 m (Manasrah *et al.*, 2006; Biton and Gildor, 2011; Carlson *et al.*, 2014).

Net surface buoyancy loss is dominated by evaporation, which leads to the salinification of surface waters, high near-surface density in winter, and a persistent tendency for local water mass formation that feeds the intermediate and deep layers of the gulf. In the Jordanian nearshore, these seasonal transitions modulate temperature (roughly a 6–7 °C annual range in the far north) and nutrient dynamics, with winter mixing supporting brief productivity pulses and summer stratification maintaining oligotrophic, high-clarity conditions essential for coral reef health (Manasrah *et al.*, 2007; Environmental Assessment of the GoA, 2013).

The Tiran sill caps the depth of external exchange so that deep and bottom waters below sill depth are ventilated primarily by wintertime convection and intrusion cascades formed within the gulf itself, rather than direct import from the Red Sea. This contributes to relatively long residence times for deep waters and sensitivity to interannual atmospheric variability (Berman *et al.*, 2000; Biton and Gildor, 2011).

Sea level fluctuations are modest but measurable, with seasonal and meteorological variations contributing to a range of approximately 1.5m relative to mean sea level. These dynamics are important for understanding sediment transport, nutrient cycling, and the dispersion of pollutants (Al-Taani *et al.*, 2020).

6.3.8.3 Tides, Internal Waves and Mixing

The tidal regime in this area is characterised as microtidal to lower mesotidal, meaning the overall tidal range is relatively small but still has a significant influence on local hydrodynamics. The tides are primarily semi-diurnal, dominated by the M2 (lunar) constituent, which produces two high and two low tides each day, with tidal ranges at Aqaba typically on the order of a few decimetres and spring ranges around ~0.6–1.0m in the broader northern Red Sea region (Monismith and Genin, 2004; FAO, 1974; Carlson *et al.*, 2012). Although the surface tidal range is relatively small, the interaction of the external tide with the Tiran Sill generates pronounced baroclinic (internal waves that form below the surface as tides move over underwater features like sills or ridges) tides. These internal tides arise from the conversion of barotropic tidal energy into internal wave motions due to the stratification of the water column and the complex topography of the sill. The effect of seawater temperature on the water column structure is so pronounced that salinity inversion is noticed in summer, where waters of higher salinity overlay waters of lower salinity (TTID, 2022). These internal tides and associated internal solitary waves propagate northward into the gulf, enhancing vertical mixing near slopes and sills and affecting thermocline structure, nutrient fluxes, and reef-slope turbulence along the Jordanian coast (Monismith and Genin, 2004; Guo *et al.*, 2018).

6.3.8.4 Winds, Circulation and Exchange

Prevailing northerly winds (NNW to NNE) dominate the GoA region, with average speeds around 4.5m/s. These winds drive weak surface currents, generally below 10cm/s, and contribute to semi-diurnal internal tides that influence vertical mixing (Berman *et al.*, 2000; Gildor *et al.*, 2010).

Prevailing winds are funnelled along the gulf's axis by the bordering mountains. Wind stress, buoyancy forcing from evaporation/heat fluxes and the restricted connection with the Red Sea together set a seasonal wind- and buoyancy-driven circulation (Berman *et al*., 2000; Biton and Gildor, 2011). In winter, this promotes down-gulf surface flow with compensating return flow at depth; in summer, enhanced stratification and weaker convection favour shallower two-layer exchanges and more persistent thermoclines. Baroclinic exchange across Tiran is seasonally modulated (Sofianos and Johns, 2003; Berman *et al*., 2000). In Jordanian waters, the practical implication is that nearshore currents are often modest but can surge with wind events, and deeper return flows and internal wave packets can create transient shears and mixing that are not readily apparent from surface observations alone.

As a result of these circulation patterns, the currents in the Jordanian section of the GoA are relatively weak, with an annual average in the upper 40m rarely exceeding 5cms^{-1}. The dominant direction is south-east parallel to the predominant wind direction in the northern Gulf (TTID, 2022). In general, current speeds during the summer months are relatively weaker compared to other seasons, which may be related to the thermocline that prevents interaction between water layers, resulting in a relatively weak current during summer (MSS, 2018). During autumn, winter, and spring, mixing and degradation conditions lead to density differences in the water column, which enhance the density current, resulting in a stronger current during these seasons. Currents are stronger at the surface with an average of 10.3 ± 9.0 cms^{-1} at 2m depth than at depth 5-30m with an average speed of 2.1 ± 1.4cms^{-1}. The average direction of the current recorded at 2m and between 5-30m depth is 246 ± 83°N and 153 ± 82°N, respectively. Currents recorded at the Marine Science Station to the north of the ESIA Study Area are generally relatively weaker during summer months and are, for 70%-90% of the year, less than 10cms^{-1} and predominantly in a south-southeast direction (MSS, 2018; TTID, 2022).

6.3.9 Water and Sediment Quality

The National Monitoring Program (NMP) (MSS, 2024) found that the GoA remains a relatively well-preserved and ecologically significant area; however, increasing human activities and potential effects of climate change are beginning to impact the health of the marine environment, including fluctuations in nutrient levels and variable water quality. The NMP surveys 18 sites spanning the whole length of the Jordanian coastline and includes a site at the Phosphate and Fertiliser Terminal located within the ESIA Study Area. The indicators studied include seawater temperature, salinity, transparency, dissolved oxygen, pH, ammonia, nitrate, nitrite, and phosphate. All indicators, both nearshore and offshore, displayed typical seasonal cycles of the GoA (Rasheed *et al*., 2012; TTID, 2022). A statistical comparison between the nearshore and offshore records on a seasonal basis revealed no significant difference in any of the studied indicators. However, compared to other coastal sites, the ESIA Study Area has shown some differences (TTID, 2022; MSS, 2024), which are detailed in sub-sections below.

6.3.9.1 Temperature, Salinity and Water Quality

In the far north near Aqaba, sea surface temperatures typically range from the low 20s °C in winter to the high 20s°C in late summer, with salinity commonly around 40–41ppt and slightly higher at depth due to evaporation-driven concentration (Manasrah *et al*., 2007; Rey-Sánchez *et al*., 2017). From 2020 to 2024, temperature values ranged from a minimum of 21.34°C in March 2022 to a maximum of 30.27°C in August 2024, showing a clear warming trend over the years (MSS, 2024). Winter temperatures remained stable, averaging around 21.3°C to 22.5°C, while summer months, particularly July and August, exhibited consistent increases, peaking sharply in 2024. This seasonal variation reflects cooler winters and progressively hotter summers, likely influenced by regional climate dynamics. The data suggests an intensifying pattern of warmer summers, with a notable rise in peak summer temperatures over the five-year period. From 2020 to 2024, winter to summer ranges of salinity have increased, which may reflect longer-term changes in seasonality and climate (from higher evaporation associated with higher temperatures) (MSS, 2024).

The water column is oligotrophic for most of the year, with exceptionally clear waters that support high-latitude coral reefs. Internal tides and occasional upwelling pulses deliver intermittent nutrient injections, and winter mixing events ventilate deeper layers that accumulate respired carbon and nutrients through summer stratification (Monismith and Genin, 2004; Environmental Assessment of the GoA, 2013; Carlson *et al*., 2014).

The GoA water is characterised by high salinity and high oxygen saturation due to deep mixing and thermal stratification in summer. Characteristics of seawater and sediment are driven by regional hydrological circulation patterns, atmospheric dynamics and land-based sources and seasonality, whereby nutrient values are relatively low in summer and higher in winter, resulting from water column stratification, lack of oceanic upwelling and high irradiance during summer (Abdel-Halim, 2016; Manasrah *et al*., 2019). Seabed sediments are primarily carbonate-rich but can also contain terrigenous materials, with nutrient levels influenced by both natural cycles and anthropogenic sources.

Salinity and temperature profiles are relatively stable, with the deep-water layer (>600m) below the surface nearly stagnant and with a stable temperature (just under 21°C) and high salinity (around 40PSU), while the upper layers experience strong seasonal cycles of mixing in winter and stratification in summer when temperatures can reach 27°C. Interannual variability in winter mixing can influence nutrient availability and biological productivity (Al-Taani *et al*., 2004; Chase *et* al., 2006; SCOR, 2023).

ESIA Study Area

The ESIA Study Area consistently recorded the highest temperatures (30.37°C), particularly in summer, compared to other Jordanian coastal sites. Offshore temperatures generally follow the same pattern as coastal sites but tend to have slightly higher values in summer (30.27°C in August). Temperatures at all coastal sites have shown a warming trend over the period 2020 to 2024.

Salinity of the GoA exhibits a seasonal trend (40.36 PSU in December and 40.73 PSU in May). However, the values within the ESIA Study Area have a lower salinity value compared to other Jordanian coastal sites, which the NMP suggests is possibly influenced by water movement and discharge effects. In general, the NMP has indicated that salinity values have indicated a gradual increasing trend over the period 2020 to 2024.

Conductivity (which reflects evaporation) has the highest maximum in the ESIA Study Area (67.04ms) compared to other Jordanian coastal sites, suggesting localised factors such as restricted water exchange or anthropogenic impacts, which could lead to increased salinity and potential stress on marine life. Over the period from 2020 to 2024, conductivity values ranged from a minimum of 56.32 mS/cm in March 2022 to a maximum of 66.91 mS/cm in August 2024, indicating a steady increase over the years.

pH (which can reflect photosynthetic activity) has higher levels in the ESIA Study Area compared to other Jordanian coastal sites, which may indicate localised influences such as reduced CO_2 accumulation or enhanced carbonate precipitation. Year-on-year pH values have been stable, reflecting the strong buffering capacity of seawater, with any seasonal variations likely driven by biological activity and temperature-dependent chemical processes.

Dissolved oxygen (DO) generally exhibits a strong seasonal pattern (peaking in winter). A summer peak at the ESIA Study Area may indicate localised biological or physical processes that could lead to stress to organisms. Year-on-year consistent seasonal fluctuations reflect the influence of temperature and water mixing on oxygen dynamics.

6.3.9.2 Seawater Chemistry

The GoA is considered oligotrophic, characterised by low concentrations of nutrients, including nitrate, phosphate, and silicate. However, seasonal winter upwelling (January to April) and episodic mixing events can introduce nutrients from deeper layers, supporting primary productivity during summer months (June to September) (Badran *et al*., 2005). Dissolved oxygen levels are generally high in surface waters but decrease with depth, particularly below around 70m (Badran & Foster, 1998; Badran *et al*., 2005).

Key characteristics of the seawater chemistry in Jordanian waters include:

- Salinity is high, ranging from 40.2 – 41 ppt (UNESCO, 2023)
- Surface water (~0-30m) temperatures typically range from 21°C in winter to 28°C in summer (UNESCO, 2023)
- Evaporation rates are high, estimated between 0.5 and 1.0 cm/day, contributing to salinity levels that often exceed 40 ppt (Manasrah *et al*., 2019)
- Dissolved Oxygen: Relatively high and well-oxygenated (6.4-7.4 mgL^{-1}), with saturation often around 100% due to annual deep mixing (Abdel-Halim *et al*., 2016; Manasrah *et al*., 2019)

The 2022 AAWDC Project ESIA (TTID, 2022) noted that studies had shown that stratification of the water column during the summer months (April-November) causes recycled nutrients to accumulate in the deep reservoir (>250m) and prevents them from being transported into the photic zone. As a result, the surface layer concentrations of inorganic nutrients, particularly nitrogen and reactive phosphorus, in the GoA are especially low during summer (<0.05 and <0.01$\mu mol.l^{-1}$, respectively). During winter, deep convective mixing (>250 m) results in nutrient enrichment (2-3 orders of magnitude) of the open and coastal surface water. This enrichment supports the growth of phytoplankton and benthic macroalgal blooms. During summer stratification, the upper ~100m of the water column are almost completely depleted of inorganic nutrients, and below this level, a nutricline develops, indicating the threshold between nutrient uptake by primary production in the photic zone and the supply of recycled nutrients from deep water across the thermocline. This pattern of repletion and depletion during summer stratification below 100m depth is typical of nitrate, phosphate, and silicate. Chlorophyll concentration in seawater indicates the abundance and distribution of phytoplankton, which is crucial for understanding ocean health, primary productivity, and the carbon cycle.

Chlorophyll exhibits seasonal fluctuations, with low surface concentrations in summer (less than 0.5μgl^{-1}), increased surface concentrations in winter, and maximum surface concentrations in spring (up to approximately 1.1 µg/l) (Dorgham *et al*., 2012; Berman & Gildor, 2022). High chlorophyll levels can signify areas of high biological productivity, whereas low levels suggest lower primary production.

Trace metals are micronutrients that can limit the growth of organisms, especially plankton, and are important for regulating marine ecosystems. However, trace metals transition from micronutrients to toxic levels when their concentrations exceed the biological need, with the threshold depending on the specific metal and environmental factors like acidity (pH) and oxygen levels (Harmesa *et al*., 2024). The availability of trace metals can also be altered by perturbations that arise from sediment resuspension and anthropogenic inputs (Boyko et al., 2019; Manasrah *et al*., 2019). In Jordanian coastal waters, observed concentrations of Co, Cu, Ni, and Zn in seawater have been found to exceed the threshold levels recommended by the Australian Water Quality Guidelines (Al-Absi *et al*., 2019). Elevated concentrations of Cd, Cr, and Zn have been found in fringing reef marine sediments along the Jordanian coast, particularly near sources such as ports and sewage outlets. These pollutants, alongside organic carbon and phosphate, often correlate with human activities; however, the effects are localised, with higher concentrations and enrichment factors found closer to the shoreline and decreasing with water depth (Al-Rousan *et al*., 2016).

Anthropogenic influences, including port activities, urban runoff, and tourism, have introduced localised chemical stressors. Monitoring data from ASEZA (2013, 2014) indicate occasional spikes in nutrient and contaminant levels near discharge points, though overall water quality remains within acceptable thresholds for most parameters.

ESIA Study Area

Ammonia (NH_4^+), phosphate, silicate, and nitrate levels in the ESIA Study Area reflect intermediate nutrient inputs for the Jordanian area of the GoA but exhibit fluctuations that could indicate the influence of industrial activity leading to nutrient enrichment. The data shows a stable trend over the years, with only minor fluctuations in peak values. Phosphate levels tended to be higher in winter, averaging around 0.06–0.1mg/L, likely due to reduced biological uptake during cooler months. In contrast, summer values were more stable and lower, ranging from 0.03 to 0.06mg/L, reflecting increased biological activity and nutrient utilisation during warmer months.

The ESIA Study Area consistently shows high levels of Chlorophyll-a, reflecting elevated phytoplankton activity, which can indicate favourable environmental conditions.

6.3.9.3 Sediment Characteristics and Quality

Sediments along the Jordanian coast of the Gulf of Aqaba are primarily composed of carbonate sands (80%) and silts, with grain size distribution influenced by bathymetry and hydrodynamic conditions (Al-Rousan *et al*., 2006). Nearshore areas tend to accumulate finer materials (such as silt and clay), while coarser sediments dominate deeper zones. Organic content is generally low (typically below 0.6%) (Al-Rousan *et al*., 2006), consistent with the oligotrophic nature of the overlying waters. Sediment transport in Jordanian waters is primarily driven by aeolian (wind-blown) dust, seasonal flash floods, and organic matter from reefs, as well as marine processes such as longshore currents. However, this is limited due to the steep coastal profile. Bioturbation of Jordanian inshore sediments, either from anthropogenic (e.g. construction) activity or biological (e.g. burrowing organisms) activity, can significantly increase the availability of trace metal elements (Abu-Hilal *et al*., 1988).

ESIA Study Area

The ESIA Study Area has shown a slight year-on-year increase in sedimentation rates, peaking at 0.8 $mg.cm^{-2}.day^{-1}$ from September to November. This reflects a stable impact from industrial activities with controlled environmental management practices. In other parameters, such as environmental quality metrics, organic dynamics, and ecosystem health, the ESIA Study Area exhibits no significant divergence from other sites along the Jordanian coast. Considering trends and dynamics, long-term records of the physical and chemical properties of bottom-surface sediments from the ESIA Study Area indicate that sediment quality is comparable to that in other sites along the northern Gulf of Aqaba (Al Hseinat *et al*., 2020). Sediments appear to have attained steady-state equilibrium, where basic environmental parameters are insignificantly modified from the baseline values of the area. A decreasing trend in pollution parameters (e.g. grain size, loss on ignition (LOI), organic carbon (OC), hydrogen sulphide (H_2S), total nitrogen (TN), total phosphorus (TP), and heavy metal contents) observed over time indicates a significant improvement in the environmental quality attributed to the stringent implementation of environmental regulation in Aqaba (Al Hseinat *et al*., 2020).

6.3.10 Plankton

The GoA plankton is highly seasonal, with distinct spring and autumn phytoplankton blooms driven by a cycle of water stratification and mixing. During the summer, nutrient-poor surface waters are dominated by picophytoplankton, such as *Prochlorococcus*, while winter mixing brings deep-water nutrients to the surface, leading to phytoplankton blooms in late winter/spring. Zooplankton, including copepods, amphipods, and mysids, exhibit seasonal fluctuations, with near-reef areas typically showing higher biomass than offshore zones (Echelman & Fishelson, 1990; Badran & Zibdah, 2005).

6.3.10.1 Phytoplankton

There are significant differences between the northern and southern parts of the GoA (Berman & Gildor, 2022; Laiolo *et al.,* 2014). The photic zone in the GoA extends to a great depth of over 170m during most of the year (April–November) (Levanon-Spanier *et al.,* 1979). According to ecological distribution, 88% of the species are marine, and 12% have a marine-brackish origin. Also, 80% of the species are of pelagic origin, and 20% are of benthic origin (Shahin *et al.,* 2022). The GoA experiences a strong spring phytoplankton bloom and a weaker autumn bloom, though their intensity and timing can vary annually (Badran & Zibdah, 2005). Phytoplankton blooms are driven by both physical (mixing, upwelling) and ecological processes. In nutrient-poor summer waters, picophytoplankton, such as *Prochlorococcus*, dominate. As winter mixing introduces nutrients, phytoplankton, such as *Chlorophyceae* and *Cryptophyceae*, replace them. Overall, 188 species have been identified under six phytoplankton classes. Dinoflagellates dominate 60% of the total species (Shahin *et al.,* 2022). Diatoms constitute 38% and other groups are represented by 2%.

6.3.10.2 Zooplankton

Winter and summer zooplankton maxima were observed on both near-reef and offshore sampling sites in the northern part of the GoA, with summer maxima smaller than those of winter and more characterised by larval forms (Echelman & Fishelson, 1990; Khalil *et al.,* 1997). Winter maxima are often characterised by copepods and tunicate larvae (*Appendicularians*) offshore, and gammarid amphipods near reefs. Summer maxima include mysids, gammarids, and fish eggs near the reef. Near-reef zooplankton biomass was generally several times greater than that observed 2km offshore (Echelman & Fishelson, 1990).

The highest biomass is recorded in January, with the lowest in October (Echelman & Fishelson, 1990; Al-Najjar *et al.,* 2008). A notable high biomass of 46.1 mg/m³, dry weight, has been recorded at Tala Bay, to the North of the project site (Al-Najjar *et al.,* 2008).

6.3.10.3 Site-Specific Plankton Dynamics

Surveys conducted on the outer slope of the fringing reef in Aqaba revealed migratory activities (horizontal and vertical distributions) that modify the composition of the planktonic population. The distribution and structure of the zooplankton population are related to the particular hydrographic conditions of the Jordan coast, including upwelling, as well as daily and seasonal variations in light intensity. Mucus produced by coral is a significant source of energy for zooplankton, with some species assimilating at least 50% of the ingested mucus (Naumann *et al*., 2012).

Observation of high levels of Chlorophyll-a, as an indicator of phytoplankton, ranged from 3.88-5.67 mg/l (average values) and 4.23-5.27 mg/l (monthly values) with an annual (1999) average value of 4.94 mg/l for the Aqaba region, which may be explained in the coastal areas by the presence of sewage outlets. In the project area, larvae of molluscs (gastropods and bivalves) are by far the most dominant zooplankton group, comprising 91% of the total larvae. At the other extreme, planulae (larvae of corals and other cnidarians) were extremely rare, with an average of 0.3m^{-3}, comprising 0.16% of the total larvae.

Plankton are highly sensitive to desalination plants, particularly phytoplankton, which have been recorded as being more sensitive to effluent discharges than zooplankton (Gomes *et al.,* 2023). Effluents can contain chemicals from the pre-treatment process, such as coagulants and anti-scaling agents, as well as hot water, which can negatively impact plankton (Grossowicz *et al.,* 2021). While some studies have found impacts on zooplankton (decreased diversity and hatching patterns), others show less impact, suggesting that sensitivity varies between species (Grossowicz *et al.,* 2021). Both phytoplankton and zooplankton can also be affected by thermal pollution from the plants, chemicals used in the desalination process, and entrainment in the intake water (Wateruse Association, 2011). The main changes observed were a decrease in primary productivity, a loss in diversity, and a change in the community structure of planktonic populations due to the dominance of saline-tolerant groups, which highlights the importance of improving treatment or dilution of effluent discharges to minimize the impacts over whole neritic trophic webs, which depend on phytoplankton (Grossowicz *et al.,* 2021; Gromes *et al.,* 2023).

6.3.11 Benthic Ecology (Including Shellfish)

The Jordanian waters of the GoA are characterised by high salinity, warm temperatures, oligotrophic (nutrient-poor) conditions, steep depth gradients, and complex benthic (seabed) habitats predominantly comprising coral reefs, seagrass beds, and sandy sediments. These ecosystems support rich biodiversity, with about 200 species of hard corals and 500 fish species, and molluscs, crustaceans and other invertebrates and flora (algae and seagrass species) (UNEP, 2015; Joydas *et al.*, 2021; Aqaba Special Economic Zone Authority, 2022; UNESCO, 2023). The mix of habitat types is driven by biological processes, including competition between species and the interaction between corals and algae, the creation of both soft habitat by sediments and hard habitat by the growth of coral and other carbonate producers, as well as physical and chemical processes such as bioerosion, bathymetry and light (Richardson *et al.*, 2017). The three principal habitat types are:

- Coral reefs
- Seagrass beds
- Deep-water benthic habitats

These habitats support a range of fauna and flora that may be distinctive to a particular habitat type, where they are substrate-dependent (e.g., certain sea cucumber species in seagrass beds) or can be present in both habitat types (e.g., fish species).

6.3.11.1 Coral Reefs

The corals of the GoA are critically important due to their exceptional thermal resilience, which makes the region a vital refuge from climate change-induced bleaching (Kochman-Gino & Fine, 2023; Kochman-Gino & Fine, 2025). The GoA has naturally high salinity, along with other factors, such as being a closed sea with limited freshwater input, which create unique conditions for its corals (Petersen *et al*., 2018; UNESCO, 2023). The Jordanian coastline is fringed by a discontinuous series of coral reefs in which two morphological units can be distinguished (Bouchon *et al*., 1981):

- Narrow reef flats characterised by, from onshore to offshore, beach sediments, seagrasses and increasing coverage of coral that leads to

- A reef edge and steeply sloping reef slope forming a steep vertical drop-off to abyssal depths (Bouchon *et al.*, 1981; Al Tawaha *et al.*, 2019)

Jordan's coral reefs have generally been maintained in good condition, and a survey of eight sites along the Jordanian coast (including the ESIA Study Area) recently found that corals killed by human activities, which serve as an indicator of reef destruction, have a cover of less than 2% (Al-Horani, 2006). Hard coral (*Scleractinia*) cover tends to increase from north to south along the Jordanian coast because sandy seabeds with seagrass dominate the northern parts of the coast, which become progressively more rocky to the south and feature more developed coral reefs (Al-Horani *et al*., 2006). Deeper (e.g. ~15m) reef transects frequently show higher hard coral cover than shallower depths (e.g. ~8m) (Al-Horani *et al.*, 2006). A total of 157 coral species have been identified in Aqaba Marine Reserve (AMR), of these, 153 are scleractinians (reef building corals – other coral taxonmic groups included an organ-pipe coral (*Alcyonacea*), and three are fire corals (*Milleporidae*) (UNESCO, 2023). 11 of the 23 hard coral species endemic to the Red Sea are found in Jordan's GoA (Al Tawaha *et al.*, 2019). In addition, 21 species of hydrozoans (in addition to fire corals) have been found (UNESCO, 2023). Southern Jordanian sites have higher coral cover than northern sites, and 15m depth transects were found to have a higher percentage of healthy coral than 8m transects (Al-Horani *et al.*, 2006).

Approximately 120 species of soft corals have been recorded in Jordanian waters (UNESCO, 2023). These species exhibit the highest coverage at sites where industrial activities are present (Al-Horani *et al.*, 2021). Soft corals, along with hard corals, play an important role in increasing habitat complexity, providing shelter for a diverse range of fauna, and contributing to nutrient cycling, which enhances overall reef biodiversity and stability (Jeng et al., 2011; Roth *et al*., 2018).

6.3.11.2 Seagrass Beds

Seagrass beds are frequently found where there is sandy shallow substrate with low disturbance, particularly occurring in the northern areas of Jordan's coastline, where there are more sandy substrates (Al-rousan *et al.*, 2005). Three seagrass species are recorded in Jordanian waters *Halodule uninervis*, *Halophila ovalis* and *Halophila stipulacea*. In some northern Jordanian coastal sediment areas, 70 -98% cover of seagrass can be found (Al-Rousan *et al.*, 2005). In seagrass habitats, 132 fish species belonging to 35 families have been recorded (Khalaf *et al.*, 2012). Seagrass beds along Jordan's coast predominately support fish populations from six families: Wrasses (Labridae), Damselfish (Pomacentridae), Goatfish (Mullidae), Cardinalfishes (Apogonidae), Butterfly fish (Chaetodontidae), and Gobies (Gobiidae) (Khalaf & Kochzius, 2002; Al-rousan *et al.*, 2005).

6.3.11.3 Deep-water Benthic Habitats

A study from the Neom territory in Saudi Arabia found that the rairphotic zone (spanning a depth range of 110-200m) can also host non-photosynthetic scleractinian corals, including *Madracis interjecta*, *Dendrophyllia minuscula*, and *Rhizopsammia compacta* (Chimienta *et al*., 2025). These corals build the framework of three different bioherms (i.e., *M. interjecta* mound-like bioherms, *D. minuscula* shelf-like formations, and *R. compacta* bio-stalactites), encrusted, cemented and reinforced by a suite of benthic taxa including other scleractinian corals, bryozoans, foraminifers, molluscs, and serpulids. Although these habitat types have not been reported in Jordanian waters, their presence in adjacent Palestinian and Saudi waters (direct observation and modelling) (Nolan et al., 2024; Chimienta et al., 2025) strongly suggests they are likely to be present. In the northern Red Sea and Gulf of Aqaba, deep coral ecosystems are found below the mesophotic zone, deeper than 150 m water depth, and convey many of the same ecosystem services as shallower coral reef ecosystems, such as providing habitat for fish, promoting biodiversity and increasing secondary production (Nolan *et al., 2024).* Species within the families

Caryophylliidae and Dendrophylliidae, that are non-photosynthetic (in contrast to shallow water reef-forming corals), are distributed between water depths of 150m and 700m and build coral frameworks *(Nolan et al*., 2024). At depths ranging from approximately 205 to 1,300m, the benthic community has been found to comprise fifty-five benthic species (predominantly polychaetes) with a density of 160-670 individuals per square meter (ind. m^{-2}) (Joydas *et al.*, 2021).

Molluscs: A total of 462 gastropod species have been identified in Jordanian waters (UNESCO, 2023), comprising 162 bivalves, including the Giant clams *Tridacna maxima* and *Tridacna squamosa*, approximately 17 chitons, and a few cephalopods and scaphopods. There are no studies relating to the specific distribution of mollusc types.

Three species of giant clam occur within the northern Red Sea and GoA. These reef-dwelling bivalves, like corals, have photosymbiotic algae, which enable them to grow more rapidly. They share other similarities with corals; they become stressed at elevated temperatures and also require oligotrophic water, as they are sensitive to eutrophication-associated turbidity (Killam et al., 2021). The most notable shellfish species in the region is the regionally endemic, endangered giant clam (*Tridacna squamosina*), which was recorded in previous marine survey work and has a very limited spatial distribution (<5m depth).

Sponges: 72 species of sponges have been recorded within the AMR (UNESCO, 2023). Sponge distribution along the south Jordanian coast of the Gulf of Aqaba is concentrated on coral reefs, where samples collected from depths of 6.6 to 22 meters indicate the presence of genera *Axinella*, *Negombata*, *Siphonochalina*, and *Diacarnus*, as well as an unidentified genus within the order Haplosclerida (Arabeyyat *et al*., 2025).

Holothurians: Holothurians, also known as sea cucumbers, are a dominant group of marine invertebrates in the Gulf of Aqaba, with common species including *Holothuria atra*, *Holothuria leucospilota*, and *Holothuria fuscogilva*. Due to overfishing, especially for valuable and vulnerable species like *H. fuscogilva*, some populations have declined (Ahmed *et al.*, 2016; Yuval *et al.*, 2014). There are no studies relating to the specific distribution of Holothurians in Jordanian waters.

Polychaetes: Polychaetes are a diverse and significant group of annelid worms found in the Jordanian GoA, particularly in sandy beach habitats. Studies have identified several taxa, with polychaetes being the most diverse group of macrofauna in the area, including species like *Glycera tesselata* and *Perinereis nuntia* (Ismail, 1986).

Macroalgae and Turf Algae

Macroalgae are ecologically significant along the Jordanian coast of the Gulf of Aqaba, as they are key primary producers in the coral reef ecosystem, providing food and shelter for marine life, and playing a role in nutrient cycling and reef building. Eighteen genera of benthic macroalgae have been recorded, including seven Chlorophytes (green algae), eleven Rhodophytes (red algae), and ten Phaeophytes (brown algae) (Al-Zibdah & Colgan, 2011). Brown algae have the highest biomass and cover within the AMR area. Coastal waters adjacent to the industrial complex (further north of the ESIA Study Area) have the highest coverage of brown algae and associated biomass, which is significantly different from that observed close to the phosphate loading port. The highest coverage appears to be evident during the spring months. Turf algae exhibit higher coverage within shallower depths (circa 8m). Areas in close proximity to disturbed sites (e.g. heavy industrial developments) tend to have lower coverage.

Fish

Fish associated with benthic habitats are diverse (~200 species on Jordanian coral reefs and seagrass sites). Fish species richness is correlated with the presence of hard substrates and habitat complexity. Fish assemblages differ between coral reefs, seagrass beds, and disturbed versus undisturbed sites (Khalaf & Kochzius, 2002). Fish are most abundant and have significantly higher diversity at 12 m depths compared to shallow 6 m depth waters (Khalaf *et al.*, 2012). This may be attributed to many planktivorous fishes that inhabit this depth, such as Pseudoanthias squampinnis, Paracheilinus octotaenia, Chromis pelloura, Decapterus macarellus, and Cirrhilabrus rubriventralis, probably with a higher abundance of plankton at 12 m depth than at 6 m. Overall, a few species dominate (e.g. *Neopomacentrus miryae*, *Lethrinus borbonicus*, *Pseudanthias squamipinnis*, *Lethrinus variegatus*, *Siganus rivulatus*) (Khalaf *et al.*, 2012).

6.3.11.4 ESIA Study Area

Al-Zibdah *et al.* (2007) conducted a detailed ecological study for three years (2001-2003) at 6m and 12 m depths in an area for three zones that included an area between the inflow channel of the Thermal Power Station and the northern section of the Industrial Jetty, which encompasses the proposed sites for inlet and outfall infrastructure of the current proposal. The status of ecological factors was assessed with respect to species diversity and abundance of the major groups of the macrobenthic (organisms typically larger than 1mm) community: corals, bivalves, hydrozoans, echinoderms, sponges and macroalgae. The results indicated that the area had been subject to habitat modifications resulting from construction activity, which had led to some disturbance of coral cover and abundance. Hard and soft coral was found to be significantly higher at 12m than at 6m, but other macrobenthos showed no change by depth. Over the three years of the study, hard coral decreased significantly at a 6 m depth (averaging ~12% to 6%) during the three successive years but remained almost unchanged at 12 m (averaging ~33%).

The Marine Science Station has carried out a National Monitoring Programme since the late 1990s, which has included a monitoring site in the embayment where the inlet and outfall infrastructure is proposed to be located, known as either the Industrial Complex site or Phosphate Port. A comparison of hard and soft coral cover at depths of either 9m (~14% & ~10% respectively) or 15m (~18% & ~5% respectively) showed no significant difference year-on-year between 2013 and 2021 (MSS, 2021). The 2024 survey (MSS, 2024) found coral cover as high as 24% and 33%, with low coral mortality at depths of 6m and 12m, respectively, at the Industrial complex site. These figures represent an increase in coral cover at depths of 6m (~8% to 24%) and 12m (~24% to 33%).

The 2022 AAWDC Project ESIA (TTID, 2022) noted that the proposed site found a total of 46 hard coral species belonging to the families *Acropora sps., Montipora sps*, *Favia sps and Fungia sps*. The bottom habitat was mainly rocky, typical of coral reef sites. Structural modifications were observed at specific locations within the study site, primarily due to construction activities, which slightly disrupted the abundance and cover of hard coral. This was particularly prevalent near the industrial jetty, where species richness and abundance correlated negatively with proximity to the industrial site. Additionally, the abundance of certain species, such as corals, echinoderms, hydrozoans, and macroalgae, was found to correlate with the level of bottom modification and proximity to the industrial site. The manoeuvring of ships and port activity may have also contributed to the observed impacts. Corals and other biotic indicators, except seagrass, showed higher abundance at the deeper transects compared to the shallower. A Remotely Operated Vehicle (ROV) survey of deeper waters revealed that below 30m, coral heads become susceptible to impacts from deposited sediments that fall from the surface and accumulate on their surfaces.

6.3.12 Fish Ecology

This section focuses on teleosts (fish species which have a bony skeleton), rather than elasmobranchs (a subclass of cartilaginous fish species (class Chondrichthyes) that include sharks, skates, rays, guitarfish, and sawfish), which are captured under Marine Megafauna (Section 6.3.13.1).

The GoA is a narrow, deep water body that contains a diverse range of valuable marine ecosystems. Key fish and shellfish habitats present include open sea, coral reefs and seagrass beds. This variety of different coastal and marine habitats supports a diverse range of fish species of conservation and/or commercial importance. The fish ecology is characterised by high biodiversity (Khalaf *et al*., 2012).

Fish populations in the GoA represent all trophic groups, with 512 species known to occur. The vast majority of these species (approximately 70%) are associated with coral reef habitats, with the remainder split between pelagic and demersal environments. The 2018 checklist of Red Sea fishes lists 1,207 species, including 73 species newly described for science since the 2010 checklist, representing a total of 164 families. Of these, 797 species were recorded from the Gulf of Aqaba. The total number of endemic Red Sea species is 174, of which 34 are endemic to the Gulf of Aqaba (Golani & Fricke, 2018).

The size and mobility of fish species vary greatly; some, such as tunas and mackerels, are pelagic (inhabit the water column), and others, such as soles, are demersal (bottom-dwelling). Some species, such as reef dwellers, may be more limited in their range and movements due to strong habitat associations, site fidelity, life history phase, or physiological limitations to propulsion.

A diverse array of fish, comprising over 500 species (UNESCO, 2023), inhabit these habitats, which are supported by a variety of ecosystems, including coral reefs, seagrass beds, and sandy seabed (Al-Rousan *et al*., 2005). About half of the fish population belongs to six families: Labridae (Wrasse), Pomacentridae (Damselfish), Mullidae (Mullets), Apogonidae (Cardinalfish), Chaetodontidae (Butterflyfish) and Gobiidae (Gobies) (Al-rousan *et al*., 2005), and the most abundant fish species on Jordanian reefs are Anthias (*Pseudanthias squamipinnis)*, Damselfish *(Chromis viridis & Dascyllus marginatus)*, humbug Damselfish (*Dascyllus aruanus)* and eightline Flasher (*Paracheilinus octotaenia)*. The distribution of the main coral reef herbivorous fishes, Surgeonfish (Acanthuridae), Parrotfish (Scaridae) and Rabbitfish (Siganidae), reach their highest abundance on the fore-reef, where 234 fishes were counted per 1,000 m^{-2} (Bouchon & Harmelin-Vivien, 1981). The density of fish decreases on the reef flat, with an average of 150 fish 1,000 m^{-2} and is lowest on the reef slope (69 fish 1,000 m^{-2}). Surgeonfish form 63% of the herbivorous fish, parrotfishes 35%, and rabbitfishes 2%. Families and species display different distributions according to biota. The Surgeonfish dominate on the reef flat, whereas the Parrotfish are more numerous on the outer reef slope.

Fish play a range of functional ecological roles; they link trophic food webs by consuming plankton, and in turn are key dietary components of higher trophic groups (e.g., marine mammals). Larger predatory fish also act as apex predators feeding on other fish, marine mammals and turtles. Fish also play key roles in maintaining the physical integrity and health of ecosystems. For instance, a healthy herbivorous fish community is critical for a reef's ability to resist and recover from severe disturbances and regain lost coral cover. A healthy fish population is critical for habitat types to be resilient to change (Khalil *et al*., 2013).

Marine Protected Areas (MPAs) in Jordan exhibit higher fish abundance and diversity compared to areas with significant human activities, such as industrial zones, tourist development and ports. Fish communities in MPAs are characterised by higher biomass, a greater number of species, and more stable populations than areas outside MPAs (Al-Zibdah, 2013; UNESCO, 2023). These areas serve as refuges for marine life and contribute to the overall resilience of the Gulf of Aqaba's ecosystems. In contrast, areas with higher anthropogenic influence, particularly around ports, marinas, and industrial zones, showed reduced fish populations and lower diversity.

Three coral reef-associated species were identified as priorities during the desk-based review, which included previous marine surveys and expert consultation phases of data collection, due to being threatened, rare, and/or vulnerable to change. These are the Endangered Humphead wrasse (*Cheilinus undulatus*), Sky emperor (*Lethrinus mahsena*), and endemic Red Sea coral grouper (*Plectropomus marisrubri*), which is currently assessed as Vulnerable but considered more likely to be Endangered due to intense fisheries pressures throughout its range. The humphead wrasse is specifically named in the Aqaba Marine Reserve Management Plan (AMRMP), but no management provisions are specified.

6.3.13 Marine Megafauna and Turtles

The GoA and the northern Red Sea form a globally significant marine ecosystem, supporting high marine biodiversity (Garzon *et al.*, 2022), including numerous species of marine megafauna, i.e., marine mammals, marine turtles and large elasmobranchs (sharks, skates and rays). Conversely, research and knowledge about these species within the GoA are very limited, particularly in Jordanian waters.

The 27km Jordanian coastline comprises a unique segment of this region, harbouring key functional habitats for threatened and endemic species, while also undergoing heightened anthropogenic pressures, including rapid coastal development and expanding maritime activity (UNESCO, 2023).

The GoA contains a mosaic of interconnected marine and coastal ecosystems and habitats essential for marine megafauna at various life stages:

- **Coral Reefs**: High coral cover and structural complexity underpin diverse megafauna communities, including reef-associated megafauna (e.g., turtles, rays and sharks)
- **Seagrass Meadows**: Three seagrass species (*Halophila stipulacea*, *Halodule uninervis*, *Halophila ovalis*) are present in seagrass meadows, providing a range of functional habitats, including foraging, nursery and inter-nesting habitats
- **Sandy/Silty Sediments**: These environments support benthic-associated elasmobranchs and are foraging areas for turtles
- **Open Water**: Deep open waters provide habitat for marine megafauna and other pelagic species (those that live in the water column), including prey such as pelagic fish, e.g., mackerels, tunas

6.3.13.1 Marine Mammals

The Red Sea is widely acknowledged to be relatively data-deficient for marine mammals, with most species currently described as understudied, particularly in relation to much-needed genetic research (Notarbartolo *et al*., 2017). Of the 16 cetacean species known, or likely, to be present in the Red Sea and GoA, only nine are considered to occur regularly; the remainder are likely to be sporadic sightings of Indian Ocean vagrants. These nine are Bryde's whale (taxonomy currently undefined, *Balaenoptera brydei* reported specifically), false killer whale (*Pseudorca crassidens*), Risso's dolphin (*Grampus griseus*), Indian Ocean humpback dolphin (*Sousa plumbea*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), Common bottlenose dolphin (*Tursiops truncatus*), Indo-Pacific common dolphin (*Delphinus delphis tropicalis*), pantropical spotted dolphin (*Stenella attenuata*) and spinner dolphin (*Stenella longirostris*) (Notarbartalo *et al*., 2017).

All species of cetacean are listed under Annex IV of the EU Habitats Directive. Large whales are seldom recorded in the GoA, but Bryde's whales and other rorquals occur in the wider Red Sea. The most relevant species are the Indo-Pacific bottlenose dolphin, the common bottlenose dolphin, the spinner dolphin and the pantropical spotted dolphin. Indo-Pacific bottlenose dolphins use shallow reef systems in the northern Red Sea for socialising and calving, with reproductive activity observed year-round and a spring–summer peak at sites just south of Jordan. Spinner and spotted dolphins use deeper water off reef slopes and occasionally enter the GoA; concentrated day-resting groups typical of other regions have been documented at Red Sea reefs to the south (Notarbartolo di Sciara *et al,* 2017; Costa *et al.*, 2019). A series of records confirms the presence of the Indian Ocean humpback dolphin in the GoA, including Aqaba. Several cetacean species exhibit ecotypic differentiation, including bottlenose dolphins (genus Tursiops) (Pratt *et al*., 2023). This is particularly significant in the Red Sea region, which is known to drive speciation, genetic diversity, and endemism. This is a notable knowledge gap for all cetacean species, not just at a national or project scale, but also at a regional scale.

There are currently three Important Marine Mammal Areas (IMMAs) in the Red Sea region, which are defined as "discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation". There are currently no IMMAs within the main body of the GoA; however, the Strait of Tiran has been identified as an Area of Interest for the potential future designation of an IMMA. This means the site has been proposed as a candidate IMMA at a regional workshop with insufficient information to meet the required criteria. It is highly likely that this relates to the recorded presence of the Endangered Indian Ocean humpback dolphin and Vulnerable dugong (Dugong dugon) around the Strait of Tiran and archipelagos within the northern Red Sea. While dugongs are recorded elsewhere in the northern Red Sea and parts of the GoA, they are not recorded in Jordanian waters. No species of seal is recorded within the GoA.

6.3.13.2 Marine Turtles

Five of the seven described species of marine turtles are found in the Red Sea region, which supports globally important foraging and nesting habitats for these threatened, protected and migratory species. The two key species of importance within the GoA, and regularly sighted and reported within Jordan's territorial waters, are the Critically Endangered hawksbill (*Eretmochelys imbricata*) and green (*Chelonia mydas*) turtle. Both species are listed on Annex IV of the EU Habitats Directive and are also listed in the CMS Appendix I, reflecting their migratory life history characteristics.

Turtles are known to traverse open water; however, their movements tend to be strongly associated with coastal habitats, particularly coral reefs and seagrass meadows (Al-Zibdah, 2007). These habitats are used for foraging, inter-nesting, refugia during migration and as developmental habitats for juveniles. Detailed studies of turtle foraging indicated a marked concentration in coral reefs (85% of observations), with far fewer turtles recorded on the scarce Jordanian seagrass and sandy habitats (10% and 5%, respectively) (Al-Zibdah, 2007; Aqaba Special Economic Zone Authority, 2022). There is currently no turtle nesting recorded within Jordanian waters (Rees & Al-Zibdah, 2025), and at present, there is no mapping of Important Marine Turtle Areas (IMTAs) in the GoA.

However, the unique physical, spatial and geographical attributes of the region catalyse evolutionary and ecological processes associated with species diversification. Recent regional research indicates that northern Red Sea hawksbill populations exhibit strong genetic distinctiveness and high site fidelity, which supports the potential existence of sub-populations.

Regional satellite tracking studies (Mann *et al*., 2024) demonstrate the GoA's role within broader migratory turtle networks across the region, with its shallow coastal belt of fringing reef systems and seagrass providing stopover and feeding areas for migrating turtles. The potential importance of transitional habitats (e.g., sandy/mixed substrate zones) within the GoA for resting and/or inter-nesting turtles has not been studied to date. The observed movement patterns highlight significant regional connectivity and indicate that turtles utilising Jordanian waters may originate from, or travel to, distant nesting or feeding areas within the Red Sea basin (Mann *et al*., 2024).

6.3.13.3 Elasmobranchs

The term elasmobranchs collectively refers to sharks, rays, and skates. Unlike most fish species, which have a bony skeleton (referred to as teleosts), elasmobranchs have a skeleton made of cartilage. Within the Red Sea region, most elasmobranch populations remain poorly studied, and the spatial-temporal distribution of most elasmobranch species in the Red Sea remains largely undescribed. There is a notable spatial bias, with most studies conducted within a limited spatial area, often in proximity to known hotspots or research institutions (Garzon *et al*., 2022).

A recent multi-method characterisation of elasmobranch communities in the north-eastern Red Sea and GoA was undertaken to address the data gaps for these species, particularly in relation to occurrence and distribution. The focal area and driver of the study were the NEOM project in northwest Saudi Arabia. Four species of rays and nine species of sharks previously unrecorded were listed, and a range extension for the pink whipray (*Himantura fai*) and the round ribbontail ray (*Taeniurops meyeni*) into the GoA was also recorded (Garzon *et al*., 2022).

Following a desk-based review and consultation with Jordanian experts, the following have been identified as key species for the Project. The Endangered spotted eagle ray (*Aetobatus ocellatus*), coach whipray (*Himantura uarnak*), spinetail devil ray (*Mobula mobular*), oceanic manta ray (*Mobula birostris*), panther torpedo (*Torpedo panthera*), shortfin mako (*Isurus oxyrinchus*) and the Vulnerable pink whipray and tiger shark (*Galeocerdo cuvier*).

There are a number of Important Shark and Ray Areas (ISRAs) within the Red Sea region. A candidate ISRA has been identified in Jordanian waters, specifically in the Northern Jordan Area of Interest, which spans from the southern Aqaba beach to Al-Ghandour Beach, with a depth range of 0-450m. It has been identified for aggregations of shortfin makos and potential, undefined aggregations of tiger sharks.

There is an ISRA in Palestine at Eilat North Beach for the coachwhipray reproductive areas, as well as the spotted eagle ray and undefined aggregations of the cowtail ray (*Pastinachus sephen*). The Strait of Tiran is also identified as an ISRA Area of Interest for elasmobranchs due to citizen science reports of whale sharks (*Rhincodon typus*) and oceanic manta rays.

6.3.14 Marine Baseline Survey and Habitat Summary

6.3.14.1 Methodology

A screening survey of benthic habitats was conducted in 2025 within the vicinity of the Project, utilising ROV technology, drop-down video, and diver surveys to collect underwater imagery. This effort aimed to identify and classify major seabed types and generate point sample habitat distribution maps to inform subsequent detailed sampling and environmental assessments. The diver surveys enable a taxonomic inventory to be produced at the genus level, and the percentage cover of benthic taxa/lifeforms to be calculated and reported.

The baseline survey collected several datasets, Table 6-48 summarises the survey types, methods, why it was employed, how and where it was applied, the key variables collected, and any notable constraints.

Table 6-48: Summary of Data Collection Surveys

Survey	Purpose	Coverage	Methods	Key Data	Limitations
Rapid screening (ROV)	Locate / classify seabed habitats and guide detailed sampling	41 stations	ROV, surface GPS	Habitat class, substrate, presence/cover of corals/algae/sponges	Camera / lighting constraints, depth limited to ~80 m in practice
Diver benthic transects	Quantify benthic cover/corals by depth, coral photography and identification	9 x Depth-stratified transects at 5m intervals 5-10m (50 m length)	Point-intercept, belt census, photography, surface GPS	% cover by group, coral colonies (genus), growth forms, photo vouchers	Topography constraints, diver depth limit ~30 m
Water sampling	Characterise water quality and plankton	14 water sample stations (profiles/surface-bottom as applicable)	Discrete sampling; calibrated multiparameter probe	Temperature, salinity, DO, pH, turbidity, euphotic depth, plankton	Nearshore turbidity pockets, offshore stratification
Sediment sampling (grabs)	Describe sediments, contaminants, infauna	18 grab sample stations	Grab sampling; photography, Surface GPS	Grain size, chemistry, infaunal taxa/abundance, position/depth/notes	Soft-sediment focus
Intertidal / very shallow walkover	Shoreline condition, shallow reef presence/health	8 shoreline transects (T1–T8)	Visual assessment, snorkel / wading, GPS & photographs	Beach form; debris; seabed type; live hard coral in shallows; shallow intertidal reef	Qualitative reconnaissance

6.3.14.2 Summary of Survey Results

The survey results confirmed a ringing-reef system with clear spatial and depth-related structure. Habitats range from seagrass meadows and patchy coral in shallow water to well-developed coral reefs on the mid-slope, and mixed coral-sediment habitats that transition to sandy seabed at depth. The bay exhibited a South to North Gradient:

- Southern bay: lower seagrass presence, moderate coral at depth
- Central bay: highest coral cover and most developed slope reef
- Northern bay: strongest shallow seagrass signal, coral increasing with depth

This gradient likely reflects wave exposure, sediment movement and basin morphology, with the northern shallows more sheltered and sediment-influenced. The bay also exhibited a depth trend, which is the dominating organising factor for flora and fauna (Table 6-49). This is consistent with fringing-reef zonation and the optical and sedimentary gradients of the northern Red Sea.

Table 6-49: Dominant Organising Factor for Flora and Fauna

Depth (m)	Dominant Habitat
0-10	Seagrass + patchy coral on sand
10-20	Emerging coral dominance, seagrass absent
20-35	Peak coral reef development
35-60	Mixed reef and sand, mesophotic transition
>60	Sand plain with isolated reef outcrops

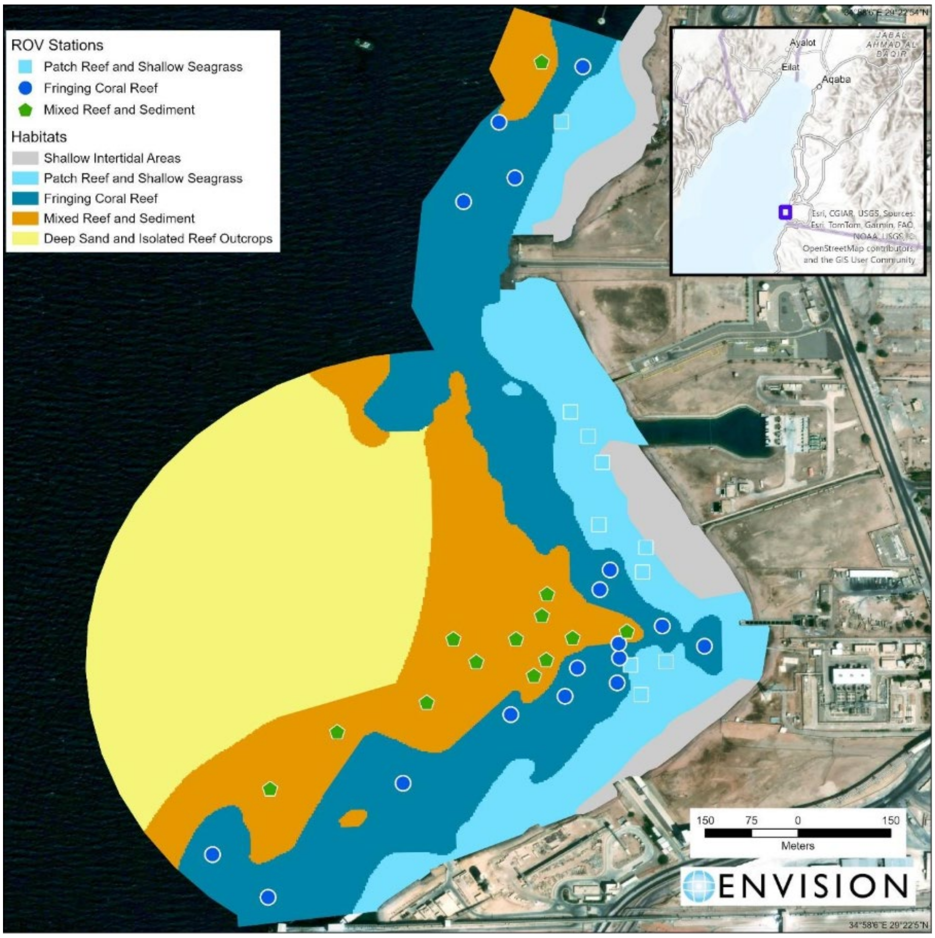
Within the majority of transects, the highest coral abundance occurs in the shallows at 10-15m. Abundance then declines with depth, with a distinct decrease by 20m, with these lower abundances continuing at 30m. This is expected of reef habitats when light availability shapes coral zonation. In total, coral species from 66 scleractinian genera were recorded, with 55 of these including species identified on the IUCN Red List. Shallow depths are dominated by genera such as *Porites*, *Goniopora*, *Pavona*, *Turbinaria*, and branching *Pocillopora*. These groups favour high light and dynamic environments. Plate and foliose forms, such as Leptoseris, become more common from about 20m, which supports their specialisation for lower-light environments, along with the occasional persistence of hardy, massive forms.

6.3.14.3 Habitats

Results from the habitat mapping process (Figure 6-58) show the area to have a fringing area of intertidal habitats and seagrass beds with patch reefs occur in the shallow sub-tidal environment. As the seabed deepens coral levels increase and fringing coral reef is present across the length of the ESIA Study Area. Mixed reef and sediment habitats become more dominated as light levels decrease with sediment and scattered reef areas becoming prevalent in deeper waters.

Specific habitats identified are presented below.

Figure 6-58: Distribution of Marine Habitats within ESIA Study Area



Shallow Intertidal Habitat: Across the survey area, the shallow intertidal habitats are rocky platforms with a mixed coral/rock/sand seabed (Figure 6-59). Live hard coral cover is relatively high in the south (35–45%), forming a continuous shallow reef flat and a well-developed mixed coral–rock habitat. No bleaching or disease was recorded, and soft corals are present in low percentages along with invertebrate fauna such as urchins, giant clams and sea cucumbers.

At the lower intertidal to ~1 m depth, habitats range from bare rock to mixed sand/rock, with only isolated massive coral colonies in the central sector, through to coral–rock assemblages. Coral cover is low in the central sector (ranging from <3% to approximately 8%), increasing on transitioning northward (~18% to ~35%), where a continuous reef flat reappears, though with moderate algal growth on the reef surface. Giant clams and other macro-invertebrates are present, but there is still no evidence of coral bleaching or disease.

In the northern sector, the shallow subtidal around 1m depth is a mix of rock, sand and scattered coral patches, with low live cover (~8%) arranged as patchy massive colonies. In the most northern part the seabed at equivalent depth is simply rock and sand with no live coral reef present, and no reef-building or soft corals recorded.

In summary, the intertidal environment transitions from relatively natural, wide sandy beaches with healthy, continuous shallow coral reef in the south, through a constrained, gravel and rock-dominated, industrially bordered shoreline with fragmented coral habitats in the centre, to more degraded, gravel/rock shores with very limited or absent coral in the north.

Figure 6-59: Shallow Intertidal Habitats within ESIA Study Area

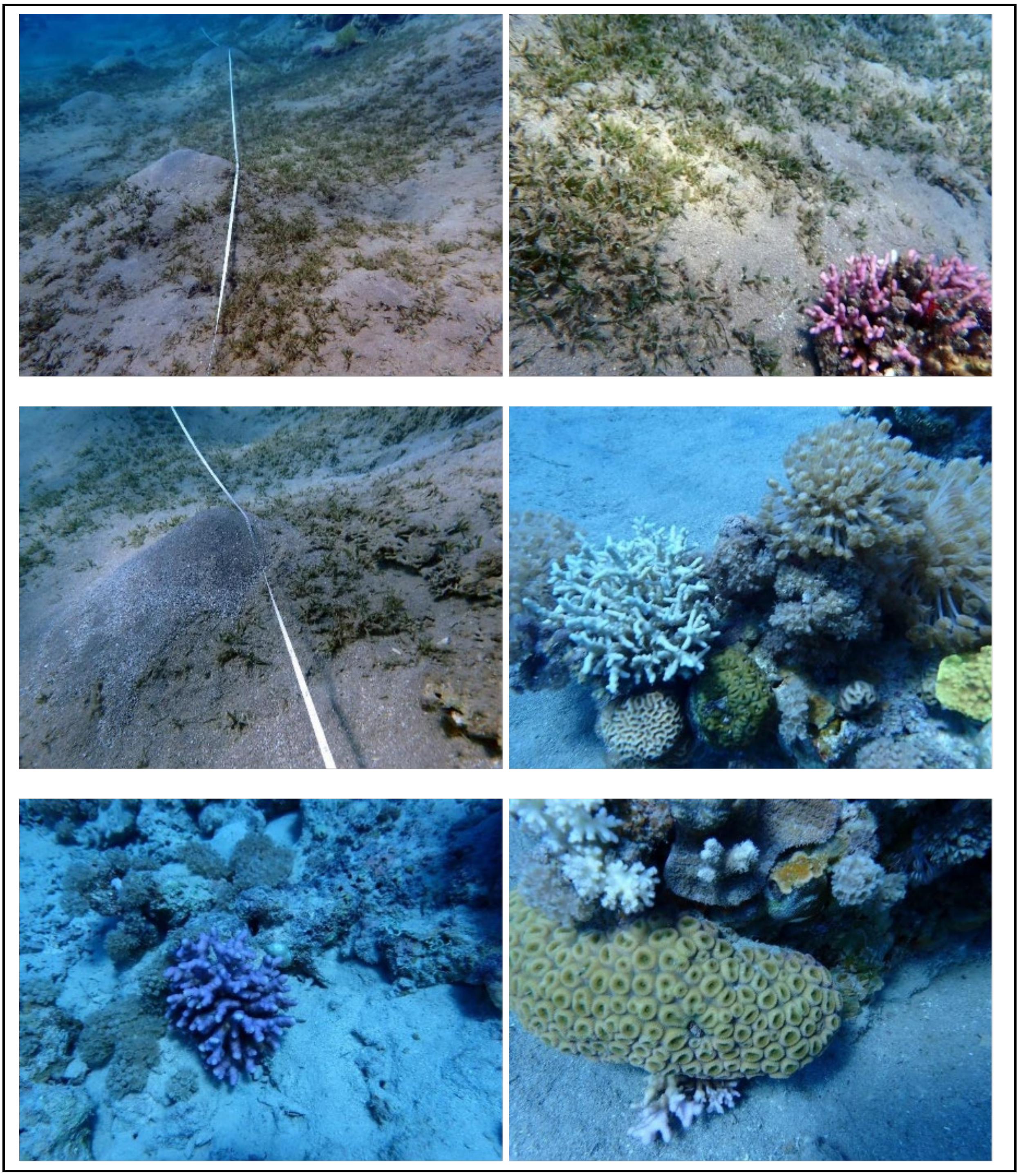
Patch Reef and Shallow Seagrass (5-15m): Shallow areas support seagrass beds interspersed with sandy areas and patches of coral with low relief on rubble patches (Figure 6-60). The corals are relatively fast growing and typical of shallow, high light environments. The sediment between the patches of coral and seagrass is often burrowed indicating active infaunal communities. Several sites show a transitional zone where seagrass declines, and coral begins to dominate. Coral colonies here are scattered and mixed with sediment pockets, creating a patchwork mosaic on the inner reef flat. Coral cover increases up to 40% by 15m. Coral lifeforms include massive Scleractinia colonies in both massive and branching forms along with branching fire coral. Some areas (adjacent to phosphate loading port) contain rubble and intermittent hard substrate, suggesting storm or physical disturbance in the past.

Notable ecological features include:

- Nursery habitat potential for juvenile fish and invertebrates
- Presence of burrowing fauna indicative of good sediment oxygenation
- Seagrass meadows provide shoreline stabilisation and carbon storage
- Pioneer coral species and small framework builders

Seagrass is sensitive to increases in sediment load, water quality decline, physical disturbance and anchoring. Transitional habitats can be vulnerable to both seagrass disturbance and coral stress from poor water clarity or sedimentation.

Figure 6-60: Shallow Subtidal Habitats within ESIA Study Area



Fringing Coral Reef (15-35m): The fringing reef is characterised by consolidated substrate and strong stony coral cover (Figure 6-61). Percentage coral cover and diversity increases from 10m through to 30m depth.

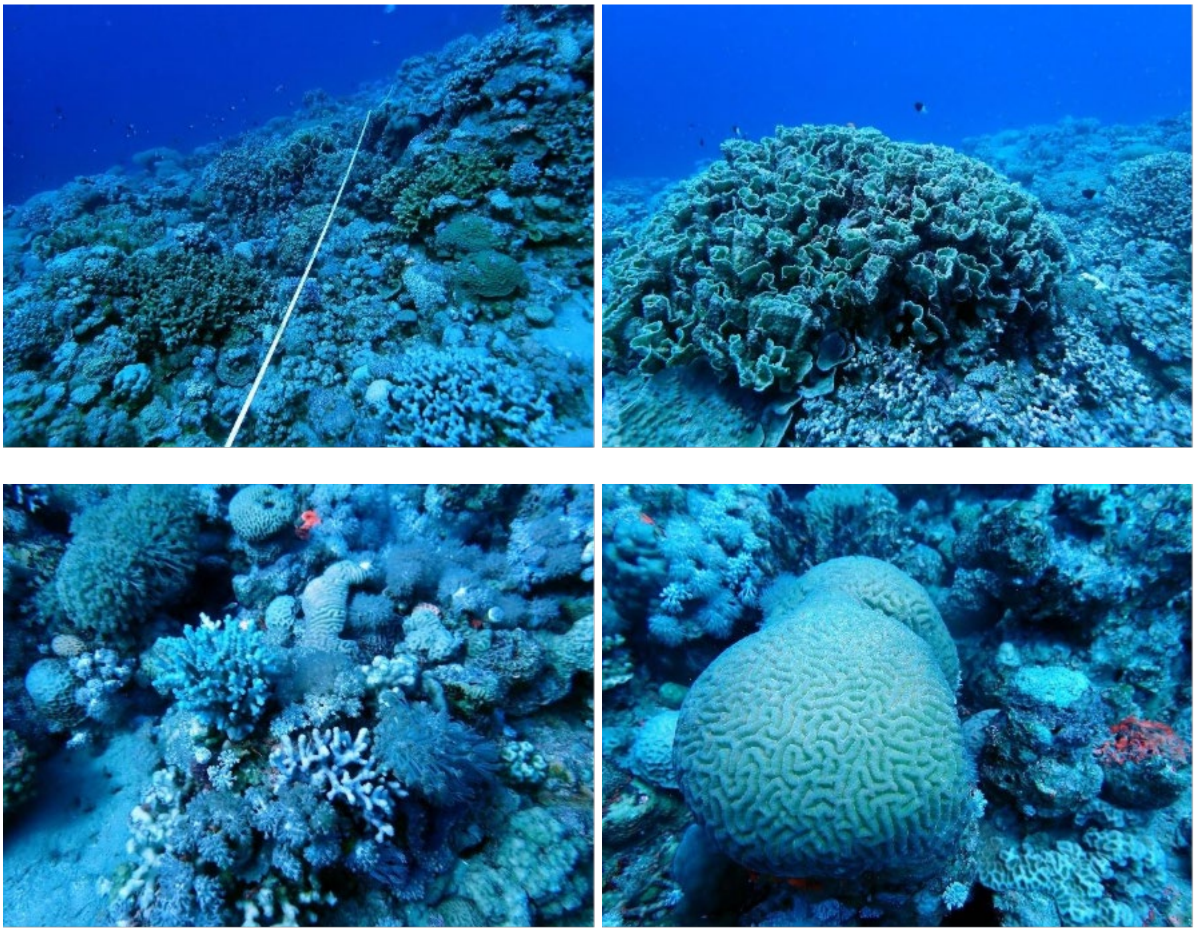
Relief/rugosity is higher in this habitat, and coral colonies form continuous patches or ledges. This habitat class represent the core coral reef habitat in the ESIA Study Area. The diver dataset shows peak coral cover at 30m, particularly at central sector. Morphologies include massive, plating, branching and encrusting corals, with soft corals and sponges also being present.

Notable ecological features include:

- Structurally complex reef with high rugosity
- Presence of plating species associated with deeper light environments
- Soft corals, cup sponges and occasional gorgonians

In terms of sensitivity, framework-building corals are critical for long-term reef accretion. Mesophotic-associated coral forms at deeper limits.

Figure 6-61: Fringing Coral Reef Habitats within ESIA Study Area



Mixed Reef and Sediment (35-60 m)

ROV footage shows patchy coral with sediment channels and outcrops (Figure 6-62). Coral cover varies widely (10-70%), depending on substrate availability. This zone likely represents a transition from mesophotic reef to deeper sand plain, with some ROV stations showing plating corals at >50 m.

Notable ecological features include:

- Continued coral presence into the mesophotic zone

- Sand channels used by mobile fauna
- Occasional debris (tyres, metal objects) indicating some anthropogenic input

Mesophotic corals may be sensitive to light reduction, turbidity and sedimentation. Debris suggests vulnerability to coastal activity or construction.

Figure 6-62: Mixed Reef and Sediment Habitats within ESIA Study Area

Deep Sediment and Isolated Reef Outcrops (>60 m)

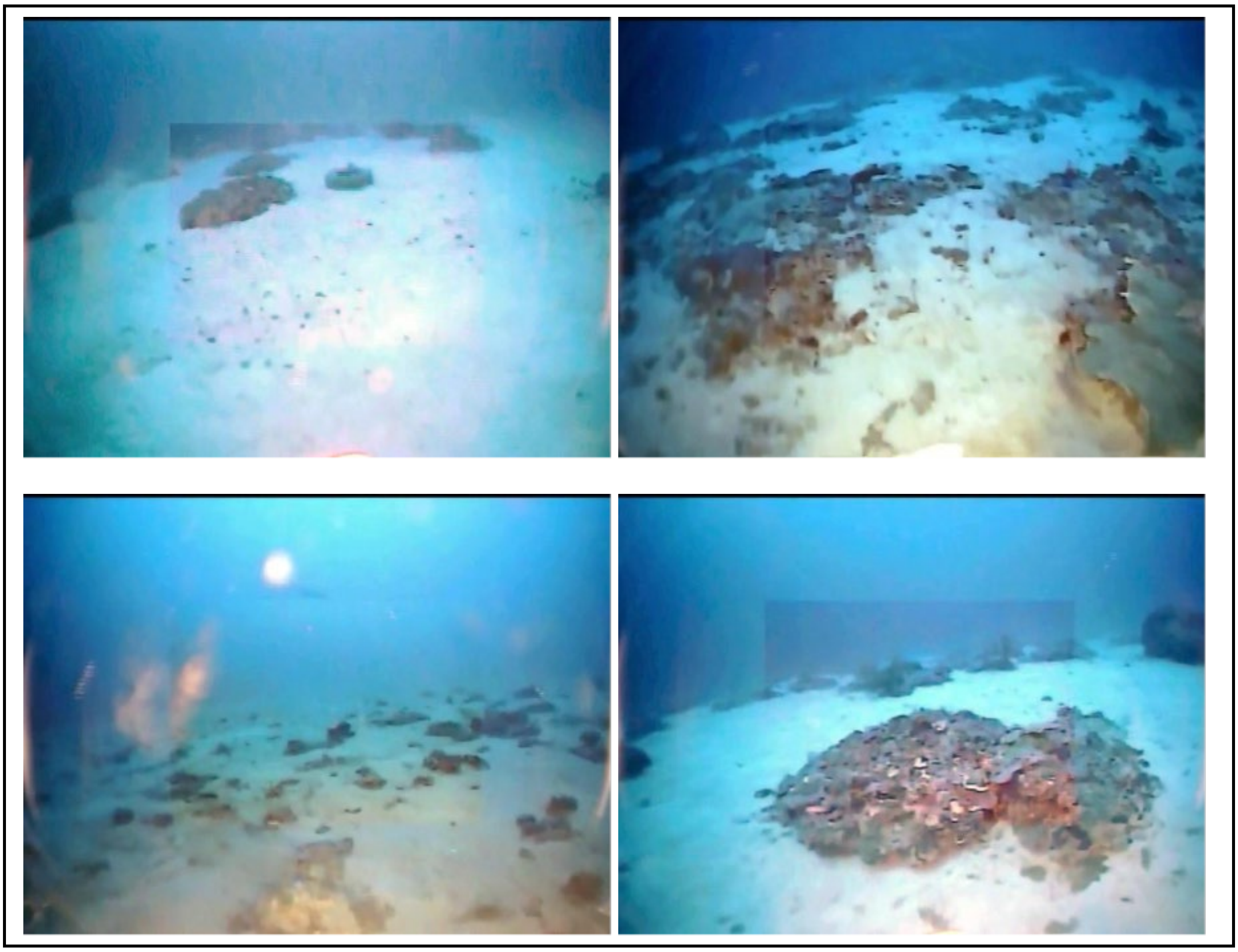
Stations at 60-77m show predominantly sandy seabed with scattered coral at the base of the reef slope (Figure 6-63)- images take from ROV looking towards deep habitats). Coral cover drops to near zero at the deepest points. Relief is low and the habitat grades into soft-bottom deep shelf conditions.

Notable ecological features include:

- Sparse but diverse benthic microhabitats
- Potential habitat for mobile demersal species

These habitats are primarily sensitive to sediment disturbance, organic input and physical impacts from infrastructure placement.

Figure 6-63: Deep Sediment and Isolated Reef Outcrops Habitats within the ESIA Study Area



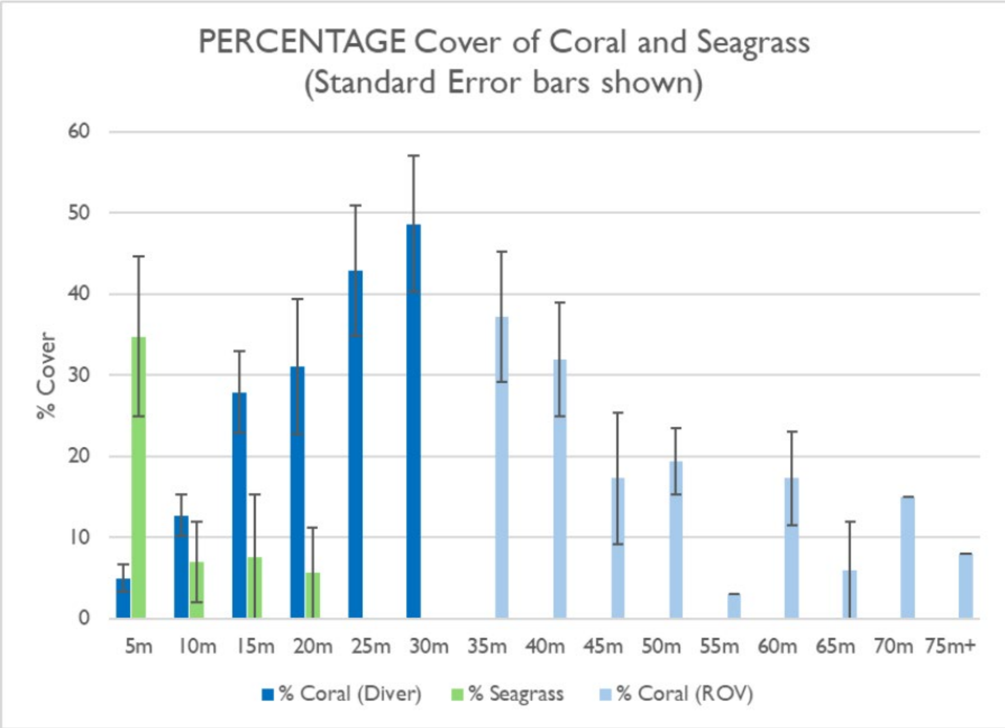
6.3.14.4 Depth Trends

Changes in percentage cover of coral and seagrass with depth, based on diver surveys in shallow water (5–30m) and ROV surveys in deeper water (35–75m+) are shown in the chart below (Figure 6-64).

In the shallow zone, coral cover recorded by divers starts low at about 5% at 5m, then increases steadily with depth to around 25–30% by 15–20m and peaks at just under 50% at 30m. Seagrass is most abundant at 5m, with roughly 35% cover, but drops sharply with depth and is below 10% by 15m, disappearing from deeper depths.

From 35m onwards, only ROV coral data are shown. Coral cover here is approximately 35–37%, then declines gradually with depth, falling to around 15–20% by 50–60m and under 10% at depths >75m. Overall, coral cover increases from shallow to mid-depths then tails off in deeper water, while seagrass is confined to very shallow depths and quickly diminishes.

Figure 6-64: Average Percent Cover of Coral and Seagrass within ESIA Study Area



Coral abundance and composition in the survey area show a clear, depth-related progression that reflects light availability, sediment influence, and substrate stability. Across both diver and ROV datasets, there is a strong gradient from low coral cover in the shallow, sandy zone to peak abundance and diversity along the mid-depth reef slope, followed by a gradual decline into deeper mixed and sandy habitats.

In the shallow zone (5m), coral cover is generally low and patchy, typically below ten percent. The seabed here is dominated by sand and seagrass, and most coral colonies are small and isolated. *Stylophora* is the dominant genus (27% of all coral colonies recorded). Also common are *Goniastrea (11%)*, *Platygyra* (9%) *Porites (8%), Pocillopora (7%)* and *Acropora (7%)*. Growth forms are largely branching or massive colonies that can withstand sediment deposition and slight movement of the substrate.

At 10m coral cover increases to over 10% (varying between 5-21%) as substrate becomes more stable and light levels remain high. *Stylophora* is still the dominant genus (18% of all colonies present). At this depth sub-massive forms of *Dipsastraea, Platygyra* and *Goniastrea* all contributed over 10% to the genus composition. Colonies are present in small patch reefs surrounded by sand and seagrass, and species richness rises substantially compared to the shallows.

Coral cover continues to increase at 15m to an average of nearly 30% over all transects surveyed within the ESIA Study Area. The dominant genera at this depth include *Goniastrea* (14%), *Dipsastraea* (11%), *Stylophora* (10%) and *Platygyra* (9%). *Acropora* and *Echinopora* each contribute 7% to the total number of corals recorded.

At 20m coral cover averages over 30%, reaching 71% at one transect (TA04). *Goniastrea* is the dominant genus (14%) and *Stylophora* presence has dropped below 10%. *Dipsastraea, Paramontastrea, Echinopora* and *Acropora* are all present representing between 7- 9% of colonies recorded.

Coral cover reaches 43% at 25m depth, having peaked at 73% in the central sector. *Goniastrea* is still the dominant genus (12%). *Portites* and *Montipora* colony numbers have both increased at this depth (9%), alongside *Mycedium* (8%). *Acropora* remain at 7%, however with depth increases growth forms tend towards table rather than branching colonies. *Leptoseris* colonies (2%) appear at this depth.

At 30m depth percentage coral cover reaches its maximum of 49% with 84% being recorded in the central sector. The community is taxonomically diverse, dominated by *Porites (12%), Montipora* (11%), *Pavona* (11%), Mycedium (8%) and *Acropora (7%). Goniastrea* is at its least common (6%) at this depth, alongside *Platygyra* (2%). *Dipsastraea* (4%*), Leptoseris* (3%) *and Pachyseris* (3%) colonies *also are present at this depth.*

Below 35m, coral abundance declines steadily as light levels drop and sediment cover increases. The community shifts toward massive and plating species, including *Porites*, *Montipora*, and, in the deepest records, thin-plating *Leptoseris* and *Pavona*. Branching corals disappear almost entirely, replaced by compact, sediment-tolerant morphologies. Colonies are scattered across mixed sand and rubble, and overall coral cover typically falls below twenty percent by 50–60m.

In summary, coral communities transition from sparse, sediment-tolerant massive forms in the shallows, to diverse and abundant branching and massive assemblages on the mid-depth reef, and finally to low-diversity, low-relief massive and plating corals in deeper, low-light environments. This progression mirrors the physical structure of the reef, with coral abundance and diversity peaking where stable hard substrate and moderate light coincide (Figure 6-65).

Figure 6-65: Depth Profile and Marine Habitats through the ESIA Study Area

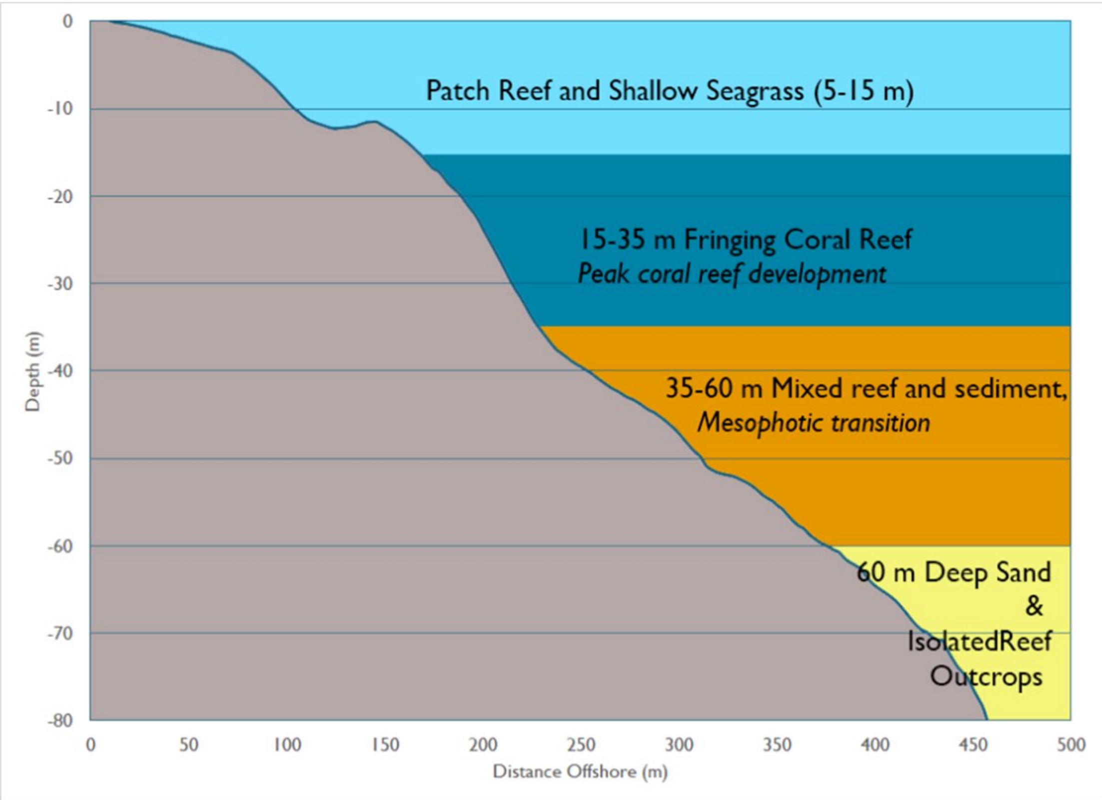
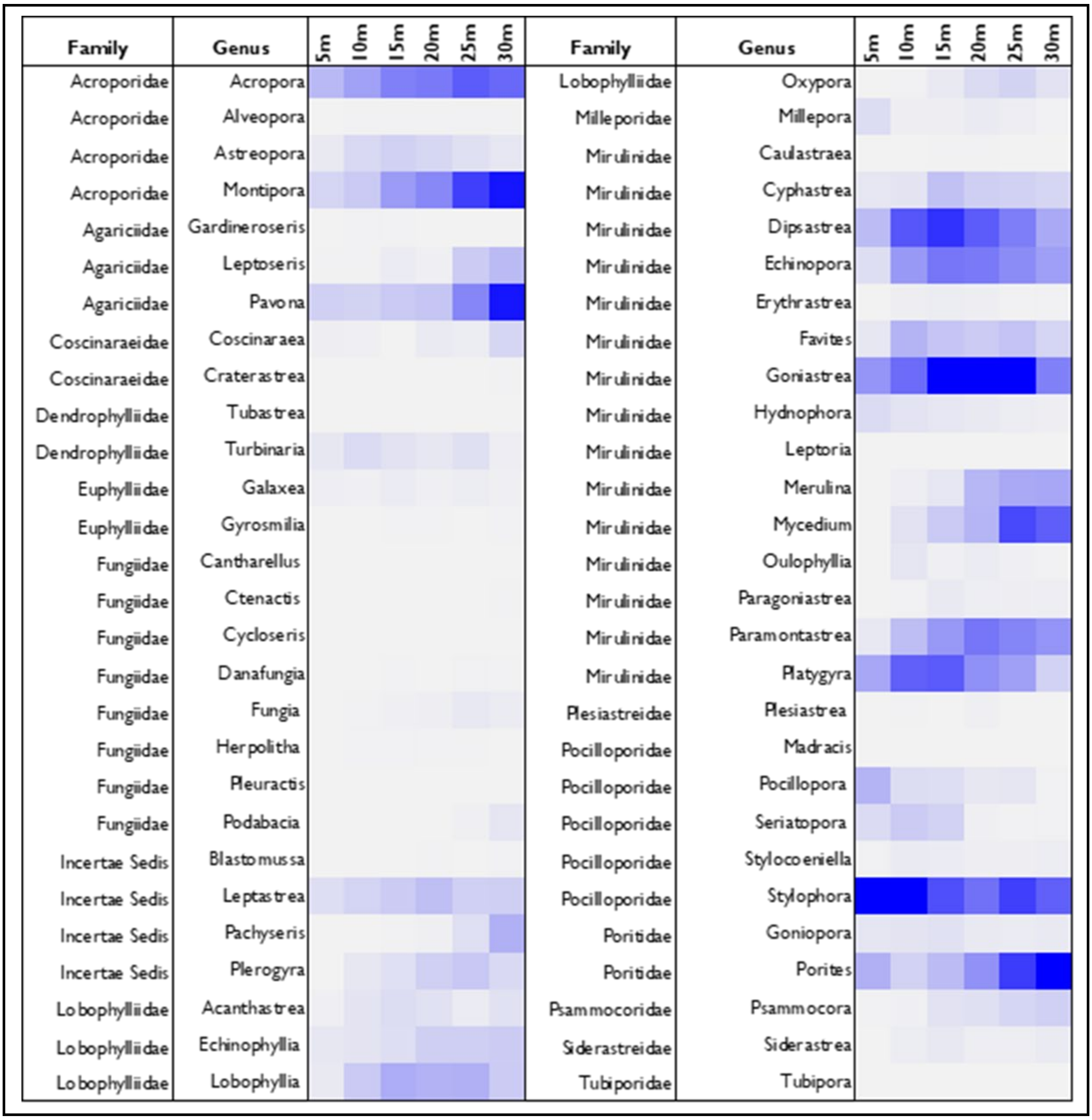


Figure 6-66 shows a heatmap (grey – low abundance; blue – high abundance) of coral genera across the depth bands surveyed and is summarised in the text above. It shows the relative importance of each genus to the composition of corals present at each depth.

Figure 6-66: Heatmap of Coral Genera Across the Depth Bands Surveyed



6.3.14.5 Spatial trends

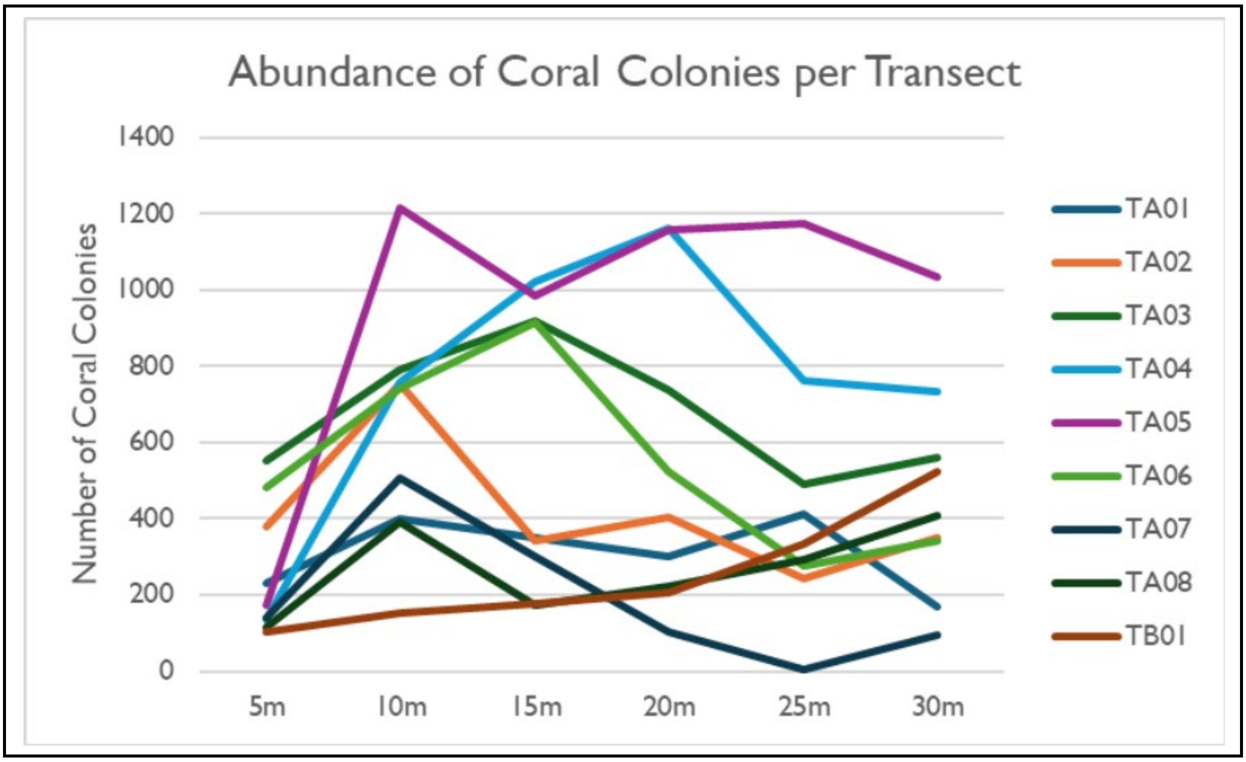
Seagrass distribution shows a clear north–south gradient across the survey area. In the northern section, seagrass beds are broader and more continuous, occupying the shallow sandy platform between about 5 and 10m. Here, the seabed is gently sloping and dominated by fine sand with scattered patches seagrass with small coral colonies. Moving southward, the shallow zone narrows and transitions into a patchier mosaic of sand, rubble, and isolated seagrass clumps. Seagrass cover becomes progressively more fragmented, giving way to increasing coral and hard substrate exposure along the mid-reef margin. By the southern transects, dense seagrass meadows are largely absent, replaced by mixed sand–rock or coral-dominated reef habitats. This pattern suggests a gradual shift from sediment accumulation and stable seagrass beds in the north towards a steeper, more wave-exposed reef slope in the south.

Coral cover and community structure also show a north-south gradient across the survey area. In the northern transects, coral occurs mainly as small, scattered colonies embedded within sandy and seagrass-dominated habitats. Hard coral cover here is low, progressing towards the central area of the bay, coral becomes more abundant and structurally complex. The central portion of the area marks the development of a continuous fringing reef edge, where hard substrate is extensive and branching, massive and plating corals form dense coral assemblages with relative high diversity. In the southernmost transects, the reef slope is steeper and transitions into reef and sediment habitats, where coral cover remains moderate but shifts toward massive and plating forms. Overall, coral communities change from sparse, low-relief colonies in the north to well-developed, framework-building reefs in the central area, then to deeper, sediment-influenced assemblages to the south.

Inshore to offshore shows the distribution of habitats reflecting the depth of the seabed which is typical for a red sea fringing reef profile.

Figure 6-67 shows the number of coral colonies recorded along the transects at distances from 5m to 30m. The central transects have the highest abundance of coral colonies overall, while central-southern and central-northern transects have lower abundance. Southern and northern transects have much lower colony numbers throughout, with the most northern transect TB01 (control site) consistently the lowest.

Figure 6-67: Number of Coral Colonies at Each Depth Along All Transects



6.3.15 Marine Cultural Heritage

The marine component of the Project represents a critical interface between national infrastructure development and Jordan's maritime heritage environment. The offshore works including the intake and outfall pipelines, dredging zones, and marine construction activities, are located within the GoA, a region of rich historical connectivity that has long served as a nexus for trade, navigation, and cultural exchange. The cultural heritage assessment recognises that the seabed and coastal zone of Aqaba may retain traces of past maritime activity, submerged archaeological features, and associations of intangible heritage value.

The Gulf of Aqaba possesses a multi-layered maritime history encompassing Nabataean, Roman, Islamic, and Ottoman phases, each contributing to the cultural palimpsest of the coastline. Historical sources describe the port of Ayla (7th–12th centuries AD) as a key node in the Red Sea trade network linking Egypt, Arabia, and the Levant. Modern archaeological investigations have focused primarily on the terrestrial remains of ancient Aqaba, while the submerged cultural landscape offshore remains largely un-investigated.

Desk-based review and limited geophysical data indicate that the seabed within the ESIA Study Area is predominantly sandy and rocky, with localized coral and rubble patches. No confirmed marine archaeological sites are currently recorded within the immediate footprint of the proposed intake and outfall pipelines. However, scattered artefactual material, such as isolated pottery sherds, anchors, and ballast stones, has been documented in other sectors of the GoA, reflecting historical anchorage and maritime activity. Given the relatively shallow depth (0–30m) and sediment movement, there remains a credible potential for stray cultural material or buried heritage deposits in the nearshore zone.

The intangible cultural heritage (ICH) associated with Aqaba's coastline is equally significant. Local fishing and seafaring traditions, knowledge of reefs and currents, and oral narratives concerning shipwrecks and coastal landmarks represent a living connection between the modern community and the maritime environment. These traditions, while evolving, embody Jordan's coastal identity and fall within UNESCO's definitions of ICH domains relating to traditional knowledge and oral expression.

Under Jordan's Antiquities Law No. 23 (General Department of Antiquities, 2024), any object older than 1750CE is legally considered an antiquity; therefore, even stray sherds must be reported to the Department of Antiquities (DoA). However, archaeological significance depends on context, association, and density. Three dispersed potsherds without stratigraphic context, diagnostic features (e.g., rim/base forms), or association with structures or seabed features are generally classed as background cultural material, not a site. Such finds are common in the GoA due to millennia of maritime activity and natural redeposition.

6.4 Critical Habitat Assessment Summary

6.4.1 Introduction

The aim of a Critical Habitat Assessment (CHA) is to identify biodiversity values which qualify as Critical Habitat (CH) or Priority Biodiversity Features (PBFs), as defined in the respective Lender Performance Standards (PSs) and Performance Requirements (PRs), in relation to the Project. The CHA process enables the Project to be aware of key biodiversity values at the early design and ESIA phases, enabling timely identification of appropriate biodiversity protection.

Individual CHAs have been undertaken for the Marine Environment (including Seabirds) and the Terrestrial Environment. These assessments have been documented in individual reports (Reference here).

Critical Habitats (CH) are high biodiversity values (i.e., species, habitats or ecosystems), that meet one or more of the following five criteria. These are defined slightly differently by different Lenders but the common focus is upon:

- Critically Endangered (CR), Endangered (EN) species and/or Vulnerable (VU) species
- Endemic and/or restricted-range species
- Migratory and/or congregatory species
- Highly threatened and/or unique ecosystems
- Key evolutionary processes and/or key scientific value
- Priority Biodiversity Features (PBFs) represent a subset of biodiversity values that are irreplaceable or vulnerable, but considered to be a lower priority level than CH
- The following sections present the outcomes of the CHA process. A detailed description of the procedures followed can be found in the individual CHA documents

6.4.2 Marine

Of the 213 biodiversity values considered through CHA screening, 92 were taken forward into the CHA process, which determined CH status for six biodiversity values and identified 13 as PBFs. A summary of the determinations is provided in Table 6-50 and Table 6-51 below.

Table 6-50: Biodiversity Values Determined to Trigger Critical Habitat (CH) and Priority Biodiversity Feature (PBF) status

Biodiversity Value	Species
Turtles (PBFs)	Hawksbill (*Eretmochelys imbricata*) Green (*Chelonia mydas*)
Marine Mammals (PBFs)	Indian Ocean humpback dolphin (*Sousa plumbea*) Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) Pantropical spotted dolphin (Stenella attenuate (subspecies: *S. attenuata attenuata*))
Elasmobranchs (PBFs)	Spotted eagle ray (*Aetobatus ocellatus*)

Biodiversity Value	Species
	Coach whipray (*Himantura uarnak*) Spinetail devil ray (*Mobula mobular*) Oceanic manta ray (*Mobula birostris*) Panther torpedo (*Torpedo panthera*) Pink whipray (*Himantura fai*) Shortfin Mako (*Isurus oxyrinchus*) Tiger shark (*Galeocerdo cuvier*)
Teleosts (Bony fish) (CH)	Humphead wrasse (*Cheilinus undulatus*) Sky emperor (*Lethrinus mahsena*) Red Sea coral grouper (*Plectropomus marisrubri*)
Clams (CH)	Giant clam (*Tridacna squamosina*)
Coral habitat (CH)	All coral reef habitat
Seagrass habitat (CH)	All seagrass habitat

As many biodiversity values met the Criteria of more than one of the Lenders these are summarised by species/species group below for ease of reference within Table 6-51.

Table 6-51: Summary of Critical Habitat and Priority Biodiversity Features Criteria Met

Biodiversity Value	Critical Habitat Criteria	Priority Biodiversity Feature Criteria
Turtles	n/a	EBRD (ESR6 paragraph 12-iii) (a)
Marine Mammals	n/a	EBRD (ESR6 paragraph 12-iii) (a)
Elasmobranchs	n/a	EBRD (PR6 para. 12-ii) (b) EBRD (PR6 paragraph 12-iii) (a)
Teleosts (Bony fish)	IFC Criterion 1a and EBRD (ESR6 para. 14-ii)(b) Coral grouper also: IFC Criterion 3a and EBRD (ESR6 para. 14-iv)(b)	n/a
Giant clam	IFC Criterion 1a /EBRD (PR6 para. 14-ii) (b) /EIB Criterion 2a	n/a
Coral	IFC Criterion 4b EBRD (PR6 para. 14-i) (c) EIB Criterion 1c IFC Criterion 5 EIB Criterion 6e	n/a
Seagrass	IFC Criterion 4b EBRD (PR6 para. 14-i) (c) EIB Criterion 1c	n/a

Of the biodiversity values for seabirds considered through CHA screening, none were considered to qualify as critical habitat. Two seabird species have been identified as PBFs. A summary of the determinations is provided in Table 6-52 below.

Table 6-52: Seabird Biodiversity Values Determined to Trigger Priority Biodiversity Feature (PBF) status

Biodiversity Value	Species
Seabirds (PBF)	Curlew Sandpiper (*Calidris ferruginea*) Grey Plover (*Pluvialis squatarola*)

6.4.3 Terrestrial

Of the 702 biodiversity values considered through CHA screening, 33 were taken forward into the CHA process, which determined CH status for 7 biodiversity values (3 confirmed and a further 4 possible candidates). It also identified 14 as PBFs. A summary of the determinations is provided in Table 6-53 and Table 6-54 below.

Table 6-53: Biodiversity Values Determined to Trigger Critical Habitat (CH) and Priority Biodiversity Feature (PBF) status

Biodiversity Value	Species
Plants (CH)	*Artemisia jordanica* *Hyoscyamus muticus* *Calligonum comosum* (Possible) *Stipagrostis* spp. (Possible)
Plants (PBF)	*Cleome droserifolia*
Avifauna (CH}	Levant sparrowhawk *Accipiter brevis* Sooty Falcon *Falco concolor* (Possible) Steppe Eagle *Aquila nipalensis* (Possible)
Avifauna (PBF)	Eastern Imperial Eagle *Aquila heliaca* Verreaux's Eagle *Aquila verreauxii* Greater Spotted Eagle *Clanga clanga* Peregrine Falcon *Falco peregrinus* Griffon Vulture *Gyps fulvus* Egyptian Vulture *Neophron percnopterus* Buff-rumped Wheatear *Oenanthe moesta* Grey Plover *Pluvialis squatarola* Syrian Serin *Serinus syriacus* European Turtle Dove *Streptopelia turtur*
Mammals (PBF)	Nubian Ibex *Capra nubiana*
Reptiles (PBF)	Spur thighed tortoise *Testudo graeca* Egyptian spiny tailed lizard *Uromastyx aegyptia*

As many biodiversity values met the Criteria of more than one of the Lenders these are summarised by species/species group below for ease of reference within Table 6-54.

Table 6-54: Summary of Critical Habitat and Priority Biodiversity Features Criteria Met

Biodiversity Value	Critical Habitat Criteria	Priority Biodiversity Feature Criteria
Plants (CH)	Assessed against C1.c of IFC PS6 and the equivalent criteria of EBRD PR6 and EIB S4	n/a
Plants (PBF)	n/a	EBRD (PR6 para. 12-ii)
Avifauna (CH)	Levant sparrowhawk assessed against C3.a of IFC PS6 and the equivalent criteria of EBRD PR6 and EIB S4 Others assessed against C1.a, C1.c and C3.a of IFC PS6 and the equivalent criteria of EBRD PR6 and EIB S4	n/a
Avifauna (PBF)	n/a	EBRD (PR6 para. 12-ii)
Mammals (PBF)	n/a	EBRD (PR6 para. 12-ii)
Reptiles (PBF)	n/a	EBRD (PR6 para. 12-ii)

6.5 Baseline Data Limitations

The information used to characterise the baseline terrestrial and marine environment had several limitations, particularly in terms of the quantity and resolution of the data. This section focuses on key terrestrial and marine sensitives identified during the baseline desktop studies, field surveys and provisional CHAs, describes these limitations and identifies the assumptions made when reviewing the data.

Where gaps in information have been identified, specific recommendations have been made to address them.

The effect of the current data limitations on assessing project impacts on terrestrial ecology has been addressed through the adoption of precautionary approach. In cases where there is uncertainty relating to the presence or absence of the key qualifying features, a worst-case scenario for impacts has been presented. The data requirements presented Chapter 9 of this document will provide information to allow a more precise quantification of impacts, contribute to the detailed design and execution of proposed mitigation activities and provide a robust baseline for subsequent monitoring to demonstrate no net loss/net gains.

Table 6-55: Key Terrestrial Sensitivities, Data Limitations and Recommendations

Limitations Sensitivity	Key qualifying feature	Data limitations
Terrestrial Ecology		
Flora – Data Gaps. Impacts of project on CH/PBF through construction activity	*Artemisia jordanica* *Hyoscyamus muticus Calligonum comosum* (Possible CH) *Stipagrostis* spp. (Possible CH) *Cleome droserifolia* (PBF)	**Distribution of significant flora.** Species which have been identified as Critical Habitat features (Likely or Possible) or PBF have not had their distribution fully determined through survey.
Fauna (Reptiles) -Data gaps. Impacts of project on CH/PBF through construction activity	*Testudo graeca* (PBF) *Uromastyx aegyptia* (PBF)	Distribution of Reptiles Species which have been identified as PBF have not had their distribution fully determined through survey.
Fauna (Mammals) – **Data gaps. Impacts of project on CH/PBF through construction activity**	*Capra nubiana* (PBF)	Definition of active range of this species. It has not been determined whether the range of this species is likely to intersect with the project
Fauna (Birds) **Data Gaps**	Steppe Eagle (Possible CH) Levant Sparrowhawk (Likely CH) Sooty Falcon (Possible CH) Syrian Serin (PBF) Eastern Imperial Eagle (PBF) Verreaux's Eagle (PBF) Greater Spotted Eagle (PBF) Peregrine Falcon (PBF) Griffon Vulture (PBF) Egyptian Vulture (PBF) Buff-rumped Wheatear (PBF) Grey Plover (PBF) European Turtle-dove (PBF)	**Field survey extent and duration:** Field surveys were only conducted for a relatively small portion (~15%) of the study area corresponding to the OHTL route as an area most important to survey. The surveys conducted were quite intensive, covering three campaigns in spring and three campaigns in autumn, with a wide range of methodologies employed. However, they did not cover the whole of the migratory season. In autumn, surveys were initiated only in September, which probably meant that the migratory peak of the species that migrate early in the season (e.g. White Stork *Ciconia ciconia*) were missed. The Levant Sparrowhawk, was not detected during the surveys. Where surveys do not cover the full duration of the migratory period, there is a high likelihood that no individuals will be recorded.
Air Quality and Noise		
Human receptors	-	Baseline air quality data sourced from secondary sources was considered appropriate for the purposes of baseline characterisation. Monitoring locations, durations and conditions were considered representative of those along the Conveyance Pipeline route and AGI locations.

Table 6-56: Marine Environment Data Limitations and Recommendations

Sensitivity	Reference to CHA	Data limitations	Recommendation
Benthic Habitats – Corals			
Coral habitats - Physical disturbance and abrasion	All coral reef habitat (CH)	Single temporal snapshot, with no seasonal coverage. Data limited to 80m depth	Implement a long-term monitoring plan Micro-siting during construction phase Relocation of habitat -temporary or permanent
Coral habitats - Increase Turbidity	All coral reef habitat (CH)	Single temporal snapshot, with no seasonal coverage. Data limited to 80m depth Limited information on sediment regimes Limited information on hydrological regime	Use construction methods to minimise sediment generation Monitor sediment deposition during construction with appropriate thresholds to trigger mitigation actions Implement a long-term monitoring plan Implement hydrological survey
Associated sediment habitats both epifaunal and infaunal components - Increase Turbidity - alteration of sediment habitat	All coral reef habitat (CH)	Single temporal snapshot, with no seasonal coverage. Data limited to 80m depth Limited information on sediment regimes	Use construction methods to minimise sediment generation Monitor sediment deposition during construction with appropriate thresholds to trigger mitigation actions Implement a long-term monitoring plan
Coral habitats - Loss of larvae from abstraction	All coral reef habitat (CH)	Limited information on coral spawning and recruitment	Incorporate design modifications to reduce larvae entrapment Coral larvae surveys to establish reproductive patterns Implement recruitment assessment surveys
Coral habitats - Salinity	All coral reef habitat (CH)	No information regarding coral thresholds for salinity tolerance	Salinity tolerance laboratory study
Coral habitats - Iron (Fe)	All coral reef habitat (CH)	No information regarding coral thresholds for iron tolerance	Iron (Fe) tolerance laboratory study
Benthic Habitats – Seagrass			
Seagrass habitats - Physical	All seagrass habitat (CH)	Single temporal snapshot, with no seasonal coverage.	Implement a long-term monitoring plan

Sensitivity	Reference to CHA	Data limitations	Recommendation
disturbance and abrasion			Micro-siting during construction phase
Seagrass habitats - Increase Turbidity	All seagrass habitat (CH)	Single temporal snapshot, with no seasonal coverage. Limited information on sediment regimes	Use construction methods to minimise sediment generation Monitor sediment deposition during construction with appropriate thresholds to trigger mitigation actions Implement a long-term monitoring plan
Seagrass habitats - Loss of pollen and seeds via abstraction	All seagrass habitat (CH)	Single temporal snapshot, with no seasonal coverage. Lack of site-specific data on seagrass reproduction	Incorporate design modifications to reduce larvae entrapment Seagrass health and reproduction assessment
Pelagic Species			
3 Fish - Loss of habitat	Humphead wrasse (*Cheilinus undulatus*) (CH) Sky emperor (*Lethrinus mahsena*) (CH) Red Sea coral grouper (*Plectropomus marisrubri*) (CH)	No site-specific information on populations of fish	Implement an eDNA survey to determine presence of CH
3 Cetaceans - Noise	Indian Ocean humpback dolphin (*Sousa plumbea*) (PBF) Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (PBF) Pantropical spotted dolphin (*Stenella attenuate* (subspecies: *S. attenuata attenuata*)) (PBF)	No site-specific information on populations of cetaceans	Implement an eDNA survey to determine presence of CH Implement MMO surveys during construction and operational phase
8 Elasmobranchs - Noise		No site-specific information on populations of elasmobranchs	Implement an eDNA survey to determine presence of CH
3 Fish, Cetaceans and Elasmobranchs	Spotted eagle ray (*Aetobatus ocellatus*) (PBF)	No site-specific information	Implement an eDNA survey to determine presence of CH Use construction methods to minimise sediment generation

Sensitivity	Reference to CHA	Data limitations	Recommendation
- Habitat change	Coach whipray (*Himantura uarnak*) (PBF) Spinetail devil ray (*Mobula mobular*) (PBF) Oceanic manta ray (*Mobula birostris*) (PBF) Panther torpedo (*Torpedo panthera*) (PBF) Pink whipray (*Himantura fai*) (PBF) Shortfin Mako (*Isurus oxyrinchus*) (PBF) Tiger shark (*Galeocerdo cuvier*) (PBF)		Monitor sediment deposition during construction with appropriate thresholds to trigger mitigation actions Mitigation against habitat loss or change
Seabirds			
2 Seabirds	Curlew Sandpiper (*Calidris ferruginea)* (PBF) Grey Plover (Pluvialis squatarola) (PBF)		
Marine Cultural Heritage			
Tangible Cultural Heritage	No confirmed marine archaeological sites are currently recorded within the ESIA Study Area, however, scattered artefactual material has been documented in other sectors of the Gulf. Given shallow depth (0–30 m) and sediment movement, there remains a credible potential for stray cultural material or buried heritage	The current heritage baseline is constrained by the absence of dedicated marine archaeological survey. The available bathymetric and geophysical data have not been interpreted from a cultural heritage perspective, and there has been no diver-based or ROV inspection to ground-truth potential anomalies.	It is recommended to consider the need for a marine archaeological survey prior to construction to be conducted under DoA oversight. The survey should integrate analysis of existing geophysical datasets with diver/ROV inspection. All anomalies should be mapped, classified, and assessed for heritage significance. During the construction, a Marine Chance Finds Procedure must be implemented as part of the Marine Cultural Heritage Plan with a watching brief for the construction activities with training for EPC contractors on appropriate response to discoveries.

Sensitivity	Reference to CHA	Data limitations	Recommendation
	deposits in the nearshore zone.		
Intangible Cultural Heritage (ICH)	Local fishing and seafaring traditions, knowledge of reefs and currents, and oral narratives concerning shipwrecks and coastal landmarks represent a living connection between the modern community and the maritime environment. These traditions, while evolving, embody Jordan's coastal identity and fall within UNESCO's definitions of ICH domains relating to traditional knowledge and oral expression.	Uncertainty arises from the limited documentation of traditional maritime use and ICH traditions within the ESIA Study Area. There is no comprehensive ethnographic record of traditional fishing zones, community-identified heritage sites, or local maritime place names that could hold intangible value, therefore the social dimension of the coastal heritage environment remains underrepresented.	It is recommended to coordinate with ASEZA and local fishing associations to document traditional maritime practices, ensuring access to fishing grounds is maintained where possible and that affected communities are informed and consulted on marine activity scheduling. Public interpretation initiatives (digital exhibits or community-led storytelling) would enhance awareness of Aqaba's maritime heritage as part of the Project's legacy commitments.

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Appendices

Appendix 6-1 Terrestrial Critical Habitat Assessment

Appendix 6-2 Marine Critical Habitat Assessment

Appendix 6-3 Terrestrial Baseline Survey Report

Appendix 6-4 Marine Baseline Survey Report

Appendix 6-5 Avifauna Potentially Present in the ESIA Study Area

Appendix 6-6 Avifauna Autumn Survey Report

Appendix 6-7 Table of Species Identified in the Terrestrial Baseline Survey

Appendix 6-8 Baseline Avifauna Report OHTL

Appendix 6-9 Annual Bird Survey Report OHTL

Appendix 6-10 Interim Bird Survey Report OHTL (Spring 2025)

Appendix 6-11 Terrestrial Baseline Survey Report (Eco Consult)

Appendix 6-12 Avifauna Survey