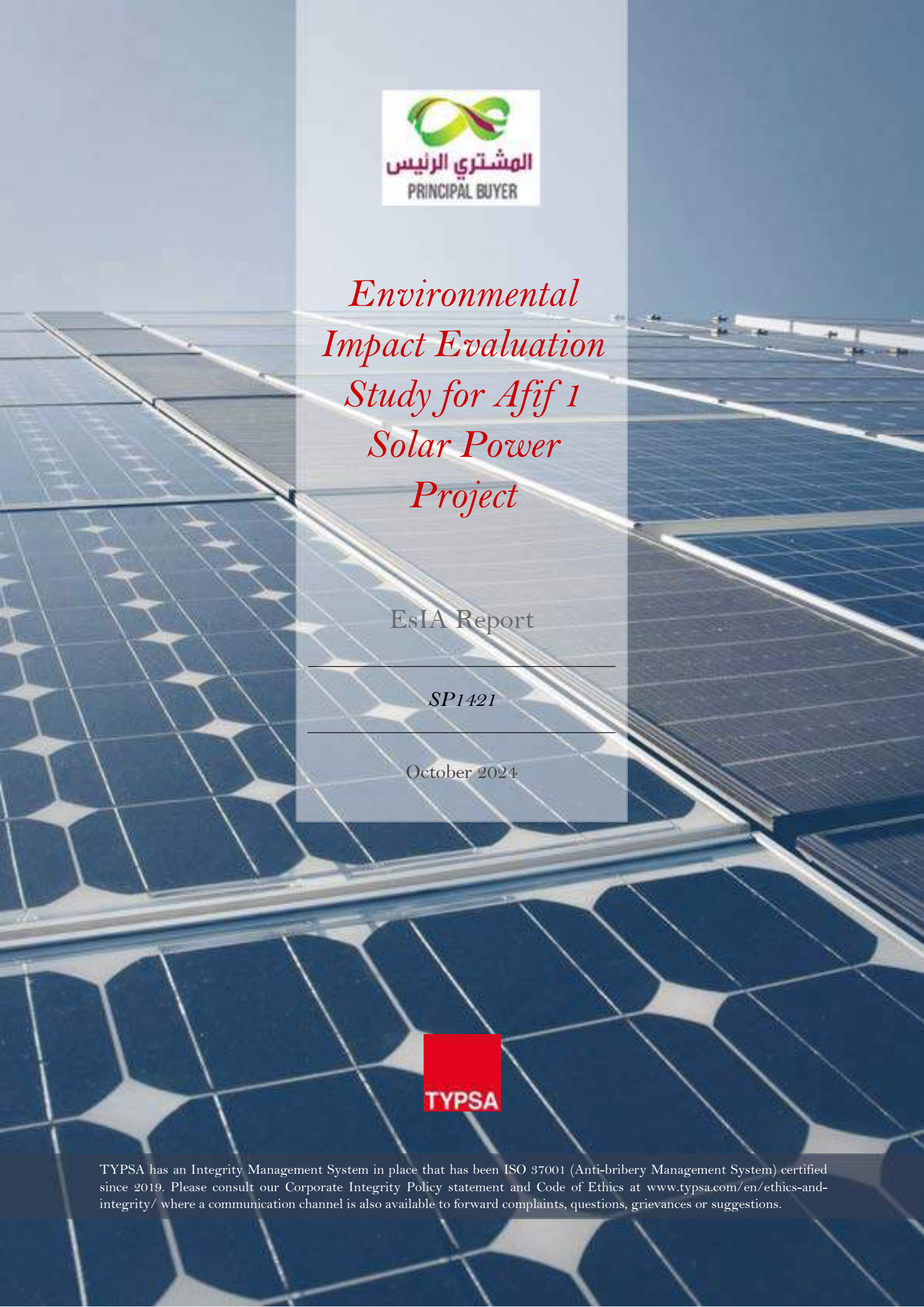

المشتري الرئيس
PRINCIPAL BUYER

Environmental Impact Evaluation Study for Afif 1 Solar Power Project

EsIA Report

SP1421

October 2024

TYPSA

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	Different sections	Added that no bats were sighted during the site surveys
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Table of contents

Non-technical Summary 28
Introduction 35
1. Introduction 35
1.1. General Information about the Study 35
1.2. Justification for the preparation of the study, its objectives, and the scope of work 37
1.2.1. Justification 37
1.2.2. Methodology 37
1.2.3. Objectives of the ESIA Report 37
1.2.4. Scope of the Study 38
1.3. Structure of the Study 38
1.4. Information about the Permit Applicant 39
1.5. Information about the Environmental Service Provider Consultant who prepared the study 40
Institutional and Regulatory framework of the study 42
2. Institutional and Regulatory framework for the study 42
2.1. Institutional Framework 42
2.2. Regulatory Framework 44
2.2.1. National environmental laws, regulations, standards and requirements 44
2.2.2. Regional environmental laws, regulation, standards and requirements 72
2.2.3. International laws, regulation, standards, and requirements. International agreements and treaties to which the Kingdom is a party 74
2.2.4. IFC Performance Standards and Equator Principles 79
Activities Description 82
3. Activities Description 82
3.1. Determine the objectives and justification for the activity 82
3.2. The proposed site for the project 82
3.3. Project elements that have a potential impact on environment 85
3.3.1. PV Plant Components 85
3.3.2. Access Roads 93
3.3.3. Earthworks and levelling 95
3.3.4. Construction requirements 96
3.4. Activities during all phases of the project 99
3.4.1. Early Works 99

3.4.2. Construction 99
3.4.3. Operation and maintenance 100
3.4.4. Decommissioning 101
3.4.5. Unplanned Events 101
3.5. The geographical scope of the project 102
3.6. The area required for the project 103
3.7. Project resources, their types and sources 103
3.7.1. Construction 103
3.7.2. Operation & Maintenance 103
3.8. Gas, Noise and liquid emission and ways to reduce them 104
3.8.1. Construction 104
3.8.2. Operation 105
3.9. Solid waste. Their types and ways of disposal 107
3.9.1. Construction 107
3.9.2. Operation 108
3.10. The schedule of the work program 108
3.10.1. Project Phases Schedule 108
3.10.2. The workforce required for implementation of the project 108
3.10.3. The workforce required for operational of the project 108
3.11. The size of the project 109
3.12. Cost of the activity 109
3.13. Checklist: Questions on project characteristics 109
3.14. Activity alternatives 117
3.14.1. Project alternatives and descriptions 118
3.14.2. Comparison of alternatives 126
Description of surrounding environment 129
4. Description of surrounding environment 129
4.1. The physical environment 131
4.1.1. Climate and Air Quality 131
4.1.2. Noise 144
4.1.3. Geology, Seismicity and Soils 149
4.1.4. Hydrology and Hydrogeology 162
4.2. Terrestrial Biodiversity 172
4.2.1. Flora and Fauna 172

4.2.2. Natural Protected Areas and other Natural Regions....198
4.2.3. Habitats....210
4.2.4. Landscape features....220
4.3. Economic and social aspects....224
4.3.1. Administration, population, and demographics....224
4.3.2. Housing....228
4.3.3. Educational Status....228
4.3.4. Employment and Labour Force....230
4.3.5. Economic profile....231
4.3.6. Tourism....234
4.3.7. Agrarian activity....235
4.3.8. Social infrastructure....237
4.3.9. Land use and occupation in the project area....242
4.4. Antiquities and Cultural Heritage....245
4.4.1. Relevant legislation and standards....245
4.4.2. Baseline condition....245
4.5. Sensitive Receptors....246
4.6. Climate Change Adaptation....247
4.6.1. Climate Trend Analysis for Saudi Arabia....247
4.6.2. Future climate trend analysis for Afif 1 Solar Park....252
4.6.3. Analysis of other climate related risks....266
4.6.4. Conclusions....266
4.7. Future Activities within the geographic scope of the project....267
4.8. Checklist of the project environment characteristics....267
Impact identification, analysis, and evaluation....270
5. Impact identification, analysis, and evaluation....270
5.1. The methodology used for impact identification, analysis, and evaluation....270
5.1.1. Identification and Evaluation of Receptors....271
5.1.2. Nature and Magnitude of Impacts....273
5.1.3. Extension of the Impact....274
5.1.4. Timing between the action and its effect....274
5.1.5. Duration of the effect from its appearance....274
5.1.6. Reversibility of the effect....275
5.1.7. Criteria for Likelihood of Occurrence of Environmental and Social Effects....275

5.1.8. Determination of Significance of Effects. The Importance of Impacts 275
5.1.9. Risk Matrix 277
5.2. Analysing and evaluating the potential impacts that are expected to be achieved during the different phases of the project 279
5.2.1. Natural Vegetation Cover. Impact assessment 279
5.2.2. Terrestrial Biodiversity. Fauna & Flora. Impact assessment 281
5.2.3. Air quality. Impact assessment 288
5.2.4. Noise & Vibration. Impact assessment 292
5.2.5. Smells. Impact assessment 297
5.2.6. Surface water quality. Impact assessment 299
5.2.7. Surface water availability. Impact assessment 301
5.2.8. Groundwater quality. Impact assessment 303
5.2.9. Hydrology and flood risk. Impact assessment 306
5.2.10. Soils quality. Impact assessment 308
5.2.11. Health & Safety. Impact assessment 312
5.2.12. Landscape & Visual comfort. Impact assessment 314
5.2.13. Land Use. Impact assessment 317
5.2.14. Waste Generation. Impact assessment 319
5.2.15. Glint & Glare. Impact assessment 321
5.2.16. Climate Change. Impact assessment 322
5.2.17. Economic and Social Aspects. Impact assessment 325
5.2.18. Traffic and Transport. Impact assessment 328
5.2.19. Antiquities and Cultural Heritage. Impact assessment 329
5.2.20. Unplanned Events. Impact assessment 331
5.2.21. Human Rights. Impact assessment 333
5.2.22. Cumulative Impacts 334
5.3. Summary of the expected impact evaluation 334
5.4. Checklist: Significance of the impacts 341
Plans 342
6. Plans 342
6.1. Emergency preparedness and response plan 342
6.1.1. Emergency procedures for accidents in construction phase 342
6.1.2. Emergency procedures for accidents in operation phase 343
6.2. Environmental rehabilitation and addressing plan 343

6.2.1. Environmental Rehabilitation Plan 343
6.2.2. Environmental Remediation Plan 345
6.3. The proposed plan to reduce environmental impacts for each environmental component 345
6.3.1. Flora 346
6.3.2. Fauna and Biodiversity 348
6.3.3. STL Relocation Plan 350
6.3.4. Air Quality 354
6.3.5. Odours (Smells) 357
6.3.6. Noise 357
6.3.7. Hydrology and Flood Risk Control 358
6.3.8. Surface Water, Groundwater, and Soil quality preservation 360
6.3.9. Spill Prevention and Control Management Plan 362
6.3.10. Health and Safety 364
6.3.11. Landscape and Visual Confort 365
6.3.12. Land Use and Local People 366
6.3.13. Waste Generation and Management 367
6.3.14. Glint and Glare 371
6.3.15. Climate Change 372
6.3.16. Employment and Social aspects 372
6.3.17. Traffic and Transport 373
6.3.18. Unplanned events 374
6.3.19. Archaeology and Cultural Heritage 374
6.3.20. Human rights 375
6.4. Proposed Environmental Management and Monitoring Plan 375
6.4.1. Environmental Management Plan (EMP) 375
6.4.2. Monitoring Plan 382
6.5. Summary of Impacts Post-Mitigation 389
Summary 392
7. SUMMARY 392
7.1. Summary of how the negative impacts on the environment or public health will be addressed and to what extent they will be reduced, improved, or controlled, and how the positive impacts will be enhanced 392
7.1.1. Summary of the environmental, social and economic losses and gains that justify the establishment of the proposed activity 392

7.1.2. Summary of the method of addressing the adverse impacts and the extent of their mitigation, improvement, or control 393
7.2. Summary of roles, responsibilities, and budget for the implementation of the environmental management plan 395
7.2.1. Roles and responsibilities of the different authorities concerned 395
7.2.2. Summary of the environmental management plan and budget for the implementation 396
7.2.3. CEMP and OEMP Roles and Responsibilities 397
Annexes 399
8. Annexes 399
8.1. Annex nº 1. List of References 399
8.2. Annex nº 2. Resumes of the Study Authors. Curriculum Vitae 402
8.3. Annex nº 3. Project Technical Documents 404
8.3.1. Annex Nº 3.1 Baseline Survey 404
8.3.2. Annex nº 3.2. Waste National Standards 405
8.3.3. Annex nº 3.3 Hydrological Report 428
8.3.4. Annex nº 3.4 Glint and Glare Assessment 429
8.4. Annex nº 4. Project Maps 430
8.5. Annex nº 5. Material Safety Data Sheet (MSDS) 431

List of figures

Figure 1. Afif 1 site 29
Figure 2. General project location 36
Figure 3. Afif 1 site and surroundings 36
Figure 4. Information about the Service Provider. 40
Figure 5. NCEC EIA flow process. 49
Figure 6. General Project Location 83
Figure 7. Surroundings 83
Figure 8. Afif 1 Project Location 84
Figure 9. Solar Power Plant layout 86
Figure 10. Bifacial modules 87
Figure 11. Semi-Automated Cleaning 88
Figure 12. Fully Automated Cleaning. 88
Figure 13. Tracker structure. Example 89
Figure 14. Inverter Example 90
Figure 15. Shape of the electric circuit. 90
Figure 16. Proposed electrical connection. 92
Figure 17. Overhead line example 93
Figure 18. Almardamah road 94
Figure 19. Typical Access Example 95
Figure 20. Waterproof area in construction camp. 97
Figure 21. Settling basin in construction 98
Figure 22. Metallic poles and panel installation. Source: Self-made. 99
Figure 23. Construction trenches & Erection of internal electrical lines. 100
Figure 24. 380 kW substations. 100
Figure 25. The geographical scope for the project and. extremity boundaries. Source: Self-made. 102
Figure 26. Source of noise. 105
Figure 27. Emissions intensity from electricity generation in Saudi Arabia from 2012 to 2021 106
Figure 28. Examples of installation systems 120
Figure 29. Module technologies. 122
Figure 30. Bifacial PV Module (Source: paradise energy solution) 123
Figure 31. Solar panel cell alternatives 124
Figure 32. Example of an AIS substation 125
Figure 33. Example of a GIS substations 126
Figure 34. Afif 1 Solar Power Project location and boundaries. Source: self-made 129
Figure 35. Location of Air Quality Monitoring Stations. Source: Environmental Baseline Survey Report 132
Figure 36. Location of Air Quality Monitoring Station at points 1 & 2. Source: Environmental Baseline Survey Report 133
Figure 37. Köppen-Geiger Climate Classification. Source: CCKP (1991-2020) 137
Figure 38. Climate summary at Afif city weather station. Source; https://weatherspark.com/ 137
Figure 39. Average High and Low Temperature at Afif city weather station, Source; https://weatherspark.com/ 138
Figure 40. Average rainfall at Afif city weather station, Source; https://weatherspark.com/ 139

Figure 41. Average daily incident shortwave energy at Afif city weather station, Source; https://weatherspark.com/ 139
Figure 42. Average Humidity Level at Afif city weather station. Source; https://weatherspark.com/ 140
Figure 43. Windspeed (km/h) at Afif city weather station, Source; https://weatherspark.com/ 140
Figure 44. Wind directions at Afif city weather station. Source; https://weatherspark.com/ 141
Figure 45. Location of Noise Monitoring points at Afif 1 Solar Plant site. Source: Environmental Baseline Survey Report 145
Figure 46. Location of Noise devices at monitoring points 1 & 2 in Afif 1 plot. Source: Environmental Baseline Survey Report 146
Figure 47. Location of the project in relation to Highway 50. Source: Environmental Baseline Survey Report 148
Figure 48. Geological Map of Saudi Arabia. Detail of Afif-1 solar plant plot location. Source: Preliminary site Assessment 152
Figure 49. Location of Afif 1 Solar Plant plot in the Arabian Shield. Source: Preliminary Site Assessment 153
Figure 50. Geology of the Solar Plant plot. Source: Geology 250K, Geospatial Portal, SGS 153
Figure 51. Overall views of the plot showing the mainly flat morphology with sand-gravel sheet. Source: site visit 154
Figure 52. Calc-alkalic granite outcrop in the Northeast corner of the plot. Source: site visit 154
Figure 53. In the central east part of the plot, some rhyolite outcrops are present (left). At west side. Source: site visit 154
Figure 54. Sand cumulations. Source: site visit 155
Figure 55. Mayor tectonic elements of the Arabian Shield and Platform (Al-Husseini, 2000) Source www.alamrigeo.com 156
Figure 56. Seismicity and seismogenic source zones of the Arabian Peninsula and Adjoining Regions Source www.alamrigeo.com 157
Figure 57. Regions for determination of the maximum considered earthquake ground motion In the Kingdom of Saudi Arabia (according to SBC-301 and SAER-6089) and location of the PV plant 158
Figure 58. Region 4. Maximum Considered Earthquake Ground Motion for Region 4 of 0.2 SEC Spectral Response Acceleration in %g 159
Figure 59. Region 4. Maximum Considered Earthquake Ground Motion for Region 4 of 1.0 SEC Spectral Response Acceleration in %g 160
Figure 60. Soils characterization of Afif 1 Solar Power Plant and surroundings. Source: Hand-in-Hand FAO Geoportal 161
Figure 61. Afif 1 PV Project location. Source: Hydrological Study Report, TYPSA 163
Figure 62. Afif 1 Solar Plant Watersheds and Area. Source: Hydrological Study Report, TYPSA 165
Figure 63. Slope analysis. Source: Hydrological Study Report, TYPSA 166
Figure 64. Physiographic basins data. Source: Hydrological Study Report, TYPSA 166
Figure 65. Representative image of the study area. Surface water overland flow paths. Source: Hydrological Study Report, TYPSA 167
Figure 66. Flooding hazard areas. Source: Hydrological Study Report, TYPSA 168
Figure 67. Simplified geological map of the Arabian Peninsula. Source: A hydrogeological overview of the Upper Mega Aquifer System on the Arabian Platform 170
Figure 68. Location of Alluvial Aquifers in Saudi Arabia. Source: Makkawi, M. (2010) Water Resources of Saudi Arabia 171

Figure 69. Location of Basalt Aquifers in Saudi Arabia. Source: Makkawi, M. (2010) Water Resources of Saudi Arabia....171
Figure 70. IUCN System of Classification for Species Threat of Extinction (IUCN, 2020)....172
Figure 71. IUCN Extinction Risk Categories....173
Figure 72. Grid System Layout for Afif 1 Solar Plant Survey. Source: Environmental Baseline Survey Report for Afif 1 PV Project....174
Figure 73. Quadrats Location. Source: Environmental Baseline Survey Report for Afif 1 PV Project....175
Figure 74. Example of Vegetation Quadrat. Source: Environmental Baseline Survey Report for Afif 1 PV Project....176
Figure 75. Drive through /Walkover transect. Source: Environmental Baseline Survey Report for Afif 1 PV Project....177
Figure 76. Vantage points for bird survey in PV Afif 1 Solar Plant site. Source: Environmental Baseline Survey Report for Afif 1 PV Project....178
Figure 77. Pitfall trap's locations. Source: Environmental Baseline Survey Report for Afif 1 PV Project....178
Figure 78. Locations of the camera traps. Source: Environmental Baseline Survey Report for Afif 1 PV Project....179
Figure 79. A camera trap near an active burrow. Source: Environmental Baseline Survey Report for Afif 1 PV Project....179
Figure 80. General view of the Project site's vegetation within the Project area. Source: TYPSA´s Preliminary Site Assessment Report....181
Figure 81. Acacia tortilis specimens (LC by the UICN) located within the limits of Afif 1 Solar Plant. Source: Environmental Baseline Survey Report for Afif 1 PV Project....186
Figure 82. Rarity-weighted richness map of Saudi Arabia and the project site area. Source: IBAT....186
Figure 83. Species occurrences reported to the Global Biodiversity Information Facility -GBIF- Project site in red color. Source: Digital Observatory for Protected Areas....187
Figure 84. Project Site Relative to the Rift Valley/Red Sea Flyway. Source: http://datazone.birdlife.org/birdlife-is-working-to-mainstream-soaring-bird-conservation-along-the-rift-valley/red-sea-flyway....188
Figure 85. Results from at BirdLife International Sensitivity Mapping Tool for Migratory Soaring Birds, showing a point in the middle of the Project Site delineation with a buffer zone of 20km.....189
Figure 86. Distance between the dumping site of Afif and the project site. Source: Environmental Baseline Survey Report for Afif 1 PV Project....190
Figure 87. Bird species richness. Source: Digital Observatory for Protected Areas....191
Figure 88. Mammal species richness. Source: Digital Observatory for Protected Areas....195
Figure 89. STL Abandoned Burrow. Source: Environmental Baseline Survey Report for Afif 1 PV Project....197
Figure 90. Photographs of the recorded invertebrates onsite. Source: Environmental Baseline Survey Report for Afif 1 Project....198
Figure 91. Project Site in relation to the existing protected areas in Saudi Arabia. Source: National Center for Wildlife....200
Figure 92. Protected Areas managed by the National Center for Wildlife and Afif 1 Solar Plant. Source: selfmade....202
Figure 93. Map of Saudi Arabia´s Protected Area System. Source: revised Protected Area System Plan, 2010....203
Figure 94. Closest proposed and existing protected areas to the project site. Source: shapefile of UNEP-WCMC (2023). Protected Area Profile for Saudi Arabia from the World Database on Protected Areas, October 2023. Available at: www.protectedplanet.net.....204

Figure 95. Red List Category summary totals for Saja / Umm ar-Rimth 205
Figure 96. Red List Category summary totals for Nafud al-Ùrayq 205
Figure 97. Red List Category summary totals for Mahazat as-Sayd 206
Figure 98. Sites of Biodiversity Importance: Important Bird and Biodiversity Areas and Other, respectively. Source: IBAT. 207
Figure 99. Map of the closest IBA (Mahazar as-Sayd) to the project site. Source: BirdLife International (2023) Important Bird Areas 208
Figure 100. Populations meeting IBA criteria (trigger species). The current IUCN Red List category was valid at the time of IBA criteria assessment (1994). Source: BirdLife International (2023) Important Bird Area factsheet 209
Figure 101. Map showing there are no close Other KBA to the project site. Source: KBA (2023) 210
Figure 102. IUCN Categories of the Protected Areas in Saudi Arabia. Study area in red colour. Source: www.protectedplanet.net/country/SAU 216
Figure 103. Project Site predominantly flat. Source: TYPSA´s site visit 221
Figure 104. Wadi with few vegetation and outcrops. Source: TYPSA´s site visit 222
Figure 105. Outcrops. TYPSA´s site visit 223
Figure 106. Road that connects routes 50 and 80 through Almardamah. Source: TYPSA´s site visit 224
Figure 107. Saudi Arabia Regions. Study area (red color) in Riyadh Region. Source: Gisgeography, 2024 225
Figure 108. Governorates in Riyadh Region. Study area (red color) in Afif Governorate. Source: Central Department of Statistics & Information, Kingdom of Saudi Arabia, 2010 226
Figure 109. Percentage share of each age group inside Riyadh Region. Source: Saudi Census 2022 227
Figure 110. Age pyramid for Riyadh Region. Source: Saudi Census 2022 227
Figure 111. Saudi Population (10 years and over) by Administrative Area and Educational Status. Source: Education and Training Survey 2017. General Authority for Statistics 229
Figure 112. Riyadh Region educational attainment. Source: General Authority for Statistics (2017) 229
Figure 113. Unemployment rate for Saudis in Riyadh Region for the year 2022 and the first two quarters of 2023. Source: General Authority for Statistics 230
Figure 114. Unemployment rate for non-Saudis in Riyadh Region. Source: General Authority for Statistics 230
Figure 115. Strategic sectors of Riyadh Region. Source: Invest Saudi, Vision 2030, KSA 231
Figure 116. Region at glance. Services across the region. Source: Invest Saudi, Vision 2030, KSA 232
Figure 117. Contribution of regions to the GDP (without crude oil and gas), 2012. Source: Saudi Cities Report, 2019 233
Figure 118. Economic contribution to GDP in regions (without crude oil and gas), 2012. Source: Saudi Cities Report, 2019 233
Figure 119. Top destinations by cities. Source: 2022 Tourism Statistics Report 234
Figure 120. Domestic destinations by provinces/regions. Source: 2022 Tourism Statistics Report 234
Figure 121. Main purposes of domestic trips in KSA. Source: 2022 Tourism Statistics Report 235
Figure 122. Holdings surveyed by administrative regions. Source: Agricultural Production Survey Bulletin, 2018 236
Figure 123. Number and area of agricultural holdings in Riyadh region, 2017. Area=1000m^2. Source: Agricultural Production Survey Bulletin, 2018 236
Figure 124. Total number of sheep by age and group sex in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018 236
Figure 125. Total number of goats by age and group sex in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018 236

Figure 126. Total number of camels by age and group sex in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018 236
Figure 127. Total number of cows by age and group sex in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018 237
Figure 128. Total number of riding and draught animals by type in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018 237
Figure 129. Total number of domestic poultry by type in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018 237
Figure 130. Total honey produced by hive type in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018 237
Figure 131. New substation under construction near Afif town. Source: TYPSA´s site visit in November 2023 238
Figure 132. Water sectoral demands in KSA between 2010 and 2019. Source: Statistical Yearbook, 2019 239
Figure 133. Sources of urban water use in KSA between 2007 and 2019. Source: Statistical Yearbook, 2019 240
Figure 134. Regional urban water demand in KSA. Source: Statistical Yearbook, 2019 240
Figure 135. Regional distribution of WWTPs, TWW (Treated Wastewater) quantities and reuse in Riyadh Region. Source: Statistical book: Year 2019, Ministry of Environment, Water and Agriculture 241
Figure 136. OSM Landuse - Landcover in the surroundings of Afif 1 Solar Power Project plot. Source: self-made 242
Figure 137. Nomadic camp location. Source: Environmental Baseline Survey Report for Afif 1 PV Plant 243
Figure 138. Nomadic camp and a camel´s enclosure within the project site. Source: TYPSA´s site visit 243
Figure 139. Cattle within the project site. Source: TYPSA´s site visit 244
Figure 140. Road adjacent to the Solar Power Plant plot. Source: TYPSA´s site visit 244
Figure 141. Abandoned garbage within the Solar Power Project boundaries. Source: selfmade 245
Figure 142. World Heritage Sites of UNESCO and Afif 1 Solar PV Plant. Source: UNESCO 246
Figure 143. Inhabited areas inside the project site. Mobile homes and camels' enclosure. Source: TYPSA´s site visit 247
Figure 144. Monthly mean temperature and precipitation for Saudi Arabia during the 1991-2020 period Source: World Bank 248
Figure 145. Maximum and minimum temperatures for Saudi Arabia for the 1901-2020 period. Source: World Bank 249
Figure 146. Precipitation for Saudi Arabia for the 1901-2022 period. Source: World Bank 250
Figure 147. Projected average maximum temperature in Ar Riyad for all SSP scenarios (Reference period: 1950-2014). Source: World Bank 253
Figure 148. Projected maximum temperatures in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank 253
Figure 149. Table with projected maximum temperatures in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank 254
Figure 150. Projected Average Maximum Surface Air Temperature Anomaly for the 2040-2059 period (SSP2-4.5 and SSP5-8.5S).ource: World Bank 254
Figure 151. Projected Average Maximum Surface Air Temperature Anomaly for the 2060-2079 period (SSP2-4.5 and SSP5-8.5). Source: World Bank 255
Figure 152. Projected Average Maximum Surface Air Temperature Anomaly for the 2080-2099 period (SSP2-4.5 and SSP5-8.5). Source: World Bank 255

Figure 153. Projected average minimum temperature in Ar Riyad for all SSP scenarios (Reference period: 1950-2014. Source: World Bank 256
Figure 154. Projected minimum temperatures in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank 257
Figure 155. Table with projected minimum temperatures in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014.). Source: World Bank 257
Figure 156. Projected Average Minimum Surface Air Temperature Anomaly for the 2040-2059 period (SSP2-4.5 and SSP5-8.5), Source: World Bank 258
Figure 157 Projected Average Minimum Surface Air Temperature Anomaly for the 2060-2079 period (SSP2-4.5 and SSP5-8.5). Source: World Bank 258
Figure 158. Projected Average Minimum Surface Air Temperature Anomaly for the 2070-2099 period (SSP2-4.5 and SSP5-8.5. Source: World Bank 259
Figure 159. Projected hot days (>40ºC) in Ar Riyad for all SSP scenarios (Reference period: 1950-2014. Source: World Bank 260
Figure 160 Projected hot days (>40ºC) in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank 260
Figure 161. Table with projected hot days (>40ºC) in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank 261
Figure 162. Projected Hot Days Anomaly for the 2040-2059 period (SSP2-4.5 and SSP5-8.5). Source: World Bank 261
Figure 163. Projected Hot Days Anomaly for the 2060-2079 period (SSP2-4.5 and SSP5-8.5). Source: World Bank 262
Figure 164. Projected Hot Days Anomaly for the 2080-2099 period (SSP2-4.5 and SSP5-8.5). Source: World Bank 262
Figure 165. Projected number of tropical nights (Tmin >29ºC) in Ar Riyad for all SSP scenarios (Reference period: 1950-2014). Source: World Bank 263
Figure 166. Projected tropical nights in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank 263
Figure 167. Table with projected tropical nights in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank 264
Figure 168. Projected Tropical Nights Anomaly for the 2040-2059 period (SSP2-4.5 and SSP5-8.5). Source: World Bank 264
Figure 169. Projected Tropical Nights Anomaly for the 2060-2079 period (SSP2-4.5 and SSP5-8.5). Source: World Bank 265
Figure 170. Projected Tropical Nights Anomaly for the 2070-2099 period (SSP2-4.5 and SSP5-8.5). Source: World Bank 265
Figure 171. Flood Hazard for Afif 1 project 307
Figure 172. Mitigation hierarchy in the Design of the Project 345
Figure 173. Temporary marking out to protect the trees (Acacia tortilis). 346
Figure 174. Plates in the fence to avoid birds´ collision. 348
Figure 175. Spiral bird protector devices in transmission lines 349
Figure 176. Relocation Plan for STL. 350
Figure 177. Burrows will be marked with a colour coded flag. 352
Figure 178. Worksites will be irrigated with water. 354
Figure 179. Speed limits onsite 356

Figure 180. Waste hierarchy. Source: The centre of waste management....368
Figure 181. Vegetation barrier example for reducing glint and glare....372
Figure 182. Incompatible Chemicals. Source: Waste Handling and Storage Standard (2012)....406
Figure 183. Potentially Explosive Chemicals. Source: Waste Handling and Storage Standard (2012)....407
Figure 184. Leaching limit values for the acceptance of wastes in hazardous landfills. Source: Waste Acceptance Criteria (2012....408
Figure 185. Additional limit values for the acceptance of wastes in hazardous landfills. Source: Waste Acceptance Criteria (2012)....409
Figure 186. Leaching limit values for the acceptance of hazardous wastes in landfills for non-hazardous waste. Source: Waste. Acceptance Criteria (2012)....410
Figure 187. Additional limit values for the acceptance of hazardous wastes in landfills for non-hazardous waste. Source: Waste Acceptance Criteria (2012)....411
Figure 188. Leaching limit values for landfills for inert waste. Source: Waste Acceptance Criteria (2012). .411
Figure 189. Additional limit values for landfills for inert waste. Source: Waste Acceptance Criteria (2012) .412
Figure 190. Hazardous Waste List. Source: Waste Classification Standard (2012). 413
Figure 191. Hazardous Waste Constituents. Source: Waste Classification Standard (2012). 414
Figure 192. Hazardous Property List. Source: Waste Classification Standard (2012)....415
Figure 193. Toxicity Property Leaching Procedure Regulatory Levels. Source: Waste Classification Standard (2012). 416
Figure 194. Details of the requirements for landfills. Source: Landfill – Design and operation (2012)....420
Figure 195. Landfill Capping Requirements. Source: Landfill- Design and Operation (2012). 422
Figure 196. Ten Step BPEO Process. Source: Best Practicable Environmental Option for Waste Disposal (2012)....423
Figure 197. Waste Tracking Form. Source: Waste Regulatory Control and Compliance (2012)....425
Figure 198. Hazard Warning Diamonds. Source: Waste Transportation (2012)....427

List of tables

Table 1. Team involved in the study and reporting 41
Table 2. Stakeholders 43
Table 3. National Standards and Regulations 45
Table 4. Air Quality Standards for Basic Pollutants Source: Executive Regulations for Air Quality (2021) 52
Table 5. Measurement noise levels for residential and commercial areas. Noise Levels Standards. Source: Executive Regulations for Noise (2021) 53
Table 6. Noise level standards on roadsides. Source: Executive Regulations for Noise (2021) 53
Table 7. Corrective limits for permitted noise levels at construction site. Source: Executive Regulations for Noise (2021) 53
Table 8. Standards for protecting soil from pollution. Source: Executive Regulations for Prevention and Treatment of Soil Pollution (2021) 58
Table 9. Measurements for treated wastewater prior to its discharge into soil, land or surface water. Source: Executive Regulations to protect aquatic environments from pollution (2021) 61
Table 10. Wastewater Treatment Techniques. Source: Executive Regulations to protect aquatic environments from pollution (2021) 61
Table 11. GAMEP Environmental Standards (2012) 65
Table 12. General Standards (2021). Source: Standards for the Discharge of Commercial Sewage into Sewage Network 67
Table 13. Trace Element Standards (Heavy). Source: Standards for the Discharge of Commercial Sewage into Sewage Network 68
Table 14. Articles of the Convention on the Conservation of Wildlife and their Habitats in the GCC 73
Table 15. Ambient air quality measures (Ambient Air Quality Regional Standards) 74
Table 16.: Summary of International agreements 79
Table 17.: IFC Performance Standards applicability to the Principal Buyer development 80
Table 18. General Site Data Table 84
Table 19. Site Coordinates 84
Table 20. List of PV plant equipment 85
Table 21. SEC substation coordinates 92
Table 22. Coordinates of the extremity boundaries of the available area for the project 102
Table 23. Waste Disposal Methods 107
Table 24. Waste Disposal Methods 108
Table 25. Checklist. Questions on project characteristics. Source: Guidance on EIA. Scoping. June 2001. Environmental Resources Management 117
Table 26. Identified criteria for location alternatives 119
Table 27. Summary of the comparison between alternatives 128
Table 28. Summary of surveys conducted. 130
Table 29. Coordinates of Air Quality Monitoring Stations at Afif 1 Solar Plant Site. Source: Environmental Baseline Survey Report 132
Table 30. WHO Ambient Air Quality Standards. Source: World Health Organization (WHO) Ambient Air Quality Guidelines 134
Table 31. Ambient Air Quality Standards for Primary Pollutants. Source: Executive Regulations for Air Quality (2021) 135

Table 32. Results Air Quality tests for SO2, NO2, NO, NOx, CO, O3, PM10 and PM2.5 at Afif 1 Solar Plant plot. Source: Environmental Baseline Survey Report 143
Table 33. Results of Meteorological data registered during Air Quality Monitoring at Afif 1 Solar Plant. Source: Environmental Baseline Survey Report....144
Table 34. Coordinates of Noise Monitoring points at Afif 1 Solar Plant site. Source: Environmental Baseline Survey Report....145
Table 35. Limit values. Source: Noise levels guidelines....146
Table 36. Noise limits near road area. Source: Executive Regulations for Noise (2021) 147
Table 37. Corrective limits for permitted noise levels at construction site. Source: Executive Regulations for Noise (2021)....147
Table 38. Noise monitoring tests results. Source: Environmental Baseline Survey Report....148
Table 39. Geotechnical site investigations proposed for Solar energy plant in Afif-1. Source: geotechnical proposal 149
Table 40. Recorded flora species during the field survey. Source: Environmental Baseline Survey Report for Afif 1 PV Project 182
Table 41. Example of the recorded Flora. Source: Environmental Baseline Survey Report for Afif 1 PV Project 185
Table 42. Globally Threatened species of Migratory Soaring Birds in Arabic Peninsula. Source: IUCN Red List 190
Table 43. Avifauna species recorded within the site. Source: Environmental Baseline Survey Report for Afif 1 PV Project 192
Table 44. Samples of the bird species observed in the study area. Source: Environmental Baseline Survey Report for Afif 1 PV Project 194
Table 45. Mammals observed in the study area during the site visit. Source: Environmental Baseline Survey Report for Afif 1 PV Project 196
Table 46. Existing protected areas in the Kingdom of Saudi Arabia. Source: National Center for Wildlife....201
Table 47. Identified habitats in the surveyed section. Source: Environmental Baseline Survey Report for Afif 1 PV Project 212
Table 48. Summary of Key Findings 216
Table 49. Critical Habitat Screening....218
Table 50. Presence of High Biodiversity Values 219
Table 51. Environmental value of receptor or resource 272
Table 52. Criteria for magnitude of impacts 274
Table 53. Criteria for extension of impacts 274
Table 54. Criteria for timing of impacts....274
Table 55. Criteria for duration of impacts....275
Table 56. Criteria for reversibility of impacts....275
Table 57. Criteria for likelihood of impacts 275
Table 58. Criteria for determining significance of effects (the importance of impacts)....276
Table 59. Definition of significance of effects (Importance)....277
Table 60. Risks Matrix for Negative impacts....278
Table 61. Risk Assessment Summary for vegetation cover,....281
Table 62. Risk Assessment Summary for flora, fauna, and biodiversity 288
Table 63. Risk Assessment Summary for air quality 292

Table 64. Typical noise levels of principal construction equipment. Source: India ministry of environment and climatic change....293
Table 65. Risk Assessment Summary for noise....297
Table 66. Risk Assessment Summary for smells....299
Table 67. Risk Assessment Summary for surface water quality....301
Table 68. Risk Assessment Summary for surface water availability.....303
Table 69. Risk Assessment Summary for groundwater quality....305
Table 70. Risk Assessment Summary for hydrology and flood risk....308
Table 71. Risk Assessment Summary for soils quality....312
Table 72. Risk Assessment Summary for health and safety....314
Table 73. Risk Assessment Summary for landscape & visual comfort....317
Table 74. Risk Assessment Summary for land use....318
Table 75. Risk Assessment Summary for waste....321
Table 76. Risk Assessment Summary for glint and glare....322
Table 77. Risk Assessment Summary for climate change....325
Table 78. Risk Assessment Summary for economic and social aspects....327
Table 79. Risk Assessment Summary for traffic and transport....329
Table 80. Risk Assessment Summary for antiquities and cultural heritage....331
Table 81. Risk Assessment Summary for unplanned events....333
Table 82. Risk Assessment Summary for human rights....334
Table 83. Summary of Impacts....340
Table 84. CEMP and OEMP Roles and Responsibilities....378
Table 85. Example of Training Requirements....380
Table 86. Environmental Monitoring Plan....388
Table 87. Summary of Impacts Post-Mitigation....391
Table 88. Summary of gains and losses....392
Table 89. Summary of Impacts....394
Table 90. Roles and responsibilities of different authorities....396
Table 91. CEMP and OEMP Roles and responsibilities....398

Abbreviations

ID	Description
AAQS	Ambient Air Quality Standard
AHEC	Ali Harbi Environmental Consulting Office
AR	Anti Reflective
asl	At sea level
ATCT	Airport Traffic Control Towers
BAT	Best Available Techniques
BCM	Billion Cubic Meters
BH	Boreholes
BOD	Biochemical Oxygen Demand
BPEO	Best Practicable Environmental Process
BS	British Standards
BSA	Bander Said Allehiany
CAPEX	Capital Expenditure
CBD	Convention on Biological Diversity
CEM	Competitive Electricity Market
CEMP	Construction Environmental Management Plan
CHA	Critical Habitat Assessment
CHMP	Cultural Heritage Management Plan
CITC	Communication and Information Technology Commission
CMS	Conservation of Migratory Species
COD	Chemical Oxygen Demand
CPT	Cone Penetration Test
CR	Critically Endangered
DAFOR	Dominant, Abundant, Frequent, Occasional, Rare
dB	Decibel
DCP	Dynamic Cone Penetration

ID	Description
DD	Data Deficient
DOC	Dissolved Organic Carbon
EBS	Environmental Baseline Survey
EN	Endangered
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPC	Engineering, Procurement, and Construction
ESIA	Environmental and Social Impact Assessment
ETLCO	Environmental Testing & Laboratories Company
EX	Extinct
EW	Extinct in the Wild
FCEMP	Framework for the Construction Environmental Management Plan
GACA	General Authority of Civil Aviation
GAMEP	General Authority of Meteorology and Environmental Protection
GCC	Gulf Cooperation Council
GBIF	Global Biodiversity Facility
GHG	Green House Gas
GPS	Ground Positioning System
GIS	Geographic Information System
HCP	High Conservation Priority
HSMS	Health & Healthy Management System
HSE	Health, Safety and Environment
HSSE	Health, Safety, Security and Environment
HV	High Voltage
IBA	Important Bird Area
IFC	International Finance Corporation
IPP	Independent Power Producer

ID	Description
IUCN	International Union for the Conservation of Nature
KSA	Kingdom of Saudi Arabia's
LC	Least Concern
LCOE	Levelized Cost of Energy
LOI	Loss on Ignition
MAWANI	Saudi Ports Authority
MCIT	Ministry of Communications and Information Technology
MEWA	Ministry of Environment Water and Agriculture
MOC	Ministry of Culture
MOD	Ministry of Defence
MODON	Saudi Authority for Industrial Cities and Technology Zones
MoE	Ministry of Energy
MOI	Ministry of Interior
MOMRAM	Ministry of Municipal, Rural Affairs and Housing
MOT	Ministry of Transport and Logistic Services
MSBs	Migratory Soaring Birds
MT	Ministry of Tourism
MV	Medium Voltage
NBSAP	National Biodiversity Strategy and Action Plan
NCEC	National Centre for Environmental Compliance
NCW	National Centre for Wildlife
NCWCD	National Commission for Wildlife Conservation and Development
NE	Not Evaluated
NL	Not Listed
NO_2	Nitrogen Dioxide
NPAS	National Protected Area System Plan
NREP	National Renewable Energy Program

ID	Description
NT	Near Threatened
OEMP	Operation Environmental Management Plan
OHTL	Overhead Transmission Line
OPEX	Operational Expenditure
PB	Principal Buyer
PIB	Public Investment Fund
PME	Presidency of Meteorology and Environment
PoT	Pull Out Test
PoWPA	Programme of Work for Protected Areas
PPE	Personal Protective Equipment
PS	Performance Standards
PV	Photovoltaic
RRP	Recommended Relocation Program
SANG	Ministry of National Guard
SANS	Saudi Air Navigation Services
SAP	Species Action Plan
SAR	Saudi Arabia Riyal
SBC	Saudi Building Code
SEC	Saudi Electricity Company
SERP	Security and Emergency Response Plan
SCTA	Saudi Commission for Tourism and Antiquities
SGS	Saudi Geological Survey
SO_2	Sulfur Dioxide
SPPC	Saudi Power Procurement Company
SPT	Standard Penetration Test
STL	Spiny-Tailed Lizard
SWA	Saudi Wildlife Authority

ID	Description
SWCC	Saline Water Conversion Corporation
TDS	Total Dissolved Solids
TGA	Transport General Authority
TPLP	Toxicity Property Leaching Procedure
TSE	Treated Sewage Effluent
TSS	Total Suspended Solids
TTOC	Total Chlorinated Hydrocarbons
TYPSA	Técnica y Proyectos S.A.
UNCBD	United Nations Convention on Biological Diversity
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
VOCs	Volatile Organic Compounds
VU	Vulnerable
WAC	Waste Acceptance Criteria
WHO	World Health Organization
WHS	Word Heritage Site
WP	Waypoint/s

Terminology Definitions

Term	Definition
Activity	Planned actions undertaken during a development, construction or operation that may or may not be a driver for change on environmental or social values.
Ambient Air	It refers to that portion of the atmosphere, external to buildings, to which the general public has access.
Ambient Noise	A totally encompassing sound in a given situation at a given time, usually composed of sounds from near and far.
Area of Influence	The area where potential environmental or social sustainability risks may occur in relation to a proposed development. At a minimum this includes the defined project boundary, but dependent on the scale, nature, and complexity of the development, the AoI may extend for hundreds of meters or even kilometers beyond the project area boundary.
Assessment Area	The physical area identified by the consultant and the proponent for assessment of potential environmental impacts.
Biodiversity	The variety of plant and animal life in the world or in a particular habitat at the following levels of organization; landscape, ecosystem, habitat, community, species, population, individual, and the structural and functional relationships.
Bottlenecks	Sites whose geographic position means that seabirds fly over or round in the course of regular migration.
Construction	The time period that corresponds to any event, process, or activity that occurs during the construction phase of the proposed project. The construction phase terminates when the project goes into full operation or use.
Construction Activity	A construction activity is any action taken by the contractor, his subcontractors, suppliers, or personnel during the construction process.
Construction Camp	Construction camp (site camps) refer to all storage and stockpile sites, site offices, staff accommodation, container sites, workshops and testing facilities, and other areas required to undertake construction activities.
Cumulative Impact Assessment	Process used to evaluate the combined predicted outcomes on an environmental or social value from several unrelated developments.
Environment	The surroundings in which development activities occur, including air, water, land, natural resources, flora, fauna, humans, and their interrelationships.
Environmental Impact	Change to the environment, whether adverse or beneficial, wholly, or partially resulting from an organization's interactions with the environment.

Environmental Impact Assessment	The process and procedure for evaluating and predicting the likely environmental impact of a proposed activity.
Environmental Management Plan	It is an environmental management tool used to ensure that undue or reasonably avoidable adverse impacts of the construction, operation and decommissioning of a project are prevented; and that the positive benefits of the projects are enhanced.
Groundwater	Water from aquifers or other underground sources.
Habitat	An ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilised by) a species population. A dominant habitat is decided on the proportional presence of particular organism, dependent upon habitat type.
Hazard	Substance, activity, structure, or event that has the potential to do harm to environmental or social values.
Hazardous Material	Those chemicals or substances which are physical hazards or health hazards, whether the materials are in usable or waste condition.
Hazardous Waste	Waste containing properties that are potentially harmful to human health and the environment, such as toxic, explosive, flammable or radioactive substances.
Likelihood	The chances of a risk or opportunity happening.
Management Measure	Mechanism devised and applied to eliminate a hazard or reduce the level of risk of a hazard from causing harm.
Mitigation	A mechanism used to respond to an event that has occurred with the intent to reduce the negative outcomes or increase the positive outcomes.
Mitigation measures	The reduction or control of the adverse environmental impact of an activity and includes restitution for any damage to the environment caused by such activity through engineering works, technological improvements, management measures or compensation to ameliorate any loss suffered by a person.
Operation	The time period that corresponds to any event, process, or activity that occurs during the operational phase (fully functioning) of the proposed project. The operation phase follows the construction phase and then terminates when the project goes into the decommissioning phase.
Pollutant	Any substance introduced directly or indirectly by man into the ambient air and likely to have harmful effects on human health and/or the environment as a whole.
Project Area	The physical area within which the proposed project—all construction, operations, and decommissioning activities and processes—will take place. The project area is equivalent to the project site.
Project Site	Definition is the same as project area.

Risk	The effect of uncertainty on an expected (negative) result. The result is generally the outcome of a hazard against the likelihood.
Sensitive areas	Those areas existing in close proximity to the Project and where occupants are more susceptible to the exposure of pollutants, chemicals, traffic, noise and vibration as a result of the project construction and operation. Sensitive receptors include schools, universities, day care centers, hospitals, housings, mosques, libraries, parks, Government buildings, compounds, sport areas, museum, investigation centers, natural protected areas, fauna, flora, etc.
Solid Waste	Rubbish, debris, garbage, and other discarded solid materials resulting from the activity.
Spoil	Surplus material from excavations which is not required to complete the works, or materials from excavations whose quality is deemed to be unacceptable for incorporation in the Project construction. Spoil is defined as 'rock' or 'other than rock' resulting from construction, excavation, and tunnelling activities such as clay, sand, lime, rock considered as inert material and does not possess any hazardous characteristics.
Value	Environmental or social phenomenon with perceived or inherent value as defined through legislation, guidance, treaties, social norms, etc.

Non-technical Summary

Introduction

The Kingdom has a distinct geographical and climatic location that makes utilizing renewable energy sources economically attractive, supporting Saudi efforts to diversify the domestic energy mix under the strategic initiative "the National Renewable Energy Program (NREP)", launched at the direction of His Majesty the King as part of Vision 2030, which aims to increase the Kingdom's share of renewable energy production, achieve a balance in the mix of local energy sources, and fulfil the Kingdom's obligations towards reducing carbon dioxide emissions.

Principal Buyer intends to develop the Afif 1 Solar Power Project plant. The plant is expected to have an overall beneficial effect on both its immediate surroundings, through the creation of job opportunities during both construction and operation, and at a Principal Buyer level by establishing a renewable energy development source as it moves away from a traditional hydrocarbon-based energy supply, towards more sustainable energy sources.

The project contributes KSAs 2030 vision of using renewable technologies to replace hydrocarbons in energy generation. It aligns with several strategic goals including:

- Reducing carbon emissions resulting from the consumption of fossil fuels.
- Preserving the national natural resources.
- Relying on an inexhaustible source of energy, which is the sun.
- Reducing the cost of producing electricity.
- Supporting global efforts to reduce emissions that cause climate change and global warming.
- Diversifying the sources of Saudi National income by relying on new and clean energy sources.

This document presents the Environmental Impact Evaluation (Assessment) Study (ESIA Report) for the proposed Afif 1 Solar Energy plant. The aim of the ESIA is to identify and categorize impacts predicted to occur as a result of the construction, operation and decommissioning of the plant, and provide mitigation measures and recommendations to avoid and minimize these impacts wherever possible.

Referring to the Environment Law, promulgated by Royal Decree No. (M/165) dated 19 Dhu al-Qadah1441 AH (corresponding to 10 July 2020) and based on NCEC decision, the Afif 1 solar plant project is classified as a Category Two which calls for an Environmental Impact Evaluation Study as a prerequisite to obtaining the environmental permitting and approval for the Project from NCEC.

An international and national pool of experts have been involved in the Environmental Impact Evaluation Study. Initial field work surveys have been carried out by TYPSA experts in November 2023. Field surveys

(noise, air quality, flora, fauna, and archaeology) were carried out by a local team (AHEC) in January 2024 and TYPSA (geotechnic and groundwater) between December 2023 and April 2024.

Legislative, Regulation, and Policy Considerations

This Environmental Impact Evaluation Study has been prepared based on the national legislative requirements, Government's guidelines as well as other international guidelines of EIA. The Environmental Impact Evaluation Study is consistent with the structure and content set out in the Appendix 2 of the Environment Law issued by Royal Decree No. M/165 of 19/11/1441 AH. This Environmental Impact Evaluation Study also addresses relevant social as well as environmental risks to of the Development align with IFC requirements.

Project Location

Saudi Power Procurement Company (Principal Buyer) is developing a new photovoltaic power plant, named Afif 1 park from greenfield inside an area of 40.0 km^2 located at approximately 23 km southeast of the city of Afif in the Kingdom of Saudi Arabia. The site is located at 978 meter above sea level. The study area is under the management of the Ministry of Municipal, Rural Affairs and Housing.

The site location of Afif 1 is shown in figure below (Figure 1). The area available for the project is 40.0 km^2.

Figure 1. Afif 1 site

Description of the Project and activities

The project consists of a photovoltaic solar power plant with a maximum production capacity of 2,636 MW, using bifacial technology.

The PV cells within modules will be installed on tracking ground mounted racks arranged to ensure the most efficient alignment for the capture of solar radiation. Dry cleaning system (fully or semi-automated cleaning robots) will be used to clean the panels when required.

Bifacial modules achieve a better collar-electric conversion performance at similar project size and more production at a barely higher installation cost. The plant will include modules, structures, and substation.

The PV solar technology chosen for this Project include of the following main components:

- Bifacial PV cell: The PV cell is the device that generates electricity when exposed to solar radiation.
- PV module: The PV module is the set of interconnected photovoltaic cells encapsulated between a transparent front (usually glass) and a backing support material then mounted in an aluminum frame.
- Mounting structures: Multiple PV modules are bolted onto a mounting structure which tracks the sun progress across the sky in an east to west direction.
- PV array: The PV array is the complete power generating plant consisting of multiple PV modules wired in series and in parallel.
- Inverters: The inverter converts the Direct Current (DC) to Alternative Current (AC).
- Substation: The substation receives all power from the inverters via underground cables and provides protection and control equipment required to safely manage the plant and to ensure grid code compliance regulations.
- Transformers: The transformer steps up the AC power from the inverters to match the grid voltage.
- Stores, offices, and control building.
- Access tracks and fencing.
- Export cables to the grid are out of the scope of this assessment.

Different technical options and alternatives considered have been analysed from different points of views, including the environmental scenario. Mitigation hierarchy (Avoid, minimize / reduce, mitigate, compensate) has been considered during the design of the project.

The Project will be completed in four phases:

- Early works.
- Construction works.
- Operation of the solar park.
- Decommissioning.

Early works activities

Early works comprise the planning and pre-construction phase involving the conceptualization of the project and has following components:

- Site Selection.
- Site surveys as topographic, geotechnical investigations, micro-siting studies, power evacuation arrangements.
- Prefeasibility study.
- Initial approvals/clearances/ permits.

- Tendering.
- Finalization of contractors.
- Design.
- Final approvals and permits.

Project construction

Principal construction activities and associated requirements in relation to civil works will include but are not limited to:

- Contractor mobilization.
- Site preparation activities such as clearance, excavation, filling, levelling, fencing, etc.
- Conditioning of external connecting road and security checks and access.
- Establishment of construction camps, site office, equipment and supplies storage areas, fuel storage areas and waste pits.
- Construction of the internal access roads.
- Erecting the foundations of the PV module by using a ramming machine to dig the metallic poles.
- Transportation of equipment including PV module, mounting structure, electromechanical equipment, and supply materials.
- Installing the modules on the supporting structure. This is a manual operation.
- Construction trenches for buried cabling.
- Completing internal electrical connections of PV module to inverters.
- Erection of internal electrical lines from inverter to substations by laying cables in the trenches.
- Erecting internal substations.
- Testing, commissioning, and interconnection to the National Grid of the complete PV plant.

The estimated number of construction workers on site during construction (with a duration of 32 months) is expected to be around 650-750 workers.

Project operation

Key operational activities will include:

- Monthly cleaning of PV modules.
- Control of vegetation, weeds, bushes etc. within the site and those immediately surrounding area.
- Routine inspection of all PV modules and associated structures, cables, transformers, inverters, mounting structures etc.
- Operation and maintenance of ancillary facilities such as power substation.
- Inspection and maintenance of transmission lines.
- Inspection and maintenance of internal pathways and access roads.
- Regular remote monitoring of the complete PV plant.
- PV module washing.
- Inverter maintenance.
- Preventive and corrective maintenance, including replacement of broken PV modules.
- Checking the electric connection.

The proposed Project is expected to operate for at least 30 years.

During the operation phase of the project, a limited number of operational workforces are likely to be required and to be engaged to carry out operation and maintenance activities of the Project.

Project decommissioning

Key decommissioning activities will include:

- Site and surrounding environment assessment.
- Protect natural resources.
- Waste management operation.
- Removal of all Project components.
- Soil remediation.
- Restoration of the terrestrial ecology habitats within the Project footprint including access roads.

Description of the surrounding Environment and Key Environmental issues

Afif 1 Solar Plant plot is located 23 km southeast of Afif city at central zone of the Arabian Shield on a roughly flat plain. The topography of the site is flat with gentle slopes and some occasional hills of rock outcrops. All the area is widely covered by sand and gravels as residual erosional materials. Some minor runoff channels cross the plot from northwest to southeast. The site is located 978 meter above sea level.

The site is remote from settlements, but there were some camps within the site, which appeared nomadic, non-permanent., having been observed facilities such as livestock enclosures and mobile homes.

The site is used extensively for grazing camel livestock. Some wheels and plastic wastes were recorded onsite.

No sensitive receptors were identified close to the project site except two nomad camps with camels. The nearest large city, which is Afif, is far from the site 23 km.

No Key Landscape Features have been found during site visit.

There is no presence of surface water in the placement of the study area.

The scope of works of this assignment includes a geotechnical survey to recognize and characterize the soil and rocks localized in the proposed site which has provided a better characterization of the ground conditions and has verified that there is presence of groundwater in the study area. Groundwater was found only in two boreholes during the geotechnical campaign. A water table is present at an approximate depth of 27.5 m in BH-01 and another at approximately 14.0 m in BH-73.

There are no significant existing sources of point source emissions within the development site or immediately adjacent to the site boundary. Mobile emission sources identified adjacent to the Study Area include the road that connects routes 50 and 80 through Almardamah, which runs through the west limit of the Project site, with few traffic. The noise levels in study area are in full compliance with NCEC standards.

PM10 and PM2.5 concentrations in Saudi Arabia are generally high due to its geographical situation, the desert climate, and the sandstorms. The study area presents pollutant values significantly below NCEC standards, although concentrations of PM2.5 are close to reference values. However, results of ambient air monitoring for all parameters and the noise levels are in compliance with NCEC Standards.

The area is poorly vegetated, with scarce tree specimens found during the field survey. The site has low flora coverage, with the sandy and gravel plain biotopes almost completely devoid of vegetation. A total of just five flora species were recorded at the Project Site, one of which, the *Acacia tortilis*, is listed as Least Concern (LC) according to IUCN categories. None is included in KSA HCP Species.

There are not protected areas in the project site. The protected area closest to the Project Site, among the ones declared and managed by the National Center for Wildlife (NCW), is Saja / Umm Ar-Rimth, a Resource Use Reserve separated approximately 30 km southwest of the plot. To the north-northwest, Nafud al-'Urayq, also a Resource Use Reserve, is placed more than 65 km away.

Fauna, same as in flora, is scarce and with a limited richness and abundance because of the ecosystem conditions of the study area. Limited fauna species were observed (few mammals and birds) during the site survey, due to, at least partially, the lack of vegetation and key landscape features.

There are not Important Bird and Biodiversity Areas (IBAs) in the project site or vicinity. The nearest IBAs - Mahazat As-Sayd -SA019 is located approximately 166 km far from the project site, southwest direction. The project site does not fall in one of the main corridors of the migratory birds. Ten bird species were recorded during site survey. Only one of these ten, the Steppe Eagle (observed due to the presence of a dumping site near Afif city, 18 km away from the project site) is currently listed as Endangered according to the IUCN Red List of Threatened Species, also listed as a KSA High Conservation Priority species, and its local status is nonbreeding for the study area., The rest of the species are categorized as Least Concern (LC) according to IUCN classification. Usual mitigation measures in design and operation will be more than enough to minimize the impact of the project on the birds.

The project site is settled in a low richness area of birds according to the Global Biodiversity Facility (GBIF) so the occurrence of this taxa is scarce probably because of the absence of wet ecosystems and the low vegetation coverage.

Four mammals were recorded during the survey (camels, goats, sheep, and a cat), none of them are classified as threatened or HCP species. No species of bats were recorded onsite during the site survey. The habitats identified in the study area are not optimal for bat species. The project site is settled in a low richness area of mammals according to the Digital Observatory for Protected Areas.

No live reptiles were recorded within the project area during the survey period, although some burrows of Spiny Tailed Lizard (STL) without any clear signs of activity (tracks) were observed. STL is listed as Vulnerable (V) according to UICN categories and is included in KSA HCP Species.

The closest heritage sites, At-Turaif District in ad-Dir'iyah, declared Word Heritage Sites (WHS) by UNESCO, is 359 km from the project site boundaries.

The **key environmental issues** for the ESIA report have been the following:

- Flora and Fauna.

Impacts

The ESIA report reveals that the major negative impacts of the proposed project will be during construction phase. These impacts are the following: increase of noise on receptors, air quality pollution due to gaseous and dust emissions, habitat destruction, ecosystem disturbance, modification of land use, and landscape

degradation. All environmental impacts are Negligible or Minor and can be mitigated and, in many cases, avoided by careful planning and compliance with Environmental Management Plan actions during the construction period. All impacts will be acceptable after that mitigation measures are applied. The negative Impacts will be monitored regularly during construction stage.

During the Operation Phases, some general environmental prevention measures have been considered to prevent negative impacts, and an effective environmental management.

During construction and operation stages there will be positive impacts on employment and livelihood. In the construction phase employment will be generated directly both for skilled and unskilled professionals at different levels. Indirectly, it will generate employment for many people in the project area and beyond. A big part of these employments will be from local sources. In addition, resources consumption during construction phase will produce an economic development both locally and nationally.

The project contributes KSAs 2030 vision of using renewable technologies to replace hydrocarbons in energy generation.

It should be noted that the expected benefits resulting from the project outweigh the foreseen negative impacts by far.

Mitigation Measures

Appropriate mitigation and management measures are proposed in this ESIA Report to reduce the impacts.

Preventing and eliminating the source of pollution is better than minimizing the associated effects. Efforts made by the construction and operation team and the environment team should be combined to achieve an environmentally friendly project with the lowest possible impact.

The ESIA Report presents the mitigation measures that must be adopted during the construction and operation phases to minimize associated negative environmental impacts as much as possible. These mitigation measures are based and aligned with the Environmental and Social Codes Practice for Construction. Some of these measures are the following: Temporary marking out to protect vegetation, protection or Relocation of Acacia species, spiral bird protector devices in transmission lines, plates in the fence to avoid birds´ collision, speed limits onsite, worksites will be irrigated with water, waste hierarchy, etc.

The environmental management plan, along with the environmental monitoring programs, must ensure proper management of these impacts.

Mitigation measures identified in the ESIA Report must be adopted by construction contractor and operator and be documented in Construction Environmental Management Plan and Operational Environmental Management Plan.

Introduction

1. Introduction

1.1. General Information about the Study

National Renewable Energy Program (NREP) is considered as a strategic initiative under the slogan of 2030 that aims to increase the share of Renewable Energy widely among the totals of energy mixes in the Kingdom. The program will determine an organized and oriented road map in order to encourage rapid diversification of the supplies of local energy, motivate the economic development and sustain the long-term prosperity in accordance with the objectives of Vision 2030 that includes establishing a new renewable industry and support building this promising sector.

The ministry works to execute the NREP, as it is responsible for the Pre-Development phase and Tendering phase for renewable energy projects across the kingdom.

Saudi Power Procurement Company (Principal Buyer) is developing a new photovoltaic power plant, named Afif 1 Solar Plant from greenfield inside an area of 40.0 km^2 located at approximately 23 km southeast of the city of Afif, in the Riyadh Province, in the Kingdom of Saudi Arabia. The study area is under the management of the Ministry of Municipal, Rural Affairs and Housing.

This development will comprise the installation of solar photovoltaic (PV) generating panels and on-site energy storage facilities together with grid connection infrastructure. The Project would allow for the generation, storage, and export of a maximum of 2,636 megawatts (MW) electrical generation capacity. The Project aligns within the main strategy of the energy sector in the Kingdom of Saudi Arabia.

Figure 2. General project location

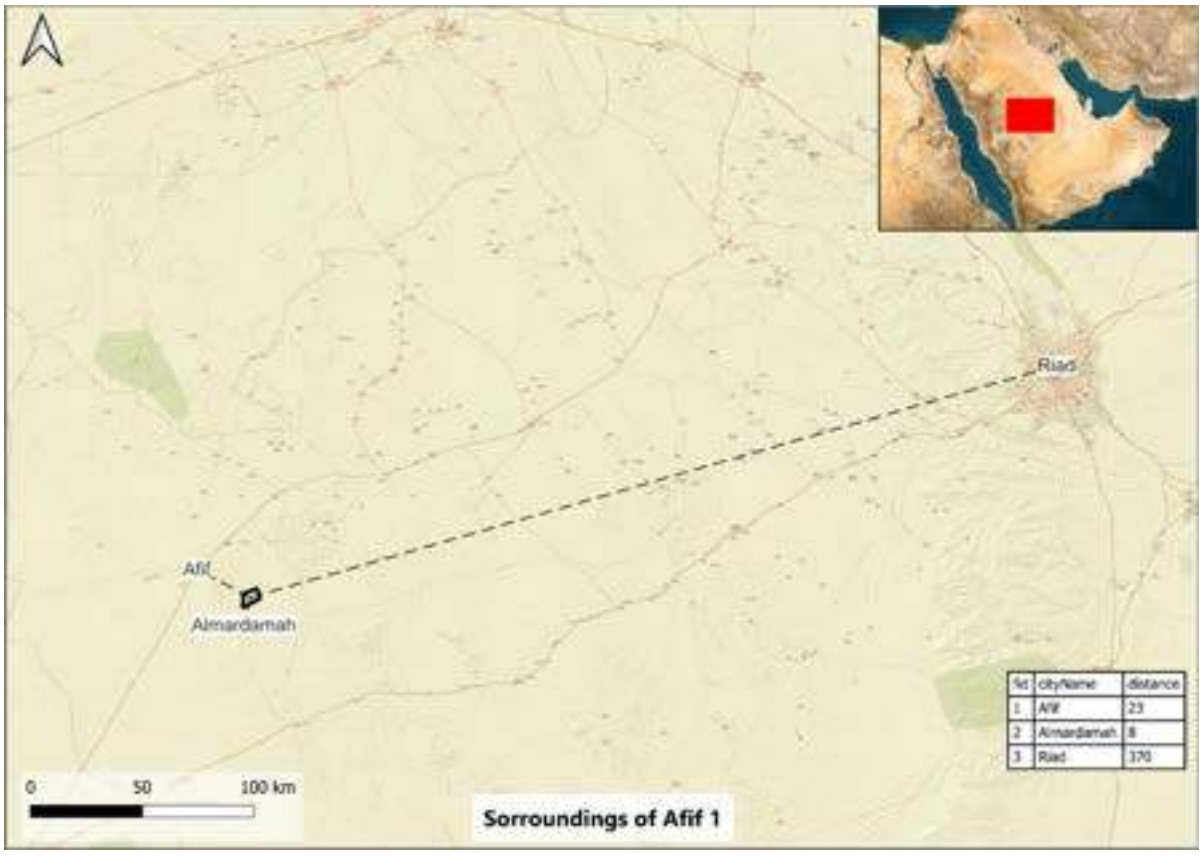


Figure 3. Afif 1 site and surroundings

Referring to the Environment Law, promulgated by Royal Decree No. (M/165) dated 19 Dhu al-Qadah1441 AH (corresponding to 10 July 2020) and based on NCEC decision, the Afif 1 Solar Plant project is classified as a **Category Two** which calls for an environmental impact evaluation study as a prerequisite to obtaining the environmental permitting and approval for the Project from NCEC.

The aim of the ESIA is to identify and categorize impacts predicted to occur as a result of the construction, operation and decommissioning of the plant, and provide mitigation measures and recommendations to avoid and minimize these impacts wherever possible.

1.2. Justification for the preparation of the study, its objectives, and the scope of work

1.2.1. Justification

The Environmental Impact Evaluation Study (ESIA Report) has been prepared to meet the national requirements to allow new activities as stipulated in the Executive Regulations for Environmental Permits for the Establishment and Operation of Activities. The study has been prepared to comply with national guidelines of the NCEC. The study meets the international guidelines, specifically the International Finance Corporation.

1.2.2. Methodology

To prepare this Environmental Impact Evaluation Study (ESIA Report) the following tasks have been done:

- Search and examine bibliography and secondary information sources (e.g., available online databases and reports).
- Study of relevant mapping and aerial photography's.
- Initial site visit and field work surveys: Fauna, flora, noise, air quality, archaeology, and geotechnical surveys.
- Review of similar projects´ EIAs and other environmental reports.
- Analysis of the project and previous proposed works.

The early incorporation of environmental mitigation measures to the project design have helped to, avoid, reduce, or offset significant adverse impacts. Mitigation hierarchy has been considered during the design of the project: Avoid, Minimize / Reduce, Mitigate, and Compensate; so, it will be possible to:

- Anticipate and avoid risks and impacts.
- If avoidance is not possible, minimize or reduce risks and impacts to acceptable levels.
- Once risks and impacts have been minimized or reduced, mitigate them.
- Compensate significant impacts occurrence.

1.2.3. Objectives of the ESIA Report

The goal of the Environmental Impact Evaluation Study (ESIA Report) is to describe the current state of the environment within and around the site area; to describe the project (its vision and actions involved), to identify the impacts that it will produce on the environmental attributes and society as well as to suggest prevention and mitigation measures for the foreseen impacts.

The main objectives of this ESIA Report related to the project are:

- Identify and analyse of sensitive components in the current environment.
- Review of existing studies; document the current environmental conditions of the specific site and regional conditions as much as possible to explain the situation of the environment before starting the project. All potentially affected receptors must be reviewed.
- Determine the type, nature, and significance of potential environmental and/or social impacts during the construction, operation, and decommissioning phases.
- Identify and recommend practical/feasible mitigation measures early in the design process to eliminate, reduce, mitigate or avoid any negative environmental and/or social impacts resulting from the project.
- Recommend environmental and social management/monitoring plans for the project in order to avoid, eliminate and/or reduce potential negative environmental and/or social impacts.

1.2.4. Scope of the Study

The scope of the study refers to all the works that, in a general way, shall be developed along Afif 1 Solar Power Project.

1.3. Structure of the Study

The Environmental Impact Evaluation Study (ESIA Report) contains the following content:

- The environmental legal framework and standards of application,
- The description of the project and alternatives,
- The analysis of the environmental baseline conditions,
- The characteristics of potential impacts and
- Mitigation measures and Plans.

The document includes maps, photographs, figures, and tables to better illustrate and present its context.

The Environmental Impact Evaluation Study is consistent with the structure and content set out in the Appendix 2 of the Environment Law issued by Royal Decree No. M/165 of 19/11/1441 AH. The structure of the study is the following:

1.Introduction.

2.Institutional and Regulatory framework of the study.

3. Activities Description.

4.Description of the surrounding environment.

5.Impact identification, analysis, and evaluation.

6. Plans.

7. Summary.

8.Annexes.

1.4. Information about the Permit Applicant

The establishment requesting the Permit is the **Principal Buyer (PB)** or Saudi Power Procurement Company (SPPC).

Principal Buyer Roles & Responsibilities are the following:

- Energy Procurement.
- Executing PPA. ECA and On-sale agreement.
- Counterparty to Existing Generation.
- Fuel Procurement.
- Cross Border Trading.
- Reducing System Costs.
- Market Transformation to Uphold central role and actively participation in the transformation of KSA Electricity Market.
- Electricity Market Efficiency Improvement.
- To create competition & Transparency.
- Contracting Excellence.
- Optimizing Balancing Funds.
- Future Capacity Planning to conduct optimum seven years future planning in order to avoid excess or short generation capacity in the market.
- System Services.
- Power Scheduling.
- Metering Compliance.

The Kingdom of Saudi Arabia (KSA) is reforming its electricity sector with the objective of introducing a Competitive Electricity Market (CEM). The Competitive Electricity Market will aim to improve efficiency, transparency of the sector through continuous competitive price discoveries and enhance participation of all market players and to sustainably move from a regulated electricity market with the vertically integrated utility towards a competitive electricity market. Principal Buyer (PB) or Saudi Power Procurement Company (SPPC) has been granted the license to facilitate the transitions and the major changes in the sector.

Principal Buyer has a central role in facilitating market transition as a "Transformation Agent" and Its governance is a key enabler. It needs give key Government bodies that have the target to transform the market the possibility to steer SPPC in the right direction and integrate relevant stakeholder views.

The new market design will be measured against the objective to increase welfare by removing operational inefficiencies and large subsidies.

To build up the National Renewable Energy Program (NREP), KSA Vision 2030 has set an initial target of generating 9.5 GW of renewable energy projects up to 2023. To ensure the successful implementation of NREP, Principal Buyer has pivotal role in the whole process and will be counterpart of all Power Purchase Agreements of renewable energy power Projects. PB will procure all energy from these RE power projects and make payments up to the useful technical and contractual life of 20 to 25 years of the projects.

1.5. Information about the Environmental Service Provider Consultant who prepared the study

AH Environmental Consulting Office has been appointed by the Applicant as Sub-contractor for the ESIA on the Proposed Development. The ESIA Report has been prepared by AH Environmental Consulting Office and TYPSA in accordance with the relevant national and international environmental laws and regulations.

Service provider	Ali Khudair Al-Harbi Environmental Consulting Office
NCEC registration Number	2371
Office address	Eastern Province - Khobar - Olaya District
Phone	+966 13 881 3898
Fax	+966 13 897 8840
E-mail	Info@ahenviro.com

Figure 4. Information about the Service Provider.

Senior and Junior national and international experts have been involved in the ESIA Report. Initial field works have been carried out by TYPSA experts. Local experts from AH Environmental Consulting Office (AHEC) have carried out environmental baseline surveys. Geotechnics´ team from TYPSA have carried out geotechnic and groundwater survey.

Team members mentioned in the following table have carried out the Environmental Studies and have prepared the present document. In coordination The CVs of the authors are listed in the annexes (section 8.2).

Name of Expert	Educational Qualification	Experience	Organization
Local team from AH Environmental Consulting Office (AHEC)			
Ennacer BESGHAEIR	BEng in Chemical Engineering	16 years	AHEC
Abderrazzak ZEMZEMI	BEng in Hydraulic and Water Resources	14 years	AHEC
Bechir FRADJ	Bachelor's Degree in Earth and Life Sciences Master's degree in Environmental Sciences	6 years	AHEC
Nadia MEDIUONI	BEng in Hydrometeorological Sciences	13 years	AHEC
Marouane CHOUCHANE	BEng in Chemical Engineering	7 years	AHEC
Amer BEN SAAD	Chemical Process Engineering	16 years	AHEC
Muhammad LLYAS	Environmental Engineer	10 years	AHEC

Name of Expert	Educational Qualification	Experience	Organization
Environment´s team from TYPSA			
Mª Luisa Villalmanzo	MSc Biological Science. 1987. Master's degree in environmental Impact Assessment and Mitigation Measures. 1989-1991.	37 years	TYPSA
Marta Muriel	BSc in Environmental Sciences 1998. Postgraduate course on Rural Planning related to the Environment 1999.	26 years	TYPSA
Patricia Rullán	BSc in Environmental Sciences 2002. Master's degree in Private Enterprise Environmental Management 2002.	22 years	TYPSA
Nuria Mesonero	BSc in Environmental Sciences 2001. Master's degree in environmental engineering and management 2002	23 years	TYPSA
Divyangi Singh	BSc in Technology, Mechanical Engineering 2019. MSc in Business and Management 2022. Master´s degree in International Management and Sustainability 2022.	5 years	TYPSA
Raúl Moral	BSc in Environmental Engineering 2023.	1 year	TYPSA
Support team from TYPSA			
Project´s team (Luis Trijueque and Alejandro Tolosa); geotechnics´ team (Pedro Adalia and Álvaro Barrero), and hydrolgy´s team (Javier Lopez and Samuel Perez) from TYPSA			

Table 1. Team involved in the study and reporting

Institutional and Regulatory framework of the study

2. Institutional and Regulatory framework for the study

2.1. Institutional Framework

During the performance of the project, several coordination activities will be carried out between the Stakeholders and the Principal Buyer with two main objectives:

- To gather information and data required for the project.
- To reach agreements and non-objection statements to the project design from the various stakeholders' involved departments.

In order to do so, several meetings, exchange of communication and discussion will be held with the officials, subconsultants and representatives.

The following stakeholders have been identified:

ID	Stakeholder	Relation with the project
1	CST (Communication, Space and Technology Commission)	Future projects of the Commission close to the project site
2	GACA (General Authority of Civil Aviation)	The flight way, if any, in the project area (impacts of solar glint and glare on aviation activity)
3	KSRNR King Salman Ibn Abdulaziz Royal Natural Reserve	
4	MAWANI (General Ports Authority)	
5	MCIT (Ministry of Communications and Information Technology)	Future projects: telecommunications networks, relay towers, broadcasting stations, and landline telephone lines at the project site
6	MEWA (Minister of Environment, Water and Agriculture)	Plans for future protected areas

ID	Stakeholder	Relation with the project
7	MIM (Ministry of industry and mineral resources)	
8	MOC (Ministry of Culture)	Interest in the development of the project. Interest may include potential environmental and social risks related to the project construction.
9	MOD (Ministry of Defence)	Neighbouring / Security restrictions that must be taken into account
10	MOMRA (Ministry of Municipal and Rural Affairs)	Solar power plant in the territory
11	MODON (Saudi Authority for Industrial Cities and Technology Zones)	Industrial projects close to the project / Industrial Permit
12	MOI (Ministry of Interior)	Security restrictions that must be taken into account
13	MOT (Ministry of Transport and Logistic Services)	Transport and traffic organization
14	MT (Ministry of Tourism)	Project impact on tourism activities
15	MWAN (National Centre for Waste Management)	Waste management
16	NCEC (National Center for Environmental Compliance)	Environmental Permit to Construct / Environmental Permit to Operate.
15	NCW (The National Centre for Wildlife)	Biodiversity protection / Environmental restrictions
17	NWC (National Water Company)	
18	PIF (Public Investment Fund)	
19	SANG (Saudi Arabian National Guard)	Neighbouring / Security restrictions that must be taken into account
20	SANS (Saudi Air Navigation Services)	
21	SAR (Saudi Railway Company)	Current and future plans for railways around the project site
22	Saudi Aramco	
23	SEC (Saudi Electric Company)	
24	SWCC (Saline Water Conversion Corporation)	
25	TGA (Transport General Authority)	Neighbouring / Transport and traffic organization

Table 2. Stakeholders

Regarding nomadic community, the presence of nomads' settlements in the desert is seasonal and variant year to year, as their lifestyle revolves around mobility and camel herding. Nomadic community is very small and personal contacts will be held with them before the construction of the solar plant, to relocate the nomad activity out of the boundaries of the site, avoiding the interference with the operations and development of the project.

2.2. Regulatory Framework

2.2.1. National environmental laws, regulations, standards and requirements

The main environmental regulator with responsibility for the terrestrial environmental management of Kingdom of Saudi Arabia's (KSA) is the Ministry of Environment, Water and Agriculture (MEWA). The National Centre for Environmental Compliance (NCEC) is concerned with preserving and protecting the environment, preserving its resources, and preserving it from deterioration, by providing high-quality services that contribute to raising the level of compliance with environmental regulations and standards.

The project will comply with the requirements of the Environmental Law issued by Royal Decree No. (M/165) dated 19/11/1441 AH and Cabinet's Decision No. (729) of 16/11/1441 AH and its implementing Executive Regulations (mainly for Environmental Permits for the Building and Operating Activities and the current 2021 Standards for Water Quality, Air Quality, Soil pollution and Noise), and other national legislation and national standards (Waste 2012 Standards).

The key elements of national legislation and standards that apply to the proposed project are summarized in table below.

ID	Regulations Description and Standards
1	Environment Law issued by Royal Decree No. (M/165) dated 19/11/1441 AH and Cabinet's Decision No. (729) of 16/11/1441 AH and its implementing Executive Regulations, which contain the current 2021 standards*. These Executive Regulations and Standards are: ▪ Air Quality. **Air Quality Standards 2021M (Ministerial Decision No. 512258/1/1442).** ▪ Control of Violations and Imposition of Penalties (**Ministerial Decision No. 312186/1/1442**). ▪ Environmental Inspection and Audit (**Ministerial Decision No. 393691/1/1442**). ▪ Environmental Permits for Establishment and Operation of Activities (**Ministerial Decision No. 436153/1/1442**). ▪ Environmental Rehabilitation for degraded sites and Remediation of contaminated sites (**Ministerial Decision No. 436146/1/1442**). ▪ Environmental Services Providers (**Ministerial Decision No. 582979/1/1442**). ▪ Noise. **Noise levels standards 2022 (Ministerial Decision No. 478038/1/1442).** ▪ Ozone-depleting Substances and Carbon Compounds 2022. **Ministerial Decision No. 446653/1).** ▪ Prevention and Treatment of Soil Pollution. **Standards for protecting soil from pollution 2022 (Ministerial Decision No. 449351/1).** ▪ Protection of Aquatic Environments from Pollution. **Ambient water quality standards (Ministerial Decision No.603639/1/1442).** ▪ **Protected Areas (Ministerial Decision No.48824/1).** ▪ **Vegetation cover development and Combating Desertification 2021M (Ministerial Decision No. 354566/1/1442).**
2	Water law issued by the Royal Decree No. (M/159) dated 11/11/1441 AH. **Treated wastewater quality standards** and **Commercial wastewater quality standards- to municipal collection systems**.
3	Basic Law of Government
4	Labour Law
5	Law of Antiquity (Royal Decree M/3 dated 9/1/1436 AH)
6	Law of Waste Management (Royal Decree M/3 dated 5/1/1443 AH)

*As an exception, the provisions relating to waste contained in the General Environmental Regulation - issued by Royal Decree No. (M/34) dated 7/28/1422 AH - continue until the issuance of its provisions, and work accordingly

Table 3. National Standards and Regulations

2.2.1.1. Environmental Law, promulgated by Royal Decree No. (M/165) dated 19/11/1441 AH and Cabinet's Decision No. (729) of 16/11/1441 AH, and its Executive Regulations

The first comprehensive Saudi Arabian National Environmental legislation was enacted in 2001 in the form of the General Environmental Regulation. It entered into force in 2002, and its Implementing Rules were published in 2003. The Environment Law, promulgated by Cabinet's Decision No. (729) of 16/11/1441 AH and Royal Decree No. (M/165) dated 19 Dhu al-Qadah1441 AH (corresponding to 10 July 2020) entered into force in January 2021, superseding the 2001 Regulation. The Cabinet Decision No. (729) and the Royal Decree M/165 have the same text in the first two articles. Article 1 refers to the Approval of the Environmental Law in both cases. The difference is in the article 3 for Cabinet Decision 729 which includes responsibilities of MEWA and the governmental entities regarding the environmental protection.

Under the General Environmental Regulation, the Presidency of Meteorology and Environment (the PME), an agency of the Ministry of Defence, was charged with the general supervision of environmental affairs in Saudi Arabia and had the responsibility of granting environmental permits. In 2019, the PME's functions and

responsibilities were transferred to four Centres for the environment sector development: The National Centre for Environmental Compliance, the National Centre for Vegetation Cover and Combating Desertification, the National Centre for Wildlife and the National Centre for Meteorology. The Ministry of Agriculture was renamed to the Ministry of Environment, Water and Agriculture (MEWA) in 2016, and now handles responsibilities related to environmental sustainability as well.

The current Environment Law has granted the National Centre for Environmental Compliance with full powers to assume the responsibility of protecting the environment in the Kingdom of Saudi Arabia and to issue environmental standards and guidelines, including environmental legislation and standards for various industrial and construction activities. This Law consisting of 49 articles divided into 9 Chapters aims at protecting the environment, its development and sustainability, adherence to environmental principles, and the regulation of the environment sector and related activities and services.

According to Article 8 of the Environmental Law, both the authorized person and the licensee who engage in activities that may emit emissions or pollutants, or that may affect the environment; commit to the following:

- Environmental requirements, controls, procedures, and standards; determined by the regulations.
- Take the necessary actions and measures when approaching the environmental standards exceedance as specified by the regulations.
- Develop programs and devices to monitor, measure and control the quality of environmental media, in accordance with the regulations.
- Providing the competent authority - on a regular basis - with data and reports related to emissions or pollutants emanating from its activities; To review and conform them, and to identify violations of standards, and requirements, in accordance with what is specified by the regulations.
- Provide the competent authority with an environmental audit study, as determined by the regulations.
- Rehabilitation of environmental environments degraded as a result of the exercise of its activities, as determined by the regulations.

The Environmental Law is implemented through Executive Regulations in different areas including:

- Environmental Inspection and Audit.
- Ozone-depleting Substances and Carbon Compounds.
- Environmental Permits for Establishment and Operation of Activities.
- Environmental Rehabilitation for Degraded Sites and Remediation of Polluted Sites
- Prevention and Treatment of Soil Pollution
- Air Quality
- Control of Violations and Imposition of Penalties
- Noise
- Environmental Services Providers
- Protection of Aquatic Environments from Pollution
- Trade in Wildlife and their Products and Derivates

Finally, the Environmental Law after its entry into force, cancels the following:

A- The law of the Saudi Wildlife Authority, issued by Royal Decree No. (M/22) dated 9/12/1406 AH.

B - The Law of Hunting Wild Animals and Birds, issued by Royal Decree No. (M/8) dated 4/16/1420 AH.

C - The law of trade in endangered wildlife and their products, issued by Royal Decree No. (M/9) dated 6/3/1421 AH.

D - The General Regulations for the Environment, issued by Royal Decree No. (M/34) dated 7/28/1422 AH.

E - The Law of Pastures and Forests, issued by Royal Decree No. (M/55) dated 10/29/1425 AH.

F- The Law of Protected Areas for Wildlife, issued by Royal Decree No. (M/66) dated 10/19/1436 AH.

G - Cabinet Resolution No. (22) dated 29/1/1430 AH, regarding the establishment of the Environment Council.

H - Cabinet Resolution No. (90) dated 10/3/1437 AH, regarding amending the governance and functions of the Environment Council.

I- All provisions inconsistent with it.

As an exception to sub-paragraph (D), the provisions relating to waste contained in the General Environmental Regulation - issued by Royal Decree No. (M/34) dated 7/28/1422 AH - continue until the issuance of its provisions and work accordingly.

Executive Regulations and Standards 2021

These Executive Regulations are approved by Ministerial Decision of the Minister of Environment, Water and Agriculture and based on Article 48 of the Environmental Law and Cabinet Resolution No. (729) dated 16/11/1441 AH. The following is a brief description of the Executive Regulations that are mainly applicable to the project and the current 2021 standards, if any.

Executive Regulations for Environmental Permits for Establishment and Operation of Activities (Ministerial Decision No. 436153/1/1442)

According to the Executive Regulations for Environmental Permits for Establishment and Operation of Activities, the provisions of this Regulations shall apply to all persons who own or operate any activity that has an environmental impact (new or existing) within the territory of the Kingdom including establishment, modification, addition, expansion, or closure.

The National Centre for Environmental Compliance is entrusted with the following tasks:

- Issuing technical standards and controls related to environmental impact assessment studies in coordination with the competent environmental centres.
- Receiving and reviewing environmental classification forms and environmental impact assessment studies and issuing relevant decisions.
- Issuing up-to-date indicative lists to classify the various activities in accordance with the provisions of the regulation.
- Defining and approving the rules, conditions and controls related to environmental permits and licenses.
- Carrying out field visits to the sites required to be authorized, when needed.
- Monitor the implementation of the environmental management plan during all phases of any environmentally authorized activity.
- Request and review self-monitoring reports during construction and operation processes.
- Issuing and renewing environmental permits and licenses and collecting the fees specified for them.

- Monitoring and supervising the implementation of the requirements of environmental permits and licenses.
- Inspection, monitoring and detection of violations of these Regulations; Coordination with the competent authority at the Ministry of Interior when needed with regard to the work of arresting violators.
- Coordination with other national environmental centres whenever the activity or studies presented are related to the competencies or powers of these centres.
- Coordination with laboratories, scientific and research centres, and experts whenever the need arises when reviewing environmental impact assessment studies.
- Ensure that all environmental impact assessment studies, analyses, tests, and environmental measurements contained in these studies are provided by a service provider licensed by the Centre.

The NCEC categorizes or revises the classification of activities according to environmental impacts into categories specified in this regulation as follows:

- Type and volume of activity.
- Energy used.
- Activity depletion of natural resources.
- Land uses.
- Sensitive receptors in areas surrounding the activity.
- The characteristics of environmental impacts, including:
    - The nature of the effects (negative or positive, direct, or indirect, cumulative...etc).
    - The range of the effects.
    - Duration of effects.
    - The ability of effects to be reversible and return to normal before effects.
    - The possibility of effects.
    - Level/level of impacts (global - regional - local).

The head of the Centre shall issue updated indicative lists to classify the various activities in accordance with the provisions of the regulations.

Activities are classified into three categories according to the environmental impacts resulting from them and accordingly, their need to conduct an environmental impact assessment study or not. This classification shall be as follows:

- First category: Activities that are expected to cause minimal impacts on the environment that do not exceed the limits of the activity site.
- Second category: Activities that are expected to cause moderate impacts on the environment through the different phases of the activity and these effects can be reduced and controlled and they do not significantly exceed the limits of the activity site.
- Third category: Activities that are expected to cause significant environmental and social impacts. These impacts exceed the boundaries of the activity site and may negatively affect the sustainability of sensitive areas and receptors.

Referring to the Environment Law, promulgated by Royal Decree No. (M/165) dated 19 Dhu al-Qadah1441 AH (corresponding to 10 July 2020) and Cabinet's Decision No. (729) of 16/11/1441, and according to NCEC

decision, the project has been classified as a Category Two which calls for an environmental impact evaluation study.

An environmental permit will be required before starting any construction or modification of the activity and also to operate before operating or practicing any activity.

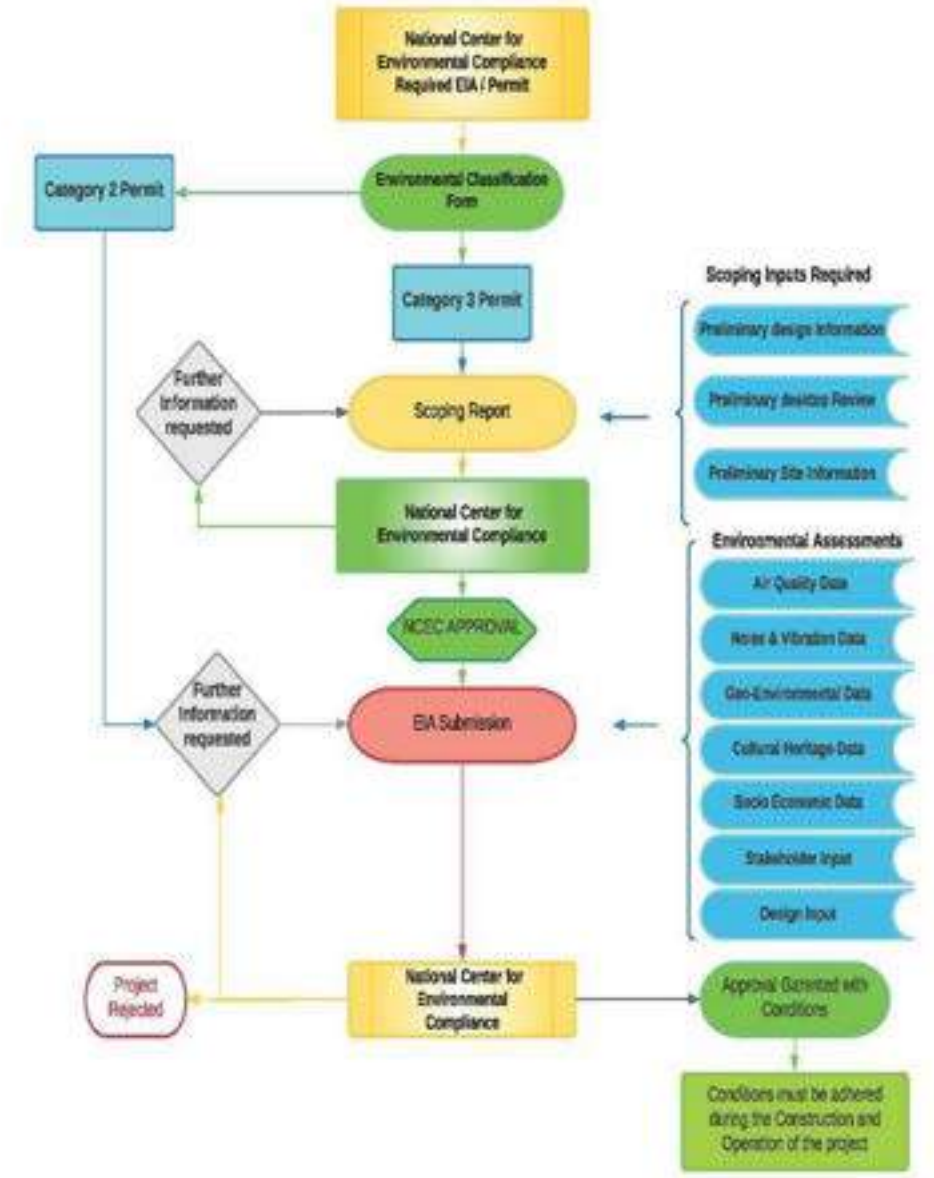


Figure 5. NCEC EIA flow process

Executive Regulations for Environmental Inspection and Audit (Ministerial Decision No. 393691/1/1442)

According to the Executive Regulation for Environmental inspection and Audit, the provisions of this Regulation shall apply to all persons who own or operate any activity that has an environmental impact (new or existing) within the territory of the Kingdom including establishment, modification, addition, expansion, or closure.

The National Centre for Environmental Compliance is entrusted with the following tasks:

- Preparing the methodology for environmental inspection for different activities based on the international best practices.

- Prepare and implement an annual environmental inspection plan.
- Inspect, control and penalties.
- Inspection, Control and Detecting violations of the environmental law or executive regulations and coordinating with the competent authority at the Ministry of Interior when needed with regard to security monitoring work and arresting violators.
- Reviewing people's environmental self-inspection reports and ensuring environmental compliance and the effectiveness of approved self-inspection programs
- Preparing requirements and controls related to environmental audit studies.
- Reviewing reports of environmental audit studies and issuing relevant decisions
- Follow up the commitment of people to implement what is stipulated in the environmental self-inspection reports, environmental audit study reports, and action plans to implement corrective measures.
- Issuance of environmental compliance certificates
- Coordination with other national environmental Centre when needed with regard to inspection work whenever the submitted reports and plans are related to the competencies or powers of these Centre.

Environmental inspection is classified into 5 categories. This classification shall be as follows:

1. Periodic inspection: It is carried out in accordance with the annual plans for environmental inspection in order to verify compliance with the rules and regulations and requirements of licenses and permits.
2. Environmental emergency inspection: It is carried out after the occurrence of any emergency to ensure that all corrective and precautionary measures have been taken.
3. Inspection to verify the validity of reports and data: It is carried out to verify the correctness of the information provided through reports and data submitted to the center.
4. Inspection upon receiving environmental complaints or communications: Execution is carried out after receiving complaints or reports to the center and based on what the center decides that the complaints or communications require inspection.
5. Inspection in partnership with the relevant authorities: In the event of the formation of committees from several specialized bodies working to study any cases related to the environment sector, emergency or environmental disaster related to all participating parties, or at the request of the supervisory authority.

The Centre conducts the inspection by sending specialized inspectors to

- review records and data and keep copies of them.
- Take pictures for documentation.
- Carrying out any operations required for inspection/examination/measurement/or testing.
- Taking samples of materials / soil / water.
- Ensure that the environmental management plan is implemented.
- Detecting violations and taking action.
- Documenting the results of the inspection process and providing companies with a copy of it to take the necessary corrective measures.

Environmental auditing

According to the Executive Regulations for Environmental inspection and audit, both the authorized person and the licensee who engage in activities that may emit emissions or pollutants, or that may affect the

environment; commit to provide the competent authority with an environmental audit study, as determined by the regulations in case of renew the environmental permit to construct or to operate or if required from the centre.

Executive Regulations for Control of Violations and Imposition of Penalties (Ministerial Decision No. 312186/1/1442)

This regulation sets out the method and procedures for detecting violations of environmental law and regulations, investigating, and proving them by the inspectors. They may request assistance and support from the security authorities when needed.

- Anyone who violates the obligations of law or regulations, as indicated in the penalty's tables attached to the regulations, shall be punished.
- The violator must remove the consequences of the violation and rehabilitate the environment in accordance with the requirements and standards set by the competent authority.

(Violations are seized by writing a seizure report that includes information on the location, date, details, time of seizure, the names of the violators, their nationalities, and their identification numbers, ...).

Executive Regulations for Air Quality (Ministerial Decision No. 512258/1/1442)

The Executive Regulations for Air Quality establishes the provisions related to air quality and its protection from pollution. It includes "Air Quality Standards for Basic Pollutants" in its Annex (1) and "Air Quality Standards for Hazardous Pollutants" in its Annex (2), excluding accidents and natural conditions such as dust storms, forest fires, volcanoes, etc. and cases decided by the Centre related to accidents and internal disasters. The table included in the annex 1 of this Executive Regulation is shown below:

Pollutant	Measurement micrograms/m3 (µg.m-3)*	Permissible transgressions	Average time
Carbon Monoxide CO	40,000	Once a year	hour
	10,000	Twice a month	8 hours
Nitrogen dioxide NO_2	200	24 per year	hour
	100	-	annual
Sulphur dioxide SO_2	441	24 per year	hour
	217	3 per year	24 hours
	65	-	annual
Ozone O_3**	157	25 days annually, averaged over 3 years	8 hours
suspended particles (<10 µm) PM_{10}***	340	12 per year	24 hours
	50	-	annual
suspended particles (<2.5 µm) $PM_{2.5}$***	35	12 per year	24 hours
	15	-	annual
Lead in suspended particles Pb (in TSP)	0.15	Average over 3 months with no irregularities	3 months

Notes:

* Values are based on a standard temperature of 25°C and a pressure of 1 atmosphere.

** To calculate the 8-hour ozone value and to assign it to the appropriate day, the following rule is applied: The maximum daily concentration for 8 hours must be determined by checking the running averages for 8 hours, calculated from the hourly data and updated hourly. Each average 8 hours calculated is assigned to the day it expires, meaning that the first calculation period for any day will be the period from 5 pm on the previous day to 1 am of the day. The last calculation period for any day is from 4 after noon to 12 o'clock at night.

*** Calculation of excesses: The contributions from natural sources can be assessed by measurements, modelling, and remote sensing. These contributions are subtracted from the air quality monitoring results, thus calculating exceedances.

Table 4. Air Quality Standards for Basic Pollutants Source: Executive Regulations for Air Quality (2021)

Executive Regulations for Noise (Ministerial Decision No. 478038/1/1442)

The provisions of the Executive Regulation for Noise shall apply to all persons in residential, commercial, industrial, and environmentally sensitive areas, roadsides, and construction sites, not including indoor noise. Article 4 contains the noise levels standards for residential and commercial areas including the following categories:

- A: includes low-density residential areas in addition to iconic areas, including tourist attractions and recreational parks, and areas around hospitals, schools and homes for the elderly, nurseries, and environmentally sensitive areas
- B: Includes residential areas of medium density
- C: Includes high-density residential areas and areas that include a mixture of residential and commercial activities
- D: Includes commercial areas, including warehouses and financial centres.

It is not permitted to exceed the noise levels established for residential and commercial areas, except with the permission of the NCEC, which are shown in the next table:

Category	Daytime $L_{Aeq,}$ T (dB)	Night-time $L_{Aeq,}$ T (dB)
A	50	40
B	55	45
C	60	50
D	65	55

Table 5. Measurement noise levels for residential and commercial areas. Noise Levels Standards. Source: Executive Regulations for Noise (2021)

Article 5 contains the standards that must be applied on the sides of roads and highways. The project area is next to a road. Therefore, it is prohibited to exceed the following noise levels standards, except with the permission of the NCEC:

Daytime $L_{Aeq,}$ T (dB)	Night-time $L_{Aeq,}$ T (dB)
70	65

Table 6. Noise level standards on roadsides. Source: Executive Regulations for Noise (2021)

Article 7 sets the limits for permitted noise levels at construction sites so that the noise level standards set out in this Regulation are allowed to be exceeded during construction works from 7 am to 6 pm, as indicated in the following table:

Duration of the construction activities	Correction of permitted noise limits $L_{Aeq,}$ T (dB)
Up to 2.5 hours	10
2.5 to 8 hours	5
Above 8 hours	0

Table 7. Corrective limits for permitted noise levels at construction site. Source: Executive Regulations for Noise (2021)

Annex 1 of this Regulation contains the requirements for monitoring noise levels:

- The information to be recorded, including date, time and place of the measurements and the name of the operator who made them; Type of devices, procedures and any calculations used, etc.
- Measurements conditions including weather and other conditions such as directing the microphone towards the noise source or avoiding electrical or electromagnetic interference such as meteorology conditions, among others.

Executive Regulations for Prevention and Treatment of Soil Pollution (Ministerial Decision No. 449351/1)

The Executive Regulation for Prevention and Treatment of Soil Pollution establish the provisions related to soil and its protection from pollution, including "Standards for protecting soil from pollution" in its Annex (1). The following table shows a summary of the table contained in Annex 1, including only the data applicable to the project:

Parameter	Unit	Soil particle size classification				Notes
		Soft soil (silt and clay)		Coarse soil (sand and gravel)		
		Types of land use				
		Commercial	Residential	Commercial	Residential	
PH (in 0.01M $CaCl_2$)	PH Unit	8.5	8.5	8.5	8.5	
Cyanide (free)	mg/kg	8	0.9	8	0.9	
Fluoride	mg/kg	2,000	200	2,000	200	
Sulphur (elemental)	mg/kg	500	500	500	500	
Metals						
Antimony (Sb)	mg/kg	40	20	40	20	
Arsenic (inorganic) (As)	mg/kg	26	17	26	17	
Barium (non-barite) (Ba)	mg/kg	2,000	500	2,000	500	
Barite-Barium	mg/kg	15,000	10,000	15,000	10,000	
Beryllium (Be)	mg/kg	8	5	8	5	
Boron (saturated phase extract)	mg/kg	5	3.3	5	3.3	
Cadmium (Cd)	mg/kg	22	10	22	10	
Chromium (Hexavelent)	mg/kg	1.4	0.4	1.4	0.4	
Chromium (Total)	mg/kg	87	64	87	64	
Cobalt (Co)	mg/kg	300	20	300	20	
Copper (Cu)	mg/kg	91	63	91	63	
Lead (Pb)	mg/kg	260	140	260	140	
Mercury (Inorganic)	mg/kg	24	6.6	24	6.6	
Molybdenum (Mo)	mg/kg	40	4	40	4	
Nickel (Ni)	mg/kg	89	40	89	40	
Selenium (Se)	mg/kg	2.9	1	2.9	1	
Silver (Ag)	mg/kg	40	20	40	20	
Thallium (Tl)	mg/kg	1	1	1	1	
Tin (Sn)	mg/kg	300	5	300	5	
Uranium (U)	mg/kg	33	23	33	23	
Vanadium (V)	mg/kg	130	130	130	130	
Zinc (Zn)	mg/kg	360	200	360	200	
Hydrocarbons						
Benzene (C_6H_6)	mg/kg	0.046	0.046	0.078	0.073	Surface soil
		0.046	0.046	0.078	0.078	Sub-surface soil
Toluene (C_7H_8)	mg/kg	0.52	0.52	0.12	0.12	Surface soil
		0.52	0.52	0.12	0.12	Sub-surface soil
Ethylbenzene (C_8H_{10})	mg/kg	0.073	0.073	0.14	0.14	Surface soil
		0.073	0.073	0.14	0.14	Sub-surface soil
Xylenes (C_8H_{10})	mg/kg	0.99	0.99	1.9	1.9	Surface soil

Parameter	Unit	Soil particle size classification				Notes
		Soft soil (silt and clay)		Coarse soil (sand and gravel)		
		Types of land use				
		Commercial	Residential	Commercial	Residential	
		0.99	0.99	1.9	1.9	Sub-surface soil
Styrene	mg/kg	0.68	0.68	0.8	0.8	
F1 (C6 to C10)	mg/kg	320	210	270	24	Surface soil
		640	420	440	30	Sub-surface soil
F2 (C10 to C16)	mg/kg	230	150	260	130	Surface soil
		520	300	520	160	Sub-surface soil
F3 (C16 to C34)	mg/kg	2,500	1,300	1,700	300	Surface soil
		4,300	2,600	3,400	600	Sub-surface soil
F4 (C34 to C50)	mg/kg	6,600	5,600	3,300	2,800	Surface soil
		10,000	10,000	6,600	5,600	Sub-surface soil
Acenapthene ($C_{12}H_{10}$)	mg/kg	0.32	0.32	0.38	0.38	
Anthracene ($C_{14}H_{10}$)	mg/kg	0.0046	0.0046	0.0056	0.0056	
Fluoranthene ($C_{16}H_{10}$)	mg/kg	0.032	0.032	0.039	0.039	
Fluorene ($C_{13}H_{10}$)	mg/kg	0.29	0.29	0.34	0.34	
Naphthalene ($C_{10}H_8$)	mg/kg	0.014	0.014	0.017	0.017	
Phenanthrene ($C_{14}H1_0$)	mg/kg	0.051	0.051	0.061	0.061	
Pyrene ($C_{16}H_{10}$)	mg/kg	0.034	0.034	0.04	0.04	
Carcinogenic PAHs	mg/kg	1	1	1	1	
Benz[a]anthracene ($C_{18}H_{12}$)	mg/kg	0.07	0.07	0.083	0.083	
Benzo[b+j]fluoranthene	mg/kg	-	-	-	-	
Benzo[k]fluoranthene ($C_{20}H_{12}$)	mg/kg	-	-	-	-	
Benzo[a]pyrene ($C_{20}H_{12}$)	mg/kg	0.7	0.7	0.77	0.77	
Chrysene ($C_{18}H_{12}$)	mg/kg	-	-	-	-	
Halogenated Aliphatic Compounds						
Vinyl chloride (C_2H_3Cl)	mg/kg	0.014	0.0083	0.043	0.034	
1,1-Dichloroethene ($C_2H_3Cl_2$)	mg/kg	0.10	0.10	0.24	0.021	
Trichloroethene (Trichloethylene, TCE)	mg/kg	0.054	0.054	0.081	0.012	
Tetrachloroethene (C_2Cl_4)	mg/kg	0.26	0.26	0.22	0.018	
1,2-Dichloroethane ($C_2H_4Cl_2$)	mg/kg	0.025	0.025	0.033	0.0027	
Dichloromethane (Methylene chloride) (CH_2Cl_2)	mg/kg	0.1	0.1	0.095	0.095	
Trichloromethane (Chloroform) ($CHCL_3$)	mg/kg	0.0029	0.0029	0.003	0.003	

Parameter	Unit	Soil particle size classification				Notes
		Soft soil (silt and clay)		Coarse soil (sand and gravel)		
		Types of land use				
		Commercial	Residential	Commercial	Residential	
Tetrachloromethane (Carbon tetrachloride) (CCl_4)	mg/kg	0.037	0.013	0.0069	0.00057	
Dibromochloromethane ($CHBr_2Cl$)	mg/kg	0.91	0.91	1.5	0.27	
Chlorobenzene (C_6H_5Cl)	mg/kg	0.61	0.39	0.22	0.018	
1,2-Dichlorobenzene ($C_6H_4Cl_2$)	mg/kg	0.097	0.097	0.18	0.18	
1,4-Dichlorobenzene ($C_6H_4Cl_2$)	mg/kg	0.051	0.051	0.098	0.098	
1,2,3-Trichlorobenzene ($C_6H_3Cl_3$)	mg/kg	0.26	0.26	0.31	0.26	
1,2,4-Trichlorobenzene ($C_6H_3Cl_3$)	mg/kg	0.78	0.78	0.93	0.23	
1,3,5-Trichlorobenzene ($C_6H_3Cl_3$)	mg/kg	1.9	1.9	1.3	0.13	
1,2,3,4-Tetrachlorobenzene ($C_6H_2Cl_4$)	mg/kg	0.042	0.042	0.05	0.05	
1,2,3,5-Tetrachlorobenzene ($C_6H_2Cl_4$)	mg/kg	0.37	0.37	0.7	0.1	
1,2,4,5-Tetrachlorobenzene ($C_6H_2Cl_4$)	mg/kg	0.19	0.19	0.37	0.052	
Pentachlorobenzene (C_6HCl_5)	mg/kg	3.7	3.7	4.5	4.5	
Hexachlorobenzene (C_6Cl_6)	mg/kg	3.6	3.6	6	0.5	
2,4-Dichlorophenol ($C_6H_4Cl_2O$)	mg/kg	0.0029	0.0029	0.0034	0.0034	
2,4,6-Trichlorophenol ($C_6H_2Cl_3OH$)	mg/kg	0.19	0.19	0.37	0.37	
2,3,4,6-Tetrachlorophenol ($C_6H_2Cl_4O$)	mg/kg	0.039	0.039	0.047	0.047	
Pentachlorophenol (C_6HCl_5O)	mg/kg	0.024	0.024	0.029	0.029	
Dioxins & Furans	mg/kg	0.000004	0.000004	0.000004	0.000004	
Polychlorinated biphenyl (PCBs)	mg/kg	33	22	33	22	
Pesticides						
Aldicarb ($C_7H_{14}N_2O_2S$)	mg/kg	0.041	0.041	0.075	0.075	
Aldrin ($C_{12}H_8C_{16}$)	mg/kg	5.1	3.4	5.1	3.4	
Atrazine and metabolites	mg/kg	0.0088	0.0088	0.01	0.01	
Azniphos-methyl ($C_{10}PN_3H_{12}S_2O_3$)	mg/kg	0.41	0.41	0.75	0.75	
Bendiocarb ($C_{11}H_{13}NO_4$)	mg/kg	0.14	0.14	0.21	0.21	

Parameter	Unit	Soil particle size classification				Notes
		Soft soil (silt and clay)		Coarse soil (sand and gravel)		
		Types of land use				
		Commercial	Residential	Commercial	Residential	
Bromacil ($C_9H_{13}BrN_2O_2$)	mg/kg	0.009	0.009	0.009	0.009	
Bromoxynil ($C_7H_3Br_2NO$)	mg/kg	0.044	0.044	0.052	0.052	
Carbaryl ($C_{12}H_{11}NO_2$)	mg/kg	1.9	1.9	3.6	3.6	
Carbofuran ($C_{l2}H_{15}NO_3$)	mg/kg	0.68	0.68	1.2	1.2	
Chlorothalonil ($C_8Cl_4N_2$)	mg/kg	0.0084	0.0084	0.01	0.01	
Chlorpyrifos ($C_9H_{11}Cl_3NO_3PS$)	mg/kg	49	49	95	95	
Cyanazine ($C_9H_{13}ClN_6$)	mg/kg	0.12	0.12	0.21	0.21	
2,4-Dichlorophenoxyacetic acid ($C_8H_6Cl_2O_3$)	mg/kg	0.43	0.43	0.67	0.67	
Dichlorodiphenyltrichloroethane ($C_{14}H_9Cl_5$)	mg/kg	12	12	12	12	
Diazinon ($C_{12}H_{21}N_2O_3PS$)	mg/kg	2.2	2.2	4.2	4.2	
Dicamba ($C_8H_6Cl_2O_3$)	mg/kg	0.5	0.5	0.79	0.79	
Dichlofop-methyl ($C_{16}H_{14}Cl_2O_4$)	mg/kg	2	2	2.4	2.4	
Dieldrin ($C_{12}H_8Cl_6O$)	mg/kg	0.59	0.59	1.1	1.1	
Dimethoate ($C_5H_{12}NO_3PS_2$)	mg/kg	0.0058	0.0058	0.0055	0.0055	
Dinoseb ($C_{10}H_{12}N_2O_5$)	mg/kg	2.8	2.8	5.5	5.5	
Diquat ($C_{12}H_{12}Br_2N_2$)	mg/kg	11	11	21	21	
Diuron ($C_9H_{10}Cl_2N_2O$)	mg/kg	1.9	1.9	3.5	3.5	
Endosulfan ($C_9H_6Cl_6O_3S$)	mg/kg	0.0013	0.0013	0.0015	0.0015	
Endrin ($C_{12}H_8Cl_6O$)	mg/kg	2.4	2.4	4.7	4.7	
Glyphosate ($C_3H_8NO_5P$)	mg/kg	0.054	0.054	0.049	0.049	
Heptachlor epoxide ($C_{10}H_5Cl_7O$)	mg/kg	0.039	0.039	0.076	0.01	
Lindane ($C_6H_6Cl_6$)	mg/kg	0.31	0.31	0.7	0.7	
Linuron ($C_9H_{10}Cl_2N_2O_2$)	mg/kg	0.051	0.051	0.059	0.059	
Malathion ($C_{10}H_{19}O_6PS_2$)	mg/kg	0.82	0.82	1.3	1.3	
MCPA	mg/kg	0.42	0.42	0.66	0.66	
Methoxychlor ($C_{16}H_{15}Cl_3O_2$)	mg/kg	0.046	0.046	0.056	0.056	
Metolachlor ($C_{15}H_{22}ClNO_2$)	mg/kg	0.048	0.048	0.055	0.055	
Metribuzin ($C_8H_{14}N_4OS$)	mg/kg	0.024	0.024	0.028	0.028	
Paraquat (as dichloride)	mg/kg	1.1	1.1	2.2	2.2	
Parathion ($C_{10}H_{14}NO_5PS$)	mg/kg	7.2	7.2	14	14	
Phorate ($C_7H_{17}O_2PS_3$)	mg/kg	0.075	0.075	0.14	0.14	
Picloram ($C_6H_3Cl_3N_2O_2$)	mg/kg	0.024	0.024	0.022	0.022	
Simazine ($C_7H_{12}ClN_5$)	mg/kg	0.033	0.033	0.038	0.038	
Tebuthiuron ($C_9H_{16}N_4OS$)	mg/kg	0.6	0.046	0.6	0.046	
Terbufos ($C_9H_{21}O_2PS_3$)	mg/kg	0.08	0.08	0.15	0.15	
Toxaphene ($C_{10}H_8Cl_8$)	mg/kg	3.3	3.3	6.3	4.8	
Triallate ($C_{10}H_{16}Cl_3NOS$)	mg/kg	0.0077	0.0077	0.0092	0.0092	

Parameter	Unit	Soil particle size classification				Notes
		Soft soil (silt and clay)		Coarse soil (sand and gravel)		
		Types of land use				
		Commercial	Residential	Commercial	Residential	
Trifluarin ($C_{13}H_{16}F_3N_3O_4$)	mg/kg	0.038	0.038	0.045	0.045	
Other organic compounds						
Aniline ($C_6H_5NH_2$)	mg/kg	0.32	0.32	0.6	0.6	
Bis (2-ethyl-hexyl) phthalate ($C_{24}H_{38}O_4$)	mg/kg	34	34	41	41	
Dibutyl phthalate ($C_{16}H_{22}O_4$)	mg/kg	0.54	0.54	0.65	0.65	
Dichlorobenzidine	mg/kg	4.2	4.2	8.1	8.1	
Diethanolamine ($C_4H_{11}NO_2$)	mg/kg	2	2	3.5	3.5	
Diethylene glycol ($C_4H_{10}O_3$)	mg/kg	10	10	10	10	
Diisopropanolamine ($C_6H_{15}NO_2$)	mg/kg	14	14	17	17	
Ethylene Glycol ($C_2H_6O_2$)	mg/kg	20	20	62	62	
Hexachlorobutadiene (C_4Cl_6)	mg/kg	0.026	0.026	0.031	0.0067	
Methanol CH_3OH	mg/kg	37	37	11	11	
Methylmethacrylate ($C_5H_8O_2$)	mg/kg	1.3	1.3	1.3	0.1	
Monoethanolamine (C_2H_7NO)	mg/kg	20	20	10	10	
Methyl tert-butyl ether (MTBE)	mg/kg	0.044	0.044	0.062	0.046	
Nonylphenol + ethoxylates	mg/kg	14	5.7	14	5.7	
Phenol (C_6H_6O)	mg/kg	0.0028	0.0028	0.0024	0.0024	
Sulfolane ($(CH_2)_4SO_2$)	mg/kg	0.18	0.18	0.21	0.21	
Triethylene glycol ($C_6H_{14}O_4$)	mg/kg	100	100	150	150	
Radioactive compounds						
Uranium -238 Series (all progeny)	Bq/kg	0.3	0.3	0.3	0.3	
Uranium - 238 (^{238}U, ^{234}Th, ^{234}mPa, ^{234}U)	Bq/kg	10	10	10	10	
Thorium-230	Bq/kg	10	10	10	10	
Radium -226(in equilibrium with its progeny)	Bq/kg	0.3	0.3	0.3	0.3	
Lead-210 (in equilibrium with 210 Bi and 210 Po)	Bq/kg	0.3	0.3	0.3	0.3	
Thorium-232 Series (all progeny)	Bq/kg	0.3	0.3	0.3	0.3	
Thorium-232	Bq/kg	10	10	10	10	
Radium-228 (in equilibrium with 228Ac)	Bq/kg	0.3	0.3	0.3	0.3	
Thorium-228 (in equilibrium with its progeny)	Bq/kg	0.3	0.3	0.3	0.3	
Potassium-40	Bq/kg	17	17	17	17	

Table 8. Standards for protecting soil from pollution. Source: Executive Regulations for Prevention and Treatment of Soil Pollution (2021)

Executive Regulations to protect aquatic environments from pollution (Ministerial Decision No.603639/1/1442)

The Executive Regulations for the protection of aquatic environments applies to all persons and activities related to aquatic environments and aims to define the scope of the work of the National Centre for Environmental Compliance. This regulation establishes the provisions related to water (coastal waters, surface water and underground water) for its protection from pollution Including preventive measures to prevent pollution., by proposing standards, controls, and requirements, and preparing and implementing plans aimed at reducing pollution of aquatic environments.

Article 1 states in its first part the classification of water bodies. Water bodies (surface water and ground water) are not present in the project area:

Annex 3 of these Regulations contains information about the measurements for treated wastewater prior to its discharge into soil, land, or surface water. This information is exposed in the following table:

Component	Unit	Medium period	Scale Average value (maximum for any sample)	
			Surface water	Soil/land
Physical metrics				
Fat Oil and Grease (FOG)	mg/l	Sample	(5)	(0)
Total suspended Solids	mg/l	30 days	(40) 25	(50) 35
Total Dissolved Solids (TDS)	mg/l	Sample	(2000)	(2000)
Turbidity	Turbidity unit	Sample	(5)	(5)
Δ Temperature [1]	Δ °C	Sample	(Natural level provided that it does not exceed temperature 40 Celsius in any section of the flat water within 15 meters of treated wastewater estuary)	(Natural level*)
Chemical standards				
Biological Oxygen Demand (BOD_5)	mg/l	30 days	(20) 15	(40) 25
Dissolved Oxygen (DO)	mg/l	Sample	(Minimum: 2)	(Natural level*)
Ammoniacal Nitrogen (NH_3, NH_4-N)	mg/l	30 days	1.9	5
Nitrate Nitrogen (NO_3-N)	mg/l	30 days	10	15
Phosphate (PO_4)	mg/l	30 days	20	30
Free Chlorine	mg/l	Sample	(0.5-0.1)	(0.5-0.1)
Phenols	mg/l	Annual average of monthly samples	0.002	0.002
pH	-	Sample	(6-8.4)	(6-8.4)

Component	Unit	Medium period	Scale Average value (maximum for any sample)	
			Surface water	Soil/land
Aluminium (Al)	mg/l	Annual average of monthly samples	5	5
Arsenic (As)	mg/l	Annual average of monthly samples	0.1	0.1
Beryllium (Be)	mg/l	Annual average of monthly samples	0.1	0.1
Boron (B)	mg/l	Annual average of monthly samples	0.75	0.75
Cadmium (Cd)	mg/l	30 days	0.01	0.1
Chromium (Cr)	mg/l	Annual average of monthly samples	0.1	0.1
Cobalt (Co)	mg/l	Annual average of monthly samples	0.05	0.05
Copper (Cu)	mg/l	Annual average of monthly samples	0.2	0.4
Fluoride (F)	mg/l	Annual average of monthly samples	1	1
Iron (Fe)	mg/l	Annual average of monthly samples	5	5
Mercury (Hg)	mg/l	Annual average of monthly samples	0.001	0.001
Lead (Pb)	mg/l	Annual average of monthly samples	0.1	0.1
Lithium (Li)	mg/l	Annual average of monthly samples	2.5	2.5
Manganese (Mn)	mg/l	Annual average of monthly samples	0.2	0.2
Molybdenum (Mo)	mg/l	Annual average of monthly samples	0.01	0.01

Component	Unit	Medium period	Scale Average value (maximum for any sample)	
			Surface water	Soil/land
Nickel (Ni)	mg/l	Annual average of monthly samples	0.2	0.2
Selenium (Se)	mg/l	Annual average of monthly samples	0.02	0.02
Vanadium (V)	mg/l	Annual average of monthly samples	0.1	0.1
Zinc (Zn)	mg/l	Annual average of monthly samples	2	4
Microbiological parameters				
Total coliform bacteria	(CFU)/ 100 ml	30 days	1,000	2,000
Viable Oval Nematode	Live egg (unit/l)	30 days	1	1

(*) Natural level: Is the level of the natural concentration, that is not affected by any human activity, of the component in the surrounding nature. Note: the natural level does not have to be lower than the levels that are considered safe for human life or wildlife.

(1) Temperature differences (ΔT): They are the maximum temperature differences between the treated wastewater that is discharged and the receiving water. The Centre proposes standards for measuring the temperature differences of treated wastewater according to the types of surface water (sewage, lakes or others) and their characteristics for approval by the Ministry.

Table 9. Measurements for treated wastewater prior to its discharge into soil, land or surface water. Source: Executive Regulations to protect aquatic environments from pollution (2021)

Annex 4 contains in its first part the Wastewater Treatment Techniques, which are shown in the next table:

Processing level	Parameter to be removed	An example of the processing process
A-Pre-treatment	Solids	Filter solids
B-Pre-treatment	Solid materials as well as easily precipitated materials	Primary deposition
C- Secondary treatment	Most solid and Biological Oxygen Demand (BOD)	Biological treatment, chemical treatment, lakes
D- Remove nutrients	Nutrients after removing solids	Biological and chemical sedimentation
E- Purification	Bacteria and viruses	Use of ultraviolet rays, chlorination

Table 10. Wastewater Treatment Techniques. Source: Executive Regulations to protect aquatic environments from pollution (2021)

Executive Regulations for Protected Areas (Ministerial Decision No.48824/1)

The provisions of this Executive Regulation apply to all protected areas managed or supervised by the Center within the Kingdom's territory.

According with article 3, the Center undertakes the tasks related to protected areas, including:

(1) Proposing protected areas in accordance with the provisions of this regulation.

(2) Planning, managing, operating, and supervising the approved protected areas.

(3) Protecting, growing, breeding, and monitoring the state of wildlife species, and restoring endangered species in protected areas and in their natural habitats to maintain a balanced biodiversity.

(4) Setting requirements and controls pertaining to the development and implementation of plans for the rehabilitation of degraded habitats of wildlife species.

(5) Supervising the implementation of programs and plans for the rehabilitation of degraded habitats of wildlife species.

(6) Monitoring habitats of wildlife species.

(7) Undertaking necessary relevant measures to ensure the application of requirements and controls during the implementation of plans for the rehabilitation of degraded habitats of wildlife species.

(8) Issuing a list of service providers licensed by the Center to develop and implement plans for the rehabilitation of degraded habitats of wildlife species.

(9) Identifying sites of degraded habitats that require rehabilitation and determining the numbers and type of wildlife species living therein as well as rehabilitation requirements.

(10) Establishing a database of degraded habitat sites for wildlife species.

(11) Conducting studies and research and collecting all information and data on biodiversity in protected areas.

(12) Coordinating with the National Center for Vegetation Cover and Combating Desertification about the development and protection of vegetation cover in protected areas, including herding.

(13) Setting controls for entering and crossing protected areas, in coordination with the concerned authority at the Ministry of Interior.

(14) Developing and implementing a management plan for the protected area system.

(15) Establishing and regulating investment projects in protected areas and setting the necessary controls and requirements therefor.

(16) Regulating the use of protected areas for tourism, environmental, scientific, research, and other purposes, and setting the necessary controls and requirements therefor.

(17) Coordinating with the concerned authorities regarding the protection of archaeological and historical monuments located in the protected areas.

(18) Developing environmental rules, requirements, and controls in its field of competency thereof for environmental licenses and permits for activities in protected areas.

(19) Coordinating with the supervisory authorities regarding the application of environmental controls and requirements for licensed activities in protected areas.

(20) Issuing licenses and permits - within its field of competency - for activities and works within the boundaries of the protected areas and collecting the financial dues therefor.

(21) Coordinating with the National Center for Environmental Compliance regarding the application of Executive Regulations that fall within its field of competency in the protected areas.

(22) Implementing national action programs and the application of the provisions of international and regional agreements regarding protected areas ratified by the Kingdom and entered into force.

(23) Introducing protected areas and developing awareness programs about the objectives of establishing protected areas and developing wildlife.

(24) Inspecting, monitoring, and apprehending all violations to this Executive Regulation; and coordinating with the security authorities at the Ministry of the Interior, whenever necessary, to apprehend violators.

(25) Set the controls for removing infringements and rehabilitating the resulting damaged and degraded areas.

(26) Issuing licenses for private reserves, including sustainable fishing reserves, in accordance with the requirements and controls specified thereby.

Article 7 refers to the Permits and Licenses Related to Activities in Protected Areas:

(1) Every person must obtain a prior permit or license from the Center to carry out any activity within the protected areas.

(2) The supervising authorities shall coordinate with the Center if they wish to carry out any activity or allocate any sites in the protected areas.

(3) The Deputy Ministry of Agriculture shall coordinate with the Center regarding agricultural activities in protected areas.

(4) The Center shall determine the documents required for each permit or license application.

(5) The Center shall issue its decision on permit and license applications within ten (10) working days as of registration date of each completed application. The Center may, if needed, extend this period by five (5) additional working days.

(6) Permits to cross or search for missing persons or lost livestock in protected areas are immediately granted in accordance with the regulations set by the Center in coordination with the Emirate of the regions.

(7) The issued permit or license shall include a validity term and any controls or requirements set by the Center.

(8) The permit or license shall be issued after paying the financial dues specified by the Center, except for investment licenses, where the dues are set in accordance with the investment contract between the Center and the investor.

(9) All persons must comply with the terms and requirements of the permit or licens.

Executive Regulations for Vegetation cover development and combating desertification (Ministerial Decision No. 354566/1/1442

The provisions of this Executive Regulation apply to all persons and all vegetation cover lands - including degraded lands – as well as lands and coasts within the territory of the Kingdom of Saudi Arabia, that fall under the Center's jurisdiction.

Permits and Licenses Pertaining to Vegetation Cover Lands (Article 10):

"(1) A person must obtain a license, permit, or approval (according to the classification specified by the Center) to allocate or use the vegetation cover lands for activities, including the following:

a. Approval of the construction of public utilities (roads, railways, water, electricity, etc.).

b. Approval of the extraction or exploitation of sand, gravel, rocks, and soil.

c. Approval of the establishment of any housing, agricultural, tourism, or development plans.

d. Approval of the allocation of any industrial or mining complexes, or sites for exploration, prospecting, or exploitation activities.

e. Approval of the exploitation of any natural water source that affects the vegetation cover.

f. Reforestation or afforestation in vegetation lands, gardens, or roads within or outside the urban boundary, and internal and external yards of civil and military establishments.

g. Restauration and leveling of vegetation cover lands.

h. Carrying out any scientific or research activities pertaining to vegetation cover lands.

i. Collection of local plant genetic resources, or any of their vegetative or reproductive parts.

j. Grazing activities in areas authorized for grazing.

k. Establishment of nurseries, herbariums, and botanical gardens.

(2) The Center shall issue its decision on license and permit applications within thirty (30) working days as of the registration date of the application with the Center.

(3) The Center issues the license, permit, or approval comprising the necessary requirements.

(4) The license or permit shall be issued after collection of the financial due; with the exception of investment licenses, where the due is pursuant to the investment contract between the Center and the investor.

(5) License and permit holders must comply with the licenses and permits' requirements.

(6) The grazing permit shall be issued comprising the numbers and types of livestock, the duration of the permit, the authorized time, and the boundaries of the authorized grazing site".

GAMEP Environmental Standards 2012

The General Environmental Regulations and Rules for Implementation were enacted in October 2001, and Appendix 1 of this law outlines the Environmental Protection Standards relevant to facilities in the Kingdom of Saudi Arabia.

In 2012, the GAMEP developed several draft supplementary Environmental Standards revising in part the General Standards for the Environment. These Standards are listed in Table below.

The new Environment Law cancels the General Environmental Regulations and Rules for Implementation but as an exception, the provisions relating to waste continue until the issuance of its provisions (highlighted in light blue in the following Table).

ID	GAMEP Environmental Standards (2012). This is an old version for GAMEP
GAMEP ES 1	Material Recovery and Recycling of Waste
GAMEP ES 2	Mobile Source Emissions (updated with NCEC 2021 standards)
GAMEP ES 3	Noise (updated with NCEC 2021 standards)
GAMEP ES 4	Air Emissions from Stationary Sources (updated with NCEC 2021 standards)
GAMEP ES 5	Prevention of Major Accidents
GAMEP ES 6	Storage and Material Reclamation Facilities-Design and Operation
GAMEP ES 7	Thermal Treatment and Incineration Design and Operation. This standard does not apply to the project
GAMEP ES 8	Waste Acceptance Criteria
GAMEP ES 9	Waste Classification
GAMEP ES 10	Drinking Water Quality (updated with NCEC 2021 standards)
GAMEP ES 11	Biological Treatment – Design and Operation. This standard does not apply to the project
GAMEP ES 12	Waste Regulatory Control and Compliance
GAMEP ES 13	Waste Handling and Storage
GAMEP ES 14	Waste Training
GAMEP ES 15	Waste Transportation
GAMEP ES 16	Landfill design. Only in case of a new Inert Landfill
GAMEP ES 17	Industrial and Municipal Wastewater Discharges Standard (Updated with Water law standards)
GAMEP ES 18	Best Practicable Environmental Option for Waste Disposal
GAMEP ES 19	Ambient Air Quality (updated with NCEC 2021 standards)
GAMEP ES 20	Ambient Water Quality Standard (updated with NCEC 2021 standards)

Table 11. GAMEP Environmental Standards (2012)

Project will comply with Waste National Standards.

A detailed description of Waste National Standards is included in **section 8.3.2**.

2.2.1.2. Water law issued by Royal Decree No. (M/159) dated 11/11/1441 AH

Article 2 states that this Law aims to:

"*1. Preserve, develop, and protect water resources; ensure their sustainability; and manage and regulate such resources, as well as rights related thereto and to their uses.*

2. Ensure the fair provision of safe, clean, reliable, high-quality water supplies to consumers at reasonable competitive prices, to meet their needs.

3. Enhance the private sector's engagement in activities subject to this Law and promote effective governance.

4. Fulfill consumers' needs by providing access to clean and safe water that meets approved specifications in accordance with approved standards, plans, and programs; and

5. Ensure the provision of water supplies to the agricultural sector to maintain its sustainability."

Article 75 contains the Laws and Regulation that are repealed by the Water Law, as follows:

"*1. Law of Water and Sewage Corporations, issued by Royal Decree No. (M/22), dated 23/6/1391H, and its Regulations.*

2. Law of Preservation of Water Resources, issued by Royal Decree No. (M/34), dated 24/8/1400H, and its Regulations.

3. Law of Treated Sewage Water and its Reuse, issued by Royal Decree No. (M/6), dated 13/2/1421H, and its Implementing Regulations."

The standards and specifications for types of water (according to the water system and its implementing regulations) establishes the provisions related to required effluent quality for restricted and unrestricted use. This includes the following:

- Standards for the quality of unbottled drinking water.
- Non-potable water quality standards.
- Treated wastewater quality standards.
- Commercial wastewater quality standards
- Sludge standards.

Only the information on the standards applicable to the project is provided.

Treated Wastewater Quality Standards

Treated wastewater is considered to be water from sewage that has been treated and transformed into environmentally drainable water or for reuse in urban, industrial, or agricultural purposes, according to the degree of its treatment. In this chapter, the following information is given:

- TABLE A - Standards for internal discharge of treated wastewater and reuse
    - Table A1: Quality Categories

- Table A2: General and Microbial Standards
- Table A3: Irrigation Standards: Main and Trace elements
- Table A4: Quality Standards for Double and Triple Treated Wastewater

- TABLE B – Standards for the discharge of treated wastewater in coastal areas
  - Table B1: General Standards
  - Table B2: Microbial Standards
  - Table B3: Standards for trace elements

Commercial wastewater quality standards

Table A of this chapter sets out the Standards for the Discharge of Commercial Sewage into Sewage Network. It contains table A1 "General Standards" and A2 "Trace Element Standards (Heavy)", which are shown below:

Standard	Unit	Specific focus or values
Rough/buoyant material		max. 15 mm
Temperature	Celsius	<45
pH		5-10
Biochemical Oxygen Demand (BOD)	mg/l	500
Chemical Oxygen Demand (COD)	mg/l	1,000
Total suspended solids	mg/l	600
Total dissolved solids	mg/l	3,000
Chloride	mg/l	1,000
Sodium	mg/l	1,000
Sulphate	mg/l	1,000
Sulphide*	mg/l	1
Fats, oils, and greases (hydrocarbons)	mg/l	60
Fats, oils, and greases (non-hydrocarbon)	mg/l	100
Kjeldahl Total Nitrogen (Organic Nitrogen)	mg/l	120
total phosphorous	mg/l	15
Detergent (active ingredients methylene	mg/l	30

Note: * Water transported by tanks for discharge at the plant, the upper limit for sulphide is 5 mg/l, provides that it does not adversely affect the treatment processes or the health of the station workers.

Table 12. General Standards (2021). Source: Standards for the Discharge of Commercial Sewage into Sewage Network

Standard	Unit	Specific focus or values
Aluminium (Al)	mg/l	30
Arsenic (As)	mg/l	1
Barium (Ba)	mg/l	2
Beryllium (Be)	mg/l	5
Boron (B)	mg/l	5
Cadmium (Cd)	mg/l	1
Chrome (total)	mg/l	1.2
Chrome (Cr) (pentagonal)	mg/l	0.5
Cobalt (Co)	mg/l	2
Copper (Cu)	mg/l	1.2
Cyanide (free)	mg/l	1

Standard	Unit	Specific focus or values
Fluoride (F)	mg/l	15
Iron (Fe)	mg/l	30
Lead (Pb)	mg/l	1
Lithium (Li)	mg/l	2.5
Manganese (Mn)	mg/l	5
Mercury (Hg)	mg/l	0.5
Molybdenum (Mo)	mg/l	0.5
Nickel (Ni)	mg/l	2
Phenols	mg/l	5
Selenium (Se)	mg/l	0.5
Silver (Ag)	mg/l	1
Tin (Sn)	mg/l	10
Petroleum hydrocarbons group	mg/l	15
Vanadium (V)	mg/l	1
Zinc (Zn)	mg/l	10

Note:

A-The urban sewage system shall not accept more than 10% (in terms of volume and organic load) of sewage, without obtaining the approval of the permission of the sewage collector.

B- The licensed sewage collector may grant permission to the sewage producer to exceed one or more specified concentrations or values, provided that the corresponding load does not affect the municipal sewage network. Provided that the permit is for a specific period, stating the limits and standards that can be exceeded and the maximum quantities that can be discharged, provided that the sewage producer pays financial compensation to the licensee in return for those standards that exceed the permissible limit according to a specific tariff proposed by the licensee with the approval of the regulator, based on the accepted load concentrations.

C- Grease or oil traps are provided for oil stations, car wash stations, restaurants, kitchens, and in general for all oil processing facilities. The owner must obtain a license and must maintain the operational state of the system.

Table 13. Trace Element Standards (Heavy). Source: Standards for the Discharge of Commercial Sewage into Sewage Network

2.2.1.3. Basic Law of Government

The Basic Law (Royal Decree No. A/90) is commonly referred to as the Constitution of Saudi Arabia.

In 1992 Saudi Arabia adopted the Basic Law setting out the system of government for the country and the obligations of the government to the people of Saudi Arabia. Article 32 of the Basic Law states that, *"The state works for the preservation, protection, and improvement of the environment, and for the prevention of pollution".*

2.2.1.4. Labour Law

Labour Law contains provisions to protect workers against environmental hazards.

2.2.1.5. Law of Antiquity (Royal Decree M/3 dated 9/1/1436 AH)

All movable and immovable antiquities in the Kingdom or maritime zones under its sovereignty or jurisdiction are considered public property of the State.

In KSA, the State owns archaeological remains, and the MOC is the statutory organization responsible for defining required mitigation measures.

Article 6 prohibits trespassing, distorting, removing, damaging, or defacing archaeological or urban heritage sites in any way, including writing, painting, inscribing, posting flyers, setting fires, or altering features. Article 22 specifies that these sites cannot be altered, their debris used, or any soil, rocks, or materials removed without the SCTA's permission and supervision.

This law states in Article 9 that:

- Archaeological and urban heritage sites shall be preserved when carrying out projects for planning, expansion, or improvement of urban or rural areas. In addition, easement rights shall be taken into consideration, including designation of construction-free areas, in coordination with the Ministry of Municipal and Rural Affairs. Planning projects, in which, or in the vicinity of which, there are archaeological and urban heritage sites, may not be adopted without the approval of SCTA (Saudi Commission for Tourism and Antiquities).
- Licenses for construction or renovation in areas adjacent to archaeological and urban heritage sites may not be issued without SCTA's agreement.

In Article 24 it is stated:

1. Activities may not be carried out within the limits of archaeological and urban heritage sites without the prior approval of SCTA:

a) Whole or partial demolition.

b) Utility, communication, and road works, as well as any activity or process that may change the physical appearance of the archaeological and urban heritage sites, or buildings thereon, or disturb their archaeological layers.

c) New construction or landscaping projects.

2. SCTA shall respond within 60 days from the date of receipt of the application for performing any of the activities set out in paragraph 1 of this Article.

3. Activities set out in paragraph 1 of this Article shall be subject to SCTA's control.

4. SCTA shall, in coordination with the Ministry of Interior and the Ministry of Municipal and Rural Affairs, develop technical and procedural mechanisms for dealing with any dilapidated heritage buildings.

Article 42 grants SCTA exclusive rights to perform archaeological surveys and excavations. However, SCTA can allow universities, archaeological excavators, and foreign missions to carry out these activities, alone or with SCTA, following the law and its regulations. Article 43 states that SCTA and authorized agencies can conduct surveys and excavations on both public and private properties, provided they coordinate with the property's owners or controllers.

Article 45 of the Antiquities, Museums, and Urban Heritage Law classifies urban heritage sites and buildings into three categories based on their significance: A for highest significance, B for medium significance, and C for lower significance.

Article 46 states that the protection zone for classified urban heritage or archaeological sites or buildings extends 200 meters, especially from the façade's side. The Ministry of Municipal and Rural Affairs will define

specific controls and conditions for this zone. The President can adjust this zone's size in coordination with the Ministry of Municipal and Rural Affairs and relevant agencies.

The Project is located far from any UNESCO Nominated Property.

2.2.1.6. Law of Waste Management (Royal Decree M/3 dated 5/1/1443 AH)

Waste Classification

Waste Management, Waste types, handling and disposal of waste follows the Implementing Regulations of the Waste Management Law (MWAN, 2021) issued pursuant to Royal Decree no (m/3) dated 5/1/1443H, corresponding to 13/08/2021G.

Waste Regulatory Control and Compliance

The procedures for the correct management of wastes are regulated by the National Centre of Waste Management (MWAN) with the Implementing Regulations of the Waste Management Law (MWAN, 2021).

In general, the standard introduces a duty of care as follows:

- All persons owe a duty of care in relation to waste.
- The Waste Producer owns all waste it produces until it either legally transfers the waste to a Service Provider to be disposed of or to the State in accordance with these Regulations and Article 7 of the Law, and without prejudice to the provisions relating to Hazardous Waste.
- The waste producer shall take the responsibility for the waste it has produced until its ownership is transferred.
- Each Waste Producer and/or Service Provider shall commit to managing waste safely at a facility licensed to perform this task. This shall be carried out under the Transport Document.
- Every person shall deal with waste either in accordance with the licence granted to him or by transferring it to a service provider who holds the appropriate licence for this, or by transferring its ownership to the State in accordance with Article (7) of the Law, and each person shall bear the responsibility for verifying the service provider validity before transporting any waste to him, by examining the relevant license and/or permit.

The responsibilities are split among waste generators, waste handlers and waste treatment/ storage/ disposal (TSD) facilities:

- Waste Producers: The waste producer shall take the responsibility for the waste it has produced until its ownership is transferred.
- Waste handlers: Responsibility for waste shall be transferred to a Service Provider at the point when the completed Transport Document for the specific Waste transfer is agreed and signed by both parties.
- Waste operators: shall commit to managing waste safely at a facility licensed to perform this task. This shall be carried out under the Transport Document.

Section 5 of Implementing Regulations of the Waste Management Law (MWAN, 2021) establishes the need for the implementation of a Waste Tracking System, including the completion of a Waste Tracking Form/Transport Document, which enables the Competent Agency to track waste from its source to the place

of storage, recycling, treatment or disposal. The Generator must give the prescribed information to the Transporter.

Waste Producers shall complete the Transport Document according to the template issued by the Centre.

The Service Provider shall be prohibited from providing the service of collecting and transporting Waste without obtaining the appropriate Licence and completing the Transport Document in accordance with the provisions of the Law, Regulations and the technical controls the Centre issues.

The transporter of Waste shall transport it to the facility for collecting Waste, temporary storage of Waste, treatment of Waste, recovery of Waste or the safe disposal of Waste after the Transport Document is completed and signed by the Waste Producer, Waste transporter and Waste recipient.

Waste Producer, Waste transporter and Waste recipient shall all provide the Centre with the Transport Document if the Centre requests so from any of them.

The Centre may specify Wastes that the management of which requires a Transport Document and/or a Disposal Document.

The Service Provider shall sign the Transport Document after receiving the Waste, and the Service Provider shall sign the Transport Document after receiving the Waste to show that he agrees on receiving it. The Service Provider that receives the Waste – after he manages it properly by way of temporary storage and/or treatment and/or recovery and/or disposal of – shall sign the Transport Document to ensure that the Waste Management activity has been carried out in accordance with the provisions of the Law and the Regulations and shall send a copy of it to the Waste Producer and the Centre.

The Service Provider shall hand a copy of the Disposal Document to the Waste Producer after the conclusion of the safe disposal of Waste process, and the Waste Producer shall ensure that he receives a copy of the Disposal Document after it is signed by the Service Provider.

Waste Handling and Storage

The procedure for the correct waste storage is regulated by Section 5 of Implementing Regulations of the Waste Management Law (MWAN, 2021). The standard establishes the need for waste segregation, to reduce the risk of waste being incorrectly classified and to ensure that the correct procedures are followed from the point of generation through to final disposal.

The Waste Producer and the Service Provider shall store waste at Waste storage sites, maintain housekeep such storage sites in a manner consistent with the environmental health and safety requirements specified by the technical controls on waste storage issued by the Centre and in accordance with conditions and provisions of the relevant License.

Waste Producers and Service Providers shall store separately the different categories of Hazardous Waste, depending on the physio-chemical properties, compatibility and nature of the extinguishing agents that can be used for each category of such Waste in the event of fire, so as to ensure the highest degree of protection of the general health, Environment, and public and worker health and safety.

Storage areas shall be located as far as practically possible from sensitive receptors.

2.2.2. Regional environmental laws, regulation, standards and requirements

The KSA is a member of the Cooperation Council for the Arab States of the Gulf (also known as the Gulf Cooperation Council or GCC) and the Council has issued the following relevant environmental laws and legislation:

- The General Environment Protection Law: A comprehensive framework incorporating the basic rules for environment conservation and protection (Muscat, 1995).
- The Common Law for the Environmental Assessment of Projects: The Law aims at observing the environmental impact of the various projects to prevent their adverse effects on the environment, natural resources, and development (Muscat, 1995).
- The Common Law for Protection of Wildlife: The Law aims at developing legislation for the protection of wildlife, both plants and animals, their habitats and rehabilitation of the environmentally affected areas (Kuwait, 1997).
- Convention on the Conservation of Wildlife and Natural Habitats. Focuses on the conservation of ecosystems and wildlife, especially those species at risk from extinction, and aims to raise the standards of conservation of flora, fauna, and natural habitats (Muscat, 2003).
- Ambient air quality standards.

Convention on the Conservation of Wildlife and their Natural Habitats in the Gulf Cooperation Council

The Kingdom of Saudi Arabia is also a signatory to the Convention on the Conservation of Wildlife and their Natural Habitats in the Gulf Cooperation Council (2001), along with six other Gulf States. This Convention, which came into effect in 2003, consists of 13 articles aiming at conserving ecosystems and wildlife, particularly species threatened with extinction, and indicates the main actions to be taken by each signatory country. It contains annexes listing floral and faunal species to be protected and animal species threatened with extinction.

The articles most relevant to the development of the solar plant are listed in table below:

Article	Description
Article 2 [Protection of Habitats]	1. Enact the necessary legislative laws to ensure conservation, and where necessary, rehabilitation and sound management of enough areas of natural habitats suitable for wildlife, particularly the species (or sub-species which are geographically isolated) or endemic species in any state that is party to this Convention. 2. Give priority to verification that the natural habitats being conserved are managed in a way that safeguards the realization of the objective of such conservation. This shall include the following: a. Banning or restricting human activities which lead to the: (i) distortion of the nature of such habitats; (ii) pollution or poisoning them or; (iii) deterioration, or threatening with deterioration, of the biodiversity of such habitats or their environmental productivity. b. Adopting appropriate measures to restore the biodiversity and productivity of the habitats which have been subjected to deterioration. 3. Coordinate and exert efforts, with other parties, to conserve the natural habitats in a proper way, particularly when: a. Such conservation is on a common border area. b. These habitats are important for the migratory species included in Appendix (II) and Appendix (III) of this Convention.

Article	Description
Article 3 [Protection of Wildlife Species]	1. Each party to this Convention shall enact the necessary legislation to conserve the species of wildlife included in the three appendices attached to this Convention, as follows: A) Flora species included in Appendix (I). i) conserving such species, wherever they exist in natural habitats or whenever it is necessary to re-distribute them; and ii) banning or regulating the uprooting or felling any parts thereof or collecting their seeds except save for authorized scientific or research purposes. B) The fauna species included in Appendix (II): • conserving such species, wherever they exist in natural habitats or whenever it is necessary to settle them; and • banning all forms of hunting or deliberate killing, destruction or collecting of eggs or causing their disturbance, particularly during seasons of propagation and breeding of their young. C) The fauna species included in Appendix (III): Verifying that any exploitation of such species is done in a rationalized way ensuring that the survival or existence of any of such species in nature is not threatened, by adopting appropriate measures, such as: • banning hunting or designating seasons when hunting is allowed, and introducing systems ensuring the rationalization of the levels of such exploitation; and • banning and/or regulating the exploitation of such groups for the purpose of affording the opportunity to them to recover their numbers in a satisfactory manner. 2. Each party to this Convention shall adopt all the necessary legislative and administrative measures in order to: A) Register all the species included in Appendix (I), Appendix (II) and Appendix (III), which are allowed to be owned in a legitimate way. B) Regulate the method of breeding such species and enhance their breading in captivity. C) Ban or regulate the release of such species to the wild. D) Ban or regulate all forms of trading, locally, regionally, or internationally, in the species included in Appendix (I), Appendix (II) and Appendix (III) or in their products or parts. 3. Ban the owning of the animals' species included in Appendix (III) or killing them, by any means, which may lead to their extinction, or through the use of any of the permitted tools without obtaining a permit specifying the conditions whereby their ownership is regulated or specifying such tool. Such permits and licenses shall be issued by the concerned authorities in the states which are parties to the Convention. 4. The party states shall, in addition to the measures provided for in this Convention, coordinate their efforts to conserve the migratory populations from those included under Appendix (II) and Appendix (III).

Table 14. Articles of the Convention on the Conservation of Wildlife and their Habitats in the GCC

Ambient air quality standards in the countries of the Cooperation Council for the Arab States of the Gulf

The list of ambient air quality standards shows the limits of pollution levels that cannot be exceeded in the surrounding air environment in the countries of the Cooperation Council for the Arab States of the Gulf in order to preserve human health from the risks and damages that may be caused by pollutants emitted from

stationary and mobile sources. This regulation also aims to explain the standards and to find the basis and mechanism for applying air quality standards and measures (see Table 15).

Ambient air quality standards are applied in all countries of the Cooperation Council for the Arab States of the Gulf. The entity responsible for the environment in the country is the competent authority that has the right to interpret and define the meaning and scope of these standards, and it also has the right to review, amend and update the standards base whenever the need arises.

Ambient air quality National Standards prevail over Ambient air quality regional standards.

Measuring method	average period	Measurement (Standard)		Pollutant
		microgram/m^3	million PPm	
UV-Fluoresence	One hour	441	0.169	Sulfur Dioxide SO_2
	24 hours	217	0.083	
	One year	65	0.076	
UV-Fluoresence	One hour	200	0.140	Hydrogen Sulfide H_2S
	24 hours	40	0.030	
Chemiluminescence	One hour	660	0.350	Nitrogen Dioxide NO_2
	One year	100	0.050	
UV-Photometry	One hour	235	0.120	Ozone O_3
	8 hours	157	0.08	
	24 hours	340	-	Inhalable suspended minutes PM_{10}
	One hour	80	-	
Non-Dispersive IR	One hour	40,000	35	Carbon Monoxide CO
	8 hours	1000	9	
GC-FID\PID	3 hours	160	0.24	Non-methane hydrocarbons
Gravimetry + AAS	24 hours	NA	NA	Lead Pb
	3 Months	1.5		
Gravimetry + Ion Chromatgraph	24 hours	23	-	Sulfate SO_4
Colorimetric	one month	1.0	-	Fluorides F
Chemiluminescence	One hour	-	0.8	Ammonia NH_3

Table 15. Ambient air quality measures (Ambient Air Quality Regional Standards)

2.2.3. International laws, regulation, standards, and requirements. International agreements and treaties to which the Kingdom is a party

The Kingdom of Saudi Arabia, represented by the National Centre for Environmental Compliance, has paid great attention to means of controlling and controlling pollution sources. The NCEC (as the focal point for environmental issues) actively contributes within the system of the international community through international environmental conventions and treaties and protocols regulating international efforts.

International conventions and treaties to which the Kingdom is a party are detailed as follows.

United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change stands for UNFCCC of the United Nation Framework Convention on Climate Change is an international agreement that has been ratified by 191 countries and has committed to developing national strategies to address global warming.

The most important commitments under the United Nations Framework Convention on Climate Change are the following:

- Emission reporting.
- National Programs: The agreement requires all parties to implement national programs and measures to control greenhouse gas emissions.
- The obligations of the industrialized countries.
- Technology exchange.

COP21- Paris Climate Agreement

One of the most important objectives of this agreement is to take into account the development and special needs of the weakest countries. In addition to the financial obligations of industrialized countries, these countries must facilitate technology transfer and, in general, adaptation to a decarbonized economy.

In the area of transparency, the Agreement establishes a system to follow up on the implementation of national commitments, with a degree of flexibility with regard to developing countries, in order to follow up on the implementation of the efforts made by the parties.

United Nations Convention to Combat Desertification

The United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, an agreement to combat desertification and mitigate the effects of drought through national programs of action that includes long-term strategies supported by international cooperation and partnership arrangements.

Convention on the Conservation of Migratory Species of Wild Animals

The Convention on the Conservation of Migratory Species of Wild Animals is an intergovernmental treaty concluded in 1979 under the auspices of the United Nations Environment Program in Bonn, Germany, and entered into force in 1983. The treaty provides a global basis for the conservation and sustainable use of migratory animals and their habitats.

International Plant Protection Convention

The International Plant Protection Convention is a 1951 multilateral treaty overseen by the Food and Agriculture Organization that aims to provide coordinated and effective action to prevent and control the introduction and spread of pests of plants and plant products. The Convention extends beyond the protection of cultivated plants to the protection of natural plants and plant products.

Convention on International Trade in Endangered Species of Wild Fauna and Flora

The Treaty on International Trade in Species of Wild Fauna and Flora in Threatened with Extinction, also known as the “Washington Convention,” which was signed in Washington, DC on March 3, 1973, and entered

into force in 1975. It is considered one of the most important international treaties for preserving wild species from the danger of extinction.

Convention on Biological Diversity

The Convention on Biological Diversity (CBD) entered into force on 29th December 1993, with 3 main objectives: the conservation of biological diversity; the sustainable use of the components of biological diversity; and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Dedicated to promoting sustainable development, the Convention was conceived as a practical tool for translating the principles of Agenda 21 into reality. It recognizes that biological diversity is about more than plants, animals and micro-organisms and their ecosystems, but about people and our need for food security, medicines, fresh air and water, shelter, and a clean and healthy environment in which to live.

Montreal Protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer is the landmark multilateral environmental agreement that regulates the production and consumption of nearly 100 man-made chemicals referred to as ozone depleting substances (ODS). Those chemicals damage the stratospheric ozone layer, Earth's protective shield that protects humans and the environment. Adopted on 15 September 1987, the Protocol is to date the only UN treaty ever that has been ratified every country on Earth (all 198 UN Member States).

Stockholm Convention

The Stockholm Convention on Persistent Organic Pollutant is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment.

Vienna Convention

The Vienna Convention for the Protection of the Ozone Layer is a framework convention that lays out principles agreed upon by many parties (however does not require countries to take control actions to protect the ozone layer (this came later in the form of the Montreal Protocol). The Convention aimed to promote cooperation among nations by exchanging information on the effects of human activities on the ozone layer, and in doing so, the creators hoped policymakers would adopt measures to combat those activities responsible for ozone depletion.

Table below provides a summary of those that are considered relevant to the Project.

Nº	Agreement Name	Year of Agreement	Summary
1	Agreement for the Establishment for Arab Centre for the Studies of Dry and Barren Land	1968	The Centre was established to conduct regional studies on barren areas in Arab countries, including e.g., studies of soils, studies on the degree of soil erosion and studies on the geological and geomorphological aspects of the different areas.

Nº	Agreement Name	Year of Agreement	Summary
2	Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Ramsar Convention)	1971	States Parties should focus on wetland conservation for land and water birds through the establishment of natural sanctuaries in wetlands and providing the necessary protection. Note that there are no Ramsar sites within the project boundary but there are sites within the region.
3	Convention for the Protection of the World Cultural and Natural Heritage	1972	Established to protect and enhance cultural and natural heritage, whilst there has been a focus on UNESCO designated sites the convention requires member states to protect all relevant resources and specifically states that because a resource is not listed it should not be implied that the resource has no value.
4	Convention on International Trade in Endangered Species of Wild Fauna and Flora and Subsequent Amendments	1973	Established to identify species at risk and control trade in endangered species
5	Convention on the Conservation of Migratory Species of Wild Animals and all amendments including MOU on Turtles	1979	Established to coordinate conservation measures for migratory species. This covers a wide range of species, including birds, marine mammals, sea turtles and bats. Requires member states to preserve and protect species and habitats which occur regularly in their area. Through linkage with the Convention on Biological Diversity, Saudi Arabia is also required to provide protection to range species of bats under the Eurobat protocol of the CMS.
6	International Plant Protection Convention (1979 Revised Text)	1979	A convention established to protect the genetic resources of native plant species for agricultural and biological conservation purposes
7	Protocol Concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency	1982	Contracting Parties undertake to cooperate in combatting pollution by oil and other harmful substances and maintain and promote contingency plans
8	Vienna Convention for the Protection of the Ozone Layer	1885	The Convention aimed to promote cooperation among nations by exchanging information on the effects of human activities on the ozone layer
9	Montreal Protocol on Substances that Deplete the Ozone Layer	1987	Established to reduce emissions of chemicals harmful to the upper ozone layer
10	Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	1989	The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes. Includes restrictions on exporting of wastes but also includes requirements on member states to minimize production of hazardous waste and manage appropriately regardless of disposal location

Nº	Agreement Name	Year of Agreement	Summary
11	United Nations Framework Convention on Climate Change	1992	UNFCCC is the main convention addressing the impacts and causes of climate change and aimed at returning global temperatures to a level which will not cause irreversible significant harm to ecosystem functioning
12	Convention on Biological Diversity	1992	Established to protect wildlife and ecosystems
13	Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa	1994	Aims to conduct research and prevent/reverse desertification of natural habitats
14	Agreement on the Conservation of African- Eurasian Migratory Waterbirds (AEWA)	1995	The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) is an intergovernmental treaty dedicated to the conservation of migratory waterbirds and their habitats across Africa, Europe, the Middle East, Central Asia, Greenland, and the Canadian Archipelago. Developed under the framework of the Convention on Migratory Species (CMS) and administered by the United Nations Environment Programme (UNEP), AEWA brings together countries and the wider international conservation community to establish coordinated conservation and management of migratory waterbirds throughout their entire migratory range.
15	Agreement on International Trade in Endangered Species of Animal and Plant Groups (CITES)	1996	This international agreement seeks to protect endangered animals from threats related to international trading in their body parts or as specimens.
16	Cartagena Protocol on Biosafety to the Convention on Biological Diversity	2000	Relates to the transfer and use of living modified organisms and may apply to any hybrid species which are imported for planting if genetically modified
17	Convention on Persistent Organic Pollutants	2001	Requires member states to eliminate use of Persistent Organic Pollutants, mainly focused on herbicides but now extended to other substances
18	Stockholm Convention on Persistent Organic Pollutant	2001	to protect human health and the environment from chemicals that remain intact in the environment for long periods
19	Convention on the Conservation of Wildlife and their Natural Habitats in the Countries of The Gulf Cooperation Council	2003	The objective of this Convention is to conserve the ecosystems and wildlife in a sound and growing state, particularly the species threatened with extinction, and specifically when the distribution of such species exceeds the international border of two neighbouring countries or more, or when such species migrate

Nº	Agreement Name	Year of Agreement	Summary
			across these countries, including the territorial waters or the airspace under their sovereignty.
20	Paris Agreement within the UNFCCC	2015	The agreement aims to strengthen the global response to the threat of climate change by holding the increase in global average temperature well below 2 degrees Celsius above pre-industrial levels as well as increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development. Managing climate change risk is critical to maintaining biodiversity and the ecosystems that support biodiversity.

Table 16.: Summary of International agreements

2.2.4. IFC Performance Standards and Equator Principles

The project has committed to meeting IFC Environmental and Social Performance Standards. While there is no explicit national legal requirement under KSA law for undertaking social impact assessment of development projects. IFC Performance Standards include extensive requirements relating to potential social risks. This ESIA Report therefore addresses relevant social as well as environmental risks to of the Development align with IFC requirements.

There are eight (8) IFC Performance Standards which cover a range of sustainable development performance metrics. The following table reports the scope of the standards and the applicability of these standards to the Principal Buyer development.

PS No.	Title	Aim	Applicability
1	Assessment and Management of Environmental and Social Risks and Impacts	Underscores the importance of identifying environmental and social risks and impacts and managing environmental and social performance throughout the life of a project.	Yes, this is the basic ESIA requirement which the ESIA report will form part of.
2	Labor and Working conditions	Recognizes that the pursuit of economic growth through employment creation and income generation should be balanced with protection of basic rights for workers.	Yes, to address the rights of construction workers. Detailed implementation of this aspect is outside the scope of the ESIA and will be addressed directly by Principal Buyer.
3	Resource Efficiency and Pollution Prevention	Recognizes that increased industrial activity and urbanization often generate higher levels of air, water, and land pollution, and that there are efficiency opportunities.	Yes, in terms of air quality and general protection of the environment from pollution during the construction phase.
4	Community Health, Safety and Security	Recognizes that projects can bring benefits to communities but can also increase potential exposure to risks and impacts from incidents, structural failures, and hazardous materials.	Yes, with respect to potential environmental impacts of the site preparation and in relation to construction workers on nearby sensitive social receptors.

PS No.	Title	Aim	Applicability
5	Land Acquisition and Involuntary Resettlement	Applies to physical or economic displacement resulting from land transactions such as expropriation or negotiated settlements.	No, land expropriations are not necessary. The terrain will be managed by leasing. The land will be under the management of the Ministry of Municipal, Rural Affairs and Housing.
6	Biodiversity Conservation and Sustainable Management of Living Natural Resources	Promotes the protection of biodiversity and the sustainable management and use of natural resources.	Yes. The area proposed for development is partially disturbed but may contain species or habitats within a national and international context.
7	Indigenous People	Aims to ensure that the development process fosters full respect for indigenous people.	No, there are no indigenous people affected by this Proposed Development.
8	Cultural Heritage	Aims to protect cultural heritage from adverse impacts of project activities and support its preservation.	No, the project area does not include heritage and archaeological resources.

Table 17.: IFC Performance Standards applicability to the Principal Buyer development

On the other hand, the Equator Principles is a risk framework for identifying, assessing, and managing environmental and social risks in project finance transactions. This framework is based on the IFC Performance Standards and the World Bank Group EHS Guidelines. Equator Principles Financial Institutions (EPFIs) have adopted the Equator Principles in order to ensure that the Projects financed are developed in a manner that is socially responsible and reflects sound environmental management practices. The principles comprise a set of ten broad principles that are underpinned by the environmental and social policies, standards, and guidance of the IFC. The Equator Principles are as follows:

- Principle 1: Review and Categorization.
- Principle 2: Environmental and Social Assessment.
- Principle 3: Applicable Environmental and Social Standards.
- Principle 4: Environmental and Social Management System and Action Plan.
- Principle 5: Stakeholder Engagement.
- Principle 6: Grievance Mechanism.
- Principle 7: Independent Review.
- Principle 8: Covenants.
- Principle 9: Independent Monitoring and Reporting; and,
- Principle 10: Reporting and Transparency.

When a Project is proposed for financing, the EPFI is required to categorize the Project based on the magnitude of its potential risks and impacts. This screening is undertaken using the following categorization scheme of the IFC:

- Category A: Projects with potential significant adverse environmental social risks and/or impacts that are diverse, irreversible, or unprecedented.

- Category B: Projects with potential limited adverse environmental social risks and/or impacts that are few, generally site-specific, largely reversible, and readily addressed through mitigation measures; and,
- Category C: Project with minimal or no adverse environmental and social risks and/or impacts.

Afif 1 Solar plant Project is considered to be a Category B project.

Activities Description

3. Activities Description

3.1. Determine the objectives and justification for the activity

The project consists of a photovoltaic solar power plant with a maximum production capacity of 2,636 MW. The solar power plant will provide new renewable alternatives for energy and reduce the Kingdom's dependence on traditional energy represented by petroleum.

The project will result in crucial positive environmental and economic impacts on the strategic and national level. The solar power plant will provide new alternatives for energy and reduce the Kingdom's dependence on traditional energy source represented by petroleum. The project will achieve several of strategic goals emanating from the Kingdom of Saudi Arabia's 2030 vision and the global will, including, but not limited to:

- Reducing carbon emissions resulting from the consumption of fossil fuels.
- Preserving the national natural resources.
- Relying on an inexhaustible source of energy, which is the sun.
- Reducing the cost of producing electricity.
- Supporting global efforts to reduce emissions that cause climate change and global warming.

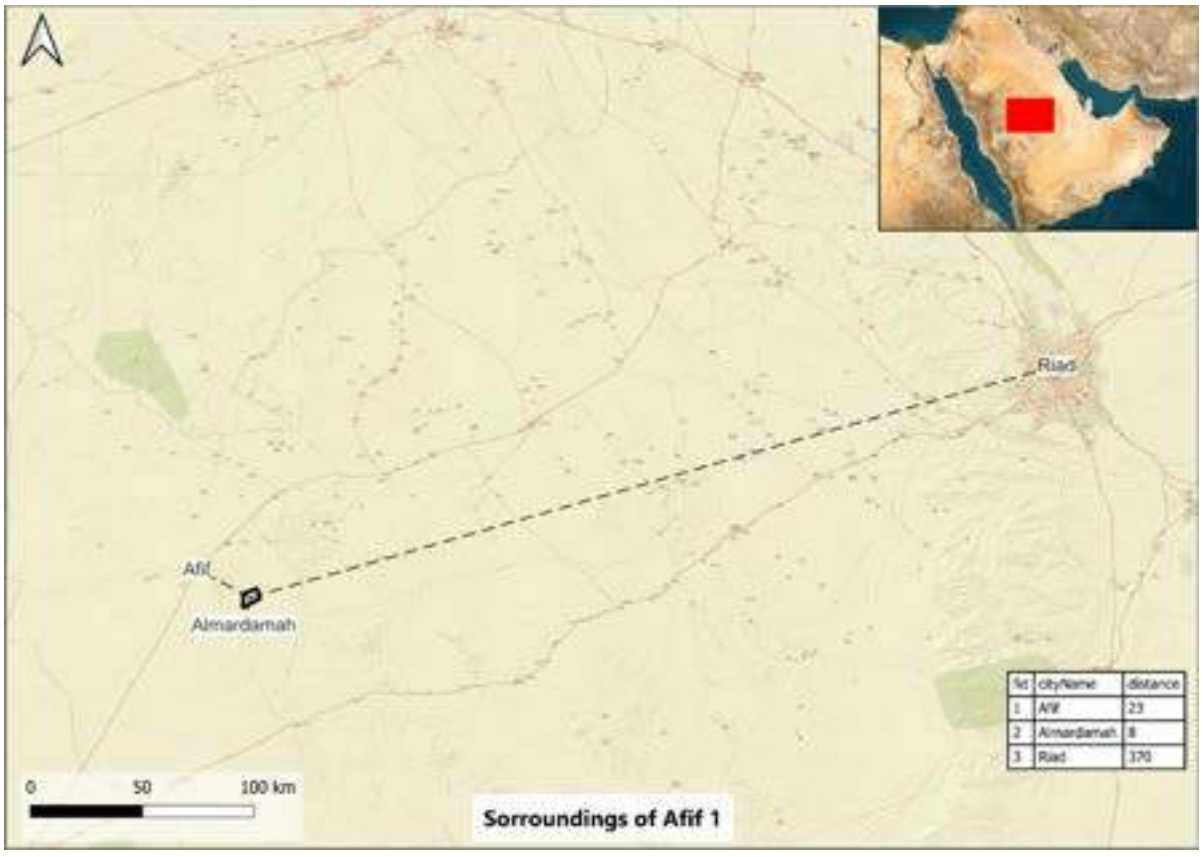
3.2. The proposed site for the project

Afif 1 Solar Energy Park is located about 23 km southeast of the city of Afif, in the Riyadh Province. From the plant, we can also locate the following urban centers:

- Almardamah (about 8 south)
- Riyadh (about 370 east)

The site is located at 978 meter above sea level.

Figure 6. General Project Location



Id	cityName	distance
1	Afif	23
2	Almardamah	8
3	Riad	370

Figure 7. Surroundings

The table below summarizes the main features of the site:

Solar Power plant	Available surface (km^2)	X (WGS84/UTM Z 38N)	Y (WGS84/UTM Z 38N)	Elevation (m.a.s.l.)
Afif 1	40.0	311,822.05	2,632,495.50	978

Table 18. General Site Data Table

The coordinates of Afif 1 boundaries are the following:

Point	X (WGS 84 / UTM zone 38N)	Y (WGS 84 / UTM zone 38N)
1	308,172.56	2,634,073.88
2	314,761.60	2,636,457.17
3	316,083.49	2,631,891.10
4	308,090.69	2,627,874.90
5	308,097.49	2,627,921.94
6	308,101.93	2,627,937.59
7	308,224.24	2,628,417.90
8	308,300.71	2,628,762.17
9	308,365.38	2,629,067.12

Point	X (WGS 84 / UTM zone 38N)	Y (WGS 84 / UTM zone 38N)
10	308,405.46	2,629,344.21
11	308,457.84	2,629,724.05
12	308,520.24	2,630,287.53
13	308,534.05	2,630,772.71
14	308,537.19	2,631,206.07
15	308,576.42	2.631,499.10
16	308,513.74	2,631,899.24
17	308,505.11	2,632,059.37
18	308,428.27	2,632,728.76

Table 19. Site Coordinates

Figure 8. Afif 1 Project Location

3.3. Project elements that have a potential impact on environment

3.3.1. PV Plant Components

The project will comprise up to 2,636 MW PV Plant using bi-facial technology. The PV cells within modules will be installed on tracking ground mounted racks arranged to ensure the most efficient alignment for the capture of solar radiation. Dry cleaning system (fully or semi-automated cleaning robots) will be used to clean the panels when required.

Bifacial modules achieve a better collar-electric conversion performance at similar project size and more production at a barely higher installation cost. The plant will include modules, structures, and substation.

Additionally, there will be a labor camp, which include different facilities, such as offices or toilets; storage areas; and emergency exits on the perimeter fence of the site.

The PV solar technology chosen for this Project include of the following main components:

- Bifacial PV cell: The PV cell is the device that generates electricity when exposed to solar radiation.
- PV module: The PV module is the set of interconnected photovoltaic cells encapsulated between a transparent front (usually glass) and a backing support material then mounted in an aluminium frame.
- Mounting structures: Multiple PV modules are bolted onto a mounting structure which tracks the sun progress across the sky in an east to west direction.
- PV array: The PV array is the complete power generating plant consisting of multiple PV modules wired in series and in parallel.
- Inverters: The inverter converts the Direct Current (DC) to Alternative Current (AC).
- Substation: The substation receives all power from the inverters via underground cables and provides protection and control equipment required to safely manage the plant and to ensure grid code compliance regulations.
- Transformers: The transformer steps up the AC power from the inverters to match the grid voltage.
- Stores, offices, and control building.
- Access tracks and fencing.
- Export cables to the grid are out of the scope of this assessment.

The Solar Power Park will utilize Photovoltaic (PV) technology and consist of PV arrays which will be mounted on tracking systems which will allow the arrays to track the movement of the sun in one direction. The modules will be connected in series through combination boxes to form a chain in order to increase the AC voltage and reduce energy losses.

Equipment	Estimated Quantities	Dimensions
Solar Modules	3,806,366 units	1,303 x 2,384 x 35 mm
Central Inverter	622 units	12,192 x 2896x2438 mm
Horizontal tracker	43,857 units	-

Table 20. List of PV plant equipment

3.3.1.1. Solar Modules

Modules will be provided by some of the Tier-1 manufacturers with a big production capacity to cover the required large number of panels. Most those top suppliers are Chinese as China owns the vast majority of the world's solar panel supply chain, controlling at least 75% of every single key stage of solar photovoltaic panel manufacturing and processing.

The estimation of the energy yield was made using the photovoltaic system of the proposed site taking into account the applied photovoltaic technology that includes monocrystalline, half-cell and bifacial solar modules. Bifacial modules achieve a better solar-electric conversion performance at similar project size and more production at a barely higher installation cost.

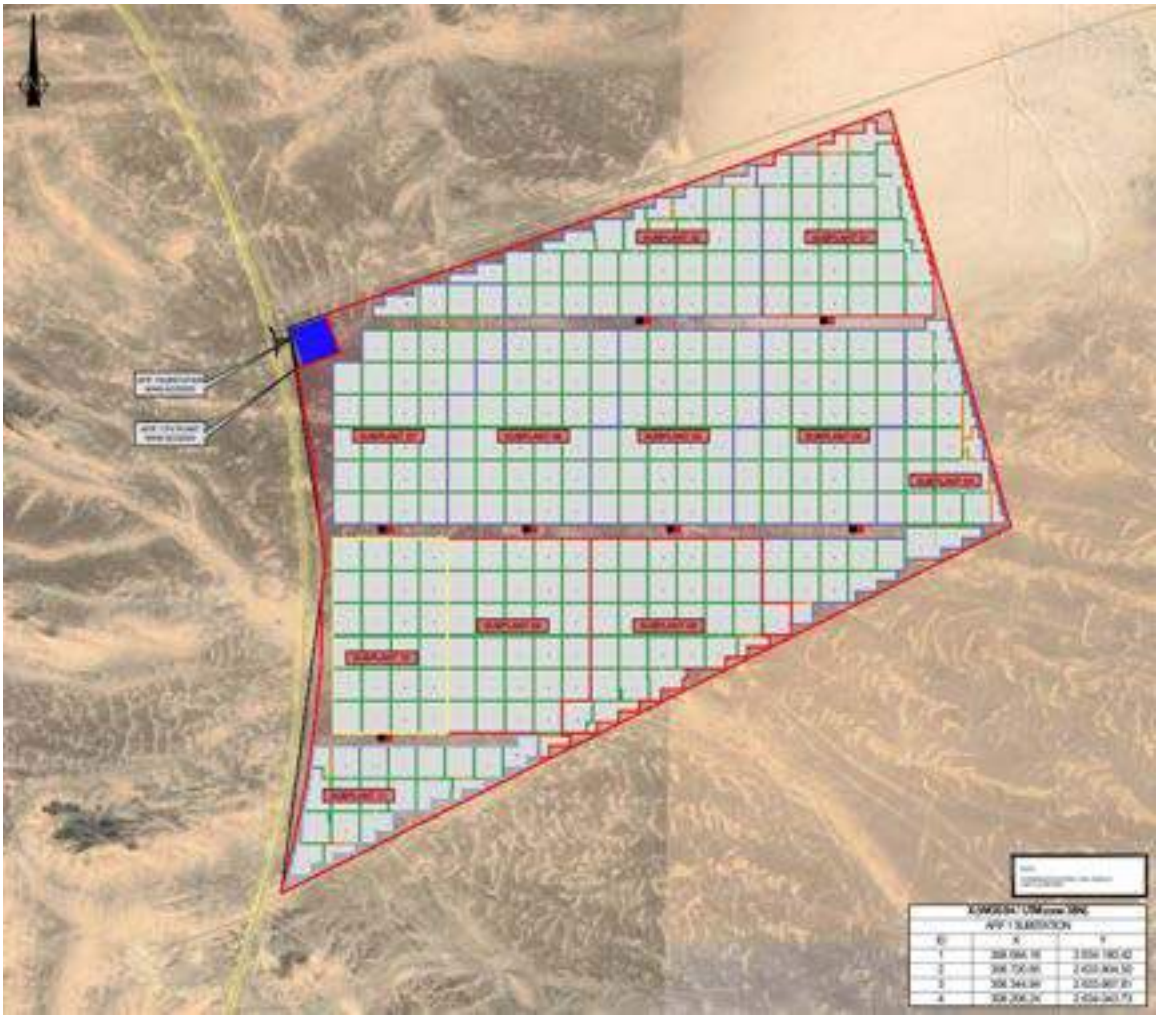


Figure 9. Solar Power Plant layout .

Figure 10. Bifacial modules

Regarding cleaning method and system, there are several choices and service companies available that may or may not include manual in addition to semi or fully automated systems:

- Non-Automated Cleaning: Cleaning modules in this category hardly ever use automation. The majority of the activity is completed by hand labor. In order to clean dirt from the modules, a brush or cloth is typically employed. In nations where labor is inexpensive, this type is typically utilized for small-scale roof top systems, such as commercial and residential systems or small-scale power plants.
- Semi-Automated Cleaning: PV module cleaning involves both a sizeable amount of automation and an equal amount of manual labor. Work is done either by moving vehicles and cleaning equipment to clean the panels directly, or by applying robots manually put on the modules. The categories that it falls into are as follows:
    - Robotic Cleaning System (Semi-Automated): Robots identical to those used in fully automated cleaning may be used in this sort of cleaning, but in order to clean every row of the power plant, these bots must be manually moved from one row to the next, from one end of the tracker to the start of the next, or as the situation may dictate. Although there are many various machine designs on the market, there are rarely any bridges connecting the robot parking spaces and rows.
    - Vehicle Driven Cleaning System: The cleaning device, which is typically a brush with controls, is connected to a tractor or other suitable human-driven vehicle. To prevent any damage to the panel surface, each machine features a safety mechanism that regulates the pressure that the driver or operator applies to the brushes when using the PV panels. Since the truck needs a large turning radius at the ends of the rows in order to turn around without losing valuable cleaning time, the latter alternative often requires more acreage.

Figure 11. Semi-Automated Cleaning

- Fully Automated Cleaning: This type works well and remarkably dependably thanks to the Automatic Robotic Cleaning System (ARCS). Compared to the other two types, there is often a higher amount of automation. Cleaning tasks are completed with the aid of robots, also known as bots, which are permanently stationed on each row in the power plant. From one end of the modules' row to the other and back, these robots travel along the panel edges. On one side of each row, they are parked or docked at a Docking Station. These stations could also be found within the rows if they extend beyond the robot's range of motion in one direction.

Figure 12. Fully Automated Cleaning.

The cleaning techniques chosen will be dry techniques using fully or semi-automated cleaning robots. At very special times when dry techniques cannot properly clean the panels, water will be used for cleaning. In such cases, an amount of 2 litres per solar panel is estimated. Water will be brought to project site by tankers. An eco-friendly biodegradable detergent will be used to have no damaging effect on the environment.

3.3.1.2. Supporting structures

The potential solution would be using 2-axis trackers. This solution maximizes the capture of irradiation by a continuous and perfect orientation to the sun during all daytime and different seasons. It was a popular solution some years ago when PV modules were 10 times more expensive and then, the design should maximize the utilization of the modules.

Single axis tracker can be classified, in general terms in the following classes:

- 1P or 2P tracker: Depending on number of modules in width, a tracker can be 1P or 2P.
- Single, dual or multiple rows: Depending on mechanical system used for tracking it's possible to connect two or several trackers to the same rotor, allowing all connected trackers to keep the same orientation with a single rotor or hydraulic system.

See picture below as example of different market options for a single axis tracking system for 1P/2P.

Figure 13. Tracker structure. Example

3.3.1.3. Central Inverter

A solar inverter or PV inverter is a type of electrical converter which converts the variable direct current (DC) output of a photovoltaic (PV) solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network. The inverter can also implement a variety of functions to increase the productivity of the power unit by monitoring performance, recording data, providing protection, and disconnecting in the event of problems in the network or in order to connect with the photovoltaic units.

Proposed inverters for the project also include a transformer unit. Transformers are an essential component in the production and distribution of solar energy. Transformers are electrical devices that convert voltage to different levels. Since PV modules and insulators typically operate at low voltages, transformers are required to convert the voltage to a level suitable for distribution corresponding to the grid voltage.

Figure 14. Inverter Example

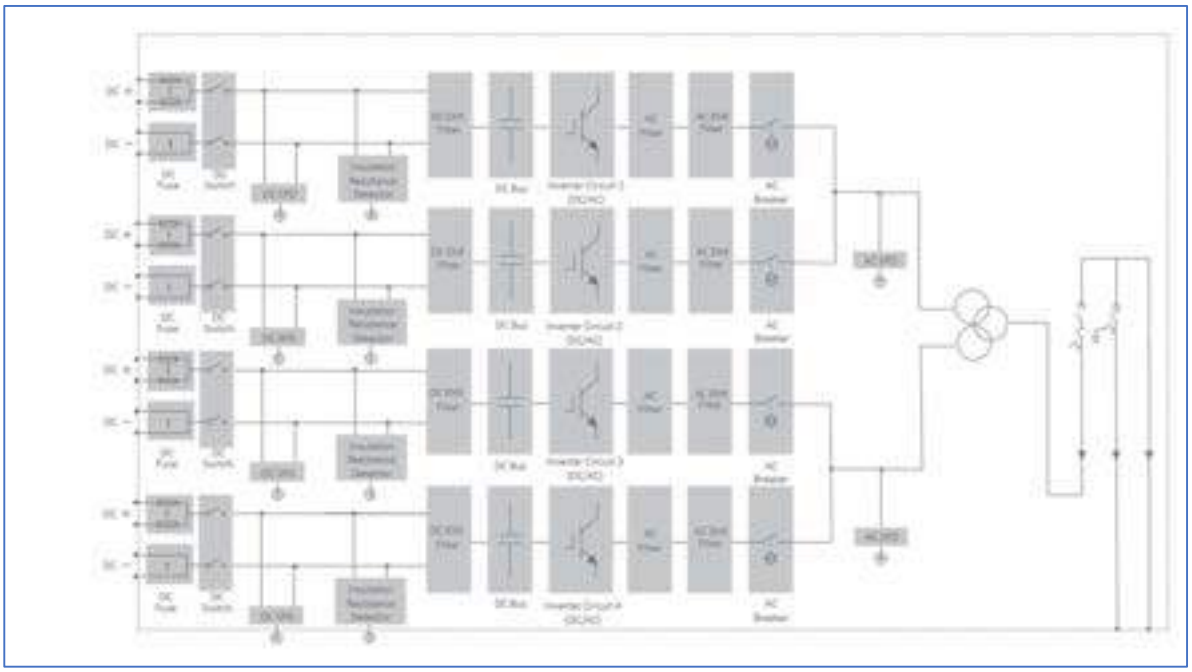


Figure 15. Shape of the electric circuit.

3.3.1.4. Cables and Electrical Connections

Cable forecast calculations are presented below:

- DC cable:
  - Level 1: Estimated total length of Level 1 cable per power block of 8.505 MWp is 41,848.60 m considering both length from positive and negative from each string to combiner box.

LV wiring – Level 1	
Installation type	Buried duct
Insulation	XLPE
Material	Cooper
Terrain temperature (°C)	30
Duct depth (m)	0.6
Terrain thermal resistivity (K · m/W)	3.0

- Level 2: Estimated total length of Level 2 cable per power block or 8.505 MWp is 8,282.32 m considering both length from positive and negative from each combiner box to central inverter.

LV wiring – Level 2	
Installation type	Buried duct
Insulation	XLPE
Material	Aluminum
Terrain temperature (°C)	30
Duct depth (m)	1
Terrain thermal resistivity (K · m/W)	3.0

- AC cable: it will connect the inverter outputs to the internal substations and then, these substations to the main step-up electrical substation. The project will include at least a main step-up electrical substation to inject the generated energy to the National Grid at a voltage level of 380 kV. These electrical infrastructures shall be included inside the physical boundaries of the project. However, the necessary 380 kV lines to interconnect to the National Grid are excluded of the limits of the Project, as the design and interconnections are part of the System Operator responsibility.

Figure 16. Proposed electrical connection.

OPTION B		
	X	Y
B1	308584,1637	2634180,424
B2	308720,8549	2633804,504
B3	308344,9353	2633667,813
B4	308208,2441	2634043,732

Table 21. SEC substation coordinates

There will be 7 internal substations. The internal substations are preliminary considered Gas Insulated Substation (GIS) type. These have most of the equipment installed indoor. These substations will include a main oil transformer. A retention pond will be constructed to provide substation oil spill control. Alternatively, Air Insulated Substation (AIS) are an equivalent technical option. However, additional integration measures such as vegetal barriers are recommended if eventually selected to reduce the visual impact.

The internal substation will be connected to the main grid substations with an overhead lines and metallic poles of approximately 30 meter high and located every 150 meters.

Figure 17. Overhead line example .

3.3.2. Access Roads

There is a road that connects routes 50 and 80 (Almardamah road) through the west limit of the Project site, adjacent to the plot.

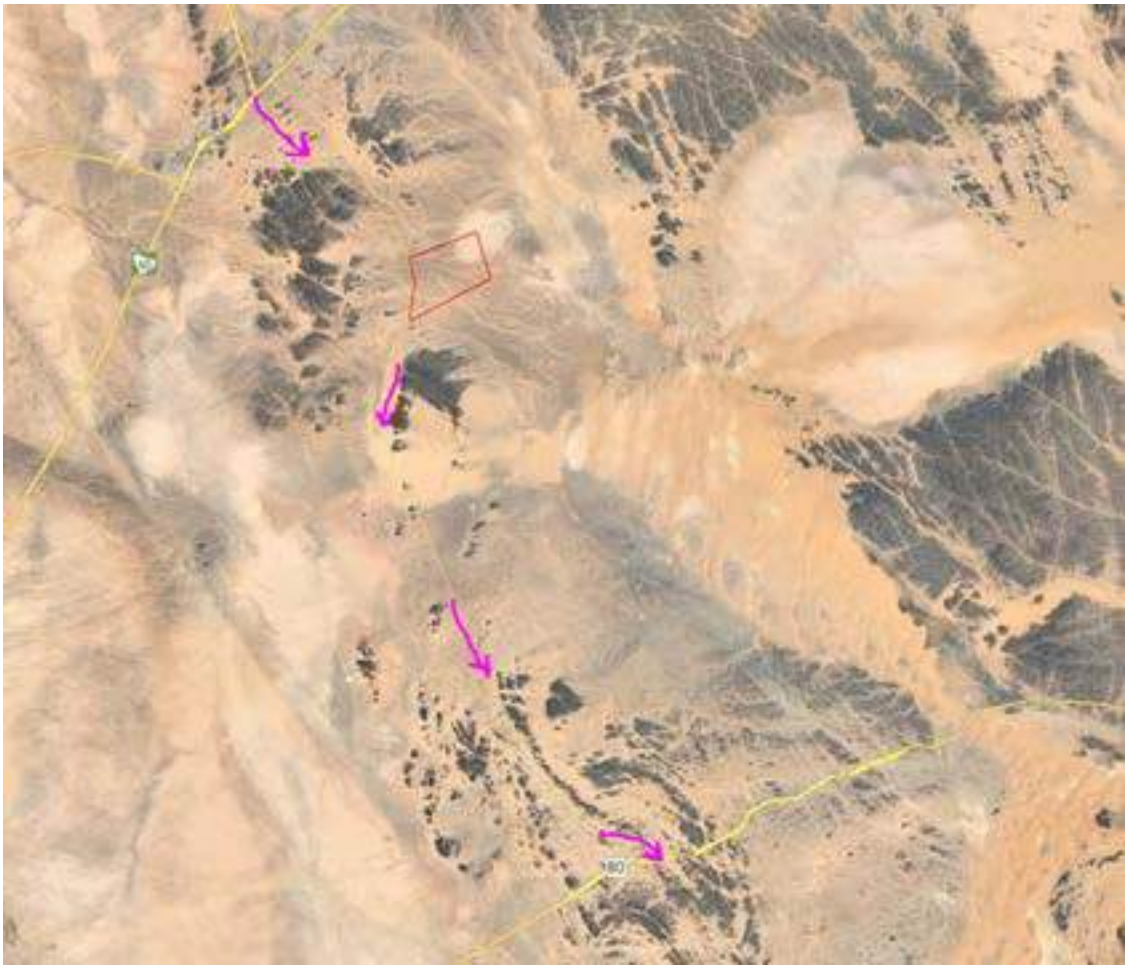


Figure 18. Almardamah road

3.3.2.1. External Access Roads

The connections to the main roads in the area shall be designed, taking into consideration the applicable traffic and mobility regulations. This design should ensure a safe and efficient integration within the transport network. To achieve this, visibility points at connections, avoiding curves or changes in the vertical road alignment, must be carefully considered. Additionally, deceleration and acceleration lanes for incorporation into the main road circulation will be included.

An individual access point will be built for the plant and the main SEC substation. However, connections with the main road should be consolidated into a single point to minimize risks associated with various acceleration and deceleration maneuvers resulting from different connections.

Figure 19. Typical Access Example

The main access will be constructed with the appropriate equipment as established HCIS. In addition, other secondary accesses may be established due to the large size of the plants.

Internal access roads will be built during land preparation. There will be internal access roads to the Project Site.

3.3.2.2. Internal Roads

The internal roads will be strategically positioned to ensure optimal connectivity between project components, facilities, and access points. Provisions will be made for emergency access routes and designated parking areas to accommodate operational needs.

The internal road network will comprise a combination of main access roads, secondary roads, and service lanes, each designed to accommodate specific traffic volumes and vehicle types. The roads will be divided into two types of roads: main roads providing access to the interconnection substations and secondary roads providing access to the central inverters and module fields.

3.3.3. Earthworks and levelling

The grading must be limited and the existing slopes and runoff direction on the natural terrain must remain as much as possible.

The preparation of the land, including cleaning and grading, will be minimal, given the flat nature of the project. It is not expected that more than 20,000m3 will be required for the installation of PV structures within tolerance. Earthworks for other elements, such as roads or foundations, will be defined in detail during further project stages but are expected to be similar to those described for PV structure installation.

The finishing of land must be natural in most of the area and no superficial layer will be removed, except at the internal roads where the superficial layer will be removed to guarantee the necessary bearing capacity of the soil.

The removed land will be spread out within the area of the project.

In general, excavations will be used for filling areas when required. Only in case of some excess, this material should be carried to some authorized landfill area.

3.3.4. Construction requirements

3.3.4.1. Temporary Facilities

The temporary facilities will be set up by the Sub-Contractor at the beginning of construction stage and it will be in site or adjacent to the site in the available area. The temporary facilities will comprise site office, warehouse, workshop, open storage, and utility areas, etc., as required.

The Sub-Contractor makes sure that all areas and locations of construction site for temporary facilities will conform to the local regulation and all site temporary facilities will be removed after completion of the project.

Temporary construction camps will be operation during the whole construction phase, one main and other secondaries. The construction camps will include the stockpiles, facilities for workers, machinery & equipment, concrete batch plant, waste storage, holding tank & chemical toilets, offices and other auxiliary facilities. In addition, there will be some specific and delimited zones for materials and waste storage scattered around the implementation area site.

3.3.4.2. Adequate location of construction camps

Construction camps and specific zones for materials and wastes´storage will be placed in areas which are acceptable from environment, cultural and social point of view. These sites have not been established in the vicinity of environmental and social sensitive places like areas with High Conservation Priority Species, key ecological areas, and permanent camps, in order to avoid environmental impacts and social conflicts.

The main construction camp will be able to occupy up to 22,500 m^2, and all infrastructures will be established inside its perimeter, including the concrete batch plant. A holding tank will be installed for wastewater generation. A waterproofed area will be constructed for the location of the machinery. Work access will be through the new permanent road access to the solar plant. A potential main storage area of 22,500 m^2 for materials and wastes will be proposed near to this camp. A waterproof concrete floor screed will be constructed for wastes storage.

The proposed secondary construction camps might cover up to 22,500 m^2, Temporary chemical toilets will be installed for wastewater generation. A waterproofed area will be constructed for the location of the machinery. Work access will be through internal roads from the road access. A potential secondary storage area of 22,500 m^2 for materials and wastes will be proposed next to this camp. A waterproof concrete floor screed will be constructed for wastes storage.

3.3.4.3. Laydown and Storage Facilities

Materials and equipment will be laid down and stored in storage facilities, such as warehouse and laydown area. Materials will be unloaded and stored according to manufacturer's manuals and requirements.

The materials that are noticed to be stored indoor, such as valves, and instruments, etc., will be kept in warehouse, while boxed equipment with a water proofing, pipe with suitable capping, cable and other equipment/materials can be kept in the laydown area.

Laydown area with a proper compaction and security system will be located inside plant site boundary.

Waterproof Area in Construction Camps

A waterproof area has been considered in both construction camps.

To avoid that a volume of water is polluted with fuels, oils, etc., in the zone of auxiliary facilities a specific area for the location of the machinery will be conditioned, which will also avoid the soil pollution by a possible spill of these elements. This area must be waterproofed and must have a specific collection zone.

The waterproofed area will be constructed with a concrete slab placed on a compacted surface to avoid breaking the slab by different places.

This waterproofed area is estimated to have dimensions of 8 x 4 m, capable of covering the projected surface of the engine space of the machines that will be used. (See figure below).

This waterproofed area will be constructed with gradients towards the center of it that allow collecting and storing the possible accidental spillage of oil or grease. The gradient towards the inside of the slab of the longest side will be 4%. This area will have a central ditch with a capacity of 200 l (volume of an oil container that can be spilled by accident during handling).

Contractor must ensure that workers have been trained on handling of fuels and spill control procedures.

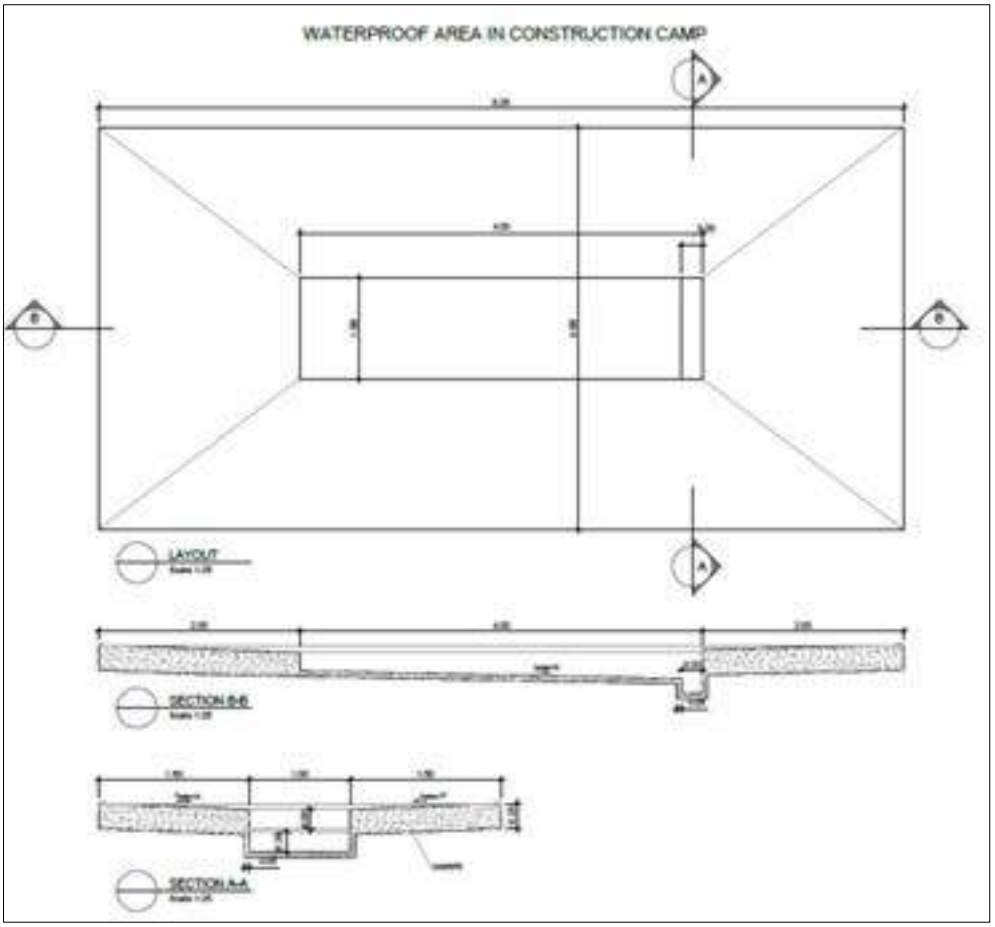


Figure 20. Waterproof area in construction camp.

Network perimeter drainage and Settling basin

To avoid the risk of accidental pollution around the areas designed for storing and parking machinery and ancillary facilities a network perimeter drainage, or side ditch, for retaining the surface water runoff around will be built before the start of work operations. This network perimeter drainage will drive the wastewater to a settling pond or basin sand trap type degreaser to avoid reaching the next wadi, as detailed in the following sketch. Considering the amount of rain wash water that these worksites will receive, the side ditches or perimeter drainage trenches will have at least 1.5 m width and 0.5 m depth and will have to be maintained in perfect operating conditions during all the work periods.

The water collected in the settling pond will be managed by specialized companies in the management of hazardous waste.

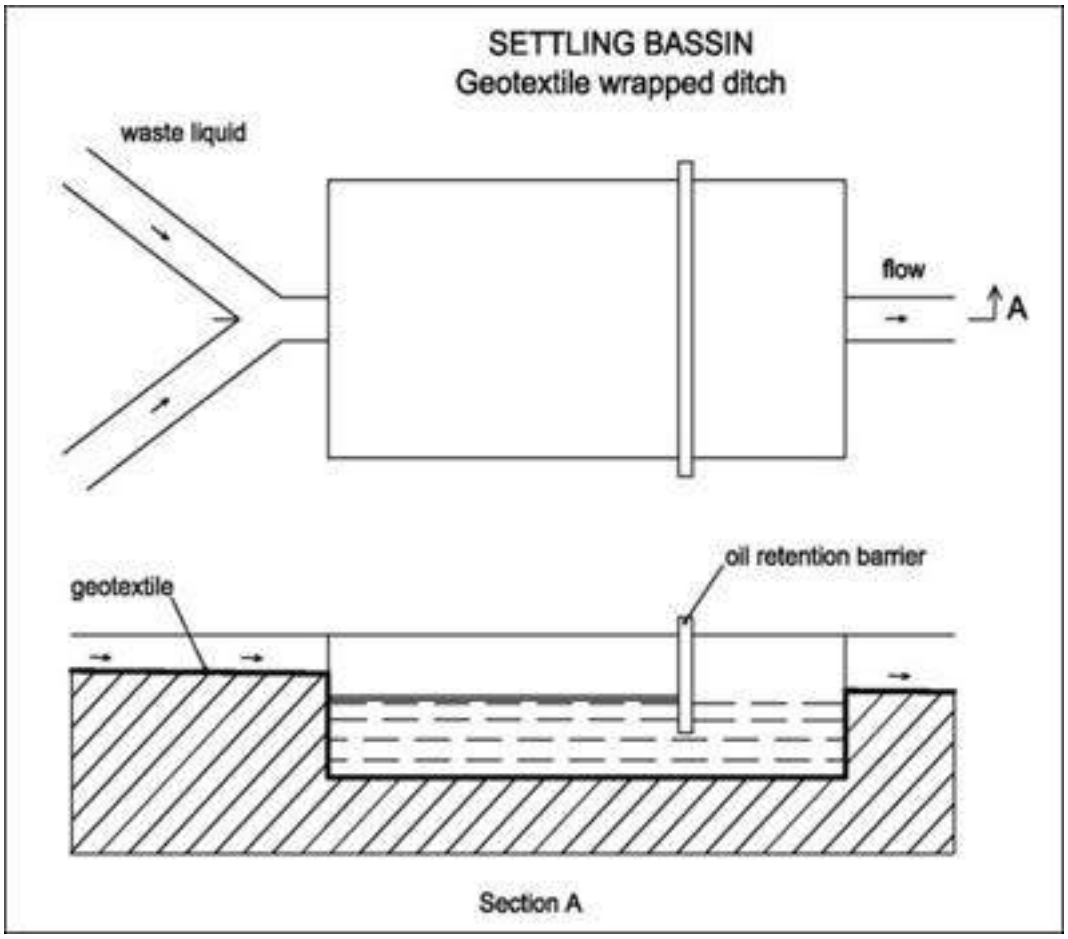


Figure 21. Settling basin in construction

3.3.4.4. Accommodation Facilities

Required accommodation facilities with sanitary block may be located and operated in site areas as needed and according to project requirements.

3.3.4.5. Manpower Requirements

The estimated number of construction workers on site during peak construction is expected to be around 650-750 workers.

3.4. Activities during all phases of the project

The following are the main phases of the activity. It's not included in them all things regarding the export lines to grid.

3.4.1. Early Works

Early works comprise the planning and pre-construction phase involving the conceptualization of the project and has following components:

- Site Selection.
- Site surveys as topographic, geotechnical investigations, micro-siting studies, power evacuation arrangements.
- Approvals/clearances/ permits.
- Design and finalization of contractors.
- Mobilization of contractors.

3.4.2. Construction

The proposed construction of solar development involves the following activities:

- Contractor mobilisation.
- Site preparation activities such as clearance, excavation, filling, levelling, fencing, etc.
- Construction of external connecting road and internal access roads.
- Construction of labour camp, site office, equipment and supplies storage areas, fuel storage areas and waste pits.
- Construction of Foundation of the PV module.
- Transportation of equipment including PV module, mounting structure, supply materials, and fuels.
- Installing the modules on the supporting structure. This is a manual operation.

Figure 22. Metallic poles and panel installation. Source: Self-made.

- Construction trenches for buried cabling.

- Completing internal electrical connections of PV module.
- Erection of internal electrical lines by laying cables in the trenches.

Figure 23. Construction trenches & Erection of internal electrical lines.

- Erecting of pooling 380 kV sub-station to interconnection to the National Grid.

Figure 24. 380 kW substations.

- Commissioning of the complete PV plant.

3.4.3. Operation and maintenance

Based on initial assessment, power requirement during daytime would be met through self-supply. During shutdown power will be supplied by the SEC network or Emergency Generators. Diesel Generators sets would also be kept at the control room for emergency power backup.

It is noted that cleaning of the PV panels/modules is planned to be conducted automatically without the use of water in order to make the cleaning process more resource efficient (i.e., avoiding water use) and economically sound. However, on some occasions, it may be necessary to utilize water to ensure effective cleaning.

The design lifetime of PV Panels is generally 30 years, but in practice panels should last longer with proper maintenance. The whole tracker structure should be made of galvanized steel or any other resisting to corrosion material with a lifetime of over 30 years.

The Project operation phase will require routine (preventive) maintenance throughout the operation phase to ensure extended system lifetime, as well as compliance with manufacturer warranty and ensure efficiency in energy production.

Routine maintenance activities include regular cleaning of panels (considering the climatic conditions of the region frequent periods may be required) and maintenance of electrical components, control equipment and access roads.

During the operation of the proposed solar power plant involves the following activities:

- Obtaining the regulatory permit and approval from competent authority prior start the operation.
- Regular remote monitoring of the complete PV plant.
- PV module washing.
- Inverter maintenance.
- Preventive and corrective maintenance, including replacement of broken PV modules.
- Checking the electric connection.

3.4.4. Decommissioning

The solar plant site is designed for a lifecycle of 30 years without any major overhaul. Once the project life is completed:

- All system and components including buried cables, foundations and internal roads of the project will be removed and the site will be restored to its preconstruction state.
- The materials for the project should come full circle by reusing or recycling for remanufacturing as part of the recovery plan.

However, the solar modules and inverters could either be revamped or replaced as per the applicable legislation.

3.4.5. Unplanned Events

Solar parks are not typically associated with significant emergency risks. However, there is a potential risk for unplanned events to occur during the construction and operation of the project. This refers to:

- Environmental incidents such as hydrocarbon or chemical spills.
- Vehicle accidents.
- Natural disasters such as flooding and fire/explosion; and
- Medical emergencies such as injury, illness, or fatalities.

Contractors and Operators must have some contingency plans to manage those events.

3.5. The geographical scope of the project

Afif 1 Solar Energy park is located about 23 km southeast of the city of Afif, in the Riyadh Province.

There is a road that connects routes 50 and 80 (Almardamah road) through the west limit of the Project site, adjacent to the plot.

Figure 25. The geographical scope for the project and. extremity boundaries. Source: Self-made.

The coordinates of the extremity boundaries of the available area for the project are indicated below.

Point	X (WGS 84 / UTM zone 38N)	Y (WGS 84 / UTM zone 38N)
1	308,172.56	2,634,073.88
2	314,761.60	2,636,457.17
3	316,083.49	2,631,891.10
4	308,090.69	2,627,874.90
5	308,097.49	2,627,921.94
6	308,101.93	2,627,937.59
7	308,224.24	2,628,417.90
8	308,300.71	2,628,762.17
9	308,365.38	2,629,067.12

Point	X (WGS 84 / UTM zone 38N)	Y (WGS 84 / UTM zone 38N)
10	308,405.46	2,629,344.21
11	308,457.84	2,629,724.05
12	308,520.24	2,630,287.53
13	308,534.05	2,630,772.71
14	308,537.19	2,631,206.07
15	308,576.42	2.631,499.10
16	308,513.74	2,631,899.24
17	308,505.11	2,632,059.37
18	308,428.27	2,632,728.76

Table 22. Coordinates of the extremity boundaries of the available area for the project

3.6. The area required for the project

The allocated area of the project is 40.0 km^2. The project will be located in the East size of the available study area. Project area will be permanently fenced. It is expected that all project activities will be within the limits of this area, so it is expected that the project's footprint will be limited to these limits. Project boundary and coordinates are presented in sections above.

In addition, layout of the solar park (Scale 1: 20,000) is given in Annexes (Section 8.4).

3.7. Project resources, their types and sources

3.7.1. Construction

3.7.1.1. Water Requirement and Resources

There are no water sources available on site and water will be supplied using:

- Potable water: Bottles of water from the nearest markets.
- Domestic uses: Water will be brought to project site by tankers.
- Water for dust suppression and for civil works: Water will be brought to project site by tankers.

A sustainability management plan to avoid the use of plastic bottlers and minimized the carbon footprint for the use of tankers will be prepared during the construction phase.

During the project construction phase, water is required for preparing RCC foundations for module mounting structures (if required), building control room and security rooms, and domestic purpose such as drinking and washing by the construction workers and staff. Water is also used for dust suppression. A licensed water supply company will supply the water required to cover the water demand of the Project to the site via water tanker trucks.

3.7.1.2. Power Requirement (Electricity & Fuel)

Due to the isolated nature of the Project site, the use of temporary diesel generators will be required during construction. Each contactor will supply its own generators for power supply to their own temporary cabins and plant.

It is expected therefore that the EPC Contractor and sub-contractors will have their own diesel storage facilities on-site, which are expected to receive fuel from tanker delivery. At this stage the total volume of power required by the Project has not been finalised.

Additionally, fuel will be used in vehicles and some transport machinery.

3.7.2. Operation & Maintenance

3.7.2.1. Water

Due to water scarcity in the region, cleaning by dry techniques is largely favored against wet cleaning. Then the water demand for panel cleaning will be considered minimal. It is noted that cleaning of the PV panels/modules is planned to be conducted automatically without the use of water in order to make the cleaning process more resource efficient (i.e., avoiding water use) and economically sound. At very special

times when dry techniques cannot properly clean the panels, water will be used for cleaning. In such cases, an amount of 2 litres per solar panel is estimated. A licensed water supply company will supply the water required to cover the water demand of the Project to the site via water tanker trucks.

3.8. Gas, Noise and liquid emission and ways to reduce them

In general, all liquid waste will be appropriately collected and disposed in accordance with applicable national requirements.

3.8.1. Construction

3.8.1.1. Gaseous emissions

Carbon dioxide (CO_2) equivalent emissions associated with materials and construction processes is called Embodied Carbon. It includes any CO_2 equivalent created during the manufacturing of all solar plant material required (extraction, transport to manufacturer, manufacturing), the transport of those materials to the job site, and the construction practices used. Put simply, embodied carbon is the carbon footprint of the solar plant before it becomes operational.

Some papers have been published that investigate how the embodied carbon of solar photovoltaic technology is changing over time and conclusions evidence embodied carbon of solar plants has fallen rapidly. Taking into consideration date sources such as Environmental Product Declarations with long-term studies, Louwen et al (2016, Reassessment of net energy production after 40 years of PV development) indicates that the embodied carbon of solar plants in 2020 is around 615 kgCO2/kWp of installed capacity.

It is worth to mention that this PV plant presents some favourable conditions for construction as the site is very flat and minor civil works will be necessary. All the components to be applied are commercially standard and manufactured under high optimized processes.

Using this average emissions factor for solar plant construction and taking into account an approximate peak capacity of 2,636 MW, the total embedded carbon of the project for the construction has been estimated to be approximately of 1,845,000t of CO2 equivalent. which is a minor adverse effect on climate change.

The significance of the impact is Negligible or Minor. The Risk Is considered Low, Tolerable but need to have best practice applied to them to ensure they comply.

3.8.1.2. Noise

Equipment and machinery are the potential source of noise during construction, Table below shows the maximum sound pressure level for some construction equipment expected to be used according to the noise database of the British Department for Environment, Food & Rural Affairs used to predict noise levels during construction and on open sites.

Equipment	Equivalent sound pressure - LAeq dB
Crawler excavator (truck loading -unloading)	85
Soil grading machine	86
Dump truck	79

Equipment	Equivalent sound pressure - LAeq dB
Dozers	75
Excavators	88
Padding Machines	83
Pile Driver Machines	95
Skid Loaders	77
Trenchers	73
Hydraulic Hammers	89

Figure 26. Source of noise.

3.8.1.3. Domestic Wastewater

During construction and operation, wastewater will be generated from human uses and portable toilets. Wastewater will be collected in designated chemical toilets during construction and holding tanks during operation that will be regularly emptied and cleaned by an approved contractor.

Estimated on the expected generated wastewater volumes during construction is not available at this stage and will depend on the number of workers employed by all contactors. This will also vary across the construction phase with the level of manpower on-site.

3.8.2. Operation

3.8.2.1. Gaseous emissions

Operational carbon of a solar plant is very low as its energy yield production essentially is basically results from dependent on the incident solar energy, requires minor very little inputs and very little maintenance activities. IPCC for example refers an average life-cycle CO2 equivalent emissions for solar plants of 48 gCO2/kWh.

However, the real benefice comes from substitution of fossil fuel-based energy generation with renewable energy generation. Effectively greenhouse gases (GHG) production would substantially be reduced.

- With the annual generating capacity of the planned plant (2,636 MW) and the estimated equivalent hours of production (2,492.41 kWh/kWp), Afif 1 plant total energy production has been estimated on 7,477.23 GWh/year.
- Emissions intensity from electricity generation in Saudi Arabia from 2012 to 2021 is indicated in the figure below.

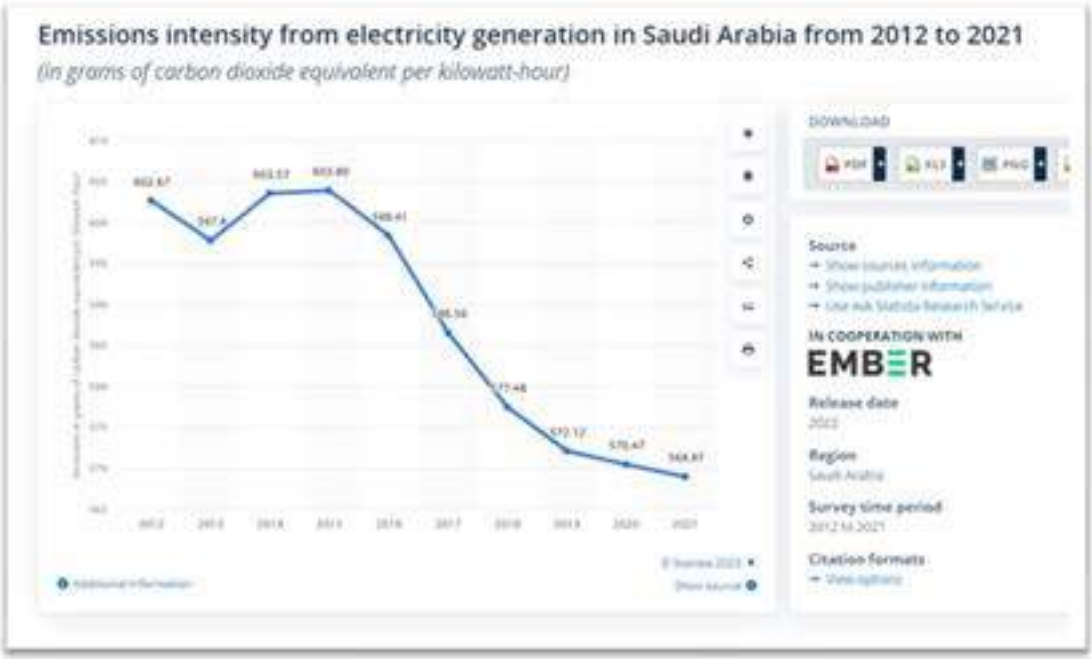


Figure 27. Emissions intensity from electricity generation in Saudi Arabia from 2012 to 2021

Taking into account this Afif 1 plant total energy production and this GHG emission factor for electricity generation with hydrocarbons it is estimated that the operation of the planned solar power plant will avoid the emission of 4,254,319.55 tCO2 GHG annually. This supposes an appreciable reduction and so on an appreciable **Positive Impact**.

3.8.2.2. Noise

During operation, transformer terminals, inverters, and transformers are the potential noise source. Noise levels vary depending on the specifications of the substation. The average noise level for a substation is 80 to 100 dB (S. Shin et al., 2014). The noise from the transformer is expected to be limited and less than 60 dB. Furthermore, the project will also include transmission lines may make droning sounds that occur during periods of high humidity Although this noise is audible to those very close to transmission lines, it dissipates quickly with distance and is easily masked by natural noise and is therefore not considered a significant noise source.

3.8.2.3. Wastewater

During operation, wastewater will be generated from human uses and portable toilets. Wastewater will be collected in designated holding tanks that will be regularly emptied and cleaned by an approved contractor.

Estimated on the expected generated wastewater volumes during operation is not available at this stage and will depend on the number of workers employed.

3.9. Solid waste. Their types and ways of disposal

3.9.1. Construction

3.9.1.1. Solid Waste

In general, all solid waste will be appropriately collected and disposed in accordance with applicable national requirements.

During the construction phase, solid waste usually includes construction waste (backfill, discarded concrete, empty drums) and municipal solid waste (paper, cardboard, plastic, other packaging materials and food waste). Municipal waste will be collected in designated locations on site and disposed by a specialized contractor at the nearest landfill. Construction waste will be reused as much as possible in construction activities, or alternatively it will be disposed at landfill.

Another source of solid waste is damaged photovoltaic panels if present during installation. For damaged panels, it will be handled by a qualified panel recycling contractor. The final management will be chosen at a later stage during the construction phase.

The table below shows the estimated quantities of waste and their disposal methods.

Type of waste	Method of Disposal (Landfill, Incineration or Recycling/Reuse)	Expected quantities
Construction phase		
Excavation and soil waste	Soil will be reused as much as possible in construction activities or it will be disposed of by an approved contractor in a licensed landfill.	Less than 10,000 tons
Construction waste includes ready-made concrete and bricks	It will be disposed of by an approved contractor at a licensed landfill.	Less than 10,000 tons
Waste packing materials, including papers, cardboard, and glass.	It will be reused as much as possible or sold for recycling.	Less than 500 tons
Food waste	It will be disposed of by an approved contractor at a licensed landfill.	Less than 200 tons
Materials contaminated with hydrocarbons including oils and cloth rags contaminated with oils	It will be disposed of by an approved contractor at a licensed landfill.	Less than 1,000 tons
Solvents and paints	It will be disposed of by an approved contractor at a licensed landfill.	Less than 50 tons
Electrical equipment and batteries	It will be disposed of by an approved contractor at a licensed landfill.	Less than 50 tons
Damaged photovoltaic panels	PV panels will be carefully installed to reduce the number of damaged panels. It will be handled by a qualified plate recycling contractor	Cannot be determined at this stage, but quantities are expected to be limited

Table 23. Waste Disposal Methods

In general, all waste will be appropriately collected and disposed in accordance with applicable national requirements.

3.9.2. Operation

3.9.2.1. Solid Waste

In general, all solid waste will be appropriately collected and disposed in accordance with applicable national requirements. During the operation phase, wastes will be managed by Independent Power Producer (IPP) Developer.

Type of waste	Method of Disposal (Landfill, Incineration or Recycling/Reuse)	Expected quantities
Operation Phase		
Food waste	It will be disposed of by an approved contractor at a licensed landfill	Less than 2 tons/year
Substances polluted with hydrocarbons less than including oils and rags	It will be disposed of by an approved contractor at a licensed landfill	Less than 1 ton/ year
Solvents and paints	It will be disposed of by an approved contractor at a licensed landfill	Less than 1 ton/year
Residues of chemical residues or expired	It will be disposed of by an approved contractor at a licensed landfill	Less than 1 ton/ year
Damaged photovoltaic panels	PV panels will be carefully cleaned to reduce the number of damaged panels. It will be handled by a qualified plate recycling contractor	Cannot be determined at this stage, but quantities are expected to be limited

Table 24. Waste Disposal Methods

3.10. The schedule of the work program

3.10.1. Project Phases Schedule

The estimated duration of each project phase is the following.

- Detailed design / feed: 8 Months.
- Site preparation and construction work: 36 Months.
- Operation: 30 Years.
- Shutdown and decommission: 1 Year.

3.10.2. The workforce required for implementation of the project

In the construction works employment will be generated directly, both for skilled and unskilled professionals, at different levels. Indirectly, it will generate employment for many people in the project area and beyond. The great majority of these employments will be from local sources. Estimated number of workers between 650-750.

3.10.3. The workforce required for operational of the project

During the operation of the project, due to the new facilities constructed for the project, manpower will be needed for maintenance and assuring the service of these new facilities. The number of workforces will be estimated before the starting of the operation phase.

3.11. The size of the project

Project initial estimated data is included in the layout (scale 1: 20000) of the solar park (Section 8.4).

It is worth mentioning that, due to the growth and development of the PV market, the estimated final capacity for the project is around 2,138MWn/2,636MWp, and is the power taken into account for this ESIA document.

3.12. Cost of the activity

Estimated cost of the activity is 4.67 billion SAR.

3.13. Checklist: Questions on project characteristics

A checklist (adapted from the European Community Check List) is included in table below regarding the characteristics of the project.

No.	Questions to be considered in Pre-Evaluation	Yes/ No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
1.	**Will construction, operation or decommissioning of the Project involve actions which will cause physical changes in the locality (topography, land use, changes in waterbodies, etc.)?**			
1.1	Permanent or temporary change in land use, land cover or topography including increases in intensity of land use?	Yes	As the site is relatively flat and barren, there will be temporary small changes in topography and the affected area will be restored. The terrain is very flat and the earthworks to be carried out should be minimal. Temporary changes in the zone of construction camps. Construction activities cannot hinder or affect the actual use of land on the site, as these lands are not of agricultural value for the population around excepting grazing activity. Once in operational phase, the project will continue its contribution to the feeling of developing the project area. Given the size of the proposed project, it is anticipated that the solar plant will remain the most prominent landscape feature in the vicinity.	No, minor. The impact on land use is minor and acceptable after that mitigation measures are applied. The area of construction camps will be rehabilitated after decommissioning. The design of the project and the related buildings have been developed focusing on the combination of operational suitability and efficiency while ensuring minimization of the environmental and visual impact.
1.2	Clearance of existing land, vegetation, and buildings?	Yes	The Project Site is situated on a wide plain terrain where the area is poorly vegetated and without presence of buildings. The project avoids the loss of vegetation.	No-Minor

No.	Questions to be considered in Pre-Evaluation	Yes/ No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
1.3	Creation of new land uses?	Yes	Once in operational phase, the project will continue its contribution to the feeling of developing the project area.	Positive. Increase development opportunities
1.4	Pre-construction investigations e.g., boreholes, soil testing?	Yes	Investigations, surveys and/or measurement campaigns have been carried out to define and determine the topographical, geological, geotechnical issues, and baseline settings (noise, air quality, fauna &flora, archaeology.	No-Minor. The permits for the investigations have been obtained
1.5	Construction works?	Yes	The topography will be modified by the project. The earthworks will be minor	No. The project includes the restoration of affected areas.
1.6	Demolition works?	No		
1.7	Temporary sites used for construction works or housing of construction workers?	Yes	Several zones will be proposed for the construction camps and auxiliary facilities. These zones will be acceptable from the environment, cultural and social point of view.	No-Minor. On completion of the project the camps shall be suitably decommissioned, and all construction debris, wastes or scraps shall be removed. These areas will be rehabilitated after decommissioning.
1.8	Above ground buildings, structures or earthworks including linear structures, cut and fill or excavations?	Yes	The project includes minor earthworks and some small buildings. Project will not require large excavations.	No. Buildings and panels will be integrated into the landscape
1.9	Underground works including mining or tunnelling?	No		
1.10	Reclamation works?	No		
1.11	Dredging?	No		
1.12	Production and manufacturing processes?	No		
1.13	Facilities for storage of goods or materials?	Yes	Storage of goods and materials in a proper way, inside zones proposed for the construction camps and auxiliary facilities, utilizing best environmental practices.	No-Minor. These areas will be rehabilitated after decommissioning
1.14	Facilities for treatment or disposal of solid wastes or liquid effluents?	Yes	During construction, disposal of spoils in approved landfills, and discharge permit for wastewater. Water system will be considered during operation phase.	No-Minor. The contractor will get the permits required

No.	Questions to be considered in Pre-Evaluation	Yes/ No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
1.15	Facilities for long term housing of operational workers?	Yes	Facilities during the construction phase.	No-Minor. On completion of the project the facilities shall be suitably decommissioned
1.16	New road or rail traffic during construction or operation?	No	There is an existing road next to the project site. New roads are not necessary. There is a road that connects routes 50 and 80 through Almardamah. The plot is easily accessible from any point of them.	
1.17	New road, rail, air, waterborne or other transport infrastructure including new or altered routes and stations, ports, airports etc.?	No		
1.18	Closure or diversion of existing transport routes or infrastructure leading to changes in traffic movements?	Yes	During construction, temporal increase of traffic in the road that connects routes 50 and 80 through Almardamah.	No-Minor. Traffic Control Plan
1.19	New or diverted transmission lines or pipelines?	No		
1.20	Impoundment, damming, culverting, realignment, or other changes to the hydrology of watercourses or aquifers?	No	The project does not include any hydrology changes.	
1.21	Stream crossings?	No	No streams will be crossed by the project.	
1.22	Abstraction or transfers of water from ground or surface waters?	No		
1.23	Changes in waterbodies or the land surface affecting drainage or run-off?	No	No waterbodies were registered in the project area. For this type of project with a minimal disturbance of natural topography, changes made to the natural paths of runoff water are considered minor and therefore their impact is assessed to be minimal.	
1.24	Transport of personnel or materials for construction, operation, or decommissioning?	Yes	Materials for construction will be transported in a correct manner. Collective transport for personnel will be considered	No-Minor. Traffic Control Plan and Dust Control Plan during construction
1.25	Long term dismantling or decommissioning or restoration works?	Yes	The solar plant site is designed for a lifecycle of 30 years	No-Minor.
1.26	Ongoing activity during decommissioning which could	No	Key decommissioning activities will include Site and surrounding environment assessment; Protect	

No.	Questions to be considered in Pre-Evaluation	Yes/ No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
	have an impact on the environment?		natural resources; Waste management operation; Removal of all Project components; Soil remediation and Restoration of the terrestrial ecology habitats within the Project footprint including access roads.	
1.27	Influx of people to an area in either temporarily or permanently?	No		
1.28	Introduction of alien species?	Yes	There is a risk that alien invasive plants may be introduced and could spread into adjacent areas If equipment and/or fill material from other areas is imported, where they may replace indigenous vegetation and/or reduce grazing potential for wild animals, camels, sheep, and goats' herds.	No-Minor. The likelihood is seldom, and preventive measures have been considered (site screened, machinery cleaning, etc.)
1.29	Loss of native species or genetic diversity?	No		
1.30	Any other actions?	No		
2.	**Will construction or operation of the Project use natural resources such as land, water, materials, or energy, especially any resources which are non-renewable or in short supply?**			
2.1	Land especially undeveloped or agricultural land?	No	These lands are not of agricultural value for the population around excepting grazing activity	
2.2	Water	Yes	There are no water sources available on site and water during construction phase will be supplied using: -Potable water: Bottles of water from the nearest markets. -Domestic uses: Water will be brought to project site by tankers. -Water for dust suppression and for civil works: Water will be brought to project site by tankers. Due to water scarcity in the region, cleaning by dry techniques is largely favoured against wet cleaning. Then the water demand for panel cleaning during operation phase will be considered minimal.	No-Minor
2.3	Minerals?	No		
2.4	Aggregates?	Yes	During construction, the aggregates will be obtained from commercial quarries during	No-Minor

No.	Questions to be considered in Pre-Evaluation	Yes/ No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
			construction phase. Estimated quantity of material: 612 cubic meters of concrete.	
2.5	Forests and timber?	No		
2.6	Energy including electricity and fuels?	Yes	Due to the isolated nature of the Project site, the use of temporary diesel generators will be required during construction, Additionally, fuel will be used in vehicles and some transport machinery. During operation phase energy resources: -From the network: Only during plant shut-downs and night. -From generator: Diesel Generator for emergency. -From other sources: Self-supply during daylight.	No-Minor. The solar power plant will provide new renewable alternatives for energy and reduce the Kingdom's dependence on traditional energy represented by petroleum.
2.7	Any other resources?	No		
3.	**Will the Project involve use, storage, transport, handling or production of substances or materials which could be harmful to human health or the environment or raise concerns about actual or perceived risks to human health?**			
3.1	Will the project involve use of substances or materials which are hazardous or toxic to human health or the environment (flora, fauna, water supplies)?	No		
3.2	Will the project result in changes in the occurrence of disease or affect disease vectors (e.g., insect or waterborne diseases)?	No		
3.3	Will the project affect the welfare of people e.g., by changing living conditions?	No		
3.4	Are there especially vulnerable groups of people who could be affected by the project e.g., hospital patients, the elderly?	No		
3.5	Any other causes?	No		
4.	**Will the Project produce solid wastes during construction or operation or decommissioning?**			
4.1	Spoil?	Yes	Spoil generation during construction phase will be minor. Reuse of suitable excavation spoil. Spoil Management Plan. The last option: Authorized landfills for spoil.	No-Minor. Spoil will be reused as much as possible in construction activities or it will be disposed of by an approved contractor in a licensed landfill

No.	Questions to be considered in Pre-Evaluation	Yes/ No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
4.2	Municipal waste?	Yes	Low volume of municipal waste will be generated during construction phase. Municipal waste generation during operation phase from workers of the Solar Plant.	No-Minor. There is an ample local waste management capacity
4.3	Hazardous or toxic wastes, including contaminated soils?	Yes	Management of the hazardous wastes during construction phase.	No-Minor. Waste Management Plan
4.4	Other industrial process wastes?	No		
4.5	Surplus product?	No		
4.6	Sewage sludge or other sludges from effluent treatment?	No		
4.7	Construction or demolition wastes?	Yes	Management of the construction debris wastes during construction phase.	No-Minor. Waste Management Plan
4.8	Redundant machinery or equipment?	No		
4.9	Agricultural wastes?	No		
4.10	Any other solid wastes?	No		
5.	**Will the Project release pollutants or any hazardous, toxic, or noxious substances to air?**			
5.1	Emissions from combustion of fossil fuels from stationary or mobile sources?	Yes	Air emissions (SO_2, NO_x, etc.) from stationary sources during construction phase. Good construction practices	No-Minor.
5.2	Emissions from production processes?	No		
5.3	Emissions from materials handling including storage or transport?	Yes	Dust from materials handling (storage and transport) during construction phase. Good construction practices	No-Minor.
5.4	Emissions from construction activities including plant and equipment?	Yes	Air emissions (SO_2, NO_x, etc.) from stationary equipment during construction phase. Good construction practices	No-Minor.
5.5	Dust or odours from handling of materials including construction materials, sewage, and waste?	Yes	Dust from earthworks during construction phase. Dust Control Plan.	No-Minor.
5.6	Emissions from incineration of waste?	No		
5.7	Emissions from burning of waste in open air	No		
5.8	Emissions from any other sources?	No		
6.	**Will the Project cause noise and vibration or release of light, heat energy or electromagnetic radiation?**			

No.	Questions to be considered in Pre-Evaluation	Yes/ No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
6.1	From operation of equipment?	Yes	Temporal and Low increase of noise on sensitive receptors during construction phase from equipment. Noise Control Plan. Mitigation Measures to Minimize noise impacts to sensitive receptor. Emissions of noise during the operation of the solar power plant will not be significant enough to generate noise nuisance.	No-Minor. Noise control Plan during construction phase.
6.2	From industrial or similar processes?	No		
6.3	From construction or demolition?	No		
6.4	From blasting or piling?	No		
6.5	From construction or operational traffic?	Yes	Temporal and minor increase of noise on sensitive receptors during construction phase from traffic.	No-Minor. Noise Control Plan and Mitigation Measures during construction phase
6.6	From lighting or cooling systems?	No		
6.7	From sources of electromagnetic radiation	No		
6.8	From any other sources?	No		
7.	**Will the Project lead to risks of contamination of land or water from releases of pollutants onto the ground or into sewers, surface waters, groundwater?**			
7.1	From handling, storage, use or spillage of hazardous or toxic materials? Use of chemical products (paints, etc.), oils and fuels	Yes	Mitigation Measures for potential hazards during construction phase will be described in the Spill Management Plan	No-Minor and Unlikely
7.2	From discharge of sewage or other effluents (whether treated or untreated) to water or the land?	Yes	Management of Wastewater generation (sanitation) from work camps during construction phase. Storage into authority approved holding tanks or chemical toilets. Management of Wastewater generation during operation phase from buildings to holding tanks or public network.	No-Minor
7.3	By deposition of pollutants emitted to air, onto the land or into water?	No		
7.4	From any other sources?	No		

No.	Questions to be considered in Pre-Evaluation	Yes/ No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
7.5	Is there a risk of long-term build-up of pollutants in the environment from these sources?	No		
8.	**Will there be any risk of accidents during construction or operation of the Project which could affect human health or the environment?**			
8.1	From explosions, spillages, fires etc. from storage, handling, use or production of hazardous or toxic substances?	Yes	Mitigation Measures for Potential hazards during construction phase will be described in the Construction Health and Safety Plan and in the Security and Emergency Response Plan	No. Close cooperation with other government agencies in the formulation and implementation of the Plan
8.2	From events beyond the limits of normal environmental protection e. g failure of pollution control systems?	No		
8.3	From any other causes?	No		
8.4	Could the project be affected by natural disasters causing environmental damage (e.g., floods, earthquakes, landslip, etc.)?	No		
9.	**Will the Project result in social changes, for example, in demography, traditional lifestyles, employment?**			
9.1	Changes in population size, age, structure, social groups etc.?	No		
9.2	By resettlement of people or demolition of homes or communities or community facilities *e.g.,* schools, hospitals, social facilities?	No		
9.3	Through in-migration of new residents or creation of new communities?	No	Residential areas are not foreseen around project area.	
9.4	By placing increased demands on local facilities or services *e.g.,* housing, education, health?	No		
9.5	By creating jobs during construction or operation or causing the loss of jobs with effects on unemployment and the economy?	Yes	Temporal jobs will be created during construction phase. Permanent jobs for the infrastructure maintenance and for the activities during operation phase will be created.	Positive impact
9.6	Any other causes?	No		
10 - Are there any other factors which should be considered such as consequential development which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality?				

No.	Questions to be considered in Pre-Evaluation	Yes/ No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
10.1	Will the project lead to pressure for consequential development which could have a significant impact on the environment e.g., more housing, new roads, new supporting industries, or utilities, etc.?	No		
10.2	Will the project lead to development of supporting facilities, ancillary development or development stimulated by the project which could have an impact on the environment?	No		
10.3	Will the project lead to after-use of the site which could have an impact on the environment?	No		
10.4	Will the project set a precedent for later developments?	Yes	The project will improve the later developments	Positive impact
10.5	Will the project have cumulative effects due to proximity to other existing or planned projects with similar effects?	No		

Table 25. Checklist. Questions on project characteristics. Source: Guidance on EIA. Scoping. June 2001. Environmental Resources Management

3.14. Activity alternatives

This chapter provides an overview of the justification for the proposed development and describes the feasible project and design alternatives that have been considered at this stage of the development. The consideration of alternatives is based on the preliminary design and is assessed against the international lending and client requirements. This includes consideration to the application of Best Available Techniques (BAT) to the development in accordance with the requirements National Center for Environmental compliance (NCEC) in addition to International Finance Corporation (IFC) Performance Standards.

The consideration of alternatives also considers IFC Performance Standard 3 and the requirements for Resource Efficiency (Greenhouse Gases and Water Consumption) and Pollution Prevention (General, Hazardous Materials Management and Pesticide Use and Management). The objectives for this Performance Standard are as follows:

- To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.
- To promote more sustainable use of resources, including energy and water; and,
- To reduce project-related Greenhouse Gas (GHG) emissions.

3.14.1 Methodology of selecting and evaluating alternatives

This step aims to describe the proposed alternatives for the project and determine the most appropriate and least impactful on the environment. This step includes a study and analysis of many technical aspects of the

project, including the location and design of the project and the technology used in the operation process. The alternatives evaluation methodology is based on making a comparison between the various proposed alternatives for the project and comparing the following aspects:

- Proposed project site alternatives.
- Economic feasibility and associated costs.
- The pros and cons of each alternative.
- Financial efficiency, including costs, environmental management.
- The degree of impact on the environmental, economic, and social aspects.
- Technology used and possible project designs.
- Consistency and not conflict with future development plans in the region.
- Possible build and run processes.
- Consumption of natural resources, especially energy and water.
- Administrative, legal, and technical difficulties associated with the implementation of each alternative.
- Risks related to the implementation of each alternative.

3.14.1. Project alternatives and descriptions

3.14.1.1. No Project Alternatives

The Proposed development aligns within the main strategy of the energy sector in the Kingdom of Saudi Arabia. The renewable energy policy in the Kingdom is a central component of the country's vision 2030.

The no-project alternative will not contribute to the Saudi Arabia's long-term strategy of diversifying energy mix and will not reduce the Kingdom's dependence on oil and gas and its greenhouse gas emissions as part of the Paris Agreement.

The 'no project' option is considered not viable due to the requirement for an economic and social roadmap targeted at increasing non-oil revenues, attracting foreign investments, and improving the lifestyle of Saudi citizens, among the reforms implemented under the umbrella of Vision 2030 as per the project's rationale. Although the construction phase of the Project will likely result in an overall negative impact, the operational phase will likely result in an overall positive impact, particularly due to the development of renewable energy, job creation and socio-economic benefits.

3.14.1.2. Proposed Project Alternatives

Various alternatives will be studied, with the aim of eliminating or reducing the impact to an acceptable degree.

All available alternatives will be presented and include:

- Location alternatives
- Technical alternatives.

3.14.1.3. Location alternatives

The site selection is the first step to determine the most relevant project features and setting up the main design criteria for the projects. In order to select the most optimal site for the future development of Afif 01

solar power plant, a methodology based on criteria and factors to facilitate the spatial site selection is adopted. To assess the suitability of land for the project, technical criteria are used including access to land and land use and socio-economic criteria including community interest, proximity to the distribution network distance to roads, distance to power lines, distance to substations and environmental criteria including protected areas, land use, hydrology, risk of dust, topography and sensitive ecologically areas outcrops, relevant flora and wadis Site selection criteria are summarized in the table below.

identified criteria		Factors
1	Socio-economic	Accessibility
		Community Interest
		Slope
		Proximity to electric transmission
2	Environmental	Used land
		Protected Area
		Flora & Fauna
3	Technical	Climate
		Land use
		Topography, geotechnical and hydrological suitability

Table 26. Identified criteria for location alternatives

The Project area was selected for the development of a PV plant. An alternative site location has not been provided.

3.14.1.4.Technical Alternatives

The photovoltaic plant is designed to reduce the cost of energy generated, while using industry-proven photovoltaic technology. The proposed project design is based on standard PV plant configurations and engineering best practices and has been combined with the results of optimization studies to define several key project parameters. A number of other considerations such as mounting system and panel cleaning are considered as detailed below.

a. Installation System

The PV installation structure is a critical component of the proposed project, due to its impact on production capacity, as well as on operational costs. There are three alternatives to the installation system:

- Fixed tilt mounting system.
- Uniaxial tracking system.
- Two-axis trackers

For a fixed-tilt mounting system, the photovoltaic panels remain in a fixed position, usually tilted toward an ideal angle, and the array is oriented in an east-west direction. For a monoaxial tracking system, the photovoltaic panels are positioned in a north-south alignment, oriented toward a single axis (+60°/-60°) to track the sun from east to the West. Figure below shows examples of mounting systems.

Solar panels fixed without tracking system

Solar panels installed with tracking system

Figure 28. Examples of installation systems

Two-axis trackers solution maximizes the capture of irradiation by a continuous and perfect orientation to the sun during all daytime and different seasons. It was a popular solution some years ago when PV modules were 10 times more expensive and then, the design should maximize the utilization of the modules. However, it requires of a much large and robust structure and also huge foundations. This entails a more complex installations and much higher impact and costs while the gain in yield is around only 10% compared to horizontal tracker.

b. Tracker

The latest state of the art for large PV power plants is to use those modules mounted on ground-mounted tracking structures. To maximize the site for annual and seasonal energy production, the tracking mechanism follow the sun daily from east to west. It could yield up to 20% more.

For this project, the tracker system is the selected alternative to fixed structure solution. Panel Cleaning System

In desert areas with a high proportion of dust in the air with little rain, dust deposition on the surface of the panels is inevitable.

Cleaning these panels is a must to achieve maximum efficiency in the generation of electricity from the solar cells. Various manual and automatic cleaning techniques are available. Cleaning expenses in a solar power plant represent nearly half of the operation and maintenance cost (Khadka et al., 2020). There are two alternatives to cleaning photovoltaic panels:

- Water-based cleaning systems: They are best suited when water is abundant. Routine cleaning is required from time to time, so that no precipitated particles or bird droppings are allowed to remain for a long time on the panels. These systems create a rain-like environment in a solar plant where hoses spray water directly onto the panels; Water falls off the panels due to the inclination of the panels and the effect of gravity.
- Waterless/dry cleaning systems: Suitable in dry places such as deserts where water is not available and deposition on the surface of the panels is caused by dust accumulation only. In the waterless cleaning technique, a brush, usually dust-repelling, rotates or moves along the surface of the board to sweep away the dust. This system is less complicated as there is no need to store water and pump it at high speed on the board.

As stated in a previous section, the cleaning techniques chosen will be dry techniques using fully or semi-automated cleaning robots. At very special times when dry techniques cannot properly clean the panels, water will be used for cleaning. In such cases, an amount of 2 litres per solar panel is estimated. Water will be brought to project site by tankers. An eco-friendly biodegradable detergent will be used to have no damaging effect on the environment.

c. Photovoltaic technology

Crystalline silicon (both mono and polycrystalline) and amorphous silicon thin film are the most popular solar technologies applied to produce electricity from the sun.

A dominant factor that is directly related to the CO_2 emissions is the module conversion efficiency. As the efficiency of the panel increases, the equivalent grams of CO_2 per kWh are reduced due to more energy is produced with the same module area. Therefore, more GHG emissions will be reduced using crystalline panels because their higher efficiency compared to the amorphous technology for the same area.

Also, as a result of the higher efficiency of crystalline modules the amount of solar equipment that is required such as arrays, cables, among others, is lower and, thus, a smaller number of modules and energy consumption to install them is required.

The amount of energy required to create photovoltaic silicon is the major consumption for both crystalline and amorphous silicon modules. Among the required materials, it is possible to mention glass and aluminum.

There are also other photovoltaics technologies like cadmium telluride (CdTe) modules and copper indium gallium selenide (CIGS), among others. They have lower efficiency compared to silicon panels which can affect their overall performance and energy yield. Additionally, CdTe panels include some toxic material like

cadmium. Regarding CIGS panels, they are flexible and hold less toxicity than CdTe PV modules, but they are much less efficient compared to the crystalline silicon PV cells.

The next figure shows the crystalline silicon (both mono and polycrystalline) and amorphous silicon thin film that was mentioned previously.

Figure 29. Module technologies.

Finally, the recycling process for crystalline modules and dedicated companies are now more advanced and widespread.

In summary, crystalline silicon is considered as the best solution for this project due to its highest efficiency and non-toxic composition compared to the other technologies, as well as its higher availability and reliability.

d. Type of Photovoltaic Panels

The alternatives considered for the type of PV modules are:

- Monofacial.
- Bifacial.

Unlike single-sided PV modules, bifacial modules absorb solar energy from both sides, front and back panel. This allows the photovoltaic cell to collect a greater amount of solar radiation, thus producing more energy (see figure below).

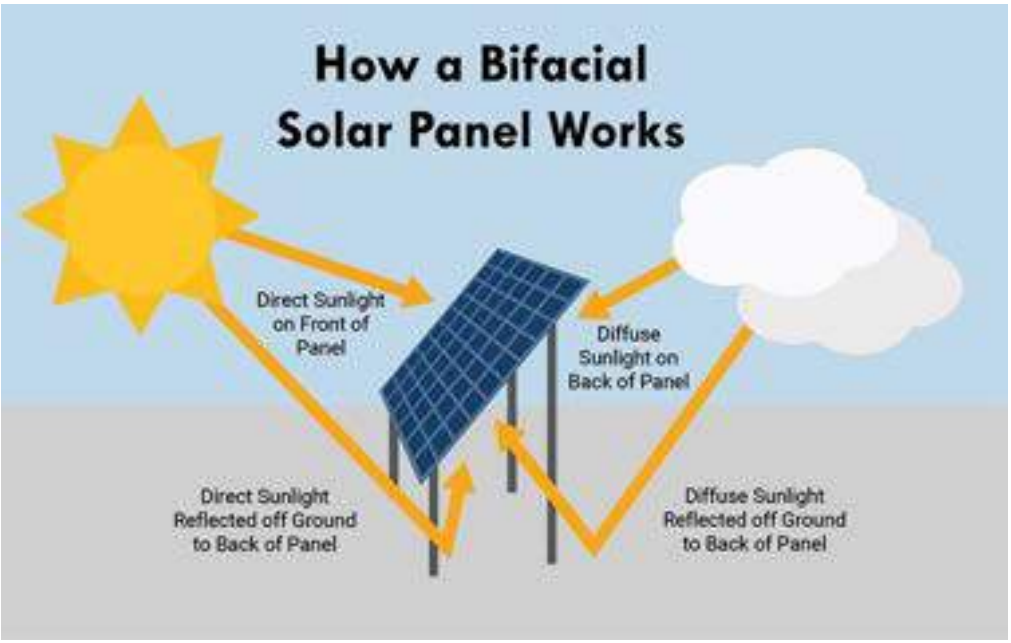


Figure 30. Bifacial PV Module (Source: paradise energy solution)

Bifacial solar panels operate with the same principle of solar photovoltaic but can produce solar power from both sides of the panel. Whereas traditional monofacial panels are opaque from rear side, bifacial modules expose both the front and backside of the solar cells to radiation. When bifacial modules are installed on a ground, it absorbs the solar radiation reflected from the ground, called as “albedo”, which results in increase of electrical output from the solar panel.

Few important aspects of energy simulation with bi-facial type solar panel are described below:

- Rear shading losses – The loss of power due to obstruction or shading of incident radiation on the rear side of the solar panel.
- The proportion of the incident light or radiation that is reflected by Earth’s surface.

The benefits of bifacial units vary greatly according to the conditions of the installation site, and specifically the surface in which they are installed. When the two-sided units are installed at sufficient distances and on a highly reflective surface (e.g., a white ceiling or on the floor with light-colored stones), production can be increased by up to 25% due to the additional radiation captured from the lower face. Conversely, narrow spaces and dark ground can nullify these gains. The other two alternatives to the PV module are (see figure below):

- Full cell.
- Half cut cell.

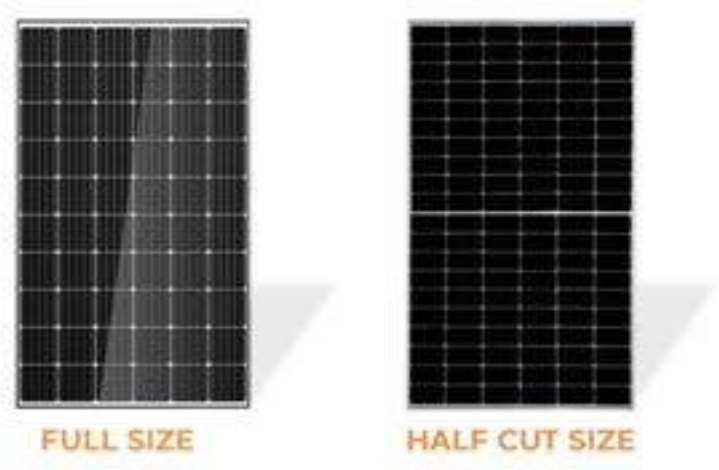


Figure 31. Solar panel cell alternatives

Half-cell modules are solar cells split in half to improve module performance and durability. When the number of solar cells is halved, their current is halved, which reduces electrical resistance (i.e.: higher yield). Smaller cells are not subjected to significant mechanical stresses, which reduces cracking. Half-cell units perform better during daily operation due to their lower power temperature coefficient, lower shading effects on power generation, reduced hotspot hazards, and enhanced mechanical load tolerance. Some manufacturers use triple cut cells, but this is not a standard/standard manufacture on the market yet. There is a trend in the market towards half-cell technology due to increased power output and reduced losses in case of shading.

Bifacial solar panels have been chosen as the final solution for the project.

e. Type of high voltage substation

The alternatives considered for the type of high voltage substation are:

- AIS (Air Insulated Substation).
- GIS (Gas Insulated Substation)

Electrical substations are a fundamental part of the internal distribution network. With them we can adapt the voltage to achieve adequate and safe power depending on each need.

There are two main types of commercial substations. AIS (Air Insulated) or outdoors substations. An AIS substation insulates the main circuit from the ground by air using porcelain or composite insulators and/or electrical bushings. The AIS arrangement is ideal for substations with ample space and no high environmental conditions.

Figure 32. Example of an AIS substation

In the Kingdom, the grid operator SEC specified GIS substations. The acronym GIS refers to "Gas Insulated Substation". This type of insulation is its main characteristic and allows the distance between its components to be reduced due to the high dielectric strength of the insulating gas encapsulated in this type of installation. This circumstance is what also leads us to talk about encapsulated substations within buildings.

The GIS will use non-SF6 gases so very small or non-existing global warming potential is expected in case of spilling.

Figure 33. Example of a GIS substations

Its high compactness allows the maximum to optimize the surface occupied by a substation to the maximum. A technology that allows us to occupy a surface area that is 90% smaller than an outdoor substation which also minimise the visual impact.

For this project, all the planned high voltage substations will be GIS.

3.14.2. Comparison of alternatives

The following table shows a summary of the comparison of the alternatives mentioned above. Selected alternatives have been marked in grey colour.

Alternatives	Advantages	Disadvantages
Project creation	▪ project contributes KSAs 2030 vision of using renewable technologies to replace hydrocarbons in energy generation. ▪ Power generation ▪ Reducing greenhouse gas emissions ▪ Providing job opportunities ▪ Investing and strengthening the local economy	▪ Limited environmental impacts during the different stages. ▪ Especially during construction. However, the effects are greatly mitigated.
"No-project"	▪ There are no environmental impacts as no construction or operation activities will be carried out.	▪ No power generation Loss of job opportunities ▪ Investment loss.
Alternatives of technology		
Installation system		
Fixed tilt mounting system	The operation and maintenance cost are lower compared to the single axis tracking system.	Reduced annual power generation rate.

Alternatives	Advantages	Disadvantages
Monoaxial tracking system	For the same power rating, the annual output of the monoaxial tracking system is about 11% higher than that of the fixed-tilt mounting system.	Operation and maintenance cost is higher compared to fixed tilt mount system.
Panel cleaning system		
Waterless/dry cleaning systems	No need to consume water or use additional equipment, reducing the use of natural resources.	▪ The need for specialized personnel to operate the system. ▪ Slight increase in fuel consumption for the use of trucks. ▪ At special times, when dry techniques cannot properly clean the panels, water will be used for cleaning. In such cases, an amount of 2 litres per solar panel is estimated.
Water based cleaning systems	Automated technology does not require the presence of equipment and workers dedicated for this purpose and the possibility of damage. The panels are few.	▪ Requires the presence of sprinklers and water tanks on site. ▪ It requires the use of water of a certain quality to not leave sediments on the panels. ▪ It requires the presence of water always on the site.
Photovoltaic technology		
Amorphous silicon & thin film modules	Lower price regarding monocrystalline panels.	▪ Lower efficiency compared to monocrystalline panels. ▪ Higher GHG emissions per kWh generated for the same area. ▪ Higher space utilization for the same production. ▪ Higher required amount of PV equipment like arrays, cables, among others. ▪ Lower service life compared to other technologies. ▪ Higher average annual degradation.
Crystalline modules	▪ Most common technology used in the industry. Therefore, higher availability of spare parts is expected. ▪ Higher efficiency compared to other technologies. ▪ Lower GHG emissions per kWh generated for the same area compared to amorphous technologies. ▪ Higher service life compared to amorphous silicon technology. ▪ Lower average annual degradation.	▪ Slightly higher prices compared to amorphous modules.

Alternatives	Advantages	Disadvantages
Solar panel type (module)		
Bifacial-monocrystalline modules	Energy production can be increased by up to 25%.	The benefits of bifacial units vary greatly according to site conditions.
Monofacial	Common technology.	The power output is lower compared to a two-sided unit.
Solar panel type (cell)		
Full cell	Common technology.	Lower performance and durability compared to the half-cell.
Half cell	Better and more durable performance compared to full cells.	
HV Substation technology		
GIS (Gas Insulated)	Compact – Smaller use of land Lower visual impact	Higher installation costs
AIS (Air Insulated)	Lower cost Use of standard equipment	Larger land usage

Table 27. Summary of the comparison between alternatives

Note: In grey color selected alternatives. Solar panel type cell has not decided yet.

Description of surrounding environment

4. Description of surrounding environment

This Environmental Impact Evaluation Study Report refers to Afif 1 Solar Power Project.

The project lies, approximately, 23 km southeast of the city of Afif, in the Riyadh Province, in Afif governorate. From the site of the Solar Power Project, we can also locate the following urban centres:

- Almardamah (about 8 km south of the project site)
- Riyadh city (about 370 km east of the project site)

The site´s available surface is 40.0 km^2 and the elevation of the site is 978 meters above sea level. The following figure shows the location and the boundaries of the Solar Power Project:

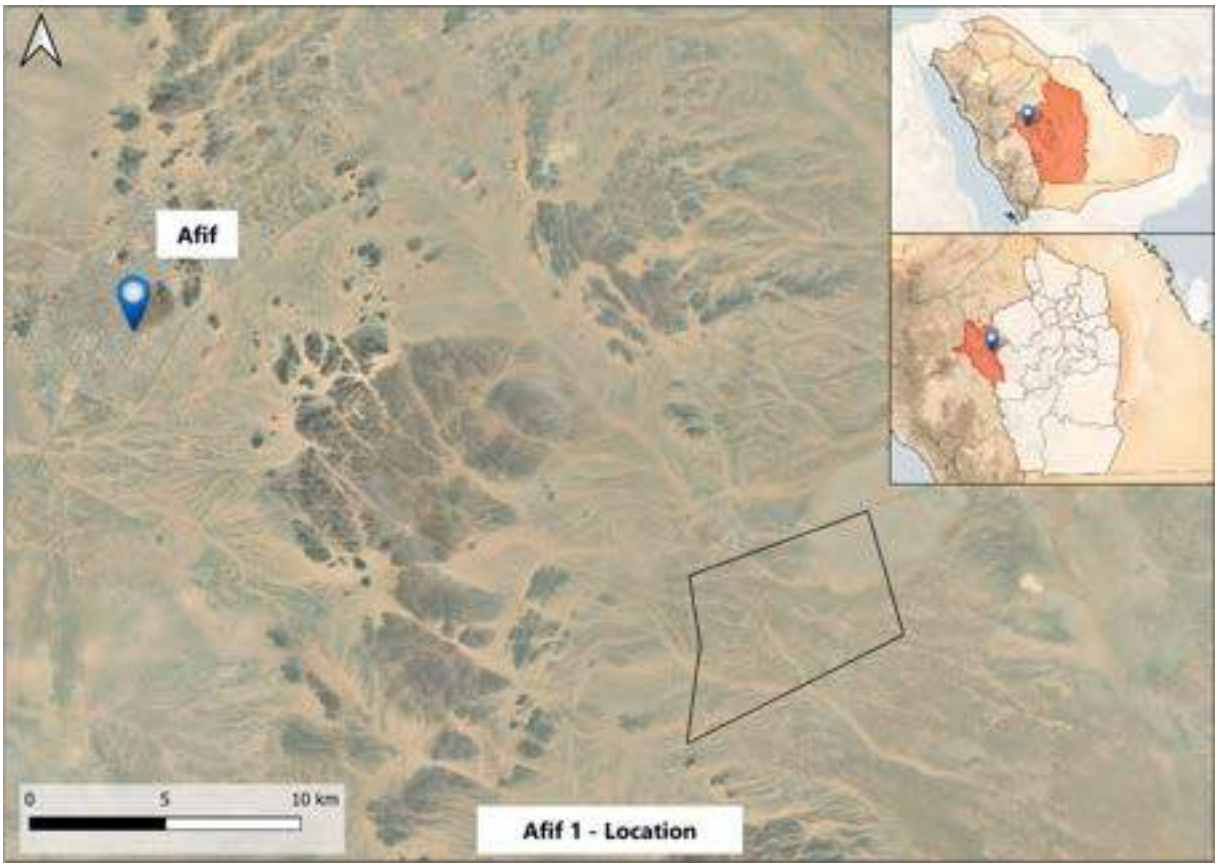


Figure 34. Afif 1 Solar Power Project location and boundaries. Source: self-made

A detailed description of environmental elements in the project area is made in the following sections. Information has been collected both from documenting information from available sources and from field visits of the site, and includes but is not limited to:

- Physical environment: climate, ambient noise, air quality, surface and ground water resources, geology, soil, land use, and landscape.
- Biological environment: biodiversity, flora and fauna, natural protected areas, and habitats.
- Economic and social environment: community structure, community employment, family structure, public safety, heritage resources and antiquities.

The **Methodology of Field Work Surveys** has been the following:

An initial site walkover survey has been carried out by TYPSA experts in November 2023, to recognize the project area and identify main environmental constrains and key environmental issues. The following goals were reached during the field journals:

- Initial approach to environmental issues.
- Photographic report of the site.

Besides, TYPSA has carried out the Geotechnical campaign from December 2023 to April 2024.

Field work surveys (fauna and flora survey, noise and air quality) were carried out in January 2024. Field work surveys have been carried out by AHEC experts The results of field work surveys have been presented in this report (**Section 8.3.1**).

The field work was the following:

- Flora and fauna survey. Terrestrial ecology survey was carried out from 1st to 11th of January 2024.
- Noise measurement survey. Noise monitoring was carried out from 16th to 18th of January 2024.
- Air quality measurement survey. Air quality monitoring was carried out from 16th to 17th of January 2024.

Surveys conducted
Initial site walkover survey
Fauna and flora survey
Noise survey campaign
Air quality survey campaign
Geotechnical survey

Table 28. Summary of surveys conducted.

The survey campaign was aimed to determine in detail:

- The current ambient noise and air quality in the site.
- The identification of flora and fauna and ecosystems occupying the site.
- Any environmental degradation or pollution.
- Any archaeology and heritage features.
- Any landscape features.
- The current land use of the whole site.

- Identification of any sensitive receptor to the project.

In addition, the surveys have included the following:

- Environmental degradation.
  During the drive through and walkover, any environmental degradation, such as solid waste dumping has been recorded and photographed and described to be presented in the survey report.
- Land use features.
  During the site sweeping any land use features have been localized and recorded. Any temporary or permanent camps, livestock have been described and mapped, including boreholes, benchmarks and built asset in the site.
- Archaeology and heritage features.
  During the site survey, AHEC experts searched for any archaeological or cultural findings within the plot. No cultural heritage features were discovered.
- Landscape features.
  The site appeared to be relatively flat, and sand/gravel plains are the predominant landscape. No key landscape features can be considered as ecologically important for flora or fauna.
- Sensitive receptors
  Any sensitive receptors such as temporary or permanent camps, herders, settlements close to the project or any ecological sensitive receptor species that have been observed onsite have been recorded and depicted on a map and presented in the baseline report (section 8.2.1).

TYPSA used existing data from the survey in conjunction with collected bibliographic data.

4.1. The physical environment

4.1.1. Climate and Air Quality

4.1.1.1. Methodology of Air Quality survey campaign

Bander Said Allehiany (BSA), a specialized organization involved in the Environmental Monitoring Services in the Kingdom of Saudi Arabia was invited by AHEC to conduct Ambient Air Quality Monitoring & reporting.

Accordingly, BSA conducted the Ambient Air Quality Monitoring for Afif 1 site, for 24 hours from 16th until 17th of January 2024, to determine the baseline ambient air quality at the project site according to NCEC.

A Mobile Air Quality Monitoring Station complying with BSA standards was used to measure ambient air pollutants concentration in real time, quickly and accurately.

Pollutants measured are essentially, ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and particulate matter $PM_{2.5}$ and PM_{10}. Meteorological data including temperature, humidity, wind speed, wind direction, atmospheric pressure was measured. For each point, the station was placed below the wind direction and ran 24 hours.

Measurement was conducted in two (02) points as shown in figure below. Since there is no activity within the plot, except for livestock camps and camel grazing, air pollutants source might be Almardamah Road. Both points were placed to check if there is any effect within the plot from the road location. Coordinates for both air quality measurement points #1 and #2 are specified in the following table and figure below.

Solar Plant		Geographical Coordinates	
Afif 1 Solar Plant	Point 1	N	23.769605
		E	43.135293
	Point 2	N	23.804565
		E	43.118066

Table 29. Coordinates of Air Quality Monitoring Stations at Afif 1 Solar Plant Site. Source: Environmental Baseline Survey Report

Figure 35. Location of Air Quality Monitoring Stations. Source: Environmental Baseline Survey Report

Figure 36. Location of Air Quality Monitoring Station at points 1 & 2. Source: Environmental Baseline Survey Report

Any activity on the site, that may interfere with the functioning of monitoring station has rescheduled to avoid any contamination of measurement.

Data collected have been compiled, analysed, and presented in an appendix of the Environmental Baseline Survey Report which is included in section 8.3.1. The report includes:

- Some photos of the measurement procedure stamped with date and location.
- Technical datasheet of the used device indicated technical features of the device.
- Calibrations certificates of the device.
- Any document and evidence proving the compliance of the device with the NCEC standards.

4.1.1.2. Relevant legislation and standards

a. International agreement & Conventions and Regional Standards

The Kingdom of Saudi Arabia cooperates internationally to protect and manage the environment and participates in the work of codification of international environmental law. This commitment is manifested in the signing and ratification of some international conventions on the environment which are developed in section 2.2.3.

Ambient Air Regional Quality Standards are applied in all countries of the Cooperation Council for the Arab States of the Gulf. These standards are developed in more depth in section 2.2.2.

b. International Finance Corporation (IFC)

The World Bank Group has prepared an Environmental, Health, and Safety Guidelines (known as the "EHS Guidelines"). The EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP) and are referred to in the World Bank's Environmental and Social Framework and in IFC's Performance Standards.

The EHS Guidelines contain the performance levels and measures that are normally acceptable to the World Bank Group. In its chapter 1 deals with Environmental issues, such as Air Emissions and Ambient Air Quality.

This guidelines for Air Emissions and Ambient Air Quality (2007) establish ambient air quality limits and guidelines for projects with significant sources of air emissions and potential for significant impacts to ambient air quality. These standards are the results of applying national legislated standards, or in their absence, the current World Health Organization (WHO) Ambient Air Quality Guidelines. The WHO Ambient Air quality standards are presented in the following table.

Pollutant	Averaging Period	NCEC (µg/Nm^3)	WHO (µg/m^3)
Sulfur Dioxide	10 Minute		500
	1 Hour	730	-
	24 Hour	365	20
	Annual	80	
Nitrogen Dioxide	1 Hour	660	200
	Annual	100	40
Particulate Matter PM10	24 Hour	340	50
	Annual	80	10
Particulate Matter PM2.5	24 Hour	35	25
	Annual	15	10
Ozone	8 Hour	157	100
Carbon Monoxide	1 Hour	40,000	
	8 Hour	10,000	

Table 30. WHO Ambient Air Quality Standards. Source: World Health Organization (WHO) Ambient Air Quality Guidelines

c. National regulations

The executive regulation For Air Quality from the Environmental Law issued by Royal Decree No. (m/165), dated 19/11/1441 Hijri in appendix (1) specify the NCEC Ambient Air Quality Standard (AAQS) for primary pollutants. This regulation is developed in more depth in section 2.2.1.

Pollutant	Measurement micrograms/m^3 ($\mu g \cdot m^{-3}$) *	Permissible transgressions	Average time
Carbon Monoxide CO	40,000	Once a year	hour
	10,000	Twice a month	8 hours
Nitrogen dioxide NO_2	200	24 per year	hour
	100	-	annual
Sulphur dioxide SO_2	441	24 per year	hour
	217	3 per year	24 hours
	65	-	annual
Ozone O_3**	157	25 days annually, averaged over 3 years	8 hours
suspended particles (<10 µm) PM_{10}***	340	12 per year	24 hours
	50	-	annual
suspended particles (<2.5 µm) $PM_{2.5}$***	35	12 per year	24 hours
	15	-	annual
Lead in suspended particles Pb (in TSP)	0.15	Average over 3 months with no irregularities	3 months

Notes:

* Values are based on a standard temperature of 25°C and a pressure of 1 atmosphere.

** To calculate the 8-hour ozone value and to assign it to the appropriate day, the following rule is applied: The maximum daily concentration for 8 hours must be determined by checking the running averages for 8 hours, calculated from the hourly data and updated hourly. Each average 8 hours calculated is assigned to the day it expires, meaning that the first calculation period for any day will be the period from 5 pm on the previous day to 1 am of the day. The last calculation period for any day is from 4 after noon to 12 o'clock at night.

*** Calculation of excesses: The contributions from natural sources can be assessed by measurements, modelling, and remote sensing. These contributions are subtracted from the air quality monitoring results, thus calculating exceedances.

Table 31. Ambient Air Quality Standards for Primary Pollutants. Source: Executive Regulations for Air Quality (2021)

4.1.1.3. Baseline Condition

a. Climate

The following data[1] are based on a statistical analysis of historical hourly weather reports and model reconstructions from January 1st, 1980, to December 31st, 2016. Due to the fact that Afif is more than 200 km

[1] *Data available at www.weatherspark.com*

away from the nearest reliable weather station, weather-related data are from a meteorological model[2] that reconstructs the hourly history of weather on a 50-kilometer grid. The coordinates for Afif city, where modelling is done, are 23.950º latitude and 42.917º longitude, at 1,045 m elevation.

The Kingdom of Saudi Arabia is predominantly classified as a desertic environment and experiences high temperatures, with many days of sunshine. It can be described by extreme heat through the day, a sudden fall in temperature al night, and little, irregular precipitation. The temperature in the summer months reaches 50ºC but typically ranges from 27ºC to 43ºC in inland areas while it typically ranges between 27ºC to 38ºC in coastal areas. In winter, temperatures range between 8ºC to 20ºC in inner parts of KSA while higher temperatures have been recorded in the coastal areas of Red Sea (19ºC - 29ºC) (Saudi Arabia 3rd NC to UNFCCC, 2016).

Rainfall is infrequent but can occur intermittently and intensely several times a year, particularly in mountainous areas. The average annual rainfall has been low and recorded in the range of 100mm in most regions. Flash floods can occur in many locations in the Kingdom after heavy torrential rains. All wadis are considered floodplains and vulnerable to flooding after severe rainstorm.

The study area is located at the northwest of Riyadh province, in a rugged area surrounded by small elevations, except for its eastern border. This area is classified as Hot desert Climate (BWh) according to Köppen-Geiger Climate Classification[3], included in the Arid group. This group designates climates in which the controlling factor on vegetation is dryness (rather than temperature) by a severe excess of evaporation over precipitation. Hot desert climate category is above 18ºC mean annual temperature.

[2] NASA's MERRA-2 satellite-era: The Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) provides data beginning in 1980. The spatial resolution is 50 km in the latitudinal direction. https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/ . The temperature and dew point estimates are corrected for the difference between the reference elevation of the MERRA-2 grid cell and the elevation of Afif, according to the International Standard Atmosphere.

[3] Climate Change Knowledge Portal-CCKP-World Bank Group1991-2020. Available at: https://climateknowledgeportal.worldbank.org/country/saudi-arabia

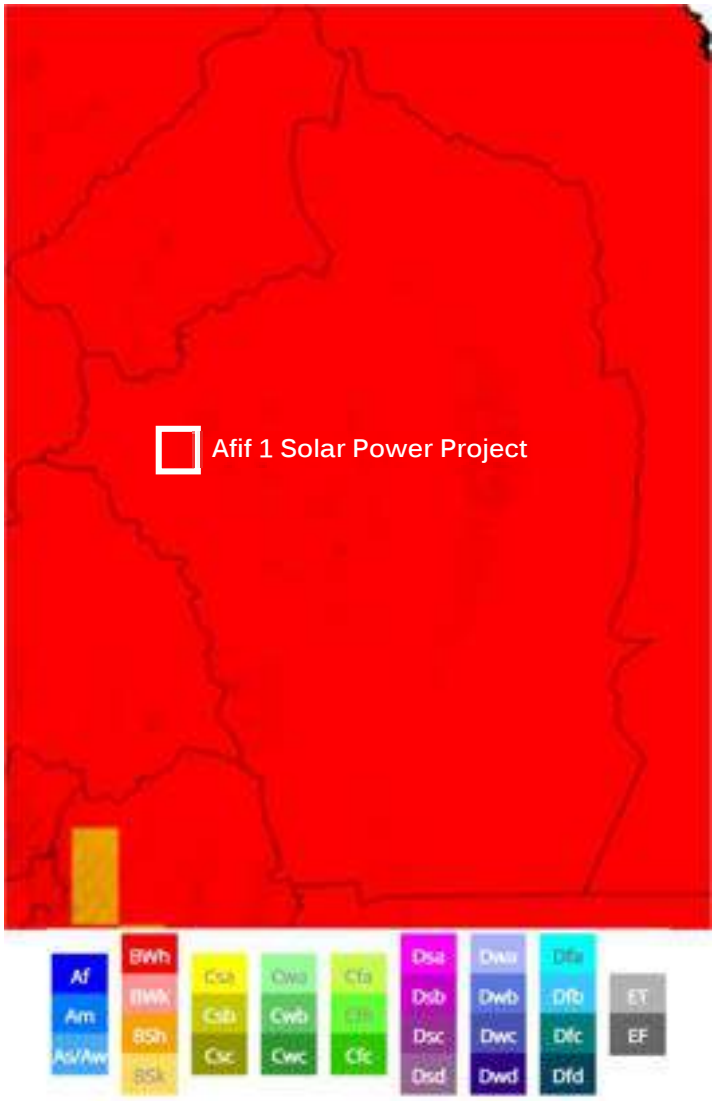


Figure 37. Köppen-Geiger Climate Classification. Source: CCKP (1991-2020)

Summer is long, swelting and arid, being winters instead cool, dry, and windy, and mostly clear all year round. Over it, temperatures vary from 7 to 41ºC and are rarely below 2ºC or above 43ºC.

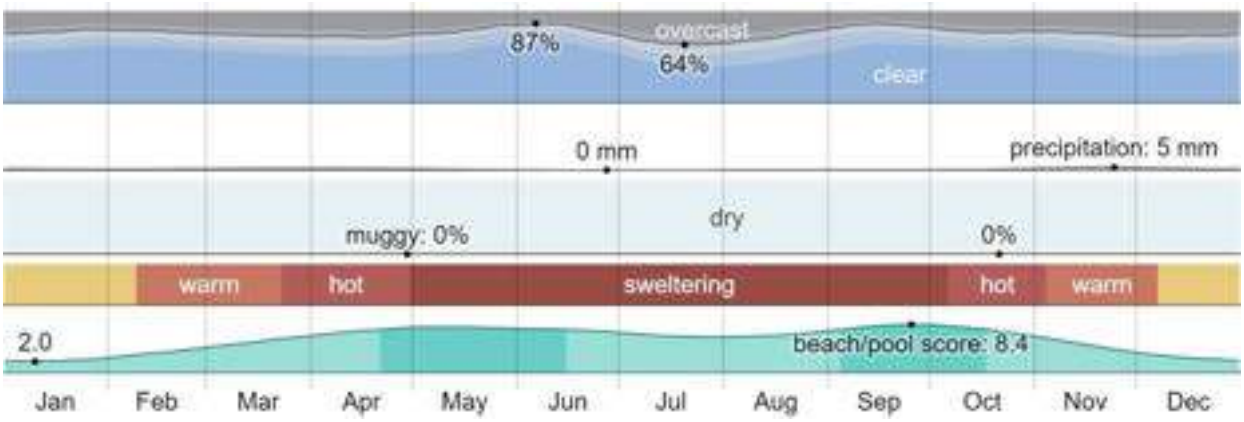


Figure 38. Climate summary at Afif city weather station. Source; https://weatherspark.com/

a. Temperature

Regarding ambient temperatures, the hot season lasts from half May to 23rd of September, when average daily high temperature is above 37ºC. August is the hottest month, with an average high of 41ºC and low of 25º. The cool season lasts from the last week of November to the last week of February, with an average daily high temperature below 26ºC. January is the coldest month, when average low decreases to 7ºC, although the high one reaches 25º.

The annual average temperature is 24.4ºC, 32.5ºC the high temperature average and 16.7 the low one. The average temperatures can be considered moderate. The months of highest temperatures are July and August, and the coldest months correspond to December and January. The maximum temperature registered is 49.2ºC on the 31st of July 2020, and the minimum being -2.8ºC, registered on the 4th of February of 2017.

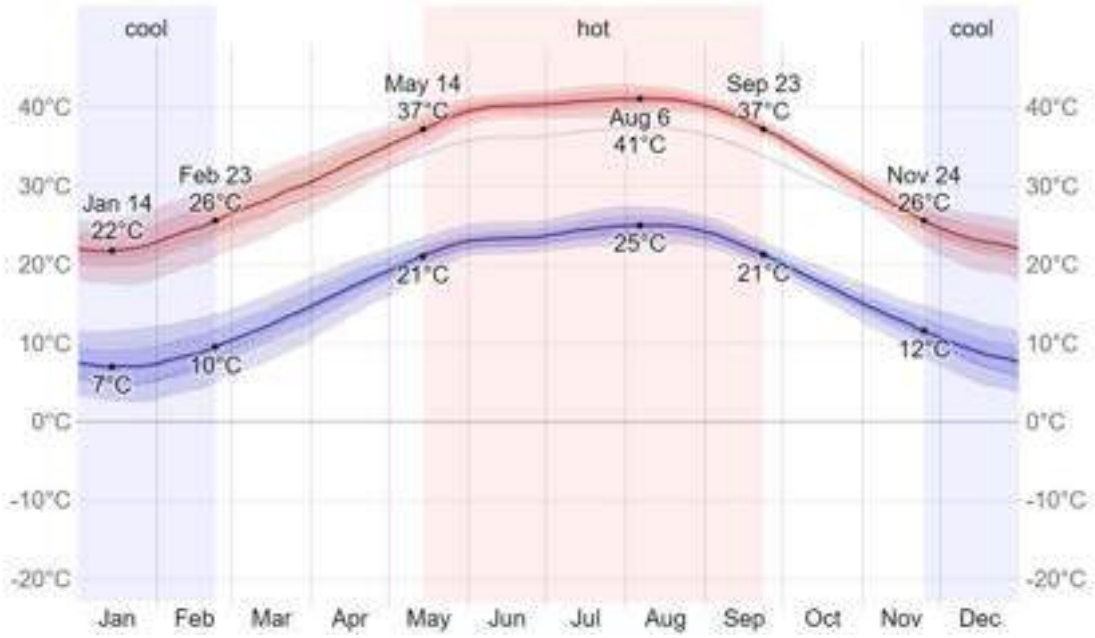


Figure 39. Average High and Low Temperature at Afif city weather station, Source; https://weatherspark.com/

b. Rainfall

Rainfall is scarce and sporadic. The annual average rises to 19.7 mm. There is a seasonal variation of monthly rainfall, with the maximum rainy period beginning in November until April. Maximum rain quantity is collected in November (4.7 mm rainfall), followed by March, April, and December with 2.9, 2.9 and 2.8 mm respectively. June, July, August, and September just accumulate 0.1-0.2 mm.

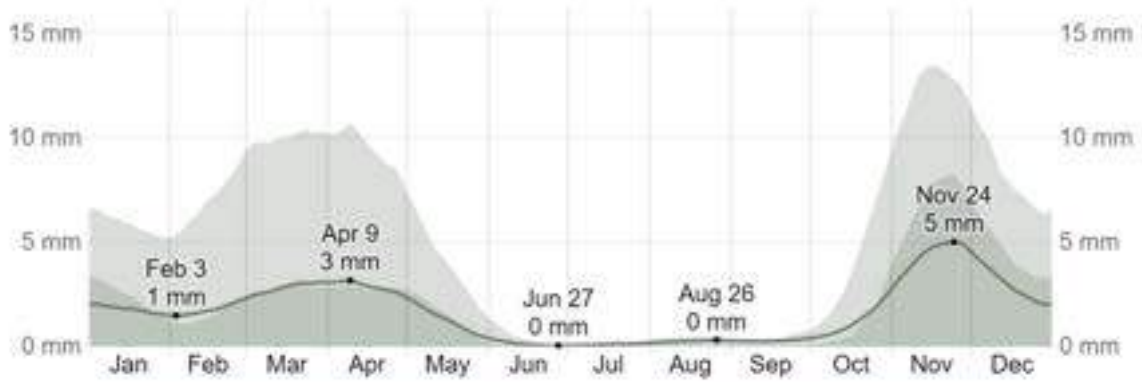


Figure 40. Average rainfall at Afif city weather station, Source; https://weatherspark.com/

c. Solar radiation

The selected location is within one area with generous irradiance in Saudi Arabia as shown in the map below, with an average daily incident shortwave solar energy that varies over the year from the minimum of 4.4 kWh/m^2 in December to the maximum of 8.4 kWh/m^2 in June at Afif city.

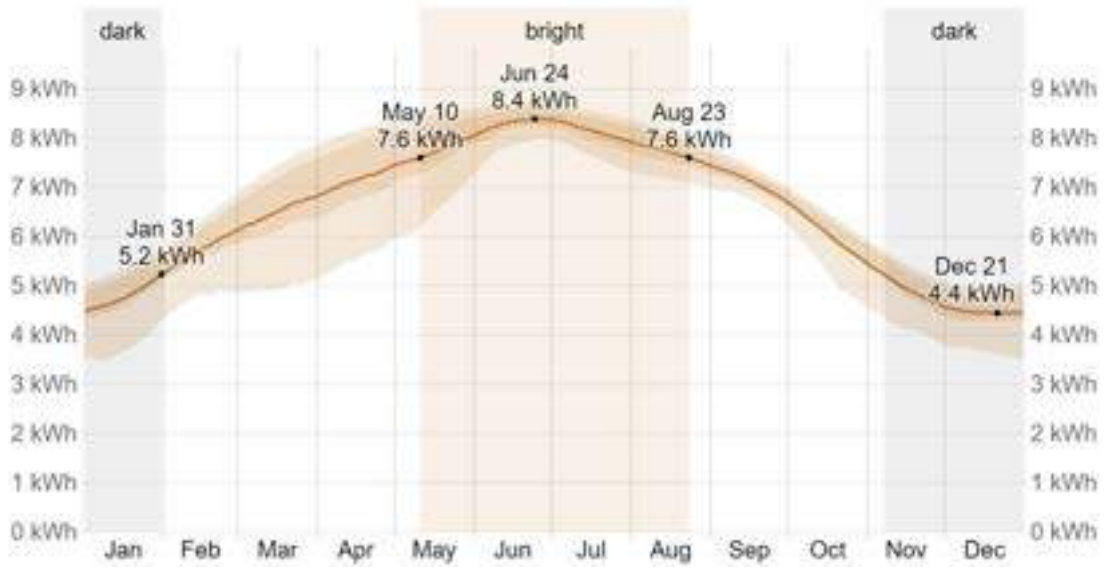


Figure 41. Average daily incident shortwave energy at Afif city weather station, Source; https://weatherspark.com/

The maximum irradiation occurs in the central months of the year, from May to September, while the minimum radiation is expected from November to January.

The largest number of sunshine hours occurs in June (average at 13 hours, 37 minutes of daylight), and the lowest ones take place in December (average at 10 hours, 40 minutes of daylight).

d. Relative humidity

The perceived humidity level in the study area, as measured by the percentage of time in which the humidity comfort level is muggy, oppressive, or miserable, does not vary significantly over the course of the year, remaining almost a constant 0%.

Figure 42. Average Humidity Level at Afif city weather station. Source; https://weatherspark.com/

e. Evaporation

The highest evaporative demands occur during the months of June and July. Potential evaporation in any month is higher than the corresponding rainfall.

f. Wind

At any given location, wind is highly dependent on local topography, among other factors. Afif city's average hourly wind speed shows mild seasonal variation along the year. The windier part occurs from the end of October to the end of April, with average speeds of more than 16.4 km/h, being March the windiest month, when speed reaches 18.4 km/h. The calmer time goes from the end of April to the end of October, and it is in September when the minimum speed values occur, 14.3 km/h.

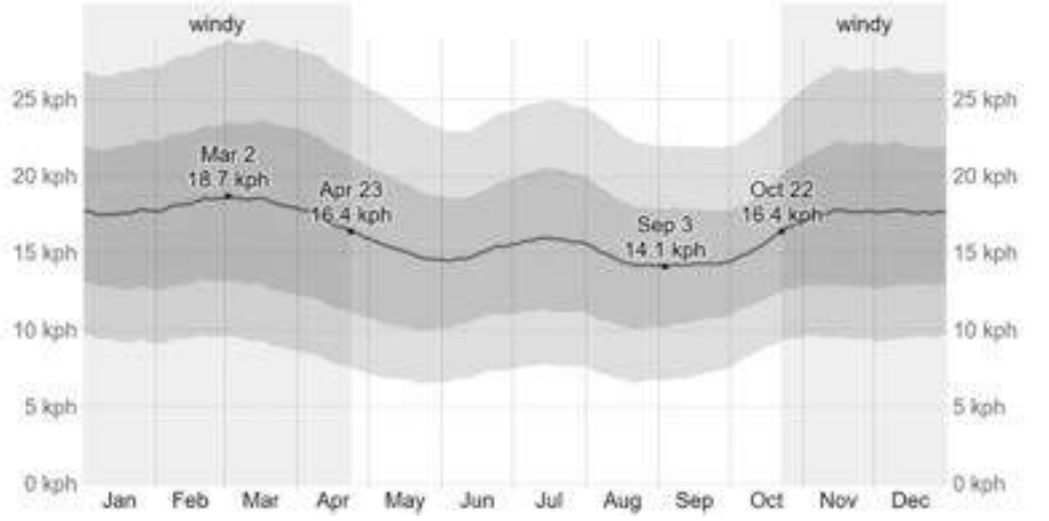


Figure 43. Windspeed (km/h) at Afif city weather station, Source; https://weatherspark.com/

Regarding wind direction, the following figure shows the percentage of hours in which the mean wind direction is from each cardinal point direction (excluding hours in which the mean wind speed is less than 1.6 km/h). The predominant average hourly wind direction varies throughout the year: winds from east are most common for nearly 2 months (June and August-September). From north they are the most common for 2 months (June to August) and for 8 months (September-May) they are from south direction.

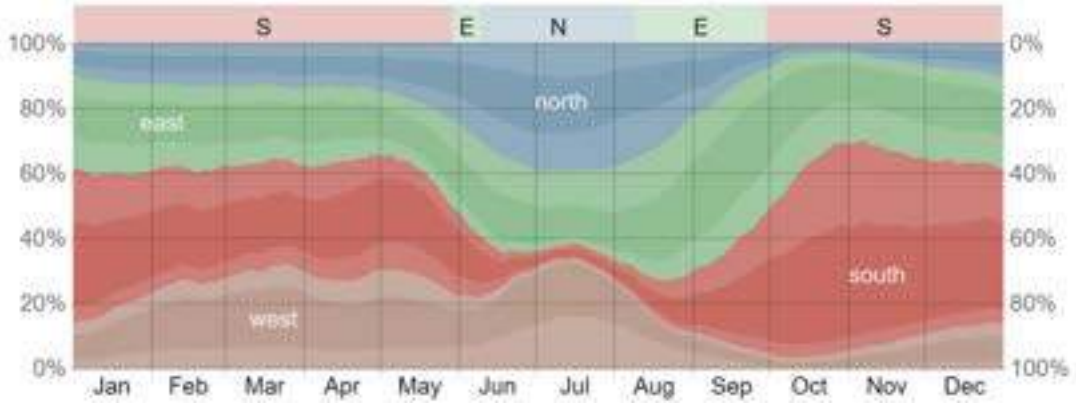


Figure 44. Wind directions at Afif city weather station. Source; https://weatherspark.com/

b. Air Quality

Scarce information is currently available to characterize air quality condition in the Region. Due to this, air quality measurements (CO, CO_2, SO_2, NO_x, O_3, PM_{10} and $PM_{2.5}$) have been carried out in the study area with the objective of maintaining the highest standards of ambient air quality achievable in the geographic context of the project. This survey has allowed to know exactly the air quality situation in the area.

The main purpose of the baseline characterization process is to identify existing air quality conditions, key sources of emissions, and environmental & social sensitive receptors that may potentially be affected by the project's construction or operation, concerning air quality. The environmental baseline is then used as the basis for the assessment of any future impacts over the identified sensitive receptors.

There is no industrial area in the immediate vicinity of the project site. There is a small settlement at an approximate distance of 1.5 km southwest direction, and Almardamah location, 8 km south. Both, within the road which arrives to Afif city from the south, might be the main emission sources in the zone. Neither of the population settlements have any larger industry so negligible gaseous emissions are expected. On the other hand, highway #50 and the smaller road beside the project plot (Almardamah Road), do not have such a volume of vehicles to pose a greater gaseous emissions source, which might be negligible in the area.

Additionally, most of the surrounding land is unused and the larger urban area close to the site is Afif city, which is 23 km west, approximately.

Sensitive receptors in the study area are scarce and limited to some nomadic camps.

Monitoring for air quality was conducted at two points within the site, both diurnally and nocturnally.

The results of air quality tests and meteorological data are shown in the following tables.

SO_2	Concentration at sampling point		NCEC Exceedance Level µg/m³	
	Point 1	Point 2	1 Hour	24 Hour
Percentage data capture (Hourly Values)	100	100	441	217
Hourly Maximum (µg/m3)	5.1	5.3		
Hourly Minimum (µg/m3)	2.1	1.9		
Daily Average (µg/m3)	2.5	2.7		
Hourly value > 441 (ug/M³)	0	0		

*There were no exceedances of NCEC standards.

NO_2	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	1 Hour
Percentage data capture (Hourly Values)	100	100	200
Hourly Maximum (ug/M³)	17.5	27.6	
Hourly Minimum (ug/M³)	0.03	1.8	
Hourly value > 200 (ug/M³)	0	0	
Daily average (ug/M³)	6.2	7.5	
NO			1 Hour
Percentage data capture (Hourly Values)	100	100	NA
Hourly Maximum (µg/m3)	7.8	6.1	
Hourly Minimum (µg/m3)	1.0	1.5	
Daily Average (µg/m3)	4.6	3.2	
NOX			1 Hour
Percentage data capture (Hourly Values)	100	100	NA
Hourly Maximum (µg/m3)	29.7	35.8	
Hourly Minimum (µg/m3)	1.7	4.5	
Daily Average (µg/m3)	13.4	12.5	

*There were no exceedances of NCEC standards.

CO	Concentration at sampling point		NCEC Exceedance Level µg/m³	
	point 1	point 2	1 Hour	8 Hour
Percentage data capture (Hourly Values)	100	100	40,000	10,000
Hourly Maximum (ug/M³)	160.0	340.1		
Hourly Minimum (ug/M³)	30.0	60.0		
8 Hour Maximum (ug/M³)	126.3	242.5		
8 Hour Minimum (ug/M³)	79.8	102.5		
Hourly value > 40000 (ug/M³)	0	0		
8-Hourly rolling average value > 10000 (ug/M³)	0	0		
Daily average (ug/M³)	106	115		

*There were no exceedances of NCEC standards.

Ozone	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	8 Hour
Percentage data capture (Hourly Values)	100	100	157
Hourly Maximum (ug/M³)	81.8	82.0	
8 Hour Maximum (ug/M³)	68.2	76.5	
8 Hour value > 157 (ug/M³)	0	0	
Daily average (ug/M³)	55.3	56.9	

*There were no exceedances of NCEC standards.

PM_{10}	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	24 Hour
Percentage data capture (Hourly Values)	100	100	340
Hourly Maximum (ug/M³)	114.0	147.6	
Hourly Minimum (ug/M³)	37.1	38.6	
Daily Values >340 (ug/M³)	0	0	
Daily average (ug/M³)	48.0	68.9	

*There were no exceedances of NCEC standards.

$PM_{2.5}$	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	24 Hour
Percentage data capture (Hourly Values)	100	100	35
Hourly Maximum (ug/M³)	30.3	31.6	
Hourly Minimum (ug/M³)	11.3	13.8	
Daily Values >35 (ug/M3)	0	0	
Daily average (ug/M³)	14.5	18.7	

*There were no exceedances of NCEC standards.

Table 32. Results Air Quality tests for SO2, NO2, NO, NOx, CO, O3, PM10 and PM2.5 at Afif 1 Solar Plant plot. Source: Environmental Baseline Survey Report

Ambient Temperature	Point 1	Point 2
Percentage data capture (Hourly Values)	100.0	100.0
Hourly Maximum (°C)	24.8	26.2
Hourly Minimum (°C)	11.2	10.1
Relative Humidity	**Point 1**	**Point 2**
Percentage data capture (Hourly Values)	100.0	100.0
Hourly Maximum (%)	83.3	49.7
Hourly Minimum (%)	19.5	21.4
Barometric Pressure	**Point 1**	**Point 2**
Percentage data capture (Hourly Values)	100.0	100.0
Hourly Max (hPa)	928.0	931.0
Hourly Minimum (hPa)	923.0	927.0
Wind Parameters	**Point 1**	**Point 2**
Percentage data capture (Hourly Values)	100.0	100.0
Wind Speed Hourly Maximum (m/s)	6.0	6.1
Wind Speed Hourly Minimum (m/s)	1.4	1.2
Mean Wind Speed(m/s)	3.7	3.2
Prevailing Wind Direction	NW/SW	

Table 33. Results of Meteorological data registered during Air Quality Monitoring at Afif 1 Solar Plant. Source: Environmental Baseline Survey Report

Values registered for all pollutants measured are significantly below standards. Since the area is far away from large urban areas, as well as industrial zones or any other potentially pollutant activities, no significant pollution values are detected. The road that connects routes 50 and 80 through Almardamah, the closest contaminant source, is not posing a problem in this regard (small road with scarce traffic). The only values which are close to the standard limit is $PM_{2.5}$ at point #1 and point #2 (30.3 and 31.6 µg/m^3 hourly maximum respectively against 35 µg/m^3). The whole country presents high PM_{10} and $PM_{2.5}$ concentrations due to its geographical situation, desert climate, and sandstorms. Even so, standard limits are not surpassed.

The results of **ambient air monitoring for all parameters are in compliance with NCEC Ambient Air Quality Standards**.

4.1.2. Noise

4.1.2.1. Methodology of Noise survey campaign

Bander Said Allehiany (BSA) carried out the noise survey from **16th January to 18th January 2024.**

This noise survey measurements were carried out using Type 1 Integrated sound level meter implementing continuous monitoring strategy recommended by NCEC. The Type 1 Integrated sound level meter was pre-set at fast response and calibrated before and after each location using Acoustic calibrator. The calibration field data was recorded accordingly. The sound level meter was stationed and mounted over a tripod.

The levels that were recorded at locations are LAeq, LA10, LA50 and LA90, LDay, Lnight. These parameters were reported as dB(A) (A-weighted decibels) at two sections of the day i.e., Morning time and Nighttime respectively.

Furthermore, GPS coordinates were taken representing each location as shown in noise measurement points selected are the same as Air Quality monitoring ones.

Also, meteorological data such as wind speed, wind direction, temperature and relative humidity were measured and recorded as these factors have a significant effect on the test results.

Afif 1 Solar Plant	Coordinates		Selection explanation
N1	N	23.769816	Representative of roadside zone
	E	43.1349910	
N2	N	23.804222	Representative of roadside zone
	E	43.118388	

Table 34. Coordinates of Noise Monitoring points at Afif 1 Solar Plant site. Source: Environmental Baseline Survey Report

Figure 45. Location of Noise Monitoring points at Afif 1 Solar Plant site. Source: Environmental Baseline Survey Report

Figure 46. Location of Noise devices at monitoring points 1 & 2 in Afif 1 plot. Source: Environmental Baseline Survey Report

4.1.2.2. Relevant legislation and standards

a. International Finance Corporation (IFC)

The World Bank Group in the Environmental, Health, and Safety Guidelines (known as the "EHS Guidelines") present both environmental and occupational health and safety noise and vibration limit values.

According to the mentioned guidelines, operational noise should not exceed the levels presented in table below or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

	Hourly ambient noise limit LAeq,1h	
Receptor	Daytime 07:00 – 22:00	Nighttime 22:00 – 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

Table 35. Limit values. Source: Noise levels guidelines

During operational phase, the project will not generate noise and/or vibration.

b. National regulations

The provisions of the Noise Executive Regulations shall apply to all persons in residential, commercial, industrial, and environmentally sensitive areas, roadsides, and construction sites; It does not include indoor noise.

Article 5 contains the standards that must be applied on the sides of roads and highways. The project area is next to a road. Therefore, it is prohibited to exceed the following noise levels standards, except with the permission of the NCEC.

Daytime $L_{Aeq,}T$ (dB)	Night-time $L_{Aeq,}T$ (dB)
70	65

Table 36. Noise limits near road area. Source: Executive Regulations for Noise (2021)

Article 7 sets the limits for permitted noise levels at construction sites so that the noise levels standards set out in this Regulation are allowed to be exceeded during construction works from 7 am to 6 pm, as indicated in the following table:

Duration of the construction activities	Correction of permitted noise limits $L_{Aeq,}T$ (dB)
Up to 2.5 hours	10
2.5 to 8 hours	5
Above 8 hours	0

Table 37. Corrective limits for permitted noise levels at construction site. Source: Executive Regulations for Noise (2021)

The regulation includes limits for residential and commercial areas, which are not located in the study area.

4.1.2.3. Current noise. Baseline conditions.

Scarce information is currently available to characterize ambient noise in the region. Due to this, noise measurements have been carried out in the study area to quantify the acoustic environment and to inform characterizations of the environment in the study area.

There are no permanent settlements within the project plot, just a small one at an approximate distance of 1.5 km southwest. Larger settlements are further, at a minimum distance of 8 km in Almardamah case and 23 km in Afif city. Noise from industrial activities is not expected to be significant due both to the inexistence of larger industrial areas and the distance to the project site.

There are also a few nomadic camps within the plot but apart from cattle grazing no other activities are carried out in it. Main roads, Highway #50 and road 5200 are located both at more than 20 km away, thus no remarkable noise is expected from them. However, a brief characterization of both is made below:

- Highway #50, which runs from west of the country to Kuwait border, northwest of the project plot. The highway connects highway #80 with Hafar Al Batin and Ar-Ruqi, close to the Kuwait border.
- Road 5200, two-way road, connects highway #80 to the 414 road, near Ar Rass, north direction from the project.
- The road that connects routes 50 and 80 through Almardamah and runs through the west limit of the Project site, adjacent to the plot, has a few traffic.

Figure 47. Location of the project in relation to Highway 50. Source: Environmental Baseline Survey Report

Ambient noise measurements, both diurnal and nocturnal, were undertaken at the same two locations where particulate matter ($PM_{2.5}$ and PM_{10}) and gaseous pollutants were measured within the project plot.

Monitoring results for noise measurements are shown in the table below.

Site ID	$L_{Aeq,\ T}$	L_{DAY}	L_{NIGHT}	L_{A10}	L_{A50}	L_{A90}	Lmax	Lmin	Day limit 7.00 am- 8.00 pm	Night limit 8.00pm-7.00 am
N1	48.7	52.6 42.1	45.5	48.2	37.5	32.5	83.6	26.2	70	65
N2	48.7	53.0 42.4	45.8	48.2	37.5	32.5	82.5	27.0	70	65

Table 38. Noise monitoring tests results. Source: Environmental Baseline Survey Report

Noise measurements (Lday and Lnight) did not exceed the benchmark national standard for limits near road areas (70 dBA – day and 65 dBA night-time) and International Finance Corporation (IFC) noise standards (IFC, 2007) (70 dBA – day and 70 dBA -night-time for industrial and commercial areas).

Since there are no larger urban areas within the plot or around, either industrial zones, or any other potential noise source, values registered within the plot are significantly under standard limits. The only noise source, the road and its traffic, are not notably in the area and thus values remain low.

The **noise levels in study area are in full compliance with NCEC standards**.

4.1.3. Geology, Seismicity and Soils

4.1.3.1. Methodology of Geotechnical survey

Between December 2023 and April 2024, a team of TYPSA management staff carried out an on-site geomorphological and geological reconnaissance with detailed observations at relevant observation points defined by the geological team to identify surface geological conditions and potential geotechnical hazards within the plots providing relevant information for the two areas to take in consideration for the geotechnical field works proposal.

The geotechnical site investigation proposal has been defined to obtain the required information for the Design. The aspects that are intended to be covered with the field works are mainly related to foundations design, excavations, structures, buildings, and groundwater level.

The geotechnical investigation works carried out at the site are shown in the table below:

AFIF-1 PLOT (40KM^2)	
Ground Investigation	**Quantity**
Borehole (10-30m depth)	80
Trial Pit	19
DPSH	60
Shallow refraction test	8
Electrical Resistivity	28
Thermal Resistivity	3
Cross-hole	1
Pull Out	40

Table 39. Geotechnical site investigations. Field work summary in Afif-1. Source: geotechnical report

The ***test pits***, up to 3 - 4 meters depth, or until a not-diggable substratum if found, will have the purpose of investigate the ground section on which the foundations of the supporting structure for the panels, substation buildings and other short facilities will be placed in a PV plant. The test pits must exceed the depth of the future piles that, in practice, will serve to support the photovoltaic panels.

In order to investigate the drivability of the proposed foundation, the most suitable test is considered the ***Dynamic probing super heavy test (DPSH)***, whose results can be correlated with the soil resistance (Standard Penetration Test, SPT), soil bearing capacity (California Baring Ratio, CBR) and soil deformability (Subgrade Modulus, E). The result obtained with DPSH test provides a better characterization of the soils. By means of a continuous recording of the dynamic resistance, these tests allow to obtain the parameters of each soil layer to be used in the design of panels, buildings and other facilities.

Test pits and dynamic penetration tests will be complemented with ***rotary boreholes with core recovery***. The objective of the boreholes will be the precise characterization of the lithological column of the ground, up to a minimum depth of 10 m (or even deeper when required for the design of foundations). SPT tests will be carried out at regular intervals to assess the soil compacity, and samples will be taken for laboratory tests. Groundwater table recordings will be taken if it is encountered at the depth investigated.

To sum up, all the mentioned tests and the main objectives for the site investigation works are briefly **described below:**

- Enable the geotechnical engineer to analyze the best foundation solution for PV panels and auxiliary buildings.
- Identify potential geotechnical risks (presence of loose or soft soils, cavities, groundwater table, soil chemical composition, etc.).
- Provide recommendations for the design of earthworks.

From an environmental point of view, the main objective of the site investigation works (geotechnical survey) is to locate the water level in case of groundwater presence in the study area.

The depth of the boreholes ranges from 10 to 30 m. The geotechnical campaign, carried out between December 2023 and April 2024 in the project area, has shown groundwater presence at a depth of 14 and 27.5 m in two boreholes. A water table is present at an approximate depth of 27.5 m in BH-01 and another at approximately 14.0 m in BH-73

Given the depth of the water presence, none of the excavations planned for a project of this nature will reach such levels, meaning that neither the SEC substation nor other plant facilities will impact on groundwater.

Soils campaign

TYPSA considered a contaminated soils campaign unnecessary because the area has not been exposed to soil-polluting activities. Field surveys have not revealed any polluted soils.

4.1.3.2. Relevant legislation and standards

a. International Finance Corporation (IFC)

a. EHS Guidelines

The IFC EHS Guidelines provides a summary of management approaches for land contamination due to anthropogenic releases of hazardous materials, wastes, or oil, including naturally occurring substances. Releases of these materials may be the result of historic or current site activities, including, but not limited to, accidents during their handling and storage, or due to their poor management or disposal (IFC, 2007).

The contaminated lands may involve surficial soils or subsurface soils that, through leaching and transport, may affect groundwater, surface water, and adjacent sites. Where subsurface contaminant sources include volatile substances, soil vapor may also become a transport and exposure medium and create potential for contaminant infiltration of indoor air spaces of buildings (IFC, 2007).

Contaminated lands should be managed to avoid the risk to human health and ecological receptors. The preferred strategy for land decontamination is to reduce the level of contamination at the site while preventing the human exposure to contamination (IFC, 2007).

An approach to managing the risk of contaminated land is set-out in the IFC General EHS Guidelines. To determine whether risk management actions are warranted, the following assessment approach should be applied to establish whether the three risk factors of 'Contaminants', 'Receptors', and 'Exposure Pathways' co-exist, or are likely to co-exist, at the project site under current or possible future land use:

- Contaminant(s): Presence of hazardous materials, waste, or oil in any environmental media at potentially hazardous concentrations.
- Receptor(s): Actual or likely contact of humans, wildlife, plants, and other living organisms with the contaminants of concern; and,
- Exposure pathway(s): A combination of the route of migration of the contaminant from its point of release (e.g., leaching into potable groundwater) and exposure routes (e.g., ingestion, transdermal absorption), which would allow receptor(s) to come into actual contact with contaminants (IFC, 2007).

No polluted soils have been observed during the field survey. Potentially soil polluting activities had not been developed in the study area.

b. IFC Performance Standard 3

Performance Standard 3 recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels. Resource efficiency is the central tenant of this standard and implementing technical and financially feasible and cost-effective measures for improving efficiency in consumption of energy, water as well as other resources and material inputs (IFC, 2012).

The objectives for this Performance Standard are as follows:

- To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.
- To promote more sustainable use of resources, including energy and water; and,
- To reduce project-related Greenhouse Gas (GHG) emissions.

Although the management of soil as a resource is not specifically stated in the performance standard, soil is a resource, and its impairment has potential to adversely impact on humans and the environment.

b. National Regulations

The executive regulation issued for the Prevention and Remediation of Soil Pollution issued by described by the Environmental Law issued by the Royal Decree No. (m/165), dated 19/11/1441 Hijri precises in its appendix 1 the Standards for Protecting Soil from Pollution. This regulation is developed in more depth in section 2.2.1.

4.1.3.3. Baseline condition

a. Introduction and local conditions

A desktop analysis of the site has been performed to determine the hydro-geological conditions. This preliminary assessment uses parameters such as morphology, soil conditions and land cover. The

geotechnical survey has been developed in a further step to allow knowing the soil thickness, its composition and hardness as well as the limit contact with the rock substratum.

As part of the early site investigation, a team of technicians from the TYPSA staff explored the site and obtained relevant information at several waypoints to better understand the site conditions and complete the final geotechnical surveys proposal.

The area allocated for the Afif-1 Project is at about 25 km east of Afif city. Afif-1 solar plant plot is located on a flat plain of the center part of Saudi Arabia (Ar-Riyad region) with a flat topography of gentle slopes and at 978 meters above sea level. The total size of the available area is approximately 40 km². **Afif 1** PV plot is located on an area where Quaternary sand, gravel and silt sheets deposits domain the whole surface with many outcrops of Felsic-plutonic rocks, and Sandstone and lithic arenite along the surface of the area of study.

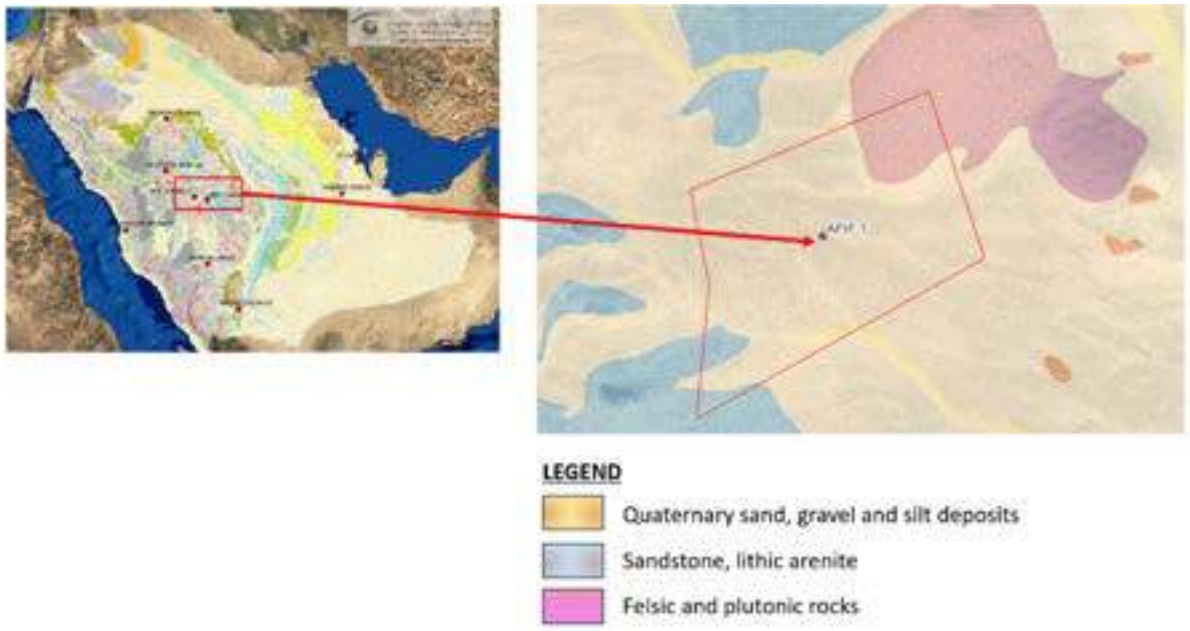


Figure 48. Geological Map of Saudi Arabia. Detail of Afif-1 solar plant plot location. Source: Preliminary site Assessment

Afif 1 Solar Plant plot is located at the central zone of the Arabian Shield (Figure 49) on a roughly flat plain. The topography presents some occasional hills of rock outcrops. All the area is widely covered by sand and gravels as residual erosional materials with thicknesses probably not exceeding 50 cm, to be verified during the geotechnical investigation. Some minor runoff channels cross the plot from northwest to southeast.

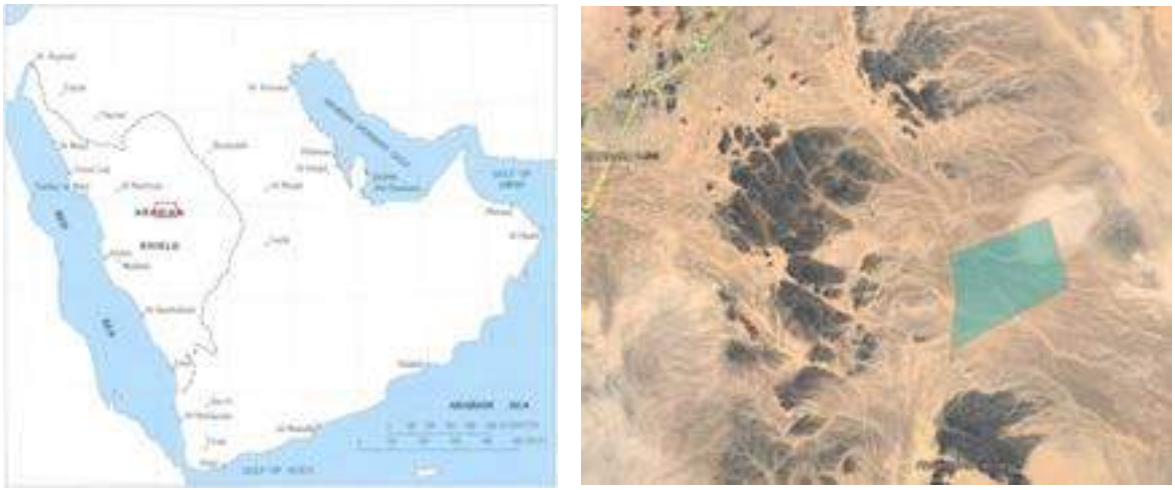


Figure 49. Location of Afif 1 Solar Plant plot in the Arabian Shield. Source: Preliminary Site Assessment

b. Geology

The Arabian Shield, where the plot is located, constitutes the Arabian segment of the African Shield, and covers one third of the Arabian Peninsula. The core of this segment is formed by crystalline rocks together with bordering sedimentary rocks and volcanic flows. The basement in the plot is composed of rocks belonging to the sedimentary Mardamah Group and plutonic Al Khushaymiyah suite.

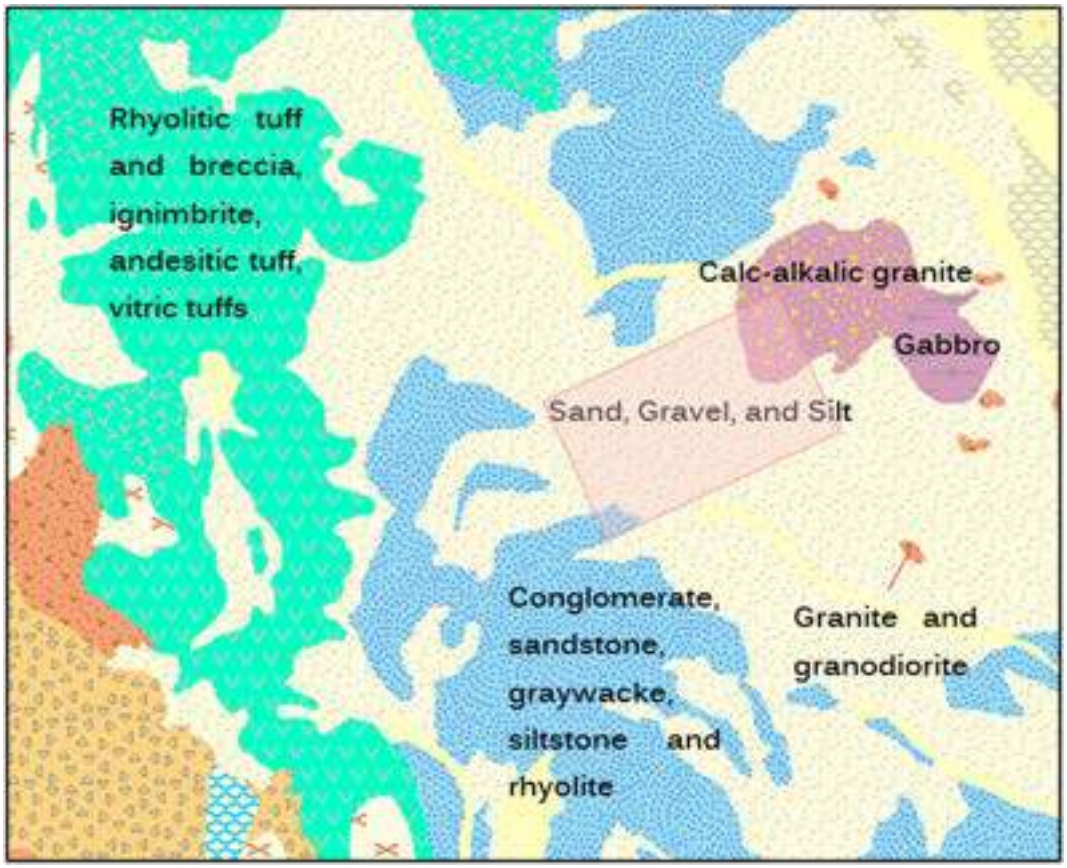


Figure 50. Geology of the Solar Plant plot. Source: Geology 250K, Geospatial Portal, SGS

But the main characteristic of the plot is the presence of a sheet of sand, gravel, and silt probably no greater than 50 cm all along the plot. The origin of the sheets is a mix of alluvial and aeolian flows with residual

fragments of rock. The west part of the plot is dominated by this material while in the eastern part a number of outcrops of sandstone and granite can be found.

Figure 51. Overall views of the plot showing the mainly flat morphology with sand-gravel sheet. Source: site visit

Figure 52. Calc-alkalic granite outcrop in the Northeast corner of the plot. Source: site visit

Figure 53. In the central east part of the plot, some rhyolite outcrops are present (left). At west side. Source: site visit

At some areas, protected by small ridges or vegetation, some cumulation of loose sand is developed.

Figure 54. Sand cumulations. Source: site visit

In terms of structural geology, the Arabian Plate underwent through major tectonic events that splits away from the African Plate through two or more episodes of Red Sea floor spreading during pre-early Miocene and post-Miocene times.

Tectonic of western Arabia is dominated by the opening of the Red Sea, which broke the African plate to form the Arabian plate, but locally, in terms of seismicity, the inner part of the Arabian Shield, where the plot is located, is mostly stable.

c. Seismicity

While the Arabian Platform is relatively quiet seismically, it is adjacent to a zone of major earthquake activity. Arabian Gulf cities are situated near the eastern margin of the Arabian plate about 300 kilometers from the collision zone between the Arabian and Eurasian plates. The Zagros fold belt (Iran) in the collision zone is a major source of large earthquakes: magnitude 5 earthquakes in the Zagros mountains are frequent, magnitude 6 earthquakes occur several times yearly, and magnitude 7 events occur every decade. It is an open question whether these large events can occur close enough to the eastern region to pose a hazard. These earthquakes may represent the classic low probability, high consequence risk for the population, buildings, and infrastructure of these cities.

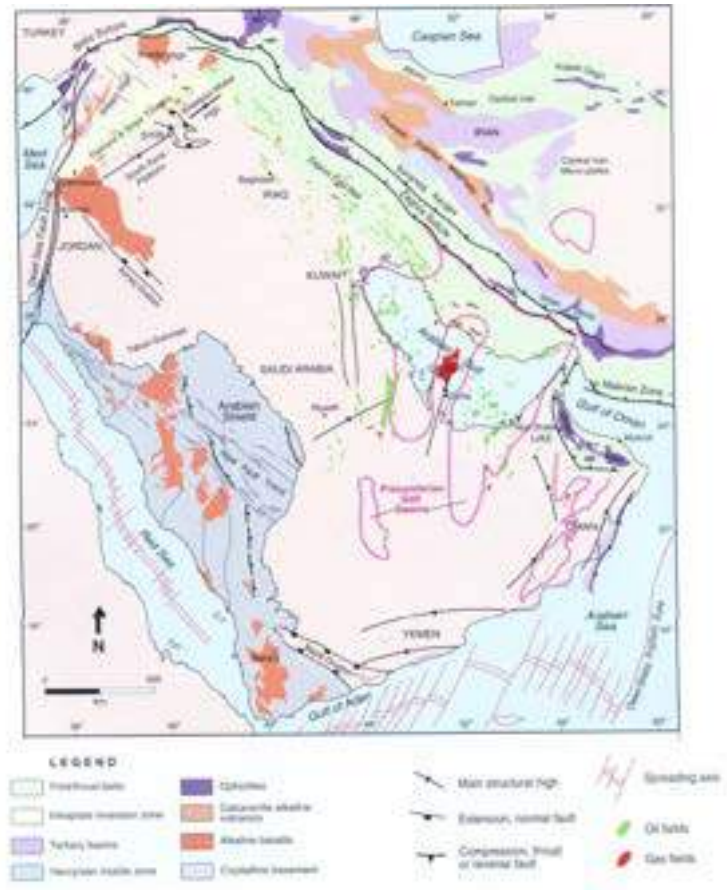


Figure 55. Mayor tectonic elements of the Arabian Shield and Platform (Al-Husseini, 2000) Source www.alamrigeo.com

The boundaries of the seismogenic source zones are the results in the inter-agreement of seismological and geological parameters with the higher priority given to the spatial distribution of epicenters due to statistical needs in statistical analysis. Seismogenic source zones are composed of systems of faults or lineaments or rift systems whose boundaries do not traverse generally other tectonic units. Some of the seismogenic source zones are relatively large due to scarcity of earthquakes in the Arabian Platform. From these considerations, there are twelve (12) seismogenic source zones that were identified and delineated.

The study plot is in seismogenic Zone 15, Najd Fault Zone.

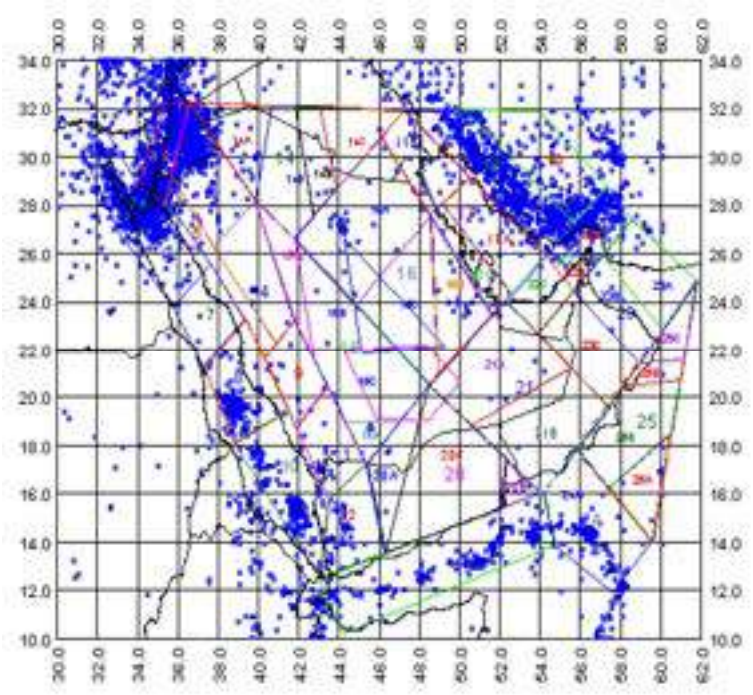


Figure 56. Seismicity and seismogenic source zones of the Arabian Peninsula and Adjoining Regions Source www.alamrigeo.com

Zone 15 (Najd Fault Zone)

No historical seismic events were observed to have occurred in this zone, and only 5 instrumental earthquakes were compiled. The observed maximum magnitude was 4.4 which had occurred on 6 November 1997, in the vicinity of Kirsh gneiss and Ar Rika fault zone. The second event of lesser magnitude has a value of 4, occurring on 17 August 1997 also within the vicinity of the Ar Rika fault zone. Since there are only 5 seismic events, the Utsu-Aki maximum likelihood was utilized in the evaluation of the values of the seismicity parameters. The obtained values of the seismic parameters are: a = 3.69; b = 0.74; Mmax = 4. However, the estimated maximum magnitude from the seismicity parameters may not be the appropriate value should dynamic dislocations from the 3 faults in this zone occur. Assuming an average fault length of 166 km, the equivalent magnitude for this fault length is 8.0 as obtained from equation.

According to the *Saudi Building Code 301 Structural-Loading and Forces*, the Kingdom of Saudi Arabia has been divided into seven regions for determining the maximum considered earthquake ground motion as shown in the following figure.

Figure 57. Regions for determination of the maximum considered earthquake ground motion In the Kingdom of Saudi Arabia (according to SBC-301 and SAER-6089) and location of the PV plant.

The parameter S_S from the 0.2 second spectral response accelerations and the parameter S_1 from the 1.0 second spectral response accelerations are given in specific figures for each region within SBC-301 to determine the maximum considered spectral response acceleration for short periods and at 1.0 second, respectively, adjusted for site class effects.

Site Class is based on the site soil properties and is classified as Site Class A, B, C, D, E or F, where:

A = Hard rock.

B = Weak and weathered rock.

C = Very dense soil and soft rock.

D = Stiff soil.

E = Non stiff soil or more than 3 m of soft clay.

F = Soils requiring site-specific evaluations:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils.

2. Peats and/or highly organic clays.

3. Very high plasticity clays.

4. Very thick, soft/medium stiff clays.

The complete definitions of these site classes are included and fully specified in Section 14.1 of SBC 301.

Site Class at Afif 1 may be pre-assessed from A to E. The site investigation results shall confirm site classes and zones to be considered.

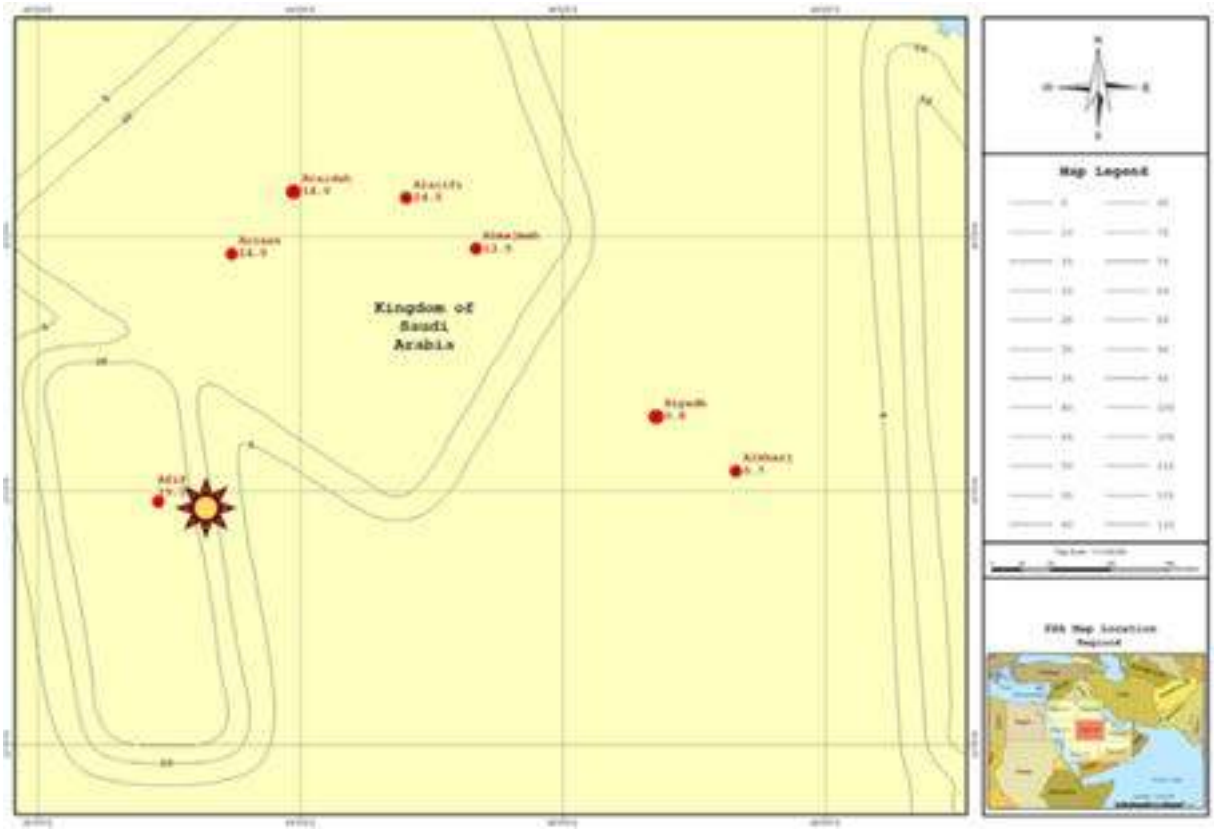


Figure 58. Region 4. Maximum Considered Earthquake Ground Motion for Region 4 of 0.2 SEC Spectral Response Acceleration in %g

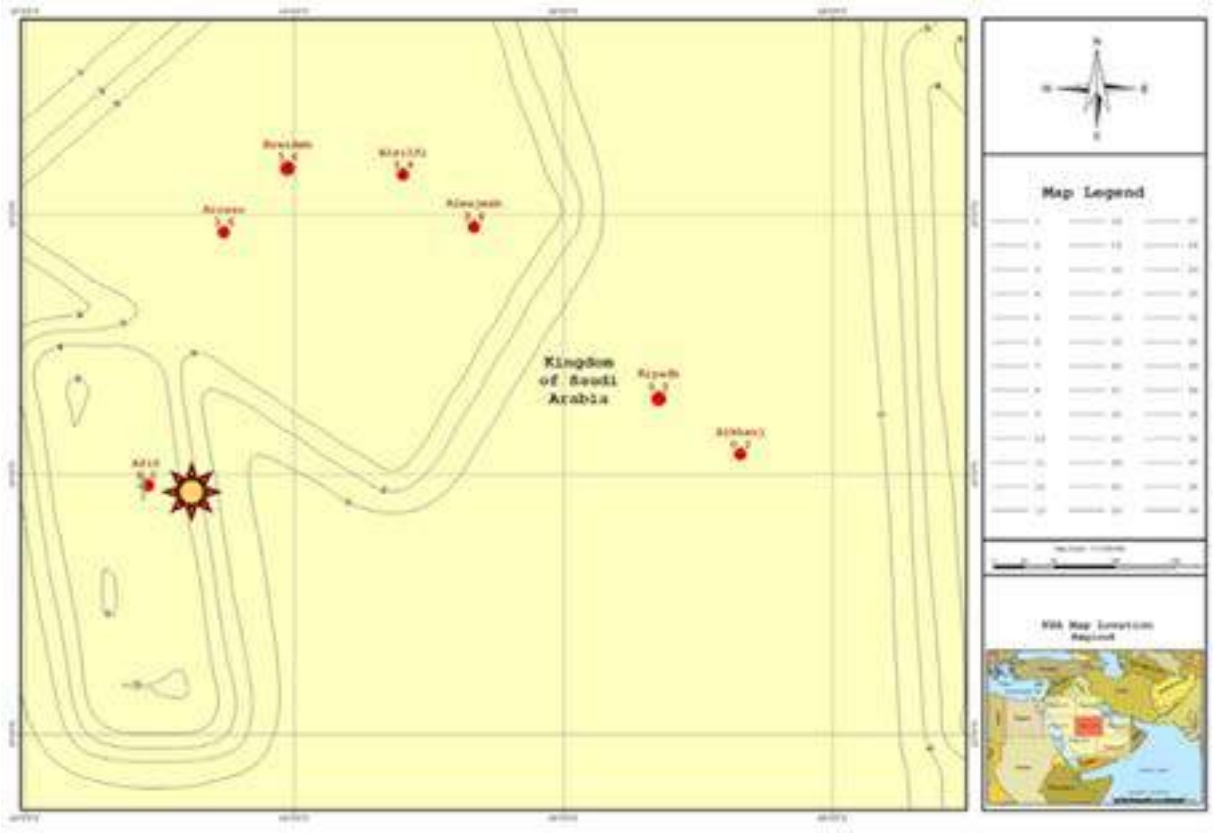


Figure 59. Region 4. Maximum Considered Earthquake Ground Motion for Region 4 of 1.0 SEC Spectral Response Acceleration in %g

d. Soils

Soils in Saudi Arabia[4] are commonly young deep clay ones over rocks, varying from shallow to deep. In Arabian desert lands most of the soils are sandy ones. Silt loam soils are distributed in the northwest side towards south, as well as southern areas, while loam ones dominate valleys and rain streams.

Sandy loam soils are the largest type, being mainly located in the south, east and northern areas of the country, as well as the coastal zones, usually in low topographic relief. Silt loam soils are found on the western highlands down to the southern highland region. Additionally, these soils are also scattered in the central part of the country and other regions. Last, loamy soils which are the less frequent and are mainly placed in the centre of Saudi Arabia, although in the northern region and the coastal one is also scattered. Is associated with low and moderate topographic reliefs as valleys and rain streams.

[4] *Khalid A. Almalki, Mobarak S. Al Mosallam, Thamer Z. Aldaajani, Ali A. Al-Namazi: "Landforms characterization of Saudi Arabia: Towards a geomorphological map". International Journal of Applied Earth Observations and Geoinformation 112 (2022). Available at: https://www.researchgate.net/publication/362487541_Landforms_characterization_of_Saudi_Arabia_Towards_a_geomorphological_map#fullTextFileContent*

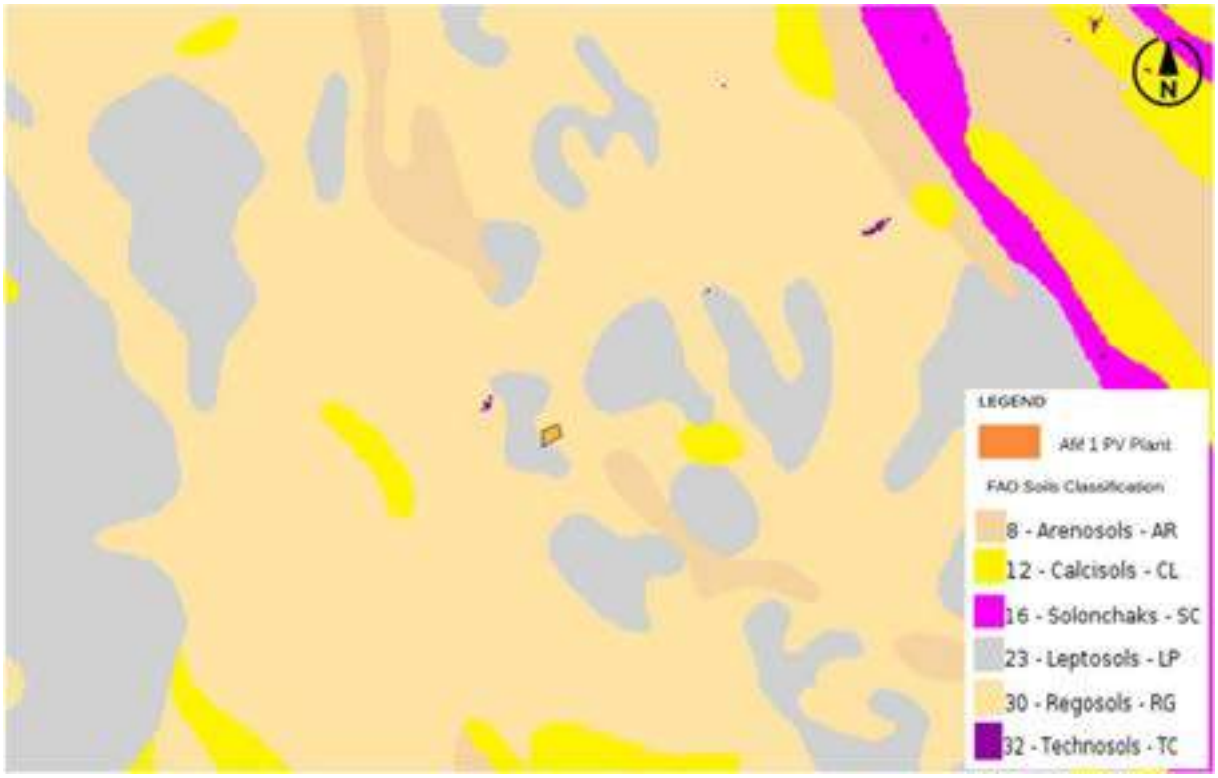


Figure 60. Soils characterization of Afif 1 Solar Power Plant and surroundings. Source: Hand-in-Hand FAO Geoportal

Afif 1 Solar Power Plant is mainly placed over regosols, extensive group set in eroding lands, particularly in arid and semi-arid areas. These soils are very weakly developed mineral ones in unconsolidated materials, having just an ochric surface horizon and not being very shallow -as leptosols-, or sandy -arenosols- or with fluvic properties -fluvisols-. Their parental material is unconsolidated, finely grained material, and their profile development minimal due to their young age and/or prolonged drought conditions. These soils are sensitive to drought due to their low water holding capacity and high permeability to water. Most common land use is associated with low volume grazing.

A small west part of the plot is placed over leptosols, characterized by being very shallow ones over hard rocks or highly calcareous material, although encompasses deeper soils extremely gravelly and/or stony. They are developed over rock or unconsolidated materials, and particularly located in strongly eroding areas. These soils usually present low water holding capacity since they are free draining soils. Their potential is limited for tree crop production or extensive grazing, and not suitable for arable cropping.

Both to north and south there are two stripes of arenosols. This group includes both sandy soils developed in residual sands (after weathering of old soil material or rock) and those developed in recently deposited sand (deserts and beach lands). Parent material is unconsolidated, translocated materials of sand texture, and their development in dry zones takes long periods of time and developed in different environments. They present high permeability, low water storage capacity, and in dry areas are used mainly for grazing although they could be cultivated if irrigated.

On the other hand, to the west and east, two spots of calcisols, which are typically characterized by showing early signs of soil formation such as changes of colour or structure. Widespread in arid and semi-arid environments, these soils are common in highly calcareous parent material areas. The parent material is mostly alluvial, colluvial and aeolian deposits, on level to hilly land with scarce natural vegetation formed by

xerophytic shrubs and trees and/or temporal grasses. Most of them are well drained and have good water holding properties. These soils are limited for agriculture, although with the proper management they may be productive, in hilly areas the predominant use is the grazing of cattle.

At a substantial distance, a stripe of solonchaks is located, soils which are defined as those having a high concentration of soluble salts at some time of the year. These soils are exclusive of arid and semi-arid climatic zones and coastal regions. They are in seasonally or year-round waterlogged areas, with a vegetation made out of grasses and/or halophytic herbs. Due to their limited potential for cultivation of salt tolerant crops, these soils are commonly used for extensive grazing.

Lastly, there are small zones occupied by technosols, which are those artificial soils derived from human activities which thus have a technic origin. Their properties are not natural anymore and include urban or mine soils, those from wastes (landfills, sludge, mine spoils or ashes), pavements, etc.

4.1.4. Hydrology and Hydrogeology

4.1.4.1. Methodology of Geotechnical and Hydrogeological survey

Field work surveys were carried out from December 2023 to April 2024. Field work surveys have been carried out by TYPSA experts.

From an environmental point of view, the main objective of the site investigation works (geotechnical survey) have been to locate the water level in case of groundwater presence in the study area.

The campaign involves several boreholes ranging from 10 to 30 meters in depth. Groundwater was found only in two boreholes in the study area during the geotechnical campaign. A water table is present at an approximate depth of 27.5 m in BH-01 and another at approximately 14.0 m in BH-73

4.1.4.2. Relevant legislation and standards

a. International Finance Corporation (IFC)

IFC Performance Standard 3 requires the avoidance of pollution or, when avoidance is not feasible, minimise and/or control the intensity and mass flow of their release. Sets out responsibilities with respect to the management of water resources in terms of quality.

b. National regulations

The Saudi National Water Strategy 2030 is a unified framework for the Saudi water sector that includes a comprehensive water strategy and integrates directions, policies, regulations, and practices in the water sector at the national level, with the principal objective of addressing the key challenges and restructuring the sector.

Saudi Water Law issued by the Royal Decree No. (M/159) dated 11/11/1441 AH preserves, develops, and protects water resources; ensure their sustainability; and manage and regulate such resources, as well as rights related thereto and to their uses. The standards and specifications for types of water (according to the water system and its implementing regulations) establishes the provisions related to required effluent quality for restricted and unrestricted use.

The Wastewater Treatment & Re-use Policy provides regulation and standards for the disposal and reuse of wastewater with a view to maximizing water efficiency while providing adequate protection of public health and the environment from pollution and infectious diseases.

The executive regulation for the Protection of Aqueous Media from Pollution from the Environmental Law issued by the Royal Decree No. (m/165), dated 19/11/1441 Hijri listed the ambient water quality standards in the article 4. The NCEC shall monitor the ambient water environmental components and indicators listed in Appendix (1) of this Executive Regulations by developing and implementing the necessary programs and taking the necessary measures in the event of detection of any exceedances to the standards in accordance with section (Third) of this article.

These regulations are developed in more depth in section 2.2.1.

4.1.4.3. Baseline Condition

a. Hydrology

There is no presence of surface water in the area allocated for Afif 1´s Solar Power Project. Occasional water-logged areas have been observed during site visit.

The region is characterized by a desert landscape, where extensive plains coexist with modest mountain ranges. The project finds its location nestled at the base of the encompassing mountain ranges, primarily covering the western horizon.

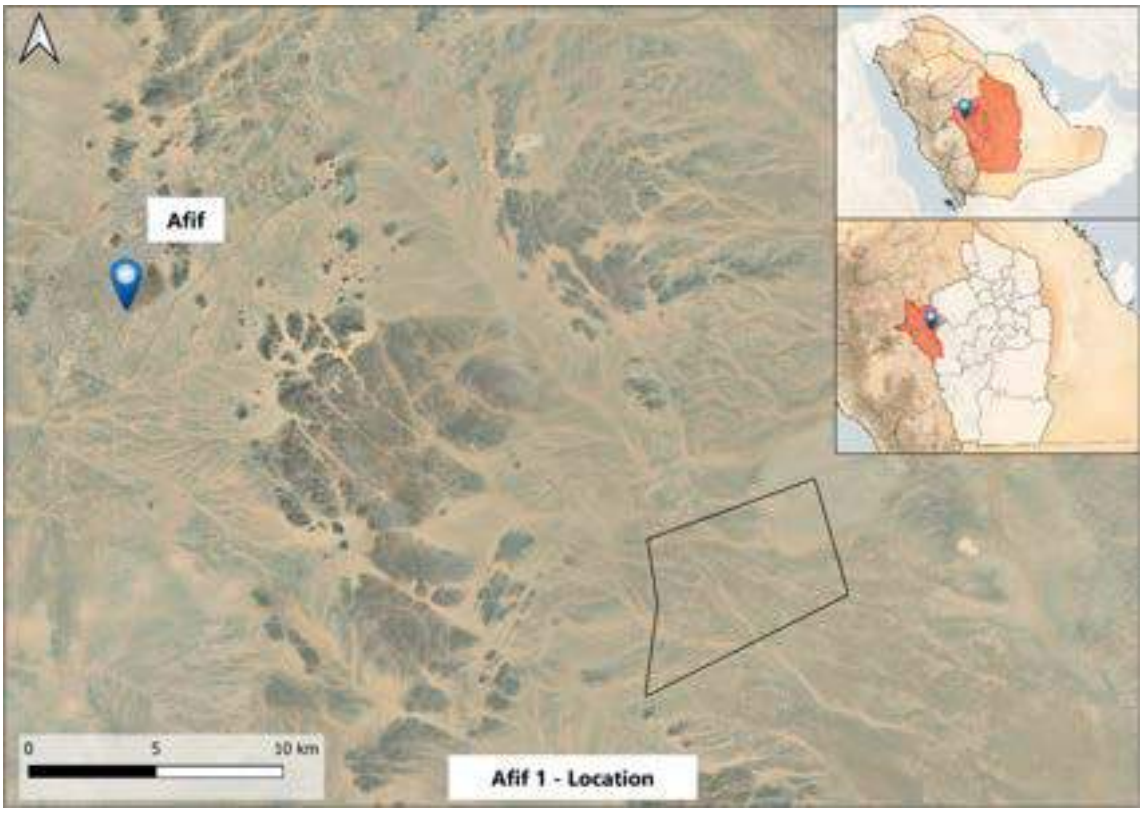


Figure 61. Afif 1 PV Project location. Source: Hydrological Study Report, TYPSA

Local Hydrology

In this regard, it is possible to observe through aerial photography how these landforms significantly shape the hydrodynamics of the area. The marks of water flow can be seen in Figure 61, originating in the mountainous areas, and subsequently meandering through the plains. Consequently, the terrain brighter hues indicate the torrential character of the storm events in this area. Additionally, the heightened density of bushes in these areas supports the hypothesis of water flow in these specific regions.

The darker areas of the orthophoto correspond to low-elevation mountainous regions. However, the areas with shades of brownish gray are due to a higher concentration of coarse sand, pebbles, or gravel boulders.

Furthermore, positioned at an average elevation of 978 m.a.s.l., the project is strategically positioned within the plain situated at the base of the mountains. Here, the topography gently slopes towards south-east, in stark contrast to the location of the mountain ranges.

Site Hydrology

A Hydrological Study has been developed by TYPSA to analyse the hydrological behaviour of the park site and its vicinity and to determine any risk associated to it. The Hydrological Report has been included in section 8.3.3.

For this purpose, the site topography has been studied to analyse and identify natural watersheds and its runoffs, which have important influence inside and outside the plot. Then, the peak flow rate of the main streams that might have influence around Afif 1 PV Plant has been assessed for different return periods (25, 50 and 100 years).

Finally, 2D Hydrodynamic analysis have been carried out to simulate the water behaviour after different rainfall scenario. As a result, the simulation provides depth and velocity evolution maps, which helps to identify potential flood hazard and erosion areas.

The site occupies an extension of approximately 40 km^2 in the Afif governorate, located in the Ar-Riyadh province. Basins have been delimited using the available cartographic information. In a first approach, the watersheds have been bounded according to ALOS PALSAR DEM of NASA, with 12.5x12.5 pixels resolution, and SRTM DEM of NASA, with 30x30 pixels resolution. Subsequently, catchment boundaries have been refined with the detailed topographic information of the site. Besides, aerial photographs of the area have verified that there were no significant modifications due to pre-existing infrastructure.

The watersheds have been delimited upstream and with north-west border of the park. This delimitation determines the geometry of the incoming basins (area, slope), that could have an impact on the water runoff, flows and velocities. The outcoming water flows and discharge points will remain since there is no change in the current situation because of the implementation of a new PV plant.

Once the previous information was collected, the next step has been the identification of natural drainage paths and main streams to provide further information about the physical characteristics of the watersheds.

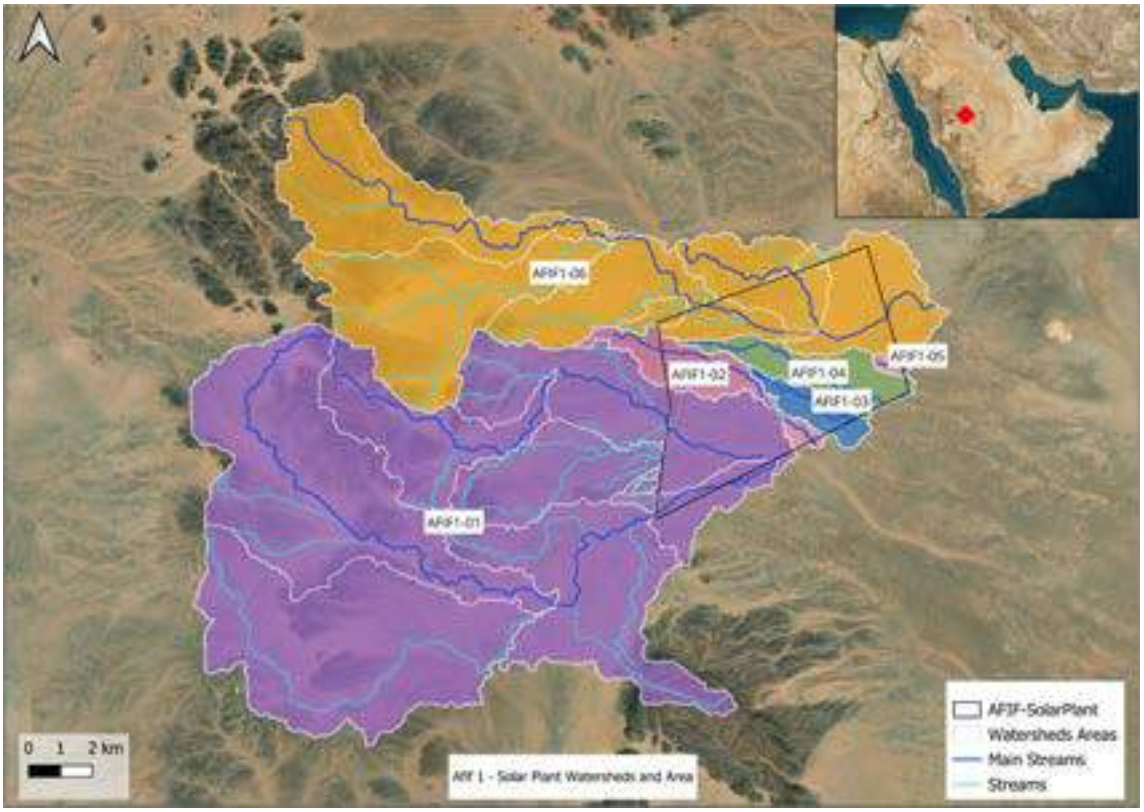


Figure 62. Afif 1 Solar Plant Watersheds and Area. Source: Hydrological Study Report, TYPSA

The process to define the runoff system has been challenging, due to the flatness and the lack of slopes over all the area. As can be seen in the image below, a slope analysis has been carried out. The results show that nearby project terrain is extremely flat. In particular, within the solar plant slopes are mainly between 0 to 3%, with some steeper slopes (>13.5%) in the upper part of the hills located to the northwest and south of the project site.

However, based on the slopes, it is possible to slightly define the hydrodynamics of the area. The site is characterized for being located in a floodplain, where water meanders gently across the terrain. With very low to negligible slopes, the water flow will normally be calm and dispersed. Consequently, it is expected a gentle water flow in the area, with a thin water layer moving at low velocities.

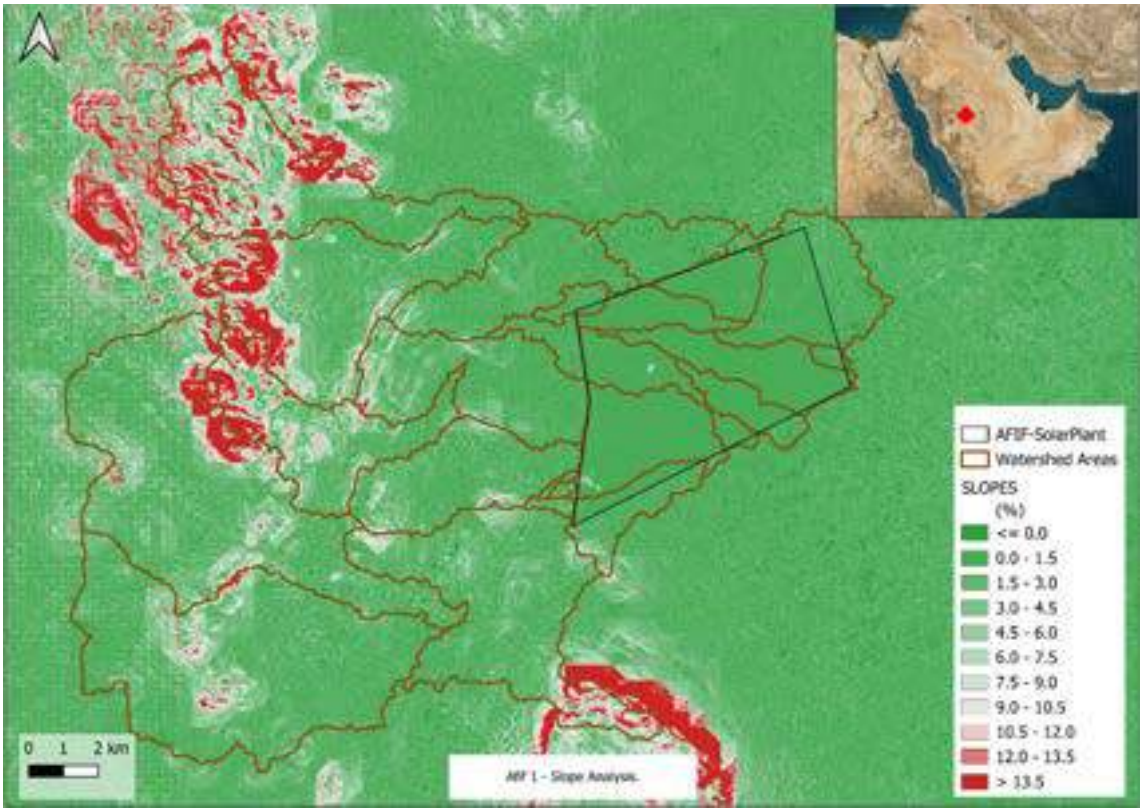


Figure 63. Slope analysis. Source: Hydrological Study Report, TYPSA

The drainage system at the Afif 1 Solar Plant and catchments areas is mainly defined by the existing surface water overland flow paths (streams), that originate in the hills to the northwest and south of the solar plant and flows through the plains and solar plant to the southwest of the project site. This drainage pattern can also be identified in the marks of water flow (erosion and superficial deposits) that can be seen in the available orthophoto.

Additionally, and considering the very low slopes in the plant area, part of the drainage system at the AFIF Solar Plant and main catchments areas is diffuse, and during rainfall events surface water runoff does not concentrate in the main streams but flow slowly and scattered, being stores on site before it drains away.

Finally, the physiographic characteristics of each watershed have been obtained measuring directly the dimensions and elevations in the topography, such as: area, length, maximum elevation, and minimum elevation.

The table below shows the physiographic characteristics of each watershed:

Basin	Area (m^2)	Main stream	Length (m)	H_{Upper} (masl)	H_{Lower} (masl)
AFIF1-01	169,106,294.90	MS-01	32,048.98	1,173.11	976.35
AFIF1-02	7,167,171.00	MS-02	9,306.96	998.36	974.17
AFIF1-03	3,374,341.19	MS-03	4,697.17	982.09	973.55
AFIF1-04	7,486,613.21	MS-04	9,786.12	989.67	970.39
AFIF1-05	573,322.08	MS-05	1,412.59	974.05	970.84
AFIF1-06	86,205,450.62	MS-06	30,678.01	1,156.41	968.22

Figure 64. Physiographic basins data. Source: Hydrological Study Report, TYPSA

Results of Flooding Analysis

The terrain of the AFIF1 project is extremely flat with some shallow and poorly defined main surface water overland flow paths (streams) crossing the site. The available orthophoto shows erosion marks and superficial deposits that have been created by the main existing surface water overland flow paths. These streams have also been identified by the available Lidar and subsequent analysis.

Figure 65. Representative image of the study area. Surface water overland flow paths. Source: Hydrological Study Report, TYPSA

Since the slope is nearly negligible at the solar plant site, surface water runoff slowly flows over the ground into the main streams where it drains away. Additionally, surface water is stored in some parts at the low points of the ground before it drains away through infiltration and evaporation.

The hydraulic modeling shows similar results for all rainfall events with surface water flowing through the existing overland flow paths with maximum depths between 0.20m to 0.40m and maximum velocities between 0.8m/s to 1.20m/s at the existing overland flow paths.

Flood Hazard

An estimation of the flooding hazard was performed by a geospatial analysis using three different raster files: flood flow, velocity, and the multiplication of both, for a return period of 100 years. Given the hydrological conditions discussed in the previous section, the most delimiting factor when studying the hazard level is the water velocity.

Finally, the combination of all these three constrains are proposed as hazardous areas for the project. While these areas may pose a risk to the planned equipment and installations, it is not sufficient reason to consider them as zones to be avoided. In this case, the areas identified as risky are few and pose a low hazard.

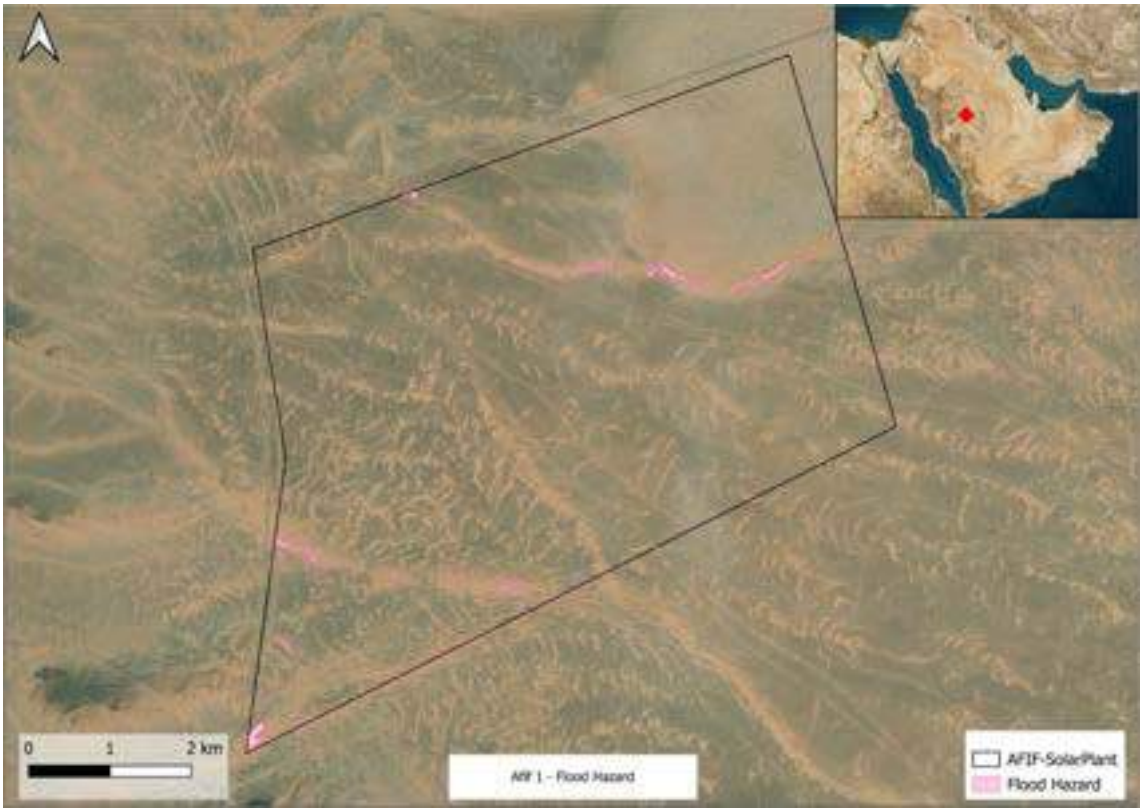


Figure 66. Flooding hazard areas. Source: Hydrological Study Report, TYPSA

Conclusions

From a hydrological point of view, the AFIF 1 area does not pose any major risk for the development of photovoltaic installations. Analyzing the results, slopes in the area are very low, between 0 to 3%. As a result, surface water runoff slowly flows over the ground into the main surface water overland flow paths (streams) where it drains away. Additionally, surface water is stored in some parts at the low points of the ground before it drains away through infiltration and evaporation. The hydraulic modeling shows similar results for all rainfall events with surface water flowing through the existing streams with maximum depths between 0.20m to 0.40m and maximum velocities between 0.8m/s to 1.20m/s at the existing overland flow paths.

Some of the water basins that drain into the site are large, that result in moderate to large volumes of water flowing through the existing streams. However, the identified surface runoff streams have a very low slope with values between 1.0% and 0.10%, so concentration times are relatively high. Moreover, the local terrain has a low runoff coefficient. Altogether these factors moderate the impact that any extreme rainfall event might have on the site. Thus, rainfall and runoffs in the site will have a low velocity or erosive potential and therefore hydrological severe impacts are unlikely to occur. Moreover, the erosion of the area is expected to be very low as the small and diffuse runoffs detected are not strong enough to wash away soil particles.

The hydrological model shows that areas subjected to flood hazard risk are entirely located within the existing streams, where the hydraulic modeling shows maximum water velocities around 1.0m/s and maximum water depths around 0.5m and have been found.

Although these hazard areas are very localized and unlikely to have any detrimental impact or potential risk to the development of photovoltaic installations at the AFIF1 project site, it is highly recommended to

introduce materials in the existing streams such as rocks or breakwater, that will increase the roughness and head losses of the stream channels (n-manning), decreasing the velocities and hazards accordingly.

Critical design elements such as transformation centers, panel inverters, substations or other any equipment should be placed and installed outside the flood hazards sections. Additionally, the electrical facilities trenches at the flood hazards areas should be concreted. For other electrical equipment located over zones where floods and high-water depths are more prone to happen, the recommendation is to place the equipment at certain level over ground level and, additionally, some waterproof protections to avoid damages.

The solar panel posts at the flood hazards sections should include local protections such as rocks surrounding them.

Furthermore, it is recommended to develop mitigation strategies, such as some grading, that definitively improve the terrain drainage capacity, so exposure time to water is shorten up and reduce the potential flooding risks. For the roads or linear works, a system of ditches and ford will be sufficient since the ditches are expected to collect the water and direct it to the existing natural streams. The road arranged over low zones where the water level is expected to be high, a minimum elevation for the road surface should be set to prevent the water from passing over the roads and avoid damages on shallow layers of the road.

In all scenarios, it can be assured that the drainage solution implemented in the park to protect the roads or the earthworks leveling to enhance the soil's drainage capacity will not result in any adverse effects on the downstream facilities. Due to the park topography, the water behavior has a well-defined path, catching the water from the north-west area and conduct it to the south-east part. Any change on the water behavior that can occur due to the drainage works inside the park will improve the drainage capacity, that means: less water or lower velocity runoffs.

b. Hydrogeology

Afif 1 Solar Power Plant sits over the Arabian Shield, which based on the literature review[5,6] consists of igneous and metamorphic rocks of Precambrian age as well as several spots of volcanic rocks of Tertiary and more recent age. Since the igneous and metamorphic rocks have generally low yield, no significant groundwater resources are expected. The volcanic rocks are characterized by medium yields, also the alluvial fillings (located in the valleys), but since their extent is limited, groundwater resources are not surpassing local importance.

[5] *Rausch, R., Dirks, H. "A hydrogeological overview of the Upper Mega Aquifer System on the Arabian Platform". Hydrogeology Journal (2024). Available at: https://rdcu.be/dywiH*

[6] *Rausch Randolf. "A brief overview of the 'Principal Aquifers' in the Kingdom of Saudi Arabia". Workshop Working Group "Hydrogeology of Arid Environments", Conference May 28-30, 2014. Bayreuth (Germany). Available at: https://www.researchgate.net/publication/363701234_A_brief_overview_of_the_Principal_Aquifers_in_the_Kingdom_of_Saudi_Arabia*

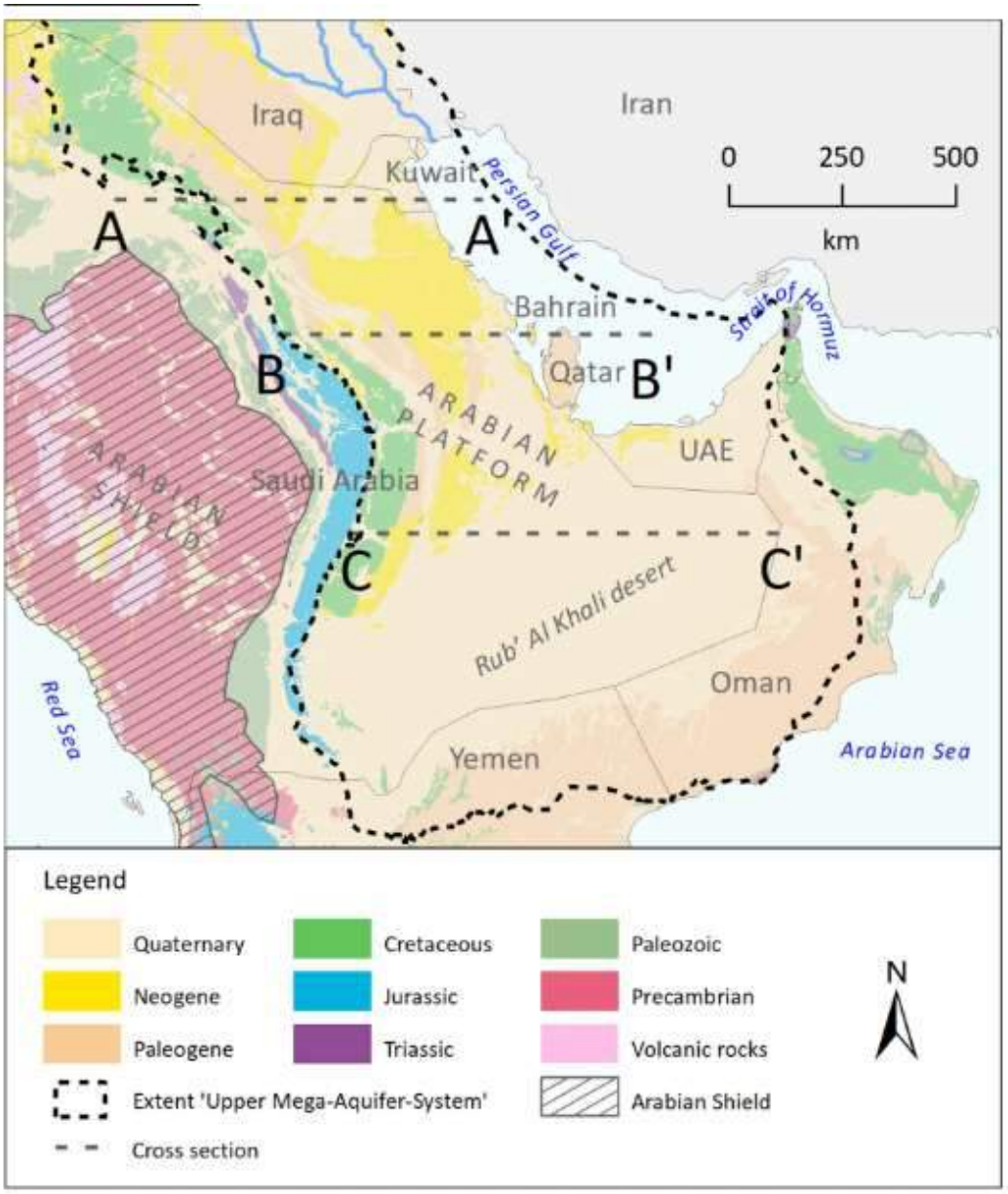


Figure 67. Simplified geological map of the Arabian Peninsula. Source: A hydrogeological overview of the Upper Mega Aquifer System on the Arabian Platform

As mentioned before, the only aquifers which might be in the area are tertiary ones due to alluvial deposits or the ones originated by the location of volcanic rocks. However, their surface would be limited and scarce, not presenting any regional importance. The following figures show the alluvial and basalt aquifers in Saudi Arabia, not being Afif 1 plot among the highlighted ones.

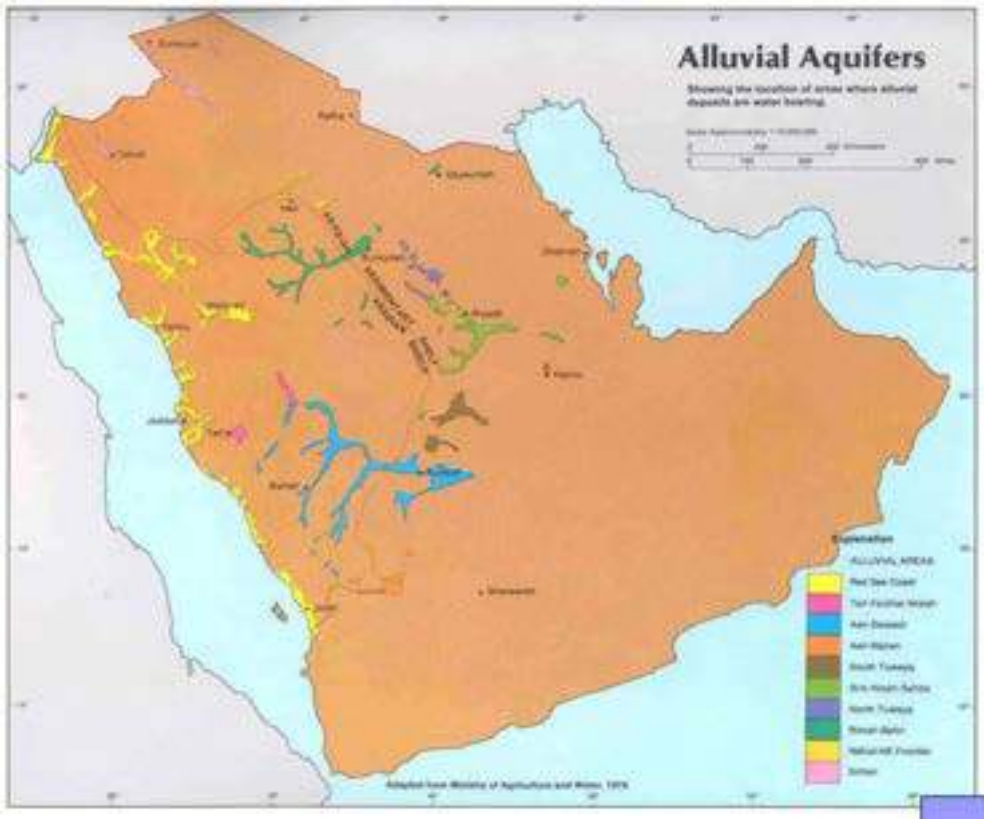


Figure 68. Location of Alluvial Aquifers in Saudi Arabia. Source: Makkawi, M. (2010) Water Resources of Saudi Arabia

Figure 69. Location of Basalt Aquifers in Saudi Arabia. Source: Makkawi, M. (2010) Water Resources of Saudi Arabia

4.2. Terrestrial Biodiversity

4.2.1. Flora and Fauna

4.2.1.1. Methodology of Flora and Fauna survey

a. Significance of Survey Findings

Three main reference criteria have been used to evaluate the significance of survey findings which are discuss further below:

- International Union for the Conservation of Nature (IUCN) Red List.
- KSA High Conservation Priority (HCP) species list; and
- International Finance Corporation (IFC) Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management.

In the absence of any national protected species list, approaches are proposed to classify species of conservation concern for the Report, IUCN Red List and the HCP species.

The categorisation of threatened flora and fauna species has followed the IUCN Red List categories. The IUCN Red List classifies species in accordance with their risk of extinction on a global basis is used. Species are classified into nine groups based on the following criteria: rate of decline, population size, area of geographic distribution and degree of population and distribution fragmentation. The IUCN Version 3.1 Categories are shown in figures below.

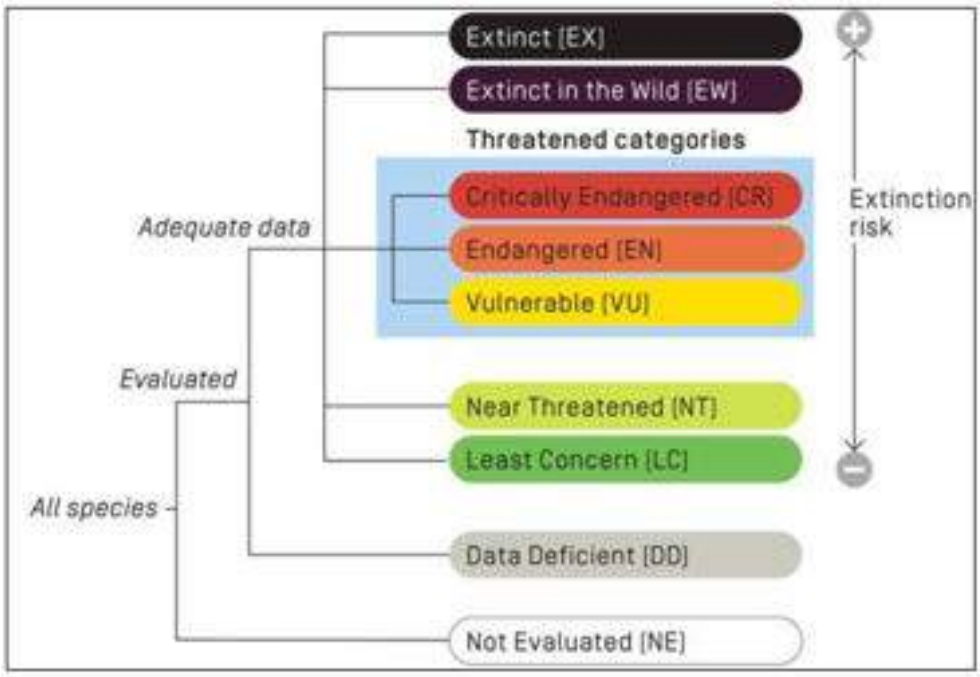


Figure 70. IUCN System of Classification for Species Threat of Extinction (IUCN, 2020)

IUCN Extinction Risk	Description
EXTINCT **(EX)**	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual) throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
EXTINCT IN THE WILD **(EW)**	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual) throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
CRITICALLY ENDANGERED **(CR)**	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered and it is therefore considered to be facing an extremely high risk of extinction in the wild.
ENDANGERED **(EN)**	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered and it is therefore considered to be facing a very high risk of extinction in the wild.
VULNERABLE **(VU)**	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable and it is therefore considered to be facing a high risk of extinction in the wild.
NEAR THREATENED **(NT)**	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category soon.
LEAST CONCERN **(LC)**	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
DATA DEFICIENT **(DD)**	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period has elapsed since the last record of the taxon, threatened status may well be justified.
NOT EVALUATED **(NE)**	A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

Figure 71. IUCN Extinction Risk Categories

b. Standards applied for Survey

The survey methods comply with:

- The British standards BS 42020:2013, Biodiversity — Code of practice for planning and development.
- Guide to Ecological Surveys and Their Purpose by Chartered Institute of Ecology and Environmental Management.
- Good practice guidelines found in literature.

c. Desk Study and Pre-survey Preparations

The following tasks were undertaken as part of the desk study and pre-survey preparations:

- Desk Study

  The Desktop Review was based on previous studies, data, surveys, and records available in published scientific papers, books, and journals on biodiversity recorded within the study region in general. It is important to note that since the available literature on the Project site and its vicinity is

relatively limited, the literature reviewed has included a wide spectrum of references including international references that have a wider focus than the area of the Project.

- Pre-survey Preparations

  The following tasks have been undertaken as part of the pre-survey preparations:

  - Identification of the survey area. The main project site was subdivided into a grid system of zones, named respectively zone 1, zone 2 and zone 3 (see figure below). Deployment of a grid system supports in defining the survey activities, such as the placement of transects for vegetation and faunal studies respectively. The heterogeneity of the habitats within the Project site is thus isolated in each grid. This also allows the true ecological representation of the Project site to be established.
  - Gathering of information of the Project site, including maps and geo-spatial imagery.
  - Selection of the tentative location and placement of survey transects.
  - Preparation of datasheets and survey pro-forma.

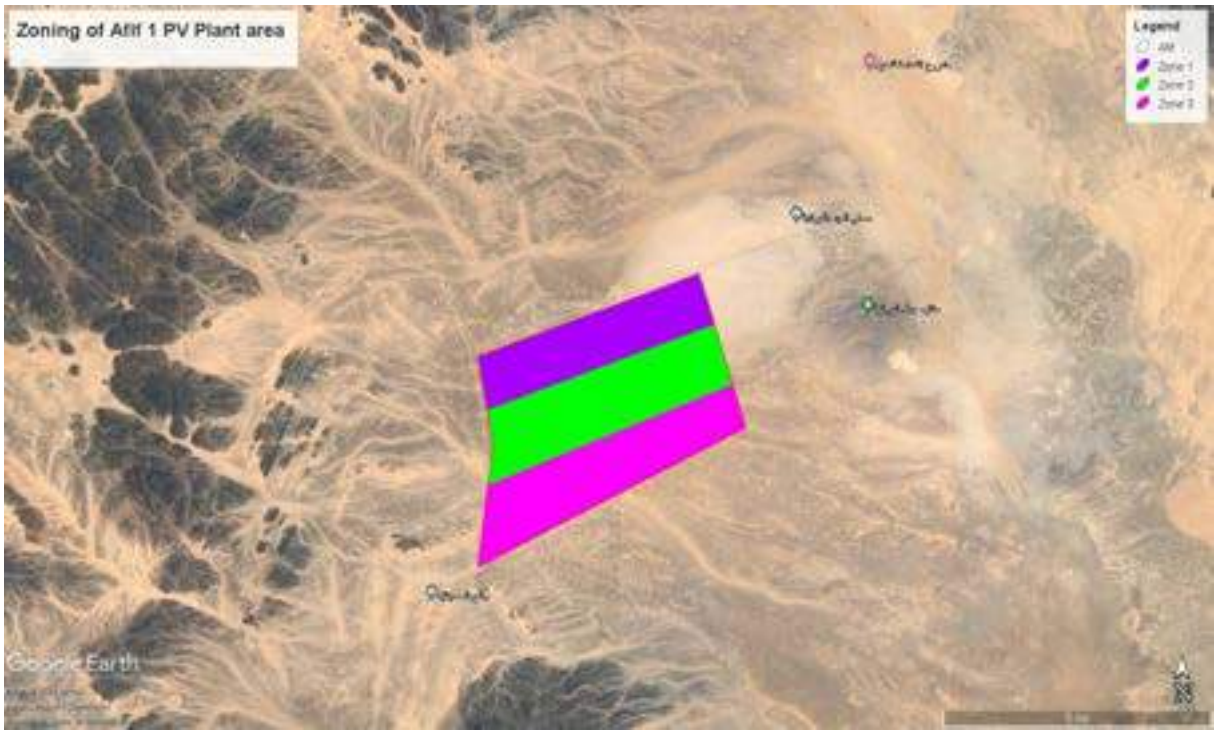


Figure 72. Grid System Layout for Afif 1 Solar Plant Survey. Source: Environmental Baseline Survey Report for Afif 1 PV Project

d. Flora Survey Methodology

Transect Survey for Flora

The site was swept by driving through and walkover by the survey team along transects. The survey team drove through the site with great attention to the vegetation cover encountered during travelling. The team get out from the car and walk, once any change in vegetation cover or any point of interest of flora are noted.

While walking, the survey team have closely observed the flora features, analyze and identify the species of plants and photograph them using a camera (close up and landscape images), and a camera (zoom images). Locations have been recorded using a handheld Garmin GPSMAP 64sx global positioning system (GPS) device, and waypoint (WP) field notes have been taken. Flora species that could not be identified in

the field, have been identified by their photos when back to office. While surveying, the team has monitored the possible growth of invasive plants.

Flora Quadrats

A total of nine (9) quadrats were placed within homogenous biotypes in the site location. Once an area for a quadrat had been selected, the four corner points were determined using a tape measure. These were then staked out using tent pegs and a tape was placed around the boundary. The quadrat size was 10 m by 10 m (see figures below).

Flora abundance was estimated for a given location and is therefore subject to observer judgement. Abundance was recorded making use of the DAFOR scale (Kent & Coker, 1992), where the relative abundance for each species, in the quadrat, is recorded as follows:

D - Species is "Dominant"
A - Species is "Abundant"
F - Species is "Frequent"
O - Species is "Occasional" R - Species is "Rare"

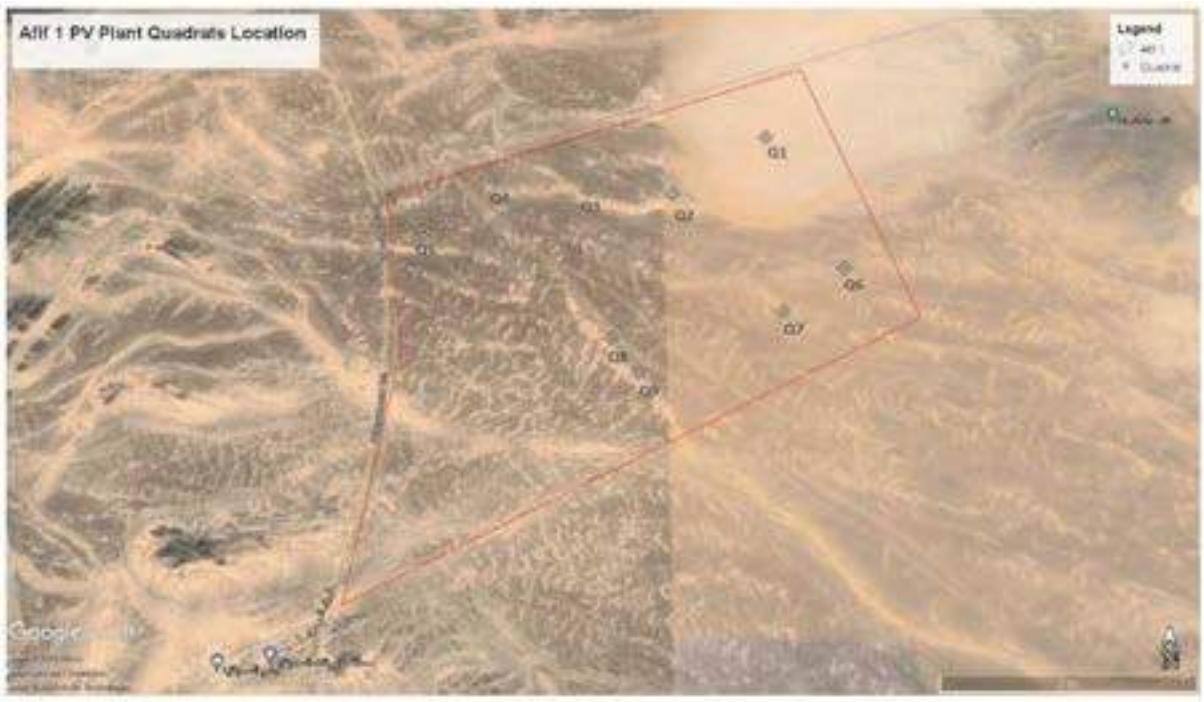


Figure 73. Quadrats Location. Source: Environmental Baseline Survey Report for Afif 1 PV Project

Figure 74. Example of Vegetation Quadrat. Source: Environmental Baseline Survey Report for Afif 1 PV Project

e. Fauna Survey Methodology

Characterisation of the terrestrial fauna (mammals, birds, reptiles, and invertebrates) within the Project site was conducted via drive through and walkover transects and the deployment of camera traps. The location and routes of the drive through and walkover transects is presented in table and figure below.

Figure 75. Drive through /Walkover transect. Source: Environmental Baseline Survey Report for Afif 1 PV Project

The terrestrial fauna survey included the following methods:

Survey Mammals

Drive through and walkover transects was conducted from at least 7h00am to 4h00 pm for indications of presence of mammals i.e., burrows, tracks showing gait characteristics, scat etc. During the survey any notable tracks, burrows or any sighting of live mammals was photographed.

Survey of Birds

Avifauna has been surveyed during the transects walks by naked-eye observation and by field binoculars (10×50) used to conduct bird counts at vantage points for a duration of 30 minutes in each point (see figure below). According to the Best Practices for bird survey the vantage point should cover a diameter between 2.5 to 3 km.

Bird species have been identified along with their migrant, breeding, and resident types based on “Avibase - Bird Checklists of the World” in the region of project.

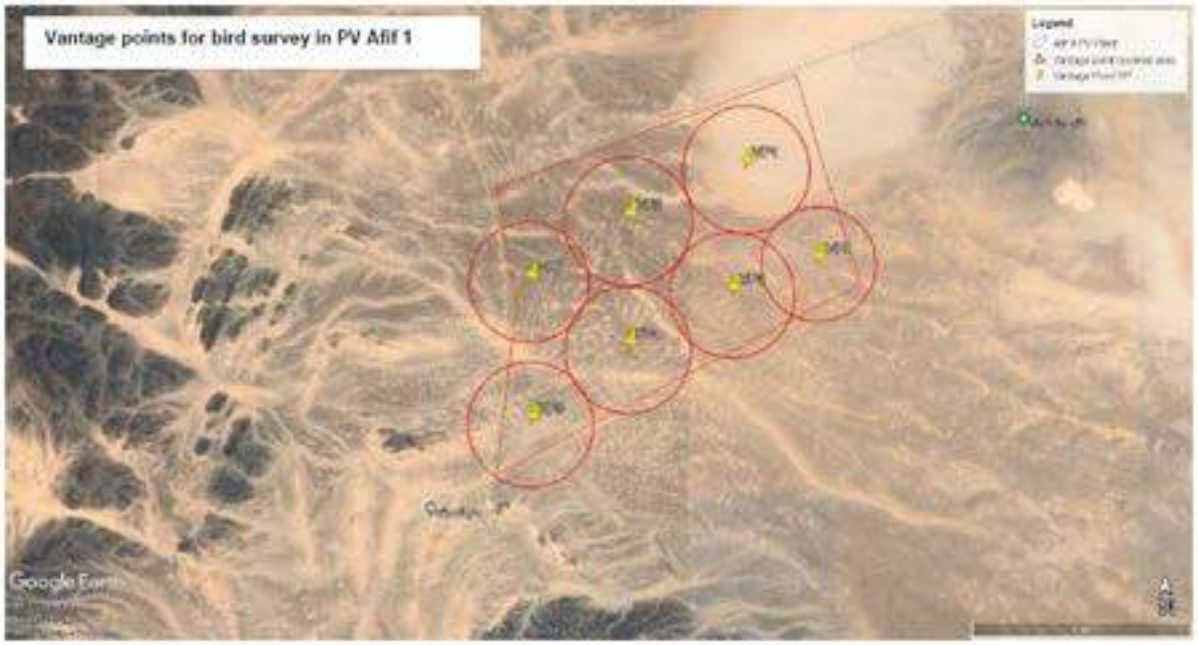


Figure 76. Vantage points for bird survey in PV Afif 1 Solar Plant site. Source: Environmental Baseline Survey Report for Afif 1 PV Project

Survey of Reptiles and Invertebrates

During the same transects, a sweeping survey of the ground has been conducted to detect the presence of any reptiles, such as lizards and for the presence of any borrow or larger reptile such as spiny tailed lizards. Surveys have been focused on areas with as understory growth, herbaceous vegetation, rocks, and anthropogenic debris. During the survey, attention was paid, also, to the presence of any invertebrates and Pit fall traps was deployed at chosen locations to identify invertebrates (see figures below).

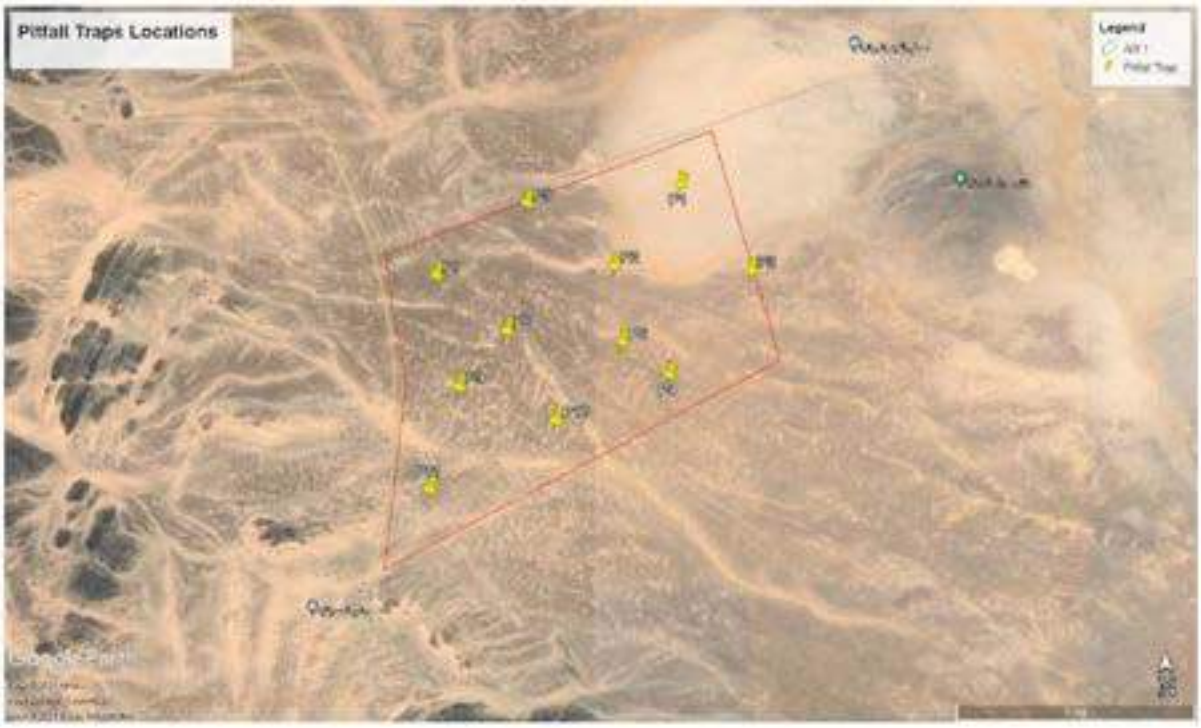


Figure 77. Pitfall trap's locations. Source: Environmental Baseline Survey Report for Afif 1 PV Project

Deployment of camera traps

The camera traps were deployed at eight different locations within the project site. These locations were selected to be near active burrows and areas where recent faunal activities were indicated (see Figures below).

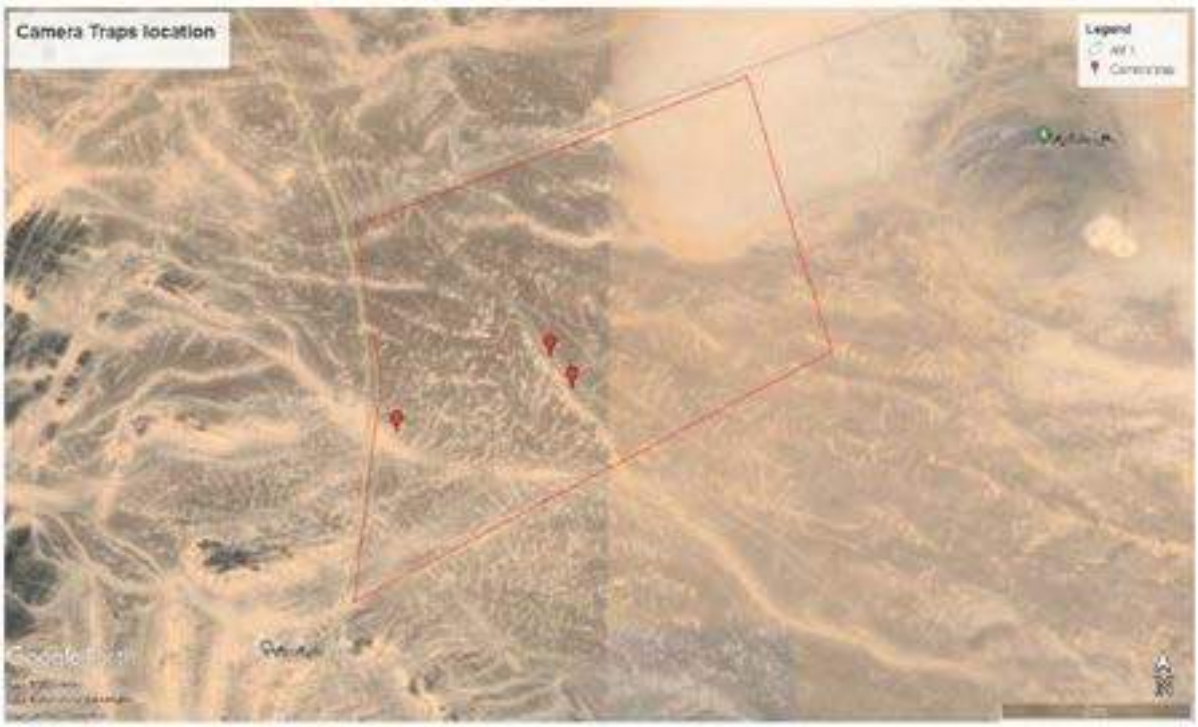


Figure 78. Locations of the camera traps. Source: Environmental Baseline Survey Report for Afif 1 PV Project

Figure 79. A camera trap near an active burrow. Source: Environmental Baseline Survey Report for Afif 1 PV Project

f. Survey Equipment and Materials

The following equipment and material have been used for the survey:

- GPS device (01).
- Relevant Maps.

- Digital Camera (01).
- Camera traps (03).
- Field Binocular (10×50) (01).
- Spotlight torches (01).
- Compass (01).
- Batteries for all electronic equipment.
- 50 m tape (or pre-measured 40m quadrat rope).
- Utility tool (pliers and hammer).
- Specimen collecting book (for identification).
- Data Sheets.
- Reference guides (Mammals, birds, plants, and reptiles).
- Small Paper bags/envelops for seeds and fruits collection.
- Pencils, Pens, Eraser etc.

4.2.1.2. Relevant legislation and Standards

a. International agreements & Conventions and Regional Standards

The Kingdom of Saudi Arabia cooperates internationally to protect and manage the environment and participates in the work of codification of international environmental law. This commitment is manifested in the signing and ratification of some international conventions on the environment which are developed in section 2.2.3.

The Kingdom of Saudi Arabia is also a signatory to the Convention on the Conservation of Wildlife and their Natural Habitats in the Gulf Cooperation Council (2001), along with six other Gulf States. This Convention is developed in more depth in section 2.2.2.

b. IFC Performance Standard 6

IFC Performance Standard 6 concerning Biodiversity Conservation and Sustainable Management of Living Natural Resources recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development (IFC, 2012). The standard is guided by the Convention on Biological Diversity in addition to setting out guidelines for the preservation of ecosystem services.

Performance Standard 6 describes ecosystem services as the benefits that people, including businesses, derive from ecosystems. Ecosystem services are organized into four types:

- Provisioning Services: the products people obtain from ecosystems.
- Regulating Services: which are the benefits people obtain from the regulation of ecosystem processes (surface water purification, carbon storage and sequestration, climate regulation, protection from natural hazards).
- Cultural Services: which are the non-material benefits people obtain from ecosystems.
- Supporting Services: which are the natural processes that maintain other services (e.g., soil formation, nutrient recycling, primary production).

Informed by the risks and impacts identification process, this Performance Standard should be applied to projects:

- Located in modified, natural and critical habitats.
- That potentially impact on or are dependent on ecosystem services over which the project proponent has direct management control or significant influence; or,
- That include the production of living natural resources (e.g., agriculture, animal husbandry, fisheries, forestry).

It states that the impact identification process should consider direct and indirect project-related impacts on biodiversity and ecosystem services and identify any significant residual impacts. The project proponent should seek to avoid impacts on biodiversity and ecosystem services, and, where avoidance is not possible, measures to minimize impacts and restore biodiversity and ecosystem services should be implemented.

The risks and impacts identification process should take account for the differing values attached to biodiversity and ecosystem services by Affected Communities, and where appropriate other stakeholders.

The area proposed for development is partially disturbed but may contain species or habitats within a national and international context. However, the baseline survey concludes that **no key landscape features can be considered as ecologically important for flora or fauna**.

c. National legislation

- Executive Regulations for Vegetation cover development and Combating desertification (Ministerial Decision No. 354566/1/1442)

  These regulations include the prerequisites for obtaining Permits and Licenses Pertaining to Vegetation Cover Lands.

4.2.1.3. Baseline conditions

a. Vegetation communities

The proposed PV Plant Site is characterized by a barren and arid landscape, typical of Saudi Arabia, with patches of scarce vegetation. Vegetation coverage is more plentiful in the eastern area, which historically has been suitable for grazing camels and sheep. Some small areas, which might be linked to preferential water flow, present trees, shrubs, and grass.

Figure 80. General view of the Project site's vegetation within the Project area. Source: TYPSA´s Preliminary Site Assessment Report

Flora is scarce and with a limited richness and abundance because of the ecosystem conditions of the study area.

A flora survey was carried out by AHEC in January 2024. The results are reported below.

During the field survey only five flora species were observed, desert typical, which indicates the lack of vegetation cover in the project area. The species are: *Calotropis procera, Acacia tortilis, Fagonia tenuifolia, Astragalus malacus* and *Citrullus colocynthis*. While *Calotropis procera* is a shrub or small tree up to 2.5m height (maximum 6) and *Acacia tortilis* is a small evergreen tree up to 20 m, the other three species are small shrubs (although *Citrullus colocynthis* is a creeper plant). During field survey, a desert truffle specimen was found. Its photograph is included even though it is not a flora species.

The conservation status of the species identified were checked against the IUCN Red List, KSA HCP listings (2004) and GCC convention (2003). There were no HCP species recorded during this survey, or GCC Convention since all species are categorised as Not Listed (NL). One of the flora species recorded is included in the IUCN classification, as Least Concern category.

No flora species recorded are listed as IUCN threatened species or as KSA HCP species.

No.	Family	Scientific Name	IUCN classification	KSA HCP Species Criteria (NCWCD, 2004)	GCC Convention (GCC, 2003)
1	Apocynaceae	*Calotropis procera*	NE	NL	NL
2	Fabaceae	*Acacia tortilis*	LC	NL	NL
3	Zygophyllaceae	*Fagonia tenuifolia*	NE	NL	NL
4	Fabaceae	*Astragalus malacus*	NE	NL	NL
5	Cucurbitaceae	*Citrullus colocynthis*	NE	NL	NL

NE: Not Evaluated, NL: Not Listed, LC: Least concern

Table 40. Recorded flora species during the field survey. Source: Environmental Baseline Survey Report for Afif 1 PV Project

Several examples of the recorded flora species are shown in table below.

Flora	Descriptive photo
Calotropis procera	
Acacia tortilis	
Fagonia tenuifolia	

Flora	Descriptive photo
Citrullus colocynthis	
Astragalus malacus	

Flora	Descriptive photo
Desert truffles	

Table 41. Example of the recorded Flora. Source: Environmental Baseline Survey Report for Afif 1 PV Project

The following figure shows the location of the *Acacia tortilis* specimens located within the plot, since it is the only flora species included in the Red List of the IUCN (Least Concern category in IUCN classification).

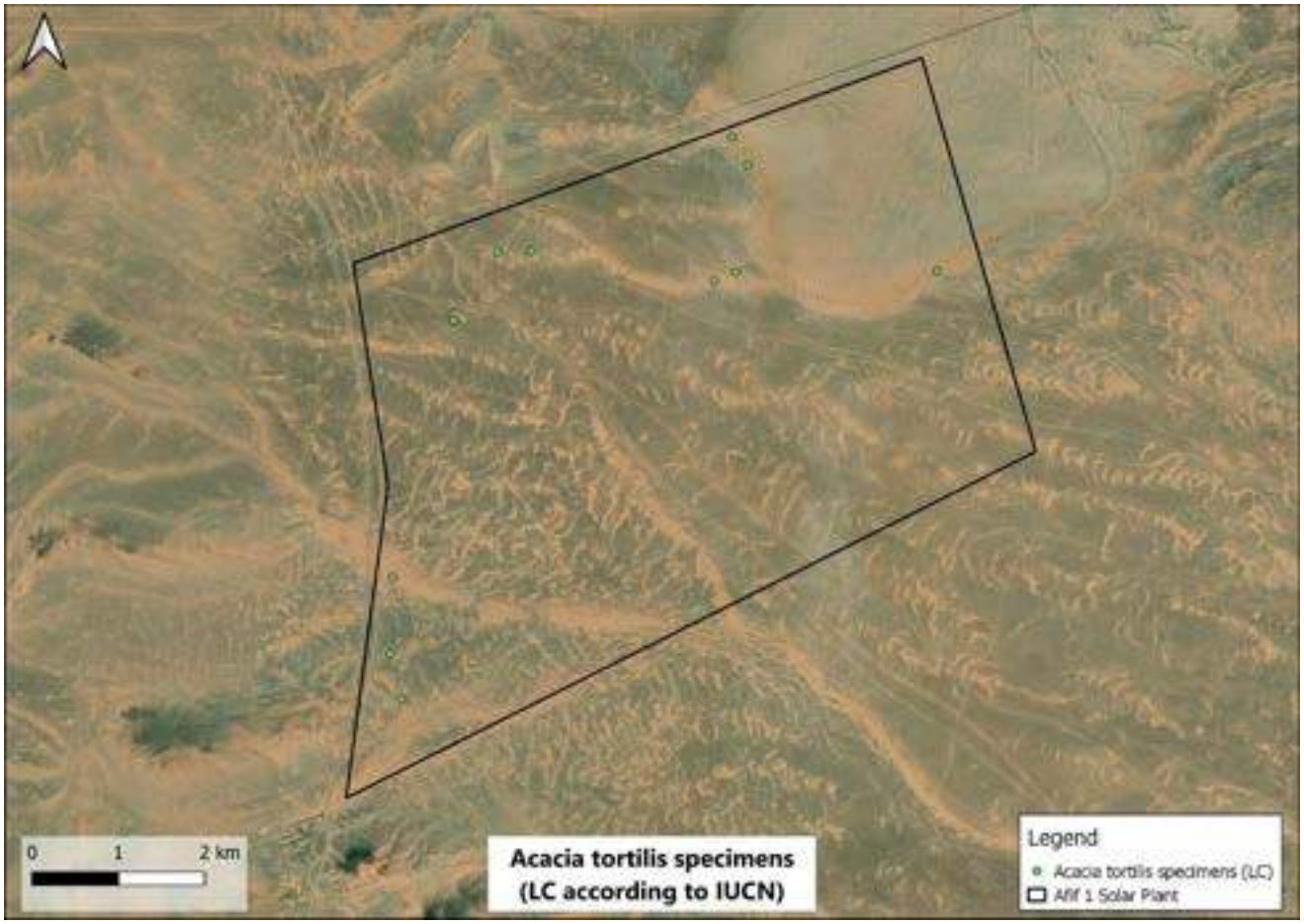


Figure 81. Acacia tortilis specimens (LC by the UICN) located within the limits of Afif 1 Solar Plant. Source: Environmental Baseline Survey Report for Afif 1 PV Project

b. Fauna

Fauna species and specimens, same as flora ones, are scarce due to limited richness and abundance of the ecosystems at the study area. Reduced fauna species were observed (some birds, reptiles, domestic mammals) during the site visit, possibly due to the lack of vegetation and key landscape features.

The following figure shows the rarity-weighted richness map[7] of Saudi Arabia and the project site area. The information is a raster layer with a 10 km grid cell, where every cell shows the relative importance in terms of aggregate contribution to the global distribution of species of mammals, birds, amphibians, crabs, crayfishes and shrimps. For each species the value was calculated as the contribution of the cell towards its global distribution. The scores were summed across the species present to give an overall score: high values show that the cell holds a large number of species and/or that the average ranges of the species present in the cell are small (so that the cell represents a relatively high proportion of their range).

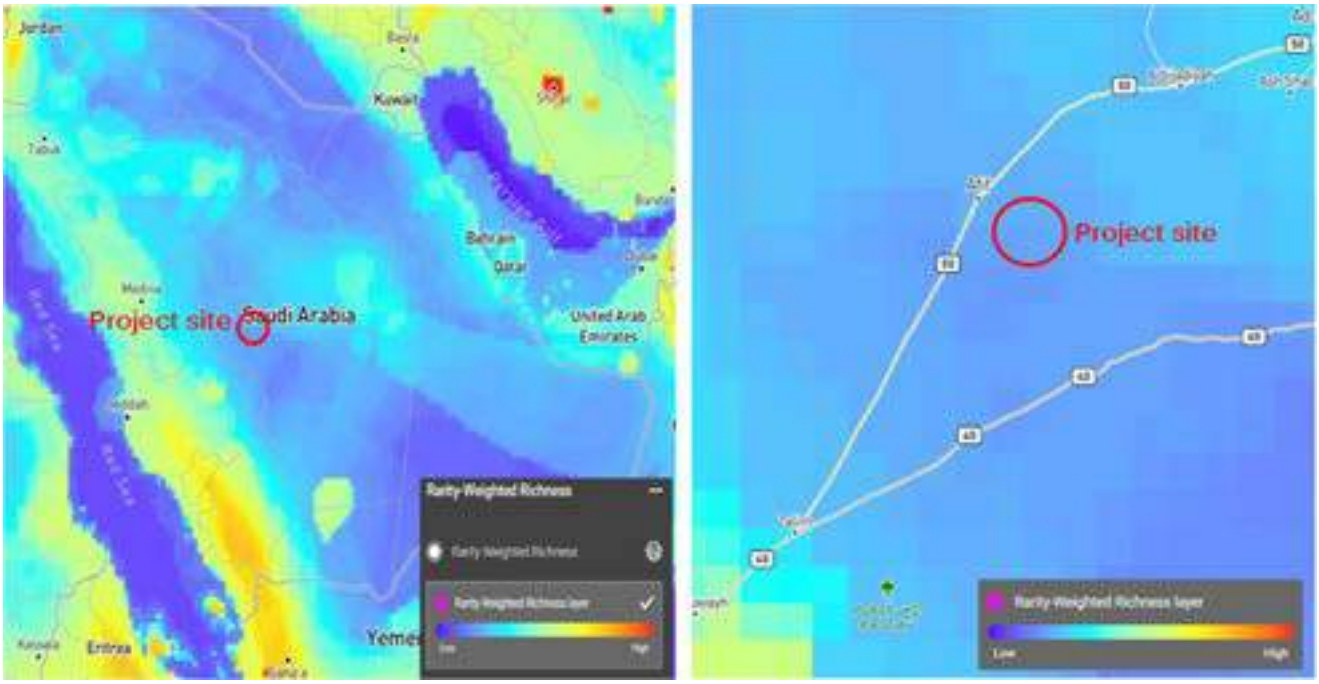


Figure 82. Rarity-weighted richness map of Saudi Arabia and the project site area. Source: IBAT

Furthermore, according to the figure below, the richness of fauna species in the project site is low. So, this area is characterized by its low diversity index which refers not to abundance but to the existence of the different species that must be prioritized in a political and scientific level according to the Convention on

[7] *Integrated Biodiversity Assessment Tool -IBAT-, UN Environment World Conservation Monitoring Centre. BirdLife International, Conservation International, IUCN and UN Environmental Programme WCMC. Downloaded 2023.* https://www.ibat-alliance.org/free-visual-data-map

Biological Diversity (CBD). The figure below shows there is a low occurrence of chordates species[8] in the area.

Figure 83. Species occurrences reported to the Global Biodiversity Information Facility -GBIF- Project site in red color. Source: Digital Observatory for Protected Areas

Avifauna

Regarding birds, Saudi Arabia is one of the most relevant pathways for bird migration because of its geographical location. Furthermore, every year new bird species occupies new sites because their habitat suitability match with the characteristics of the area. The total number of bird species registered in the Kingdom is 499 species. About (276) migratory or kingdom's territory crossing species have been recorded.

It is common to find resident or migratory species associated to natural wet areas like wadis and to areas that humans have created (such as artificial lakes and swamps in farms as well as treated sewage water). The study of the migration periods of some bird species shows that the species that are found in abundance in the spring are not necessarily found in the same numbers in the fall. As for waterfowl and wading birds in particular the opposite is true, as they are abundant during autumn and are only rarely seen in the spring. There are not wet areas in the project site.

[8] *Species are displayed as spatial layers made available from the Global Biodiversity Information Facility -GBIF- that derive from many sources, including everything from museum specimens collected in the 18th and 19th century to geotagged smartphone photos shared by amateur naturalists in recent days and weeks. This dataset may help you identifying information gaps and factors limiting the dissemination of biodiversity information that are recognized as priorities both at the political and scientific levels of the Convection on Biological Diversity -CBC-, GBIF.org (2021), GBIF Home page available from https://www.gbif.org*

BirdLife is working to conserve soaring birds during their migration along the Rift Valley/Red Sea flyway. According to BirdLife map the project site location is far from the entrance/exit routes of the migratory birds (see figure below).

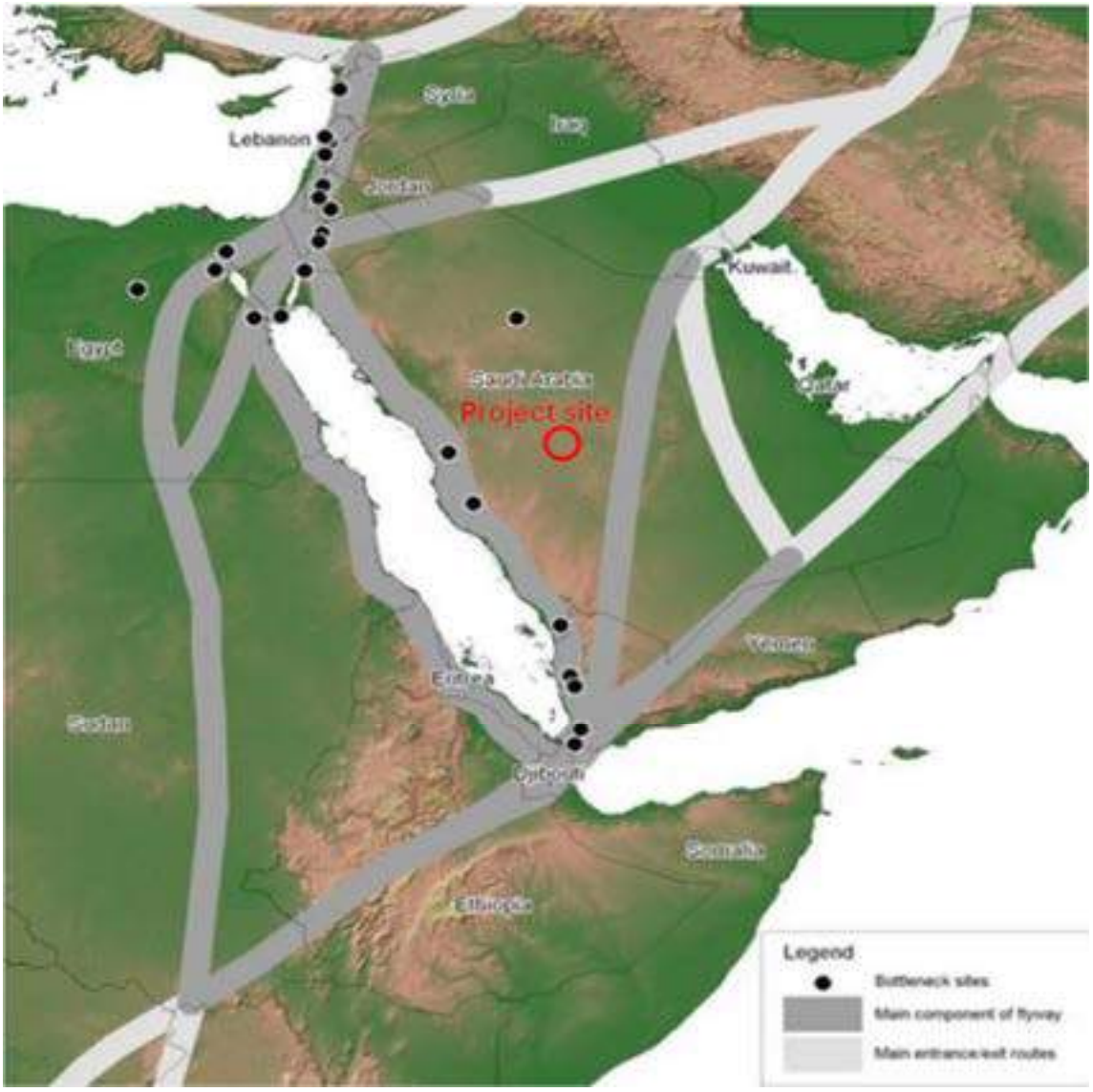


Figure 84. Project Site Relative to the Rift Valley/Red Sea Flyway. Source: http://datazone.birdlife.org/birdlife-is-working-to-mainstream-soaring-bird-conservation-along-the-rift-valley/red-sea-flyway

According to the Sensitivity Mapping Tool, six species of Migratory Soaring Birds (MSBs) are considered to have their distribution range covering the Project Site (see figure below). These species are:

- Common Kestrel (*Falco tinnunculus*)
- Eastern Imperial Eagle (*Aquila heliacal*)
- Griffon Vulture (*Gyps fulvus*)
- Egyptian vulture (*Neophron percnopterus*)
- Lappet-faced Vulture (*Torgos tracheliotos*)
- Steppe Eagle (*Aquila nipalensis*)

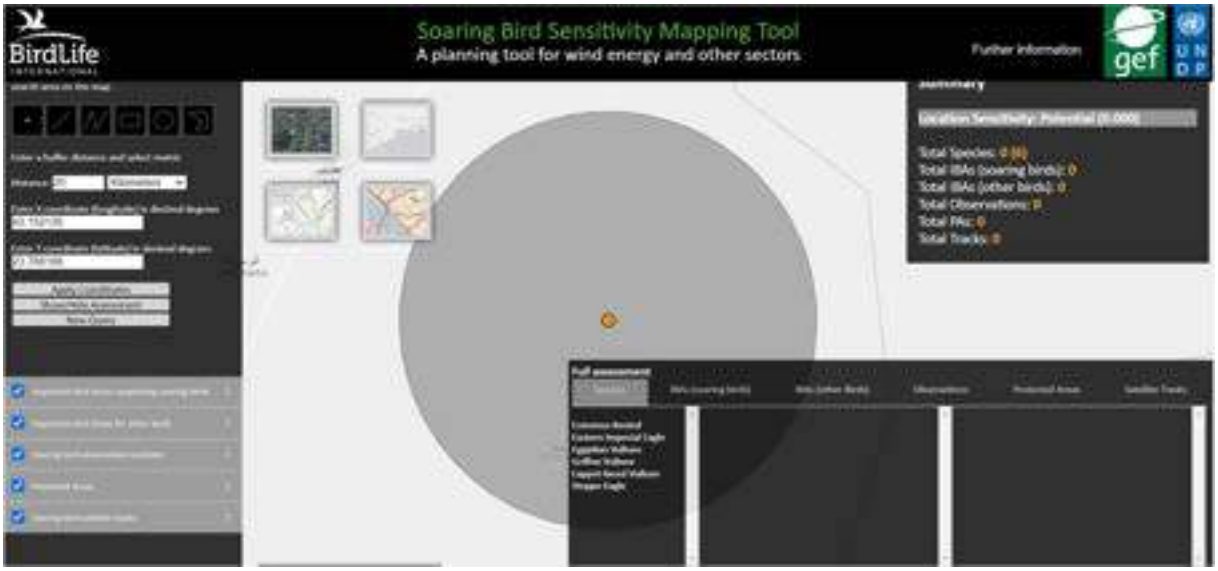


Figure 85. Results from at BirdLife International Sensitivity Mapping Tool for Migratory Soaring Birds, showing a point in the middle of the Project Site delineation with a buffer zone of 20km.

Taking a more comprehensive review of the distribution range of all globally threatened species shows that 19 species of Migratory Soaring Birds in Saudi Arabia Peninsula that could be found potentially in the project site (see table below).

Family	English name	Scientific name	Global IUCN Red List Category
Anatidae (Ducks, Geese, Swans)	Common Pochard	*Aythya ferina*	VU
Columbidae (Pigeons, Doves)	European Turtledove	*Streptopelia turtur*	VU
Otididae (Bustards)	Asian Houbara	*Chlamydotis macqueenii*	VU
Threskiornithidae (Ibises, Spoonbills)	Northern Bald Ibis	*Geronticus eremita*	EN
Phalacrocoracidae (Cormorants)	Socotra Cormorant	*Phalacrocorax nigrogularis*	VU
Charadriidae (Plovers)	Sociable Lapwing	*Vanellus gregarius*	CR
Scolopacidae (Sandpipers, Snipes, Phalaropes)	Slender-billed Curlew	*Numenius tenuirostris*	CR
Scolopacidae (Sandpipers, Snipes, Phalaropes)	Great Knot	*Calidris tenuirostris*	EN
Accipitridae (Hawks, Eagles)	Egyptian Vulture	*Neophron percnopterus*	EN
Accipitridae (Hawks, Eagles)	Bateleur	*Terathopius ecaudatus*	EN
Accipitridae (Hawks, Eagles)	Lappet-faced Vulture	*Torgos tracheliotos*	EN
Accipitridae (Hawks, Eagles)	Greater Spotted Eagle	*Clanga clanga*	VU
Accipitridae (Hawks, Eagles)	Tawny Eagle	*Aquila rapax*	VU
Accipitridae (Hawks, Eagles)	Steppe Eagle	*Aquila nipalensis*	EN
Accipitridae (Hawks, Eagles)	Eastern Imperial Eagle	*Aquila heliaca*	VU
Falconidae (Falcons, Caracaras)	Sooty Falcon	*Falco concolor*	VU
Falconidae (Falcons, Caracaras)	Saker Falcon	*Falco cherrug*	EN
Corvidae (Crows and jays)	Asir Magpie	*Pica asirensis*	EN
Acrocephalidae (Reed-warblers)	Basra Reed-warbler	*Acrocephalus griseldis*	EN

Family	English name	Scientific name	Global IUCN Red List Category

VU: Vulnerable, EN: Endangered, CR: Critically endangered, NT: Near Threatened

Table 42. Globally Threatened species of Migratory Soaring Birds in Arabic Peninsula. Source: IUCN Red List

Only one of these potential threatened species have been observed in study area during field survey, the Steppe Eagle, and this species is nonbreeding in the study area.

The Steppe Eagle (*Aquila nipalensis*) is currently listed as endangered according to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (international and/or regional assessment list). However, this species, Steppe Eagle, is nonbreeding in the study area. The presence of a dumping site near Afif (approximately 18 Km) could attract Steppe Eagles due to the availability of food resources. Dumping sites often contain organic waste, which can attract rodents and other small animals that eagles prey upon. Additionally, eagles are known to scavenge for food, so they may be drawn to the site to feed on discarded food scraps. The proximity of the dumping site to Afif could provide a reliable and easily accessible food source for Steppe Eagles, explaining their presence in the area (see figure below).

Figure 86. Distance between the dumping site of Afif and the project site. Source: Environmental Baseline Survey Report for Afif 1 PV Project

Usual mitigation measures in design and operation will be more than enough, given the case of the Steppe Eagle, to minimize the impact of the project on the birds classified in the IUCN List of Threatened Species.

Although some bird species were observed during site visit, figure below shows that the project site is settled in a low richness area of birds according to the Global Biodiversity Facility (GBIF). The occurrence of this taxa is scarce probably because of the absence of wet ecosystems and the low vegetation coverage.

Figure 87. Bird species richness. Source: Digital Observatory for Protected Areas

A fauna survey was carried out by AHEC in January 2024. The avifauna results are reported below.

Ten bird species were recorded during site survey. Only one of these ten, the Steppe Eagle is currently listed as Endangered according to the IUCN Red List of Threatened Species, also listed as a KSA High Conservation Priority species (Criteria 7, 5), and its local status is nonbreeding for the area. All other recorded bird species are categorized as Least Concern (LC) according to the IUCN Red List (not classified as KSA HCP species or in the GCC Convention) as shown in the following table. This reflects a scarce richness probably due to low vegetation coverage and absence of wet ecosystems and key landscape features. Nevertheless, it must be highlighted that usual mitigation measures in design and operation will be included to minimize the impact of the project on the birds.

Order	Common name	Scientific name	IUCN Status (2021, ver3.1)	KSA HCP Species Criteria (NCWCD, 2004)	GCC convention (2003)	Local Status
Accipitriformes	Steppe Eagle	*Aquila nipalensis*	EN	7,5	NL	Extant nonbreeding
Falconiformes	Common Kestrel	*Falco tinnunculus*	LC	NL	NL	Extant resident
Columbiformes	Eurasian Collared Dove	*Streptopelia decaocto*	LC	NL	NL	Extant resident
Passeriformes	The greater hoopoe-lark	*Alaemon alaudipes*	LC	NL	NL	Extant resident

Order	Common name	Scientific name	IUCN Status (2021, ver3.1)	KSA HCP Species Criteria (NCWCD, 2004)	GCC convention (2003)	Local Status
Passeriformes	The crested lark	*Galerida cristata*	LC	NL	NL	Extant resident
Passeriformes	Isabelline Wheatear	*Oenanthe isabellina*	LC	NL	NL	Extant resident
Passeriformes	Temminck's lark	*Eremophila bilopha*	LC	NL	NL	Extant resident
Passeriformes	Tawny pipit	*Anthus campestris*	LC	NL	NL	Extant nonbreeding
Passeriformes	The brown-necked raven	*Corvus ruficollis*	LC	NL	NL	Extant resident
Bucerotiformes	Common Hoopoe	*Upupa epops*	LC	NL	NL	Extant passage

Table 43. Avifauna species recorded within the site. Source: Environmental Baseline Survey Report for Afif 1 PV Project

Type	Descriptive Photo
Steppe Eagle (*Aquila nipalensis*)	

Type	Descriptive Photo
Common Kestrel (*Falco tinnunculus*)	
The greater hoopoe-lark (*Alaemon alaudipes*)	
The crested lark (*Galerida cristata*)	

Type	Descriptive Photo
Isabelline Wheatear (*Oenanthe isabellina*)	
Common Hoopoe (*Upupa epops*)	

Table 44. Samples of the bird species observed in the study area. Source: Environmental Baseline Survey Report for Afif 1 PV Project

Mammals

Regarding mammals, in the Kingdom there are about 86 species of mammals. Large mammals represent important elements in the maintenance of ecosystems as they contribute to the conservation and safety where they are found.

Regarding mammal's occurrence in the project site, same as referred about birds, figure below shows that richness is low, according to the Global Biodiversity Facility (GBIF) (see figure below), so the occurrence of any species is very low.

Figure 88. Mammal species richness. Source: Digital Observatory for Protected Areas

A fauna survey was carried out by AHEC in January 2024. The mammals´ results are reported below.

Four mammals were sighted during the walkover including herds of Camels (*Camelus dromedarius*), goats (*Capra hircus*) and sheep (*Ovis aries*). The eastern area has been used for grazing of these animals. Also, one cat (*Arabian mau*) was observed within the project site (see following tables and figures).

None of the mammals recorded are classified as threatened or HCP species (NL: Not Listed).

No species of bats were sighted during the site survey of Afif 1 PV Plant. The habitats identified onsite were not optimal for these kinds of species.

Type	IUCN Status (2021, ver3.1)	KSA HCP Species Criteria (NCWCD, 2004)	GCC convention (2003)	Descriptive Photo
Domestic Sheep and goats	NL	NL	NL	
Camels *(Camelus dromedarius)*	NL	NL	NL	
Cat *(Arabian Mau)*	NL	NL	NL	

Table 45. Mammals observed in the study area during the site visit. Source: Environmental Baseline Survey Report for Afif 1 PV Project

Reptiles and amphibians

Regarding reptiles, 107 species have been recorded in the Kingdom of Saudi Arabia. It must be considered that 5 reptiles' species are listed in Annex I of the Convention on the Conservation of Migratory Species of Wild Animals.

All reptile activity within the Arabian Peninsula is seasonal and almost exclusively triggered by heat (eg. Wilms et Al, 2009; Al-Johany, 1999). Many reptile species could simply reduce the daily activity window during the cold period (winter months).

A fauna survey was carried out by AHEC in January 2024. The reptiles´ results are reported below.

The site provides suitable habitat for reptiles within both the sandy and rocky habitats onsite. However, **no live reptiles were recorded** in the study area during the site survey (maybe because it was carried out in January). An abandoned Spiny Tailed Lizard (STL) burrow was recorded without any clear signs of activity (tracks, fresh faeces, etc.). See figure below.

Spiny Tailed Lizard is listed as Vulnerable according to the IUCN Red List, the HCP List of KSA, or the Conservation of Wildlife and their Natural Habitats in the Countries of the Gulf Corporation Council.

Figure 89. STL Abandoned Burrow. Source: Environmental Baseline Survey Report for Afif 1 PV Project

Regarding amphibians, the kingdom hosts 7 species belonging to the family of frogs (Bufonidae) and two species belonging to the family of toads (Ranidae). Since they live in wet areas, there was no evidence of the existence of any amphibian species inside the project site boundaries.

Invertebrates

The overall abundance and diversity of invertebrates in the project area were low, despite the presence of a wide variety of beetles, including several species of Tenebrionidae (darkling beetles) and Scarabaeidae (scarab beetles). The Ground mantis (*Eremiaphila baueri*) was also recorded onsite. The abundance and diversity will be influenced by vegetation cover, seasonality, and weather conditions. The following figures present examples of the recorded invertebrates onsite.

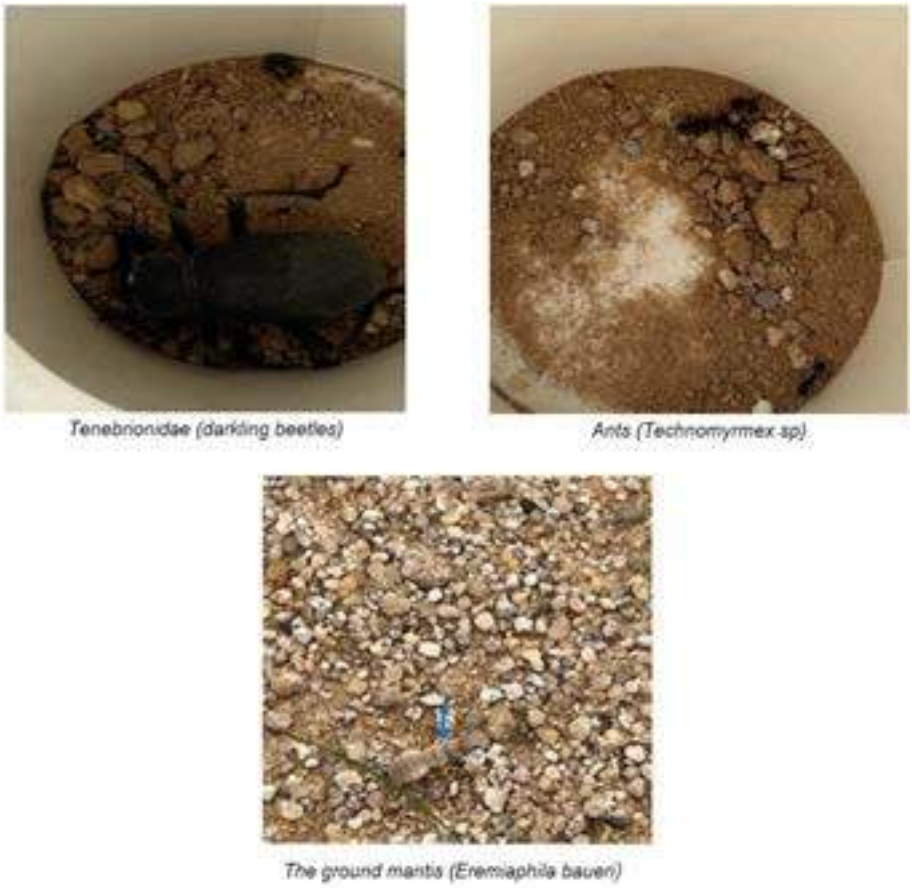


Figure 90. Photographs of the recorded invertebrates onsite. Source: Environmental Baseline Survey Report for Afif 1 Project

4.2.2. Natural Protected Areas and other Natural Regions

4.2.2.1. Relevant legislation and standards

a. National legislation

- Executive Regulations for Protected Areas (Ministerial Decision No.48824/1)

  The National Center for Wildlife (NCW), previously known as the Saudi Wildlife Authority (SWA), bears the primary responsibility for the protection and conservation of terrestrial and marine wildlife. This included implementing programs aimed at mitigation threats, rehabilitating endangered species, and restoring critical ecosystems. The NCW oversees the management of protected zones within the Kingdom of Saudi Arabia (KSA).
  These regulations encompass guidelines for the establishment and management of protected areas, as well as the prerequisites for obtaining permits for any activities within areas designated as protected.
  Notably, the project site does not fall within the NCW-designated protected areas.

b. Policy documents

- National Biodiversity Strategy and Action Plan (NBSAP):
  The NBSAP outlines 17 strategic goals, with the first two being crucial for the execution of the Convention on Biological Diversity's Programme of Work on Protected Areas:

NBSAP Strategic Goal 1 (In-Situ Conservation - Inside Protected Areas): The aim is to safeguard terrestrial, marine, and freshwater ecosystems through the establishment of a comprehensive system of protected areas. This system is designed for the in-situ conservation of biodiversity within Saudi Arabia.

NBSAP Strategic Goal 2 (In-Situ Conservation - Outside Protected Areas): This goal focuses on the conservation and management of terrestrial, marine, and freshwater biodiversity. It aims to ensure the safety of wild populations of flora and fauna in their natural habitats beyond the confines of officially recognized protected areas.

Additionally, the National Strategy delineates a series of 23 actions to achieve these two Strategic Goals.

- National Protected Area System Plan:

  This plan establishes national targets and outlines a vision for Protected Areas in the Kingdom, serving as the foundational guide for Saudi Arabia to meet its in-situ conservation commitments under the Conventional on Biological Diversity. Initially published in 1990 and subsequently revised in 2010, the National Protected Area System Plan identifies potential sites for protection, conducts a gap assessment, and includes a Policy Statement that articulates the vision for a national network of Protected Areas. The Policy Statement emphasizes:

  "*To maximize the potential of protected areas for the conservation of biological diversity and to ensure equitable and sustainable benefits for local communities*".

4.2.2.2. Baseline condition

a. Existing System of Protected Areas. National Center for Wildlife -NCW-

The National Commission for Wildlife Conservation and Development (NCWCD), also National Center for Wildlife of the Kingdom of Saudi Arabia (NCW), formerly the Saudi Wildlife Authority (SWA), is a government agency in Saudi Arabia that was established in 1986 by the Royal Decree No. M/22. This Royal Decree, under Article 3(4), mandates the NCWCD with the responsibility for the establishment of a national system plan of protected areas for the conservation and management of wildlife in the country.

The main objectives of NCW´s Protected Area Management are as follows: 1. Achieving Vision 2030 according to the Saudi Green Initiative by protecting 30% of the land and sea areas, 2. Preserving natural habitats and biodiversity in the Kingdom, and 3. Achieving the Kingdom´s commitment to the Convention on Biological Diversity (CBD) and sustainable development goals (SDGs).

The existing System of Protected Areas[9] presents a total of 23 clearly defined geographical regions that are classified as protected areas. These regions are divided depending on the administrative bodies who are responsible for their management. Out of the 23 regions, 10 are managed by the National Center for Wildlife (NCW), 8 are designated as Royal Reserves and are managed by different royal management authorities and the remaining 5 are responsibility of the Royal Commission for Al-Ula (RCU). The Royal Commission for AlUla

[9] *National Center for Wildlife (NCW). "Geographic Information System Gate". https://www.ncw.gov.sa/en/gis.html*

was established by royal decree in July 2017 to preserve and develop AlUla, a region of outstanding natural and cultural significance in north-west Saudi Arabia.

The National Center for Wildlife reports that Protected Areas cover about 16.5% of Saudi Arabia's total surface area (365,400 km^2), offering local communities socio-economic benefits including regulated grazing, hunting, fishing, and related recreational and tourism activities. These areas serve multiple purposes, including biodiversity conservation, cultural and spiritual enrichment, and improving the well-being of both visitors and locals.

The figure below presents the distribution and classification of the existing protected areas in Saudi Arabia, reported by the NCW, in relation to the emplacement of the solar power plant:

Figure 91. Project Site in relation to the existing protected areas in Saudi Arabia. Source: National Center for Wildlife

None of these protected areas are located in the project site.

The table below includes the existing protected areas presented officially by the National Center for Wildlife.

#	Name	Management Authority	Surface
1	Jubail Marine Area	NCW	2,410 km^2
2	'Uruq Bani Ma'arid	NCW	12,787 km^2
3	Jabal Shada	NCW	68.62 km^2
4	Juzur Umm al-Qamari	NCW	4.03 km^2
5	Ibex Reserve	NCW	1,840.9 km^2

6	Nufud Al urayq	NCW	2,036.1 km^2
7	Raydah	NCW	<10 km^2
8	Majami al-Hadb	NCW	3,400 km^2
9	Saja/Umm ar-Rimth	NCW	6,528.2 km^2
10	Farasan Islands	NCW	5,408 km^2
11	Al-Gharameel	RCU	<5,000 km^2
12	Harrat az-Zabin	RCU	<5,000 km^2
13	Harrat 'Uwayrid	RCU	<7,000 km^2
14	Jabal Sharaan	RCU	<5,000 km^2
15	Wadi Nakhla	RCU	<5,000 km^2
16	King Abdul-Aziz Royal Reserve	Royal	28,340 km^2
17	Imam Abdul-Aziz bin Mohammad Royal Reserve	Royal	11,269 km^2
18	Prince Mohammad bin Salman Royal Reserve	Royal	24,500 km^2
19	Imam Turki bin Abdullah Royal Reserve	Royal	91,507 km^2
20	King Salman Royal Reserve	Royal	129,576.31 km^2
21	Imam Faisal bin Turki	Royal	30,152 km^2
22	Imam Sa'ud bin Abdul-Aziz Royal Reserve	Royal	2,553 km^2
23	King Khaled Royal Reserve	Royal	1,160 km^2

Table 46. Existing protected areas in the Kingdom of Saudi Arabia. Source: National Center for Wildlife

All these protected areas under the administration of the National Center for Wildlife are far from the study area as shown in the figure below.

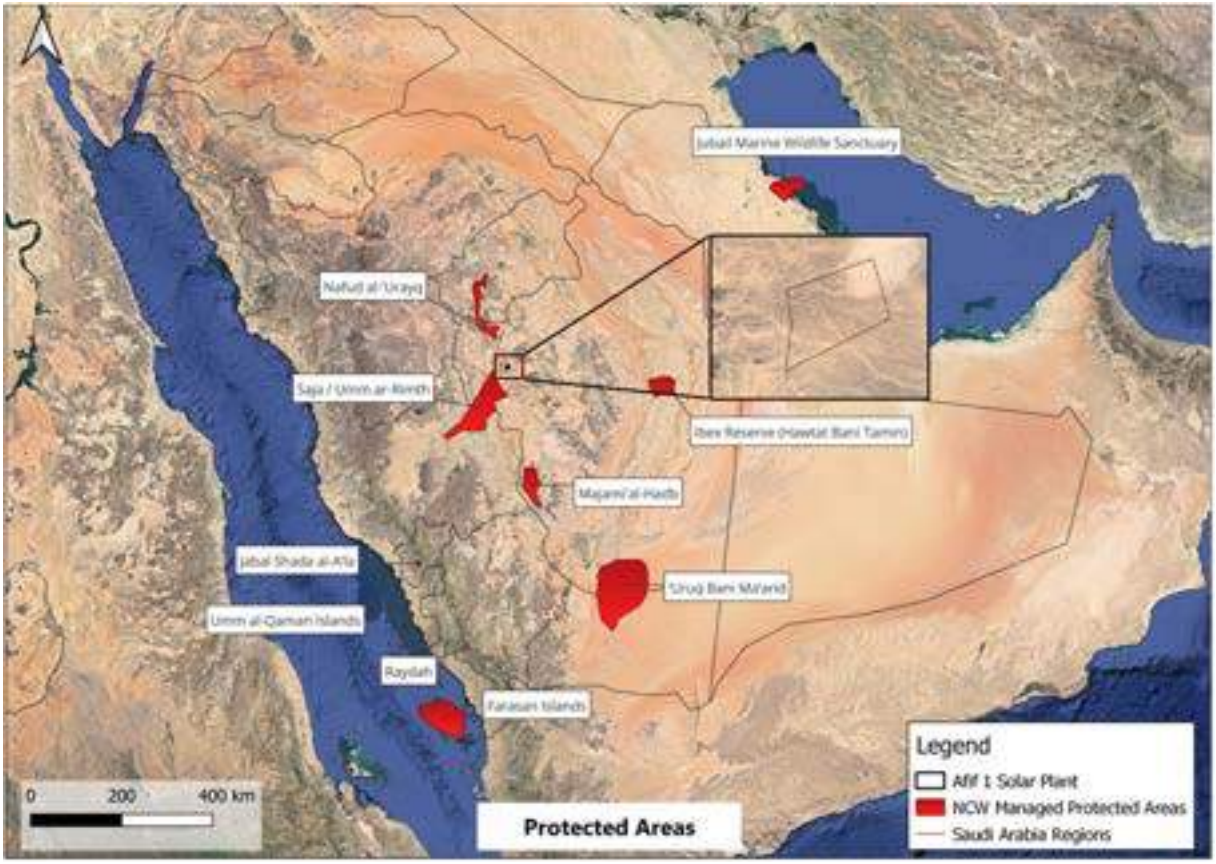


Figure 92. Protected Areas managed by the National Center for Wildlife and Afif 1 Solar Plant. Source: selfmade

As the figure above shows, the protected area closest to the Project Site, among the ones declared and managed by the National Center for Wildlife (NCW), is Saja / Umm Ar-Rimth, a Resource Use Reserve separated approximately 30 km southwest of the plot. To the north-northwest, Nafud al-'Urayq, also a Resource Use Reserve, is placed more than 65 km away.

The National Protected Area System Plan, first published in 1990 and later revised in 2010, showed that the existing protected area network did not represent all bioregions in the Kingdom. The revised system plan aimed to fill gaps in the network to increase the representation of these bioregions by proposing areas to be managed. The Action Plan for Implementing the Convention on Biological Diversity´s Program of Work on Protected Areas draws elements from the National System Plan and the National Biodiversity Strategy for the future implementation of the Program of Work for Protected Areas (PoWPA) in Saudi Arabia.

The Figure below shows the objectives of the mentioned 2010 revised Saudi Arabia´s Protected Area System Plan. The 15 protected areas that were managed by the SWA at that time are shown in red, and the 18 existing protected areas managed by partner agencies in orange. The 20 proposed protected areas to be managed by NCW and the two proposed extensions of existing protected areas are in green and the 22 proposed protected areas to be managed by partner agencies are shown in blue.

Figure 93. Map of Saudi Arabia´s Protected Area System. Source: revised Protected Area System Plan, 2010

b. Closest protected areas

The study site is located far from any protected area in Saudi Arabia. The closest existing and proposed protected areas to the site are the following[10]:

- Saja / Umm ar-Rimth, designated Protected Area, Resource Use Reserve
- Nafud al-'Urayq, designated Protected Area, Resource Use Reserve
- Jabal Tukhfah, proposed Reserve
- Mahazat as-Sayd, designated Special Nature Reserve
- Maqlà Timiyah / Harrat Kishb, proposed Special Nature Reserve.

See figure and description of each protected area below:

[10] *Shapefile of UNEP-WCMC (2023). Protected Area Profile for Saudi Arabia from the World Database on Protected Areas, October 2023. Available at: https://www.protectedplanet.net./country/SAU*

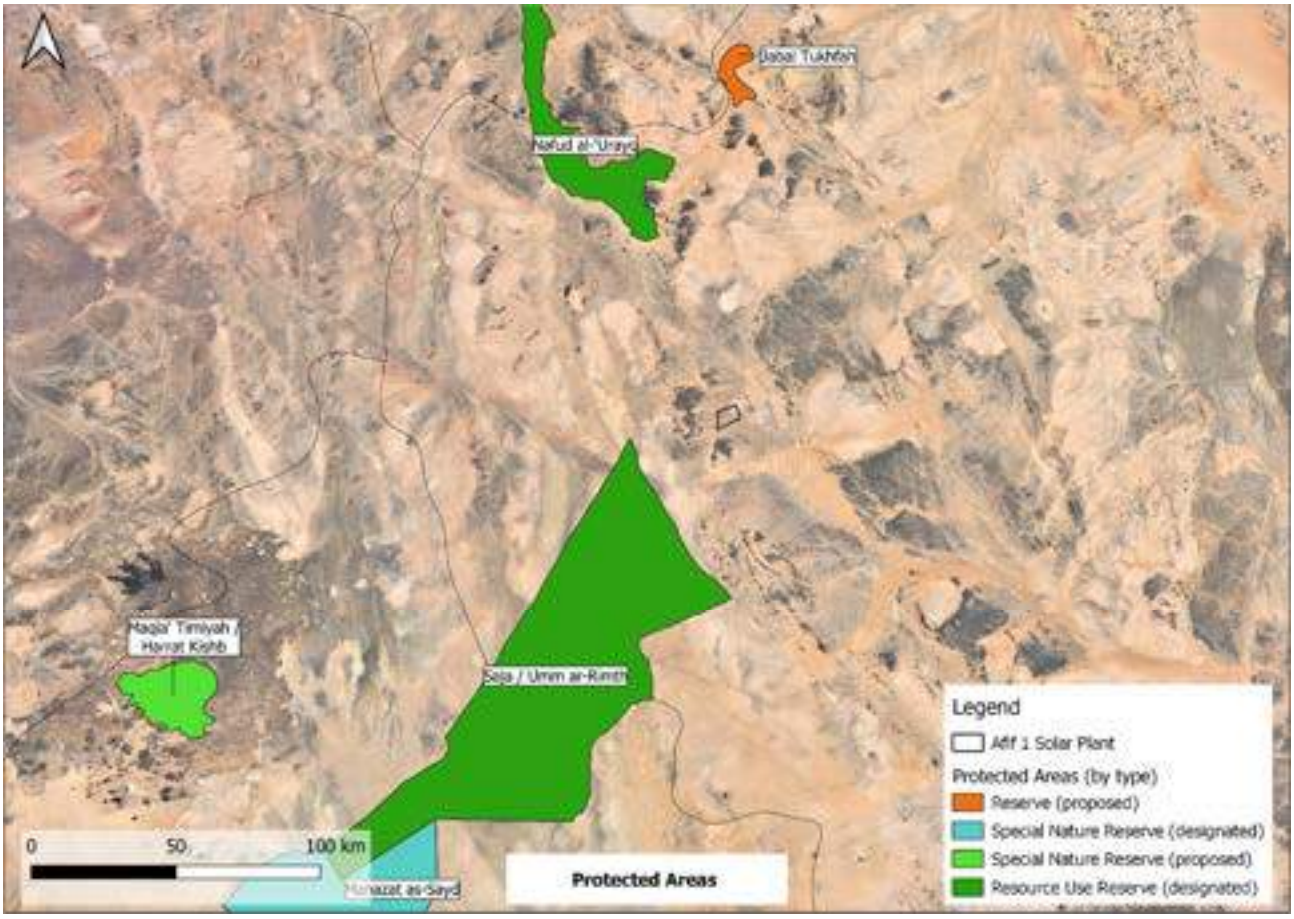


Figure 94. Closest proposed and existing protected areas to the project site. Source: shapefile of UNEP-WCMC (2023). Protected Area Profile for Saudi Arabia from the World Database on Protected Areas, October 2023. Available at: www.protectedplanet.net.

Saja / Umm ar-Rimth is the closest protected area, located at a minimum distance of 29 km southwest direction from the Project Site. It is a designated Protected Area, Resource Use Reserve, declared in 1995 at national level and managed by the National Center for Wildlife (NCW)[11]. In the IUCN classification is included as a category VI - "Protected area with sustainable use of natural resources". The area is a vast reserve of desert plains and scrubland, chosen to introduce Houbara Bustards (*Chlamydotis undulata macqueenii*). The initiative is to share management between the National Center for Wildlife and local communities, since the aim is developing livestock herding practices that could improve grazing efficiency and recover the natural vegetation[12].

The following table summarizes statistics computed at site level using the species assessed globally by IUCN and Birdlife (Digital Observatory for Protected Areas -DOPA- Explorer[13]):

[11] *UNEP-WCMC (2023). Protected Area Profile for Saja / Umm ar-Rimth from the World Database on Protected Areas, November 2023. Available at: www.protectedplanet.net*

[12] *Othman Abd-Ar-Rahman Llewellyn (2000). "The WCPA regional action plan and project proposal for North Africa and the Middle East" in PARKS – Protected Areas Programme. Vol 10 Nº 1 – February 2000. Published by World Commission on Protected Areas -WCPA- of IUCN -The World Conservation Union. Available at: https://parksjournal.com/wp-content/uploads/2017/07/parks_10_1.pdf*

[13] *European Commission, Joint Research Center (2024). The Digital Observatory for Protected Areas -DOPA- Explorer On-line, (January 2021 version), Ispra, Italy. Available at: https://dopa-explorer.jrc.ec.europa.eu/*

Red List Category summary totals for this Protected Area

Class	No. Species	No. Threatened	No. Critically Endangered	No. Endangered	No. Vulnerable	No. Near-threatened	No. Least concern
Birds	59	6	0	3	3	1	52
Mammals	24	2	0	0	2	1	21

RLTS Jan 2019. © DOPA Services

Figure 95. Red List Category summary totals for Saja / Umm ar-Rimth

Among these species, there are three Endangered (EN), Steppe eagle (*Aquila nipalensis*), Egyptian vulture (*Neophron percnopterus)* and Lappet-faced vulture (*Torgos tracheliotos)*; five Vulnerable (VU), Eastern imperial eagle (*Aquila heliacal),* Macqueen´s bustard (*Chlamydotis macqueenii),* European turtle dove (*Streptopelia turtur),* Arabian sand gazelle (*Gazella marica*) and the Arabian Oryx (*Oryx leucoryx);* and two Near Threatened (NT) species, Ferruginous duck (*Aythya nyroca*) and the Striped hyena (*Hyaena hyaena*). The rest of the species listed (73) are under the Least Concern (LC) status.

Nafud al-Ùrayq is at a minimum distance of 65 km north-northwest of the project site. It is a designated Resource Use Reserve at national level (1995), also managed by the National Center for Wildlife. It is classified as a VI - "Protected area with sustainable use of natural resources" by the IUCN[14]. The site is part of the Great Nafud, an extent desert area composed of transverse sand dunes. Its red sand is characteristic due to iron oxide coating, and, apart from the main Dahna area, is divided into smaller sand bodies, among which Al Urayq is one. Great Nafud is dominated by *Calligonum comosum, Artemisia monosperma* and *Scrophularia hypercifolia* community[15].

The following table summarizes statistics computed at site level using the species assessed globally by IUCN and Birdlife (Digital Observatory for Protected Areas -DOPA- Explorer):

Red List Category summary totals for this Protected Area

Class	No. Species	No. Threatened	No. Critically Endangered	No. Endangered	No. Vulnerable	No. Near-threatened	No. Least concern
Birds	46	6	0	3	3	1	39
Mammals	15	1	0	0	1	0	14

RLTS Jan 2019. © DOPA Services

Figure 96. Red List Category summary totals for Nafud al-Ùrayq

Among these species, there are three Endangered (EN), Steppe eagle (*Aquila nipalensis*), Egyptian vulture (*Neophron percnopterus)* and Lappet-faced vulture (*Torgos tracheliotos);* four Vulnerable (VU), Eastern

[14] *UNEP-WCMC (2023). Protected Area Profile for Nafud al-'Urayq from the World Database on Protected Areas, November 2023. Available at: www.protectedplanet.net*

[15] *Sandy Deserts of Saudi Arabia. Plant diversity of Saudi Arabia, Jacob Thomas. Herbarium (KSU), Dept. of Botany & Microbiology, King Saud University, Riyadh -2011-Available at: https://plantdiversityofsaudiarabia.info/Biodiversity-Saudi-Arabia/Vegetation/Deserts%20of%20Saudi%20Arabia.htm*

imperial eagle (*Aquila heliacal),* Macqueen´s bustard (*Chlamydotis macqueenii),* European turtle dove (*Streptopelia turtur)* and Arabian sand gazelle (*Gazella marica*); and one Near Threatened (NT) species, the Ferruginous duck (*Aythya nyroca*). The rest of the species listed (53) are under the Least Concern (LC) status.

Jabal Tukhfah is at an approximate distance of 103 km north of the project site. It is a proposed Reserve, at national level, since 2000 and catalogued as a category IV - "Habitat or species management area" by the IUCN[16].

The Digital Observatory for Protected Areas has not yet available data for this protected area.

Mahazat as-Sayd is located southwest of the Project site at an approximate distance of 165 km. It is a designated Special Nature Reserve (1988) at national level and managed by the National Center for Wildlife. It is classified as Ia - "Strict Nature Reserve" under the IUCN protected areas categories[17]. The site was intended to be a reintroduction site for Arabian Oryx, Houbara Bustard and gazelles. The whole area is fenced[18].

The following table summarizes statistics computed at site level using the species assessed globally by IUCN and Birdlife (Digital Observatory for Protected Areas -DOPA- Explorer):

Red List Category summary totals for this Protected Area

Class	No. Species	No. Threatened	No. Critically Endangered	No. Endangered	No. Vulnerable	No. Near-threatened	No. Least concern
Birds	60	6	0	3	3	1	53
Mammals	26	2	0	0	2	1	23

RLTS Jan 2019 © DOPA Services

Figure 97. Red List Category summary totals for Mahazat as-Sayd

Among these species, there are three Endangered (EN), Steppe eagle (*Aquila nipalensis*), Egyptian vulture (*Neophron percnopterus)* and Lappet-faced vulture (*Torgos tracheliotos)*; five Vulnerable (VU), Eastern imperial eagle (*Aquila heliacal),* Macqueen´s bustard (*Chlamydotis macqueenii),* Greater spotted eagle (*Clanga clanga),* Arabian sand gazelle (*Gazella marica*) and the Arabian Oryx (*Oryx leucoryx);* and two Near Threatened (NT) species, Ferruginous duck (*Aythya nyroca*) and the Striped hyena (*Hyaena hyaena*). The rest of the species listed (76) are under the Least Concern (LC) status.

Maqlà Timiyah / Harrat Kishb is placed at approximately 195 km of the Project site, direction west-southwest. It is a national level proposed Special Nature Reserve from 1990, to be managed by the National

[16] *UNEP-WCMC (2023). Protected Area Profile for Jabal Tukhfah from the World Database on Protected Areas, November 2023. Available at: www.protectedplanet.net*

[17] *UNEP-WCMC (2023). Protected Area Profile for Mahazat as-Sayd from the World Database on Protected Areas, November 2023. Available at: www.protectedplanet.net*

[18] *Othman Abd-Ar-Rahman Llewellyn (2000). "The WCPA regional action plan and project proposal for North Africa and the Middle East" in PARKS – Protected Areas Programme. Vol 10 Nº 1 – February 2000. Published by World Commission on Protected Areas -WCPA- of IUCN -The World Conservation Union. Available at: https://parksjournal.com/wp-content/uploads/2017/07/parks_10_1.pdf*

Center for Wildlife. Its IUCN category is Ia - "Strict Nature Reserve"[19]. The Harrat Kishb is a volcanic field comprised of basaltic scoria cones, tuff rings and maars, and phonolitic lava domes and flows[20].

The Digital Observatory for Protected Areas has not yet available data for this protected area.

c. Key Biodiversity Areas: Important Bird and Biodiversity Areas (IBAs) and other categories

The Key Biodiversity Areas (KBA)[21] are "sites contributing significantly to the global persistence of biodiversity". The sites qualify as global KBAs if they meet one or more of eleven criteria, clustered into five categories: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability.

They encompass Alliance for Zero Extinction Sites, Important Bird and Biodiversity Area and Other. No Zero Extinction Sites are located in Saudi Arabia. The following figure show the other two categories in relation to the Project site.

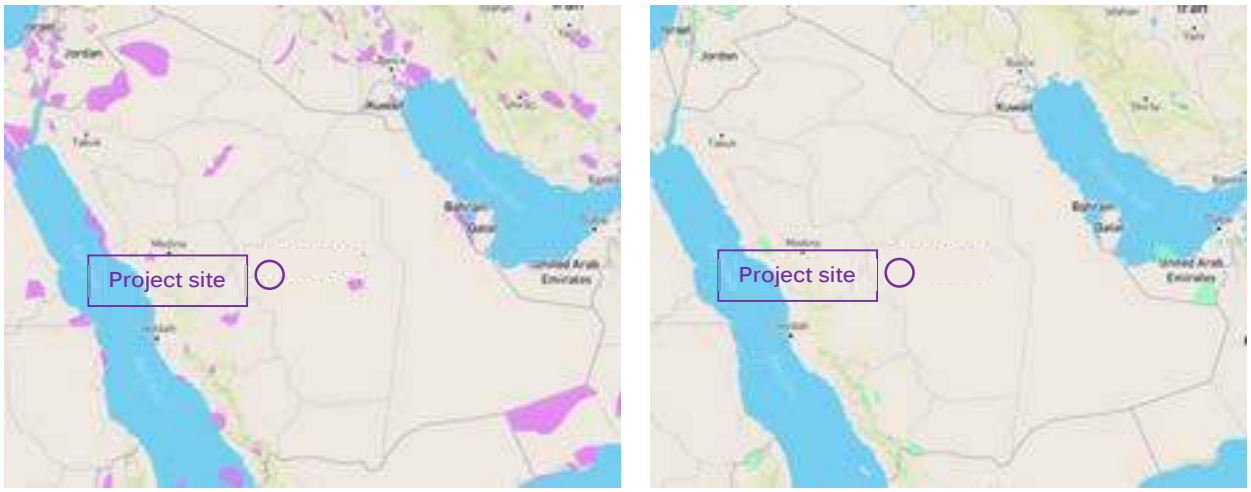


Figure 98. Sites of Biodiversity Importance: Important Bird and Biodiversity Areas and Other, respectively. Source: IBAT.

Important Bird and/or Biodiversity Areas -IBAs-

The Important Bird and Biodiversity Areas (IBAs)[22] are identified by Birdlife International as globally important for the conservation of bird populations to secure a long - term conservation of sites that are of significant importance for birds and biodiversity.

According to the studies conducted to identify the important areas for birds in the Kingdom, about 39 important bird areas (IBAs) have been identified, particularly for species threatened with extinction or globally significant populations.

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[19] *UNEP-WCMC (2023). Protected Area Profile for Maqla' Timiyah / Harrat Kishb from the World Database on Protected Areas, November 2023. Available at: www.protectedplanet.net*

[20] *Global Volcanism Program. Department of Mineral Sciences, National Museum of Natural History Smithsonian Institution – 2013. Available at: https://volcano.si.edu/volcano.cfm?vn=231071*

[21] *IBAT, UN Environment World Conservation Monitoring Centre. BirdLife International, Conservation International, IUCN and UN WCMC. 20023. https://www.ibat-alliance.org/free-visual-data-map*

[22] *IBAT, UN Environment World Conservation Monitoring Centre. BirdLife International, Conservation International, IUCN and UN WCMC. 20023. https://www.ibat-alliance.org/free-visual-data-map*

There are no Important Bird or Biodiversity Areas of Saudi Arabia located in the vicinity of the project site (see figure below).

Figure 99. Map of the closest IBA (Mahazar as-Sayd) to the project site. Source: BirdLife International (2023) Important Bird Areas

According to the Bird Life International website the closest IBAs to the study site are the following:

- **Mahazat As-Sayd -SA019- IBA**[23,24]

  This IBA is located at a minimum distance of approximately 166 km southwest of the project site.

  This IBA, assessed in 2013, meets A1, B1i, B2 and B3 (1994) IBA criteria, as well as is confirmed as a KBA -Key Biodiversity Areas- status and is a NCWCD Reserve. It is a fairly level, sandy plain at 900-1,100 masl with a few rock outcrops, where temporary pools can form due to rainfall. The site is moderately to well vegetated, in parts with *Acacia tortilis Indigofera* spp. And *Salsola* spp. as dominant shrubs/trees, dense grass (e.g. *Panicum* spp.) often covers sandier areas, and some dry

[23] *BirdLife International (2023) Important Bird Area factsheet: Mahazat as-Sayd. Downloaded rom http://datazone.birdlife.org/site/factsheet/mahazat-as-sayd-iba-saudi-arabia*

[24] *Key Biodiversity Areas Partnership (2023) Key Biodiversity Areas factsheet: Mahazat as-Sayd. Extracted from the World Database of Key Biodiversity Areas. Developed by the Key Biodiversity Areas Partnership: BirdLife International, IUCN, American Bird Conservancy, Amphibian Survival Alliance, Conservation International, Critical Ecosystem Partnership Fund, Global Environment Facility, Re:wild, NatureServe, Rainforest Trust, Royal Society for the Protection of Birds, World Wildlife Fund and Wildlife Conservation Society. Downloaded from https://www.keybiodiversityareas.org/*

shallow wadis have large *Maerua* spp.trees. There is a diverse and, at times, abundant community of breeding larks, including *Eremalauda dunni*. *Torgos tracheliotus* breeds, and the largest non-breeding concentrations in Arabia have been recorded. The reserve will probably be the first release site for the reintroduction of *Struthio camelus*. About 115 species have been recorded.

Related to non-bird biodiversity, among mammals there are *Felis margarita* and *Vulpes rueppelli*. The reserve is a key reintroduction site for the *Oryx leucoryx* and *Gazella subgutturosa*.

The site was identified as important for supporting significant populations of the following species, meeting IBA criteria:

Populations meeting IBA criteria ('trigger species'):

Species	Current IUCN Red List Category	Season	Year(s)	Population estimate at site	IBA criteria met
Collared Pratincole *Glareola pratincola*	LC	passage	1993	300 individuals	B1i
Lappet-faced Vulture *Torgos tracheliotus*	EN	resident	1991-1993	15 breeding pairs	A1, B2
Eastern Imperial Eagle *Aquila heliaca*	VU	winter	1993	present	B2
Menetries's Warbler *Curruca mystacea*	LC	winter	1993	abundant	B3
White-throated Robin *Irania gutturalis*	LC	passage	1993	uncommon	B3
Finsch's Wheatear *Oenanthe finschii*	LC	passage	1993	present	B3
Red-tailed Wheatear *Oenanthe chrysopygia*	LC	winter	1993	uncommon	B3
Hypocolius *Hypocolius ampelinus*	LC	winter	1993	uncommon	B3
Pale Sparrow *Carpospiza brachydactyla*	LC	passage	1993	25 individuals	B3

Figure 100. Populations meeting IBA criteria (trigger species). The current IUCN Red List category was valid at the time of IBA criteria assessment (1994). Source: BirdLife International (2023) Important Bird Area factsheet.

Completely fenced since 1989, there are no threats to it, although the reintroduction of *Oryx leucoryx*, *Gazella subgutturosa* and *Chlamydotis undulata* has priority over general conservation of wild birds. School parties visit regularly, and increased supervised access by the public is likely in future.

Other Key Biodiversity Areas

Sites qualified as a Key Biodiversity Area of International significance meets at least one of the previously established criteria and threshold for identifying sites of biodiversity importance. According to the studies conducted there are several KBA included in "Other" category in the Kingdom, although none of them are even close to the Project site.

There are no other Key Biodiversity Areas located in the vicinity of the project site (see figure below).

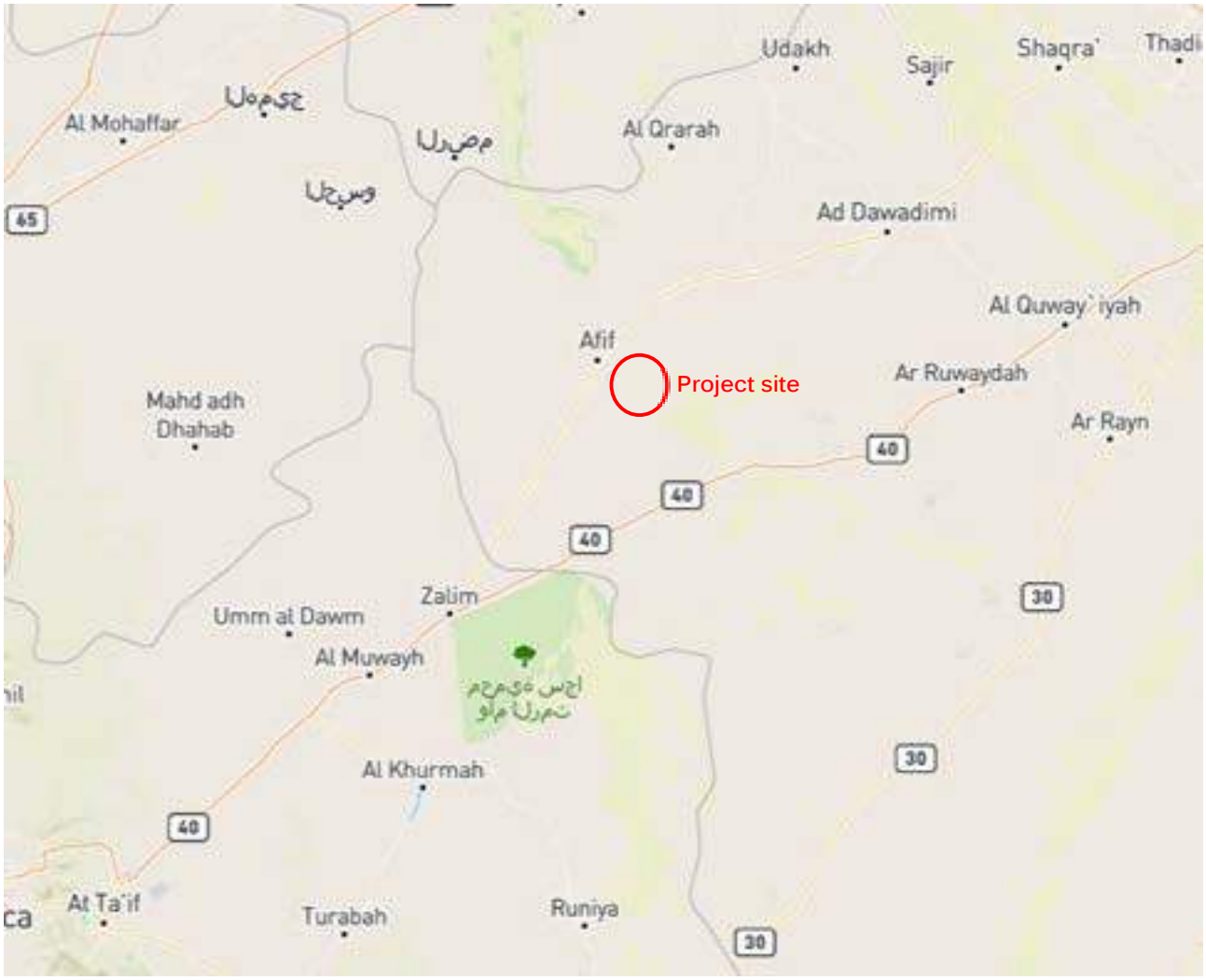


Figure 101. Map showing there are no close Other KBA to the project site. Source: KBA (2023)

4.2.3. Habitats

The proposed PV plant site is characterized by a barren and arid landscape, typical of Saudi Arabia, with patches of sparse vegetation. Vegetation coverage is denser in the eastern area, which historically has been suitable for grazing camels and sheep. The terrain was observed to be predominantly flat during the field survey, with isolated outcrop formations located in the upper northern corner of the site and on its eastern boundary. Although the area is poorly vegetated and has low vegetation cover, there are several specimens of *Acacia tortilis*, in both shrub and tree stage.

The project area comprises four key habitats, which can be named as follows, and are shown below:

- Sandy plains (10% of the project site area approximately).
- Sandy sheet with dwarf shrub cover (15% of the project site area approximately).
- Gravel plains (45% of the project site area approximately).
- Gravel plains with dwarf shrubs cover (30% of the project site area approximately).

Most of the study area is covered by gravel plains habitat.

Biotopes	Waypoint (lat./log.)	Descriptive photo
Sandy plains	23°49'16"N, 43°9'41"E	
Sandy sheet with dwarf shrub cover.	23°48'32"N, 43°7'32"E	
Gravel plains	23°48'50"N, 43°10'8"E	

Biotopes	Waypoint (lat./log.)	Descriptive photo
Gravel plains with dwarf shrubs cover	23°48'23"N 43°7'4"E	
Isolated outcrops formations	23°49'27"N 43°10'15"E	

Table 47. Identified habitats in the surveyed section. Source: Environmental Baseline Survey Report for Afif 1 PV Project

The project site, situated beyond key protection areas and within a region where the predominant habitat type is abundant, implies that the recorded flora and fauna are not of significant concern. Generally, the area is considered to have low environmental sensitivity.

4.2.3.1. Critical Habitats

a. Introduction

The project has committed to meeting the IFC Environmental and Social Performance Standards. Of particular relevance to this document is **IFC Performance Standard 6 (PS6)** which recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. Its core objectives are:

- To protect and conserve biodiversity.
- To maintain the benefits from ecosystem services.

- To promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

PS6 is guided by and supports the implementation of applicable international law and conventions, including the following:

- The Convention on Biological Diversity, 1992.
- The Convention on the Conservation of Migratory Species of Wild Animals, 1979 (Bonn Convention).
- The Convention on International Trade in Endangered Species of Wild Flora and Fauna, 1975.
- The Convention on Wetlands of International Importance especially as Waterfowl Habitat, 1971 (Ramsar Convention).
- The Convention Concerning the Protection of World Cultural and Natural Heritage, 1972 (UNESCO World Heritage Convention).

PS6 divides and demarks habitats within them determining them to be modified, natural and critical. Critical habitats being a subset of modified or natural habitats, often these occur along a continuum. These are defined in PS6, along with the compliance requirements within each, follows:

Modified Habitat

Paragraph 11 of PS6: *"Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Modified habitats may include areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands"*.

Paragraph 12 of PS6*: "This Performance Standard applies to those areas of modified habitat that include significant biodiversity value, as determined by the risks and impacts identification process required in Performance Standard 1. The client should minimize impacts on such biodiversity and implement mitigation measures as appropriate"*.

Natural Habitat

Paragraph 13 of PS6: *"Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition"*.

Paragraph 14 of PS6: "*The client will not significantly convert or degrade natural habitats, unless all of the following are demonstrated:*

- No other viable alternatives within the region exist for development of the project on modified habitat.
- Consultation has established the views of stakeholders, including Affected Communities, with respect to the extent of conversion and degradation; and
- Any conversion or degradation is mitigated according to the mitigation hierarchy".

Paragraph 15 of PS6: *"In areas of natural habitat, mitigation measures will be designed to achieve no net loss of biodiversity where feasible. Appropriate actions include:*

- Avoiding impacts on biodiversity through the identification and protection of set-asides.
- Implementing measures to minimize habitat fragmentation, such as biological corridors.
- Restoring habitats during operations and/or after operations; and
- Implementing biodiversity offsets".

Critical Habitat

Paragraph 16 of PS6: *"Critical habitats are areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes"*.

Paragraph 17 of PS6: "*In areas of critical habitats, no project activities can be implemented unless all of the following are demonstrated:*

- No other viable alternatives within the region exist for development of the project on modified or natural habitats that are not critical.
- The project does not lead to measurable adverse impacts on those biodiversity values for which the critical habitat was designated, and on the ecological processes supporting those biodiversity values.
- The project does not lead to a net reduction in the global and/or national/regional population of any Critically Endangered or Endangered species over a reasonable period of time.
- A robust, appropriately designed, and long-term biodiversity monitoring and evaluation program is integrated into the client's management program".

Paragraph 18 of PS6: *"In such cases where a client is able to meet the requirements defined in paragraph 17, the project's mitigation strategy will be described in a Biodiversity Action Plan and will be designed to achieve net gains14 of those biodiversity values for which the critical habitat was designated*".

Paragraph 19 of PS6: "*In instances where biodiversity offsets are proposed as part of the mitigation strategy, the client must demonstrate through an assessment that the project's significant residual impacts on biodiversity will be adequately mitigated to meet the requirements of paragraph 17*".

b. Methodology

The assessment of impacts upon terrestrial ecology is made with due reference to the IFC Performance Standard 6 on Biodiversity Conservation and Sustainable Natural Resource Management which establishes requirements for protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources. When avoidance of impacts is not possible, measures to minimize impacts and restore biodiversity and ecosystem services should be implemented.

Three step process have been considered for Critical Habitats Assessment (CHA) process:

- Step 1: Initial Literature Review.
  Aim: To obtain an understanding of biodiversity within the landscape.
  Process: Desktop research.

- Step 2: Field Data Collection and Verification of Available Information.
  Aim: To collect field data and verify available detailed information necessary for the critical habitat assessment.
  Process: Engage qualified specialists to collect field data as necessary both within and outside of the ecologically appropriate area of analysis.
- Step 3: Critical Habitat Determination
  Aim: Determine whether the project is situated in critical habitat.
  Process: Analysis and interpretation of the desktop and field data collected.
  Critical habitat determination is undertaken completely independently of the project type, impacts or its mitigation strategy. The definition of the critical habitat is based on the presence of high biodiversity values regardless of whether a project is to be undertaken in that habitat. The CHA process identifies key biodiversity features and delineates areas of critical, natural, and modified habitats, PS6 2012 defines the respective requirements for any project activities to be permitted within these.

c. Baseline and Finds

A summary of the key findings of the baseline survey performed by experts and outlined in table below.

Flora and Fauna	Species category IUCN Listed Species	Endemic Species	Invasive Species
Flora	The area is poorly vegetated, with low vegetation coverage. A total of five (5) flora species were identified to species level and recorded for the Project Site. No species recorded are listed as IUCN threatened species or as KSA HCP species. Only one tree species (*Acacia tortilis*) was found during the field survey. This species is Least Concern (LC) according to IUCN category.	No species endemic to the KSA were found within the Project area.	No exotic or invasive species were recorded on the site.
Reptiles	No live reptiles were recorded within the project area during the survey period. However, one abandoned Spiny Tailed Lizard (STL) burrow was recorded onsite. This species is listed as vulnerable according to the IUCN Red List, the HCP List of KSA, or the Conservation of Wildlife and their Natural Habitats in the Countries of the Gulf Corporation Council. The project site is not the best place for STL because of the scarce trees that can be used for feeding during the hot season.	No species endemic to the KSA were found within the Project area.	No exotic or invasive species were recorded on the site.
Mammals	Four species of mammals were recorded during the survey, none of them are classified as threatened or HCP species. No species of bats were recorded onsite.	No species endemic to the KSA were found within the Project area.	No exotic or invasive species were recorded on the site.
Birds	Ten bird species were observed onsite. This reflects a scarce richness probably due to low vegetation coverage and absence of wet ecosystems and key landscape features. Only	No species endemic to the KSA were found within the Project area.	No exotic or invasive species were recorded on the site.

Flora and Fauna	Species category IUCN Listed Species	Endemic Species	Invasive Species
	the Steppe Eagle, recorded onsite, is listed as Endangered according to the IUCN Red List of Threatened Species, it is also listed as a KSA High Conservation Priority species (Criteria 7, 5), and its local status is nonbreeding for the area. All other recorded bird species are categorized as Least Concern (LC) according to the IUCN Red List (not classified as KSA HCP species or in the GCC Convention).		

Table 48. Summary of Key Findings

d. Critical Habitat Screening

Project area is far from areas classified as IUCN Nature conservation categories (see figure below).

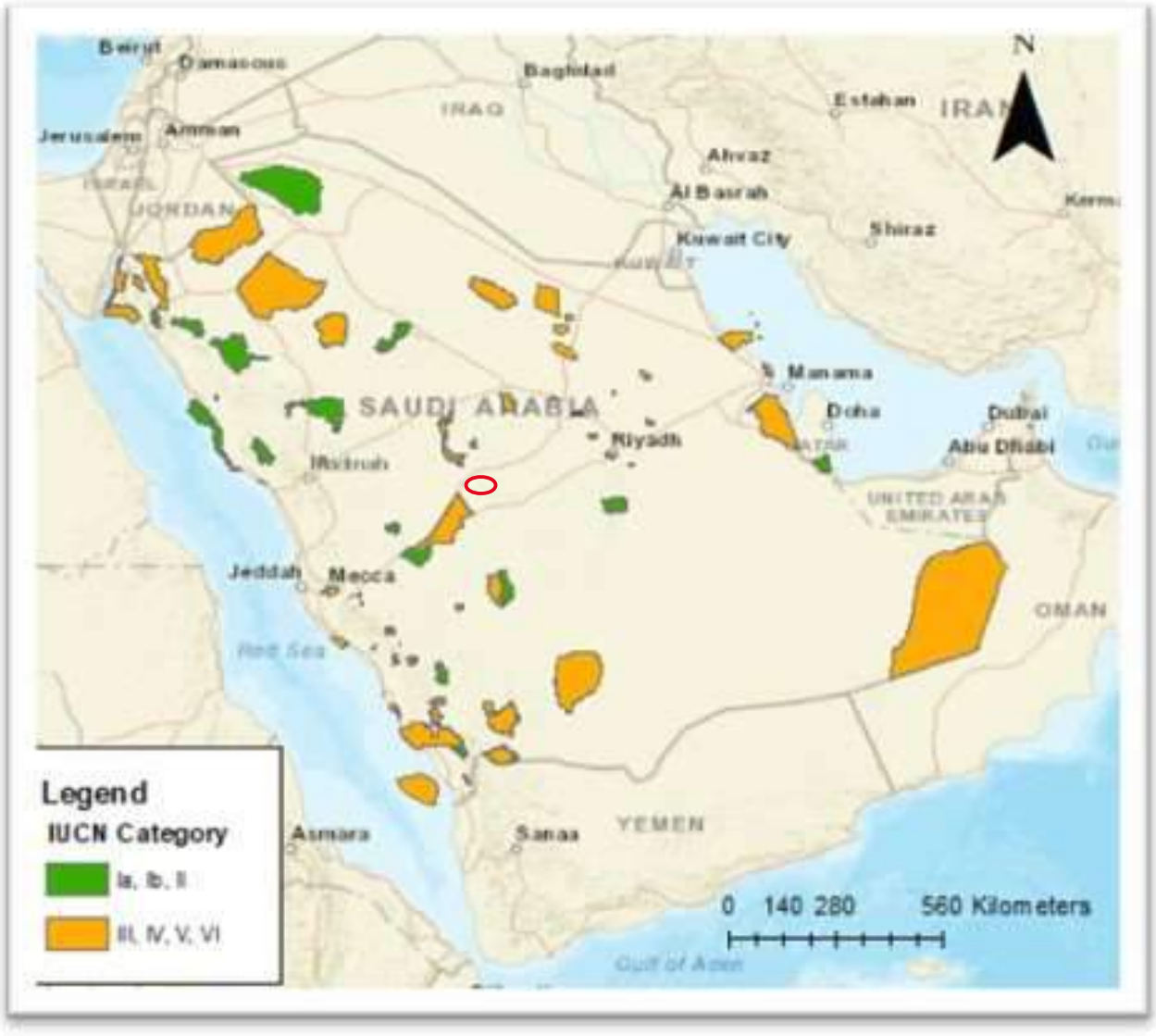


Figure 102. IUCN Categories of the Protected Areas in Saudi Arabia. Study area in red colour. Source: www.protectedplanet.net/country/SAU

Critical habitat is defined in the IFC PS 6 as an area with high biodiversity value. A rapid screening was undertaken to establish whether the Project site is likely to constitute as a Critical Habitat.

In order to meet the definition of a Critical Habitat, the occurrence of one or more of following criteria needs to be satisfied:

- Criterion 1: Critically Endangered (CR) and / or Endangered (EN) species.
- Criterion 2: Endemic and / or restricted-range species.
- Criterion 3: Migratory and / or congregatory species.
- Criterion 4: Highly threatened and/ or unique ecosystems; and,
- Criterion 5: Key evolutionary processes.

A summary of the Project against the Critical Habitat Criteria is shown in table below.

Critical Habitat Criteria	Project Site	Likely to be Critical Habitat?
Criterion 1: Critically Endangered (CR) and / or Endangered (EN) Species	Few fauna species were observed, possibly due to the number of camps and movement of livestock and vehicles over the general area and the scarce vegetation, and the lack of wet areas. No live reptiles were recorded within the project area. Only one abandoned burrow of STL was recorded onsite. STL is listed a KSA HCP species and is classified vulnerable according to the IUCN Red List. A STL Relocation Plan will be implemented if active burrows are detected before the construction phase. Steppe Eagle, a notable fauna species, Endangered (EN) in the UICN list, was recorded during the field surveys. This could be due to the presence of a dumping site near Afif city, 18 km away from the project site. This species is nonbreeding in the study area. The vulnerability of birds to collision incidents with overhead lines will be considered and incorporate steps to protect. Spiral bird protector devices will be installed in the transmission lines to avoid electrocution risk. It should be noted that the fencing of the facilities has been marked with high visibility elements (plates) to prevent birds from collision.	No. No Critically Endangered (CR) Species were recorded. Only the Steppe Eagle (Endangered by the UICN) was observed during field survey according to baseline results. This species is nonbreeding in the study area. There are not critical habitats in the study area.
Criterion 2: Endemic and / or Restricted-Range Species	None Present	No
Criterion 3: Migratory and / or Congregatory Species	There are no locations or habitats within the site which might be regarded as particularly attractive or important to be Endangered or Vulnerable to visitors. No significant avifauna constraints are considered in the study area.	No, there are not habitats in the study area particularly attractive or important to be Endangered or Vulnerable to birds 'visitors

Critical Habitat Criteria	Project Site	Likely to be Critical Habitat?
	There is a dump site of organic waste near Afif city, approximately 18 Km from the project site, that could attract Steppe Eagles due to the availability of food resources. Eagles are known to scavenge for food, so they may be drawn to the site to feed on discarded food scraps. Steppe Eagles have been observed in the study area but this species, Steppe Eagle, is nonbreeding in the study area. Consider the vulnerability of the Steppe Eagles to collision incidents with overhead lines, spiral bird protector devices have been incorporated in the transmission lines design, to protect them.	according to baseline results and bibliography.
Criterion 4: Highly Threatened, and / or Unique Ecosystems	Project site is located outside of Highest Priority Conservation Areas,	No. Project site does not contain highly threatened or unique ecosystems according to baseline results and bibliography.
Criterion 5: Key Evolutionary Processes	The site does not contain presence of the physical features of a landscape that might be associated with particular evolutionary processes; and / or sub- No populations of species that are phylogenetically or morphogenetically distinct.	No. Project site does not contain key evolutionary processes according to baseline results and bibliography.

Table 49. Critical Habitat Screening

The determination of critical habitat can also include other recognized high biodiversity values which are to be evaluated on a case-by case basis, as for example:

- Areas required for the reintroduction of CR or EN species and refuge sites for these species (habitat used during periods of stress (e.g., flood, drought or fire).
- Ecosystems of known special significance to EN or CR species for climate adaptation purposes.
- Concentrations of Vulnerable (VU) species in cases where there is uncertainty regarding the listing, and the actual status of the species may be EN or CR.
- Areas of primary/ old growth / pristine forests and I or other areas with especially high levels of species diversity.
- Landscape and ecological processes (e.g., water catchments, areas critical to erosion control, disturbance regimes (e.g., fire, flood)) required for maintaining critical habitat.
- Habitat necessary for the survival of keystone species.
- Areas of high scientific value such as those containing concentrations of species new and/or little known to science; and,
- Internationally and/or nationally recognized areas of high biodiversity value.

When considering the examples above, the Project site does not include any other recognized high biodiversity values that meet the criteria.

High Biodiversity Value Examples	Project Site	Likely to be Critical Habitat?
Areas required for the reintroduction of CR or EN species and refuge sites for these species (habitat used during periods of stress (e.g., flood, drought or fire).	Not applicable	No
Ecosystems of known special significance to EN or Not Applicable CR species for climate adaptation purposes.	Not applicable	No
Concentrations of Vulnerable (VU) species in cases where there is uncertainty regarding the listing, and the actual status of the species may be EN or CR.	Not applicable. There are not concentrations of vulnerable species. Regarding reptiles, the project includes the following measures: Incorporate in situ conservation measures to protect HCP species. Where in situ conservation is not possible, trap and relocate HCP species. Regarding avifauna, due to the vulnerability of the Steppe Eagle to collision incidents with overhead lines, the project includes measures to protect birds from collision	No. There are not concentrations of vulnerable species according to baseline results and bibliography
Areas of primary/ old-growth /pristine forests and/or other areas with especially high levels of species diversity.	Not Applicable	No
Landscape and ecological processes (e.g., water catchments, areas critical to erosion control, disturbance regimes (e.g., fire, flood) required for maintaining critical habitat.	Not Applicable	No
Habitat necessary for the survival of keystone species.	Not Applicable	No
Areas of high scientific value such as those containing concentrations of species new and / or little known to science.	Not Applicable	No
Internationally and / or nationally recognized areas of high biodiversity value.	Not Applicable	No

Table 50. Presence of High Biodiversity Values

e. Summary and Recommendations

Based on the screening, **the Project site does not constitute a Critical Habitat or site of High Biodiversity Value**.

As the Project site is located outside of key protection areas and given the relative abundance of the predominant habitat type within the region, flora and fauna recorded in these areas are therefore not considered to be of significant concern and are in general of low sensitivity. No further field surveys are considered to be necessary.

There is not occurrence in the study area of one or more of the following criteria which are necessary to be a Critical Habitat:

- Criterion 1: Critically Endangered (CR) and / or Endangered (EN) species.
- Criterion 2: Endemic and / or restricted-range species.
- Criterion 3: Migratory and / or congregatory species.
- Criterion 4: Highly threatened and/ or unique ecosystems; and,
- Criterion 5: Key evolutionary processes.

The determination of critical habitat also considers other recognized high biodiversity values which have been evaluated on a case-by case basis. The Project site does not include any other recognized high biodiversity values that meet the criteria assessed.

There are no special habitats for endangered fauna in the site. There are not sensitive habitats within the PV site that will need be protected. There are not areas within the PV site with high ecological value.

Tree Acacia specimens (Least Concern according to UICN classification) will be preserved. Where disturbances cannot be avoided, relocation of plants have been considered.

Regarding avifauna, the vulnerability of the Steppe Eagle to collision incidents with overhead lines has been considered and incorporate steps to protect. Spiral bird protector devices will be installed in the transmission lines to avoid electrocution risk.

It should be noted that the fencing of the facilities has been marked with high visibility elements (plates) to prevent birds from collision.

In addition, prior to the start of the works, the presence of HCP bird species in the surroundings of the infrastructures will be checked; in the event that nuptial flights or nesting are detected in the area, the calendar of the work will be readjusted in order not to affect its reproduction.

With regard to reptiles, conservation measures in situ have been incorporated to protect HCP species (Spiny Tailed Lizard). Where in situ conservation is not possible, trap and relocate HCP species have been considered.

4.2.4. Landscape features

4.2.4.1. Baseline conditions

Afif 1 Solar Plant plot is located 23 km southeast of Afif city at central zone of the Arabian Shield on a roughly flat plain. The topography of the site is flat with gentle slopes and some occasional hills of rock outcrops. All the area is widely covered by sand and gravels as residual erosional materials. Some minor runoff channels cross the plot from northwest to southeast.

No Key Landscape Features where some vegetation or wildlife can find some protection except for some outcrops and wadis with few vegetation. The following figures present the landscape in the study area.

Figure 103. Project Site predominantly flat. Source: TYPSA´s site visit

The general landscape of the proposed Afif 1 Solar Plant plot is characterized by being barren and arid, although some patches of sparce vegetation, including Acacia trees, are located within its boundaries. Vegetation is more frequent in wadi habitats.

Figure 104. Wadi with few vegetation and outcrops. Source: TYPSA´s site visit

The terrain's topography of the area is generally smooth. Some rocky outcrops were recorded onsite as it is presented in the following figures.

Figure 105. Outcrops. TYPSA´s site visit

Afif-1 solar Plant plot is located on a flat plain of the center part of Saudi Arabia (Ar-Riyad region) with a flat topography of gentle slopes.

The landscape is natural and does not feature any prominent human interventions**.** However, a few structures were identified during field surveys:

- Roads: the road that connects routes 50 and 80 through Almardamah runs through the west limit of the Project site.
- Few settlements: Nomadic camps.
- Livestock enclosures and mobile homes.

No Key Landscape Features have been found in the study area.

Regarding **visibility**, the solar plant will not be observed from inhabited areas. The project site is located 23 km away from the city of Afif. The solar plant will be observed from the road that connects routes 50 and 80 through Almardamah, which runs through the west limit of the Project site.

Figure 106. Road that connects routes 50 and 80 through Almardamah. Source: TYPSA´s site visit

4.3. Economic and social aspects

In this chapter, TYPSA provides an overview of the existing socio-economic conditions in the project area, including population, demography, economy, employment, etc. This information is crucial for understanding the context in which the project will be implemented and for identifying potential challenges and opportunities.

4.3.1. Administration, population, and demographics

The study area is located in **Riyadh Region** (see figure below).

Figure 107. Saudi Arabia Regions. Study area (red color) in Riyadh Region. Source: Gisgeography, 2024

Riyadh Region is divided into various administrative units, including the Emirate Quarter, **Ar-Riyad Governorate,** and nineteen other governorates. The study area is located inside **Afif Governorate** (see figure below).

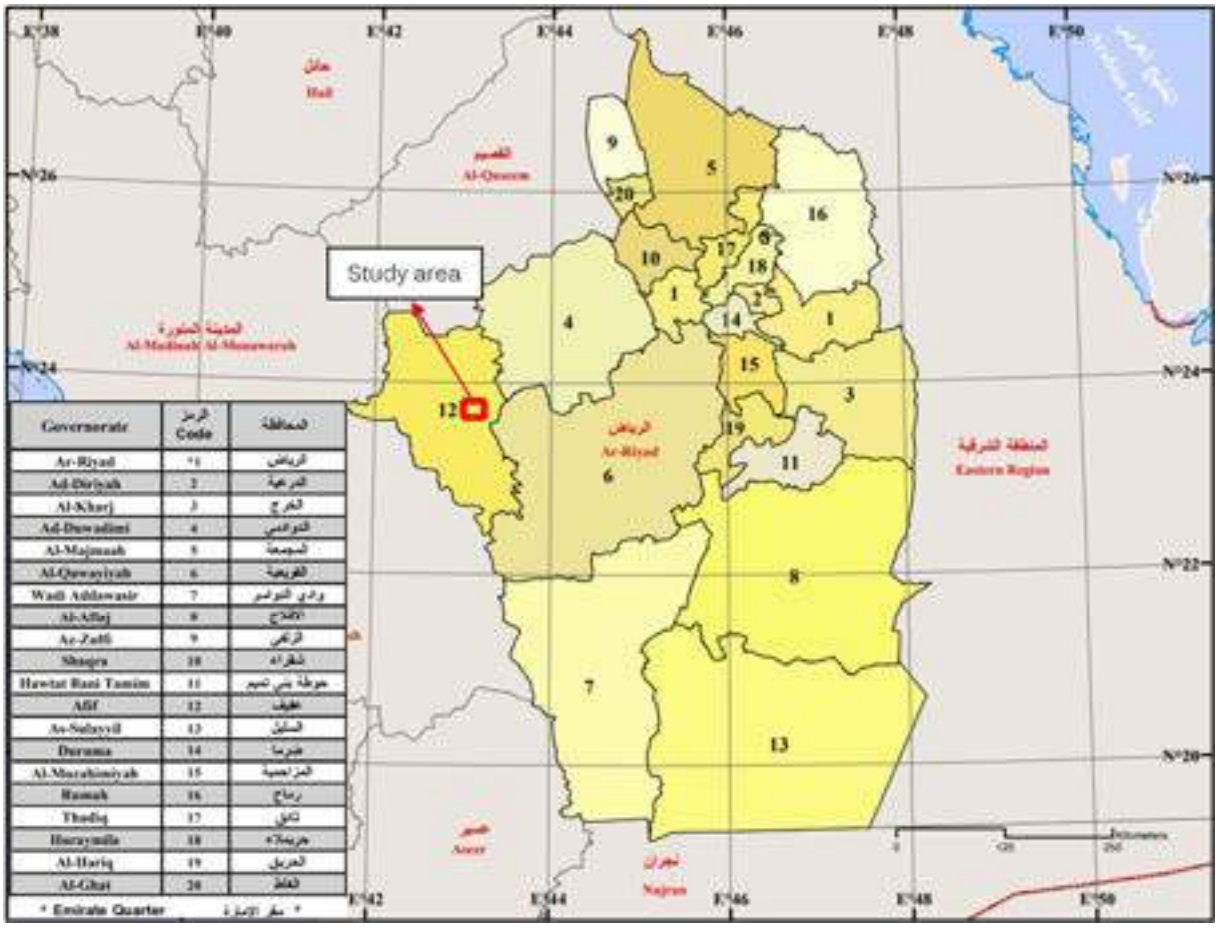


Figure 108. Governorates in Riyadh Region. Study area (red color) in Afif Governorate. Source: Central Department of Statistics & Information, Kingdom of Saudi Arabia, 2010

The Central Department of Statistics and Information of the Kingdom of Saudi Arabia published in 2010 the "Population and Housing Census" of the Kingdom[25]. This report shows an estimated total population of between 40,000 and 106,000 registered inhabitants for Afif Governorate, of which an approximate 70% are Saudis and the remaining 30% are non-Saudi. It also estimates a total number of males of between 24,000 and 62,000 and a total number of females of between 24,000 and 98,000.

A comprehensive census for 2022 was designed by the General Authority for Statistics to provide and update a complete and accurate count of the population along with information on housing, across all locations in the Kingdom and sub-groups of the population[26]. Currently, the results of the census that can be consulted in the Saudi Census 2022 Website indicate a total population of 32,175,224 people across the country. The nationality split is of 18.8M Saudis and 13.4M non-Saudi, and the gender split is of 19.7M males and 12.5M females.

The estimate population for Afif Governorate in the 2022 census is an approximate 71,600 inhabitants, being this estimation for Ar-Riyadh Governorate of 7,009,120 inhabitants. The Saudi Census of 2022 indicates that

[25] *Population and Housing Census of the Kingdom of Saudi Arabia, 2010. Distribution Maps of preliminary results. Ministry of Economy and Planning. Central Department of Statistics and Information. Source: Census*

[26] *Saudi Census 2022 website. Source: Saudi Census 2022*

the city of Afif, 21.7 km away from the power plant, has a population of 47,340 inhabitants[27]. The gender structure is of 27,360 males (57.8%) and 19,980 females (42.2%). The citizenship of the inhabitants of the city is 35,961 Saudis (76%) and 11,379 people (24%) of a foreign citizenship.

Regarding population by broad age groups, the following graphic, extracted from the Saudi Census 2022 website, shows the percentage share of each age group inside Riyadh Region:

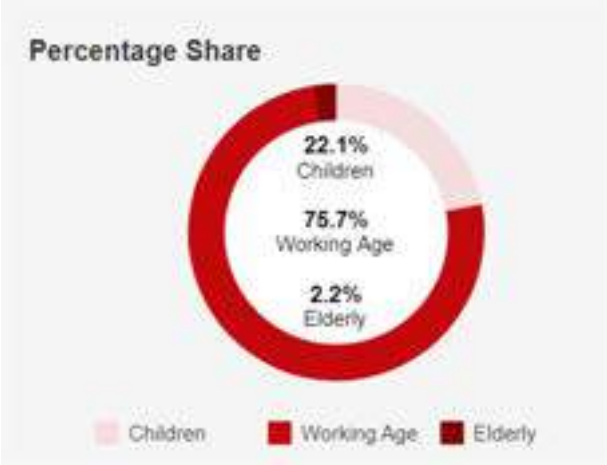


Figure 109. Percentage share of each age group inside Riyadh Region. Source: Saudi Census 2022

Currently, the average age of the population inhabiting Afif governorate is 27.8 years old.

For further information, the following age pyramid presents more detailed data for Riyadh Region:

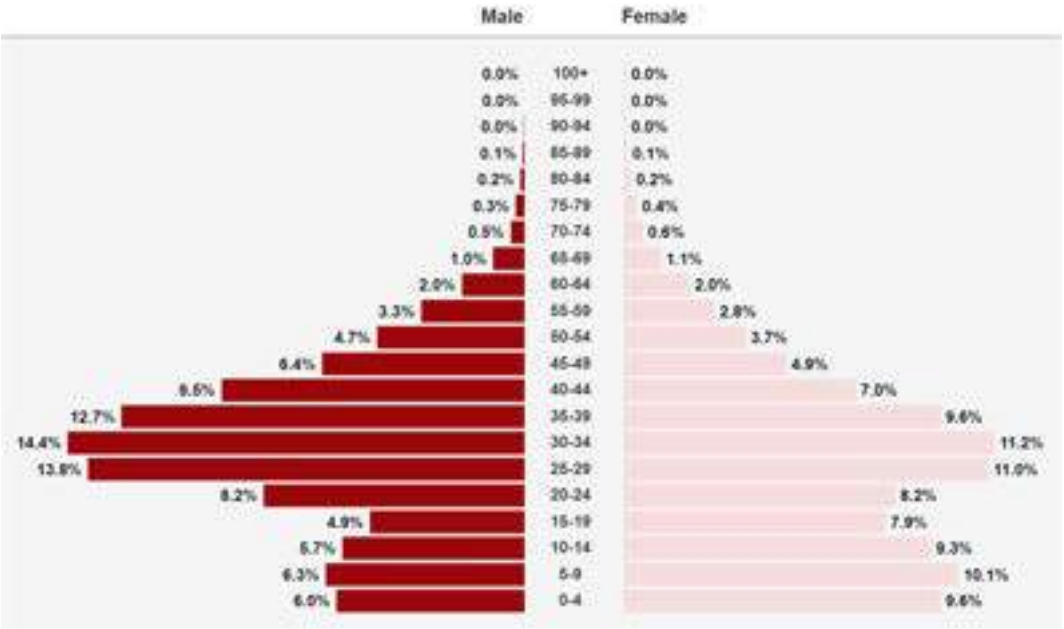


Figure 110. Age pyramid for Riyadh Region. Source: Saudi Census 2022

[27] *Afif city population. Source: Saudi Census 2022*

4.3.2. Housing

As it can be extracted from the housing program of Saudi Arabia[28]: "*Before the launch of Vision 2030, families in Saudi Arabia could wait up to 15 years to receive housing support. Today, that support is instant. ...By easing access to financial support, streamlining processes and digitizing documentation, homeownership increased from 47% to more than 60% in the end of 2022.*"

The tables of results about households contained in the Saudi Census of 2022[29] show a total number of households in the kingdom of 8,174,674, being the highest number of households registered for Riyadh Region (2,273,197). Saudi households reach up to 4,153,497 while non-Saudi households are 4,021,177, being the results very close to 50% each of the total households registered.

The total number of households registered for Afif governorate in the Saudi Census 2022 is of 17,067. Saudi households reach up to 12,070 and non-Saudi to 4,997.

Regarding the number of members inhabiting households (Saudi Census 2022), the total number of households in the kingdom with single members reach 2,133,066, and the total number of households in the kingdom with multiple members reach 6,041,608. For Afif governorate, there is a total of 17,067 households registered, 4,574 with single members and 12,493 with multiple members.

When studying the housing type of the registered households (Saudi Census 2022), Afif governorate has a total of 4,631 villas, 1,956 floors in a villa, 647 apartments in a villa, 3,356 apartments in a multi-Story building, 554 apartments in traditional houses, 269 floors in traditional houses, 4,459 traditional houses and 1,195 registered as other households.

4.3.3. Educational Status

To provide an accurate summary of the current educational situation in Saudi Arabia, the document "Education in Saudi Arabia" published by the OECD in 2020 has been utilized as a primary source[30]. This comprehensive review, titled "Reviews of National Policies for Education", offers valuable insights into the educational landscape of Saudi Arabia.

Since 2016, Saudi Arabia has initiated a comprehensive reform agenda called Vision 2030, aimed at reducing the nation's dependence on fossil fuels and fostering a diverse, dynamic, and sustainable economy. As part of Vision 2030, Saudi Arabia has introduced 13 programs, including the Human Capability Development Program (HCDP), which targets the enhancement of the education system to produce a highly skilled and productive workforce tailored for the knowledge-based labour market of the 21st century.

Investment in the education sector has been substantial, with expenditure reaching 7.8% of the country's GDP in 2015. This level of investment surpasses the average expenditure on education across OECD countries, indicating a strong commitment to improving educational outcomes. Consequently, Saudi Arabia

[28] *Housing program of Saudi Arabia. Source: Vision 2030*
[29] *Households in the Saudi Census of 2022: Source: Households*
[30] *OECD (2020), Education in Saudi Arabia, Reviews of National Policies for Education, OECD Publishing, Paris, https://doi.org/10.1787/76df15a2-en*

has made significant progress in expanding access to education, with enrolment rates in primary and secondary education approaching universality.

Overall, Saudi Arabia's educational status reflects a proactive approach towards aligning its education system with the demands of a rapidly evolving economy, as evidenced by the ambitious Vision 2030 agenda and substantial investments in education. These efforts aim to cultivate a highly skilled and adaptable workforce capable of driving sustainable economic growth and development in the country.

More specifically, for Riyadh Region, where the city of Afif is located, the following results of Education and Training, of the 2017 Survey, are presented:

Saudi Population (10 years and over) by Administative Area and Educational Status

Administative Area	Educational Status											
	Total	Ph. D.	Master	Higher Diploma	Bachelors	Pre-Univ. Diploma	Secondary/ Equivalent	Pre-Secondary. Diploma	Inter-mediate	Primary	Read& Write	Illiterate
Al-Riyadh	3652087	11271	40435	5421	678994	162800	1098461	31140	547037	527872	404780	143876
	100%	0.31%	1.11%	0.15%	18.59%	4.46%	30.08%	0.85%	14.98%	14.45%	11.08%	3.94%

Figure 111. Saudi Population (10 years and over) by Administrative Area and Educational Status. Source: Education and Training Survey 2017. General Authority for Statistics

In relation to educational attainment in Riyadh Region, related to 10 years old and above population in the year 2017, the 3.94% were illiterate, the 11.08% only knew how to read and write, the 14.45% completed Primary, the 14.98% have an Intermediate level, the 30.08% completed high school education, the 18.59% completed Bachelor, and only the 1.50% completed postgraduate educational levels (Source: General Authority for Statistics). The following figure presents the results in a graph.

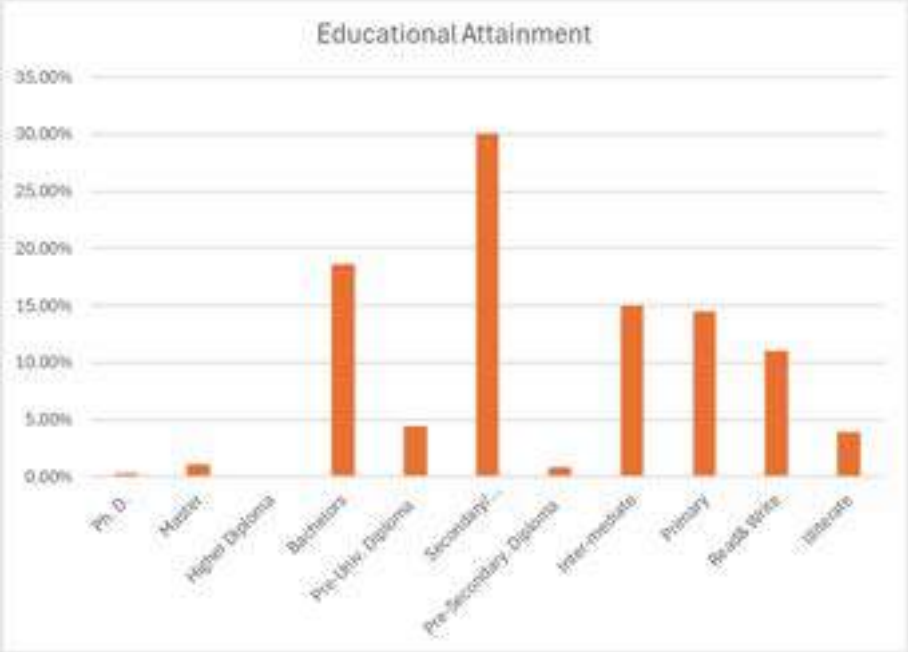


Figure 112. Riyadh Region educational attainment. Source: General Authority for Statistics (2017)

4.3.4. Employment and Labour Force

Based on the results of the International Monetary Fund´s (IMF) consultation with Saudi Arabia[31], the following summary on the overall employment and labour force status in the kingdom is presented.

In 2022, Saudi Arabia emerged as the fastest-growing economy among G20 nations, achieving an overall growth rate of 8.7 percent. This remarkable growth was fuelled by robust oil production as well as a notable 4.8 percent expansion in the non-oil GDP, driven by strong private consumption and substantial investments in non-oil sectors, including giga projects. Key contributors to the non-oil growth were wholesale and retail trade, construction, and transportation sectors. By the end of 2022, the output gap is estimated to have closed, with the momentum in non-oil growth expected to persist into 2023.

Remarkably, Saudi Arabia also witnessed a historic low in its unemployment rate, dropping to 4.8 percent by the end of 2022 from 9 percent during the Covid-19 pandemic. This decline can be attributed to an increase in labour force participation, with a surge in Saudi workers joining the private sector and expatriate workers, particularly in construction and agriculture, returning to pre-pandemic levels. Moreover, youth unemployment was halved to 16.8 percent in 2022 compared to the preceding two years, signifying significant improvements. Furthermore, female participation in the labour force reached 36 percent in 2022, surpassing the 30 percent target outlined in the Vision 2030 reform agenda set by the authorities.

The Saudi unemployment rate for Riyadh Region can be consulted in the Statistical Database of the General Authority for Statistics[32]. The following table presents the results of the unemployment rate for Riyadh Region Saudis for each of the quarters of the year 2022 and the first two quarters of 2023.

Region	Year / Quarter					
	2022 / Q1	2022 / Q2	2022 / Q3	2022 / Q4	2023 / Q1	2023 / Q2
Riyadh	8.0	7.5	7.5	6.7	6.8	6.6

Figure 113. Unemployment rate for Saudis in Riyadh Region for the year 2022 and the first two quarters of 2023. Source: General Authority for Statistics

As it can be observed in the figure above, the unemployment rate for Saudis in the Riyadh Region has plummeted since the start of the year 2022, being the rates for the years 2019 to 2021 higher due to Covid-19 pandemic.

Non-Saudi´s unemployment rate for Riyadh Region is presented below.

Region	Year / Quarter					
	2022 / Q1	2022 / Q2	2022 / Q3	2022 / Q4	2023 / Q1	2023 / Q2
Riyadh	1.7	1.7	2.0	1.5	1.3	1.3

Figure 114. Unemployment rate for non-Saudis in Riyadh Region. Source: General Authority for Statistics

[31] *2023 Article IV Consultation – Press release; staff report; and informational annex. Saudi Arabia. September 2023. International Monetary Fund. Source: Article*

[32] *Statistical Database of the General Authority for Statistics. Source: website*

4.3.5. Economic profile

Saudi Arabia is one of the richest and fastest growing countries in the Middle East. It is the world's largest producer and exporter of oil, which constitutes the major portion of the country's revenues. In recent decades, however, Saudi Arabia has diversified its economy, and today produces and exports a variety of industrial goods all over the world. Based on 2021 information, Saudi Arabia is ranked at a high level in the Human Development Index (0.88).

To gain a deeper understanding of the economic profile defining the study area and its surroundings, this section will extend to the entire Riyadh Region.

Contributing nearly 50% to the Kingdom's non-oil GDP, various sectors in the region -including petroleum, commerce, manufacturing, finance, real estate, building and construction, insurance, trade, mining, quarrying, banking, and tourism- are bolstering the country's diversification efforts. Additionally, the region hosts significant quality of life initiatives.

Boasting a population of 8,872,712 (as of 2020), spanning an area of approximately 380,000 km^2 and comprising 21 governorates, the Riyadh Region's updated strategic sectors include:

Figure 115. Strategic sectors of Riyadh Region. Source: Invest Saudi, Vision 2030, KSA

For a clearer view of the infrastructure, development projects, and other key indicators in the region, the following figure presents various significant economic assets:

Figure 116. Region at glance. Services across the region. Source: Invest Saudi, Vision 2030, KSA

In 2016, Riyadh Region accounted for 39.6% of the country's 129,900 commercial company registrations. The Kingdom's development has largely followed the National Spatial Strategy, which seeks to balance regional development and ensure an even distribution of the population across the country. Despite these efforts, urbanization trends have primarily benefited major urban centers, which have gained significantly from the wealth generated by increasing oil prices and the Kingdom's economic expansion (Saudi Cities Report, 2019). The upcoming figure illustrates how regions with the most favored cities dominate the economy:

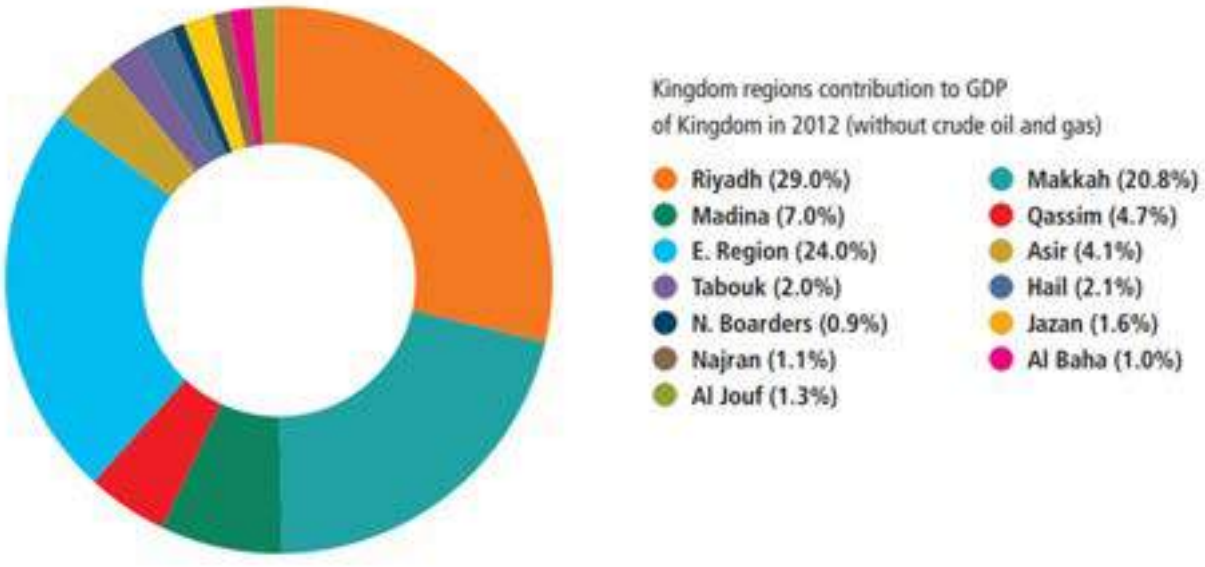


Figure 117. Contribution of regions to the GDP (without crude oil and gas), 2012. Source: Saudi Cities Report, 2019

The Saudi Cities Report of 2019 states: "*Riyadh is the largest urban agglomeration in the Gulf Region. It is Saudi Arabia's largest economic centre, accounting for about one-third (34 per cent) of national employment or 3.6 million jobs in 2016. The city's productivity is further enhanced by being a major educational centre, accounting for 20 per cent of higher education enrolments.*" Figure 118 shows that in the Riyadh Region, financial and real estate services, trade, and government services are the most significant contributors to GDP. Beyond that, manufacturing, construction, and wholesale and retail trading are the top employers.

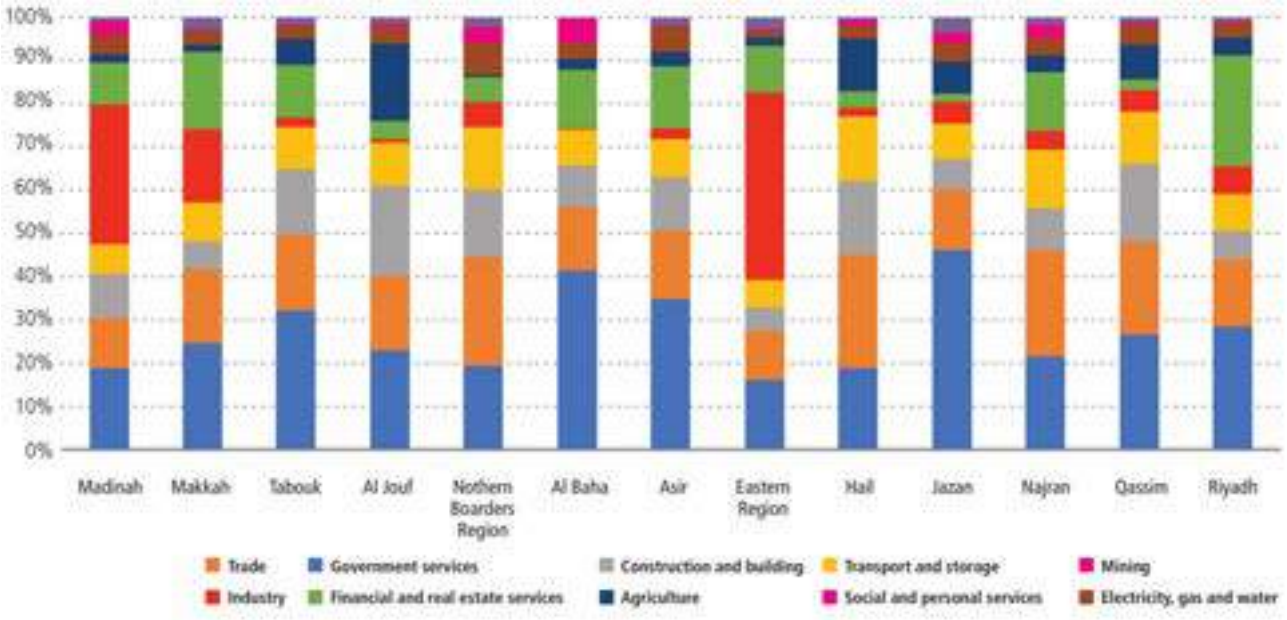


Figure 118. Economic contribution to GDP in regions (without crude oil and gas), 2012. Source: Saudi Cities Report, 2019

4.3.6. Tourism

According to the Tourism Statistics in Saudi Arabia Annual Report – 2022, prepared by the Ministry of Tourism of KSA, the kingdom attracted a total of 94.5 million tourists, comprising 16.6 million inbound tourists and 77.8 million domestic tourists.

Among top city destinations, Riyadh led in domestic tourism in 2022, attracting 9.6 million tourists. This accounts for 12.3% of the kingdom's domestic tourism (see figure below).

Figure 119. Top destinations by cities. Source: 2022 Tourism Statistics Report

Among provinces, Makkah emerged as the top destination for domestic tourists, attracting 22.7 million visitors. Riyadh Region followed as the second most popular destination, capturing 20.7% of the total domestic tourism, equivalent to 16.1 million tourists. Refer to the following figure for more details.

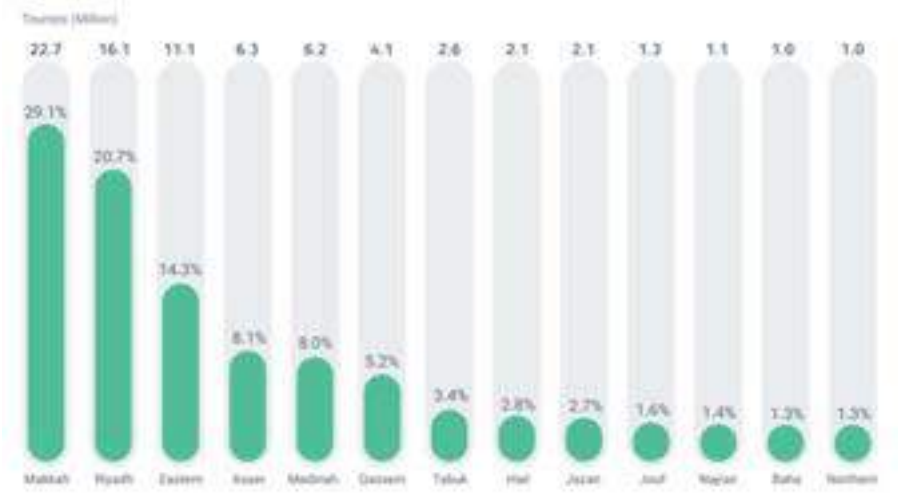


Figure 120. Domestic destinations by provinces/regions. Source: 2022 Tourism Statistics Report

In 2022, the primary reason for the 77.8 million domestic trips in KSA was visiting friends and family (VFR), with leisure and religious activities as the next most common purposes (see figure below).

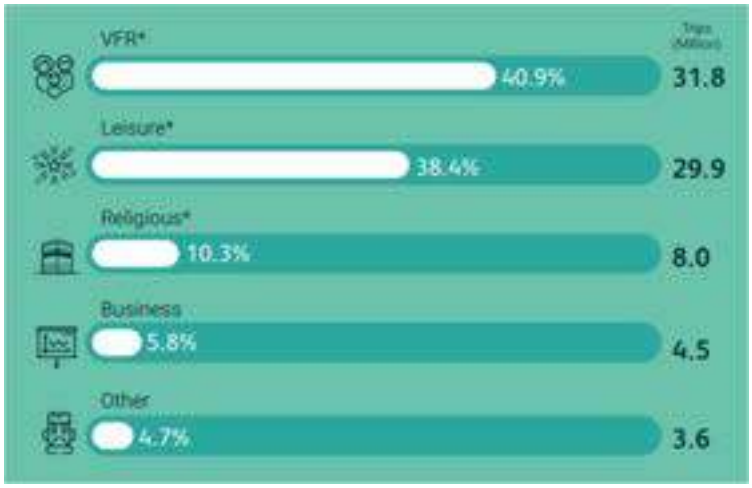


Figure 121. Main purposes of domestic trips in KSA. Source: 2022 Tourism Statistics Report

4.3.7. Agrarian activity

a. Agricultural production

The General Authority for Statistics' 2019 estimations indicate that Saudi Arabia's agricultural production volume was 14.4 million tons. This total includes 9.1 million tons of fodder, 1.9 million tons of vegetables, 1.5 million tons of grain, and 1.9 million tons of fruit. The total cultivated area, fruit excluded, spanned 843 thousand hectares across Saudi Arabia. Fodder cultivation covered 57.8% of this area, grain 31.9%, and vegetables 10.3%. By the end of 2018, fruit-bearing palm trees numbered 31.2 million, with other permanent fruit-bearing trees (excluding palm trees) totaling 20.6 million, as presented in the Annual Report of the Saudi Arabian Monetary Authority (for the year 1441H - 2020).

During field work surveys no lands dedicated to agriculture were observed within the boundaries of the project or in the surrounding area. No close agricultural activity was observed either by TYPSA´s team during the site visit and while analysing documentation and satellite imagery for the development of the Preliminary Site Assessment Report.

b. Animal production

According to GaStat statistics, Saudi Arabia's total livestock production, including camels, sheep, goats, cows, and poultry, reached 20 million in 2018. This represents a 1.1 percent increase from the previous year (Annual Report of the Saudi Arabian Monetary Authority, 1441H-2020).

The "Poultry and Products Annual Report", jointly prepared by the United States Department of Agriculture (USDA) and the Global Agricultural Information Network, indicates that while poultry farms are distributed across 12 Saudi Arabian provinces, 88% of the production is concentrated in 6 provinces. The Riyadh Region contributes 15% to total Saudi Arabia's chicken meat production.

To accurately depict animal production in the Riyadh Region, the 2018 Agricultural Production Survey Bulletin (General Authority for Statistics) was reviewed. This survey gathers data via visits to a representative sample of holdings across all administrative regions of the Kingdom of Saudi Arabia (see Figure 122).

Administrative Region	Number of Holdings	Administrative Region	Number of Holdings	Administrative Region	Number of Holdings
Riyadh	3,618	Asir	2,491	Najran	499
Makkah	2,600	Tabuk	922	Al-Baha	437
Madinah	687	Hail	1,166	Al-Jouf	921
Qassim	2,309	Northern Borders	28		
Eastern Region	2,556	Jazan	1,279		

Figure 122. Holdings surveyed by administrative regions. Source: Agricultural Production Survey Bulletin, 2018

The Riyadh region encompasses the following total agricultural area and total agricultural holdings (see figure below):

Area	Number	Administrative Region
8,217,580.87	24,990	Riyadh

Figure 123. Number and area of agricultural holdings in Riyadh region, 2017. Area=1000m². Source: Agricultural Production Survey Bulletin, 2018

The total livestock volume results for the region of Riyadh are presented below:

- **Sheep:**

Milking females	Total		12 months and over		Under 12 months		Administrative Region
	Female	Male	Female	Male	Female	Male	
601,172	1,808,336	364,598	1,459,189	76,747	349,147	287,851	Riyadh

Figure 124. Total number of sheep by age and group sex in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018

- **Goats:**

Milking females	Total		12 months and over		Under 12 months		Administrative Region
	Female	Male	Female	Male	Female	Male	
179,027	559,277	127,721	413,174	25,967	146,103	101,754	Riyadh

Figure 125. Total number of goats by age and group sex in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018

- **Camels:**

Milking females	Total		4 years and over		Under 4 years		Administrative Region
	Female	Male	Female	Male	Female	Male	
32,358	114,820	20,394	96,389	6,275	18,431	14,119	Riyadh

Figure 126. Total number of camels by age and group sex in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018

- **Cows:**

Total							Administrative Region
Milking females	Total		2 years and over		Under 2 years		
	Female	Male	Female	Male	Female	Male	
3,346	8,630	3,928	8,161	3,171	469	757	Riyadh

Figure 127. Total number of cows by age and group sex in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018

- **Riding and draught animals:**

Total	Other animals	Deer	Donkey	Mule	Horse	Administrative Region
12,121	18	6,961	1,068	64	4,010	Riyadh

Figure 128. Total number of riding and draught animals by type in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018

- **Domestic poultry:**

35,608,700	288	446	1,411	88,114	94,518	5,822	5,477	25,084	947,441	712,174	Riyadh

Figure 129. Total number of domestic poultry by type in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018

- **Honey:**

Total	Industrial (modern)	Free range (traditional)	Administrative Region
Produced honey (ton)	Produced honey (ton)	Produced honey (ton)	
9,745.6	6,874.2	2,871.4	Riyadh

Figure 130. Total honey produced by hive type in agricultural holdings of Riyadh region. Source: Agricultural Production Survey Bulletin, 2018

During field work surveys, herds of camels (*Camelus dromedarius*), goats (*Capra hircus*) and sheeps (*Ovis aries*) were sighted. The eastern area of the project´s plot has been historically used for the grazing of these animals. Livestock enclosures were also identified onsite.

4.3.8. Social infrastructure

a. Electricity

Saudi Arabia has become the Middle East's fastest-growing electricity consumer, with a significant portion of this demand coming from transportation fuels. Almost all of its electricity is generated from fossil fuels, with natural gas accounting for 51% and oil for 49%. Over the last decade, the country's electricity consumption has surged by 59%.

Saudi Arabia faces an impending energy shortage, necessitating a capacity increase. By 2024, peak electricity demand is projected to near 60 GW, with plans to expand capacity to 120 GW by 2032. The investment required for this expansion could surpass $90 billion. This situation urgently calls for the development of energy conservation policies to ensure sustainable development.

Quality housing infrastructure in urban areas represents another strength. The "Riyadh Urban Observatory Report" (ADA, 2016) notes that all dwellings in Riyadh have electricity, while 86% have improved sanitation facilities, 96% have access to enhanced water sources, and 91.46% have upgraded shelter. As the most populous region, Riyadh Region accounts for the largest portion of household electricity consumption at 28.5%, with Makkah Region following at 24.4%. In contrast, Al-Baha Region registers the smallest share of electricity usage at just 1.3%.

During the first site visit, performed by TYPSA´s team in November 2023, no electrical infrastructure was detected in the nearby area. Two main electrical substations were identified close to Afif town, around 31 km and 37 km away from Afif 1 Solar Power Plant.

In addition, during the site visit, one new substation under construction was detected near Afif town. See figure below:

Figure 131. New substation under construction near Afif town. Source: TYPSA´s site visit in November 2023

b. Water and Municipal Services

The water supply and sanitation sector in Saudi Arabia faces both significant challenges, such as water scarcity, and notable achievements. To combat scarcity, the country has heavily invested in seawater desalination, water distribution networks, sewerage systems, and wastewater treatment facilities. Currently, approximately 50% of the nation's drinking water is sourced from desalination, 40% from non-renewable groundwater extraction, and a mere 10% from surface water, predominantly from the mountainous southwest. Although water is almost freely provided to households, the quality of service, including the consistency of the supply, still requires improvement.

Efforts to conserve water have included media awareness campaigns and the distribution of educational pamphlets. Specifically, in Riyadh city, authorities have implemented a leakage control program alongside the introduction of a higher water tariff. Additionally, the provision of free water-saving appliances, such as taps, shower heads, and toilet boxes, has reportedly reduced residential water consumption by 25-35%.

Water demand in Saudi Arabia rose from 19.2 BCM to 24.6 BCM from 2011 to 2015, as reported by the National Water Strategy 2030 (2018). In 2019, the demand decreased to 17.4 BCM, with the urban sector (encompassing domestic and commercial use) accounting for 20%, the industrial sector for 8%, and the agricultural sector for a substantial 72%, according to the Statistical Book for the Year 2019 (1440-1441). Figure below illustrates a comparative analysis of the sectoral water demands within the kingdom from 2010 to 2019.

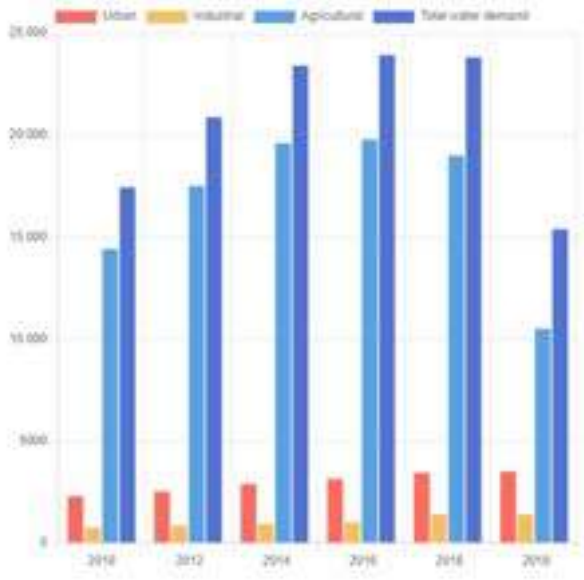


Figure 132. Water sectoral demands in KSA between 2010 and 2019. Source: Statistical Yearbook, 2019

The Statistical Yearbook of 2019 reveals urban water consumption details. In 2019, urban areas in Saudi Arabia used 3,493 MCM/yr, with the domestic sector accounting for 2,895.5 MCM/yr and the commercial sector for 595.4 MCM/yr. The primary sources of urban water were desalination and groundwater. Figure below illustrates that 35% (1,237 MCM) of the urban water demand was met through groundwater, while desalination contributed 65% (2,256 MCM).

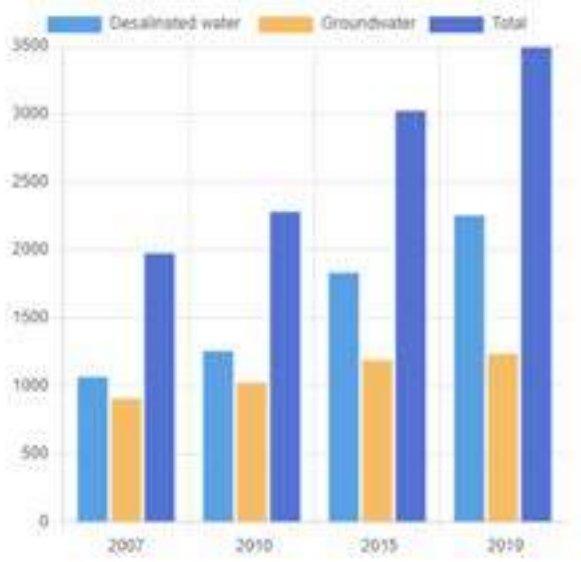


Figure 133. Sources of urban water use in KSA between 2007 and 2019. Source: Statistical Yearbook, 2019

As shown in figure below, Riyadh Region was the province with the highest urban water consumption in 2019, totaling 1,088.5 million cubic meters per year (MCM/yr).

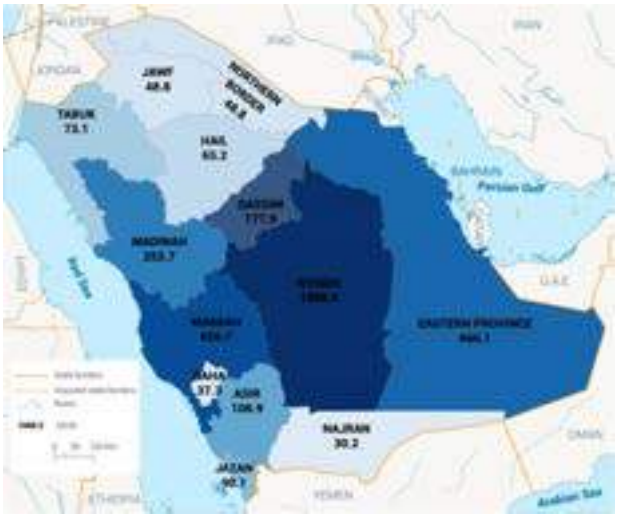


Figure 134. Regional urban water demand in KSA. Source: Statistical Yearbook, 2019

In KSA, the agricultural sector consumes almost 72% of total water yet contributes just 2.2% to the GDP. Notably, 90% of the water utilized in agriculture comes from groundwater aquifers (Ghanim, 2019)[33].

Riyadh has the highest count of artesian wells, numbering 21,301, which tap into deep groundwater aquifers. This is followed by the Eastern region, Qassim, Medina, and Hail, signaling increasing depletion of non-renewable groundwater resources in these areas. The majority of agricultural regions rely on extracting deep groundwater for irrigation, a process that is both challenging and expensive (Ghanim, 2019).

[33] *Ghanim, AA, 2019. Water resources crisis in Saudi Arabia, challenges and possible management options: An analytic review. World Academy of Science, Engineering and Technology International Journal of Environmental and Ecological Engineering 13(2).*

Among the achievements is a significant increase in desalination, and in access to water, the expansion of wastewater treatment, as well as the use of treated effluent for the irrigation of urban green spaces, and for agriculture.

By the end of 2017, the Kingdom of Saudi Arabia ranked among the leading producers of desalinated water, contributing 18% to global production. The kingdom operates 35 desalination plants along its western and eastern coasts. In 2015, the total desalination capacity was estimated at 6.28 BCM/d, with projections to increase to 7.4 BCM/d by 2020, according to the National Strategy 2030 (2018). Desalination accounts for roughly 70% of Saudi Arabia's national water supply.

The Saline Water Conversion Corporation (SWCC) stands as the largest desalinated water producer in KSA, operating the majority of the nation's desalination plants and accounting for 73% of the total production capacity. In anticipation of a potable water demand projected to reach 8.5 MCM/d by 2025, SWCC plans to expand its installed production capacity to approximately 8.8 MCM/d by 2030, as outlined in the National Strategy 2030 (2018).

Municipal wastewater production rose from 2,125 MCM in 2007 to 2,884 MCM in 2018, with projections to escalate to 5,090 MCM by 2050, driven by demographic growth (Journal of Water Process Engineering 32, 2019). Currently, 99 wastewater treatment plants (WWTPs) are operational for treating this wastewater.

Region	Number of WWTPs	TWW (MCM/yr)	Amount of treated water (MCM/d)	Amount of reused TWW (m3/d)	Wastewater reuse (%)
Riyadh	15	540.111	1.480	137,575	9.30

Figure 135. Regional distribution of WWTPs, TWW (Treated Wastewater) quantities and reuse in Riyadh Region. Source: Statistical book: Year 2019, Ministry of Environment, Water and Agriculture

During the site visits, TYPSA´s and AHEC´s, no municipal services such as water supply pipes or sanitation network were observed onsite.

c. Health Services

The health law in the Kingdom of Saudi Arabia is designed to ensure comprehensive and equitable health care access for everyone. The Ministry of Health represents the Kingdom in offering a widespread network of health services across all regions. Furthermore, health care at government facilities is offered to citizens at no cost, underpinned by a new health care law tailored to the sector's requirements.

The article "Mapping the Private Healthcare Sector in Riyadh Region: Size, Services, and Alignment with the Saudi Ministry of Health Priorities" by Alshahrani et al. (2023) reveals significant growth in the private healthcare sector from 2017 to 2021. The number of private hospitals increased from 40 to 46, and hospital beds in the private sector grew from 5,426 to 6,339. The composition of private health institutions was as follows: pharmaceutical institutions (55.4%), polyclinics (23%), and supportive health services centres (17.1%), with laboratories, hospitals, and clinics making up 2%, 1%, and 0.5%, respectively. The least common were ambulance and radiology service centres, each accounting for 0.1%. Services such as home healthcare, remote care, telemedicine, family medicine, and long-term care were provided by 1.3%, 0.5%, 0.4%, and 0.1% of institutions, respectively. Private hospitals represented 41.4% of all hospitals, with their beds

making up 30.9% of the total in Riyadh, averaging 137.8 beds per hospital. Approximately 82% of private health institutions were located in Riyadh city, with the remaining 18% in surrounding provinces.

No infrastructure associated with healthcare was observed onsite or in the surrounding area during the site visits. The closest health services are provided in Afif town.

4.3.9. Land use and occupation in the project area

4.3.9.1. Baseline conditions

a. Land use

The current land use of the project site was also assessed by using Open Street Map (OSM) Landuse – Landcover satellite imagery of the area. A web map service of OSM was connected to a Geographical Information System and the following figure was extracted.

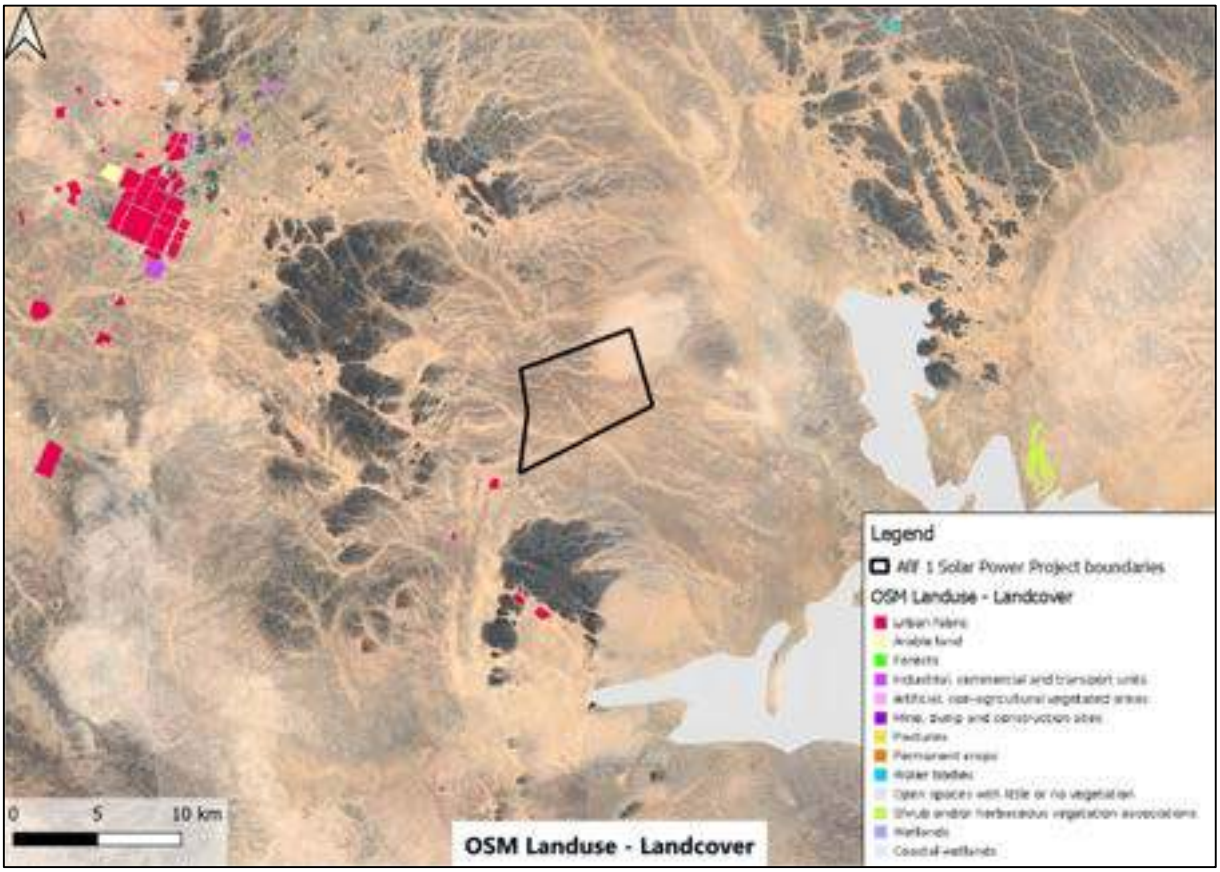


Figure 136. OSM Landuse - Landcover in the surroundings of Afif 1 Solar Power Project plot. Source: self-made

As it can be observed in the figure above, the land use registered for this area by OSM Landuse – Landcover imagery is the urban fabric of Afif town and the **open spaces with little or no vegetation**, in grey in the figure, registered for the southeast of the plant. Even though it is not stablished by OSM Landuse, the other major percentage of territory is also covered by **open spaces with little or no vegetation**.

b. Land occupation

The Project site does not present any major settlements (villages or towns).

During the Environmental Baseline Survey of the site, what appeared to be a nomadic camp was sighted onsite. It seems unlikely to become a permanent feature. A drill rig of the geotechnical campaign was also observed. Facilities such as livestock enclosures and mobile homes were observed too.

The location of the mentioned nomadic camp and some photographs are presented in the figures below.

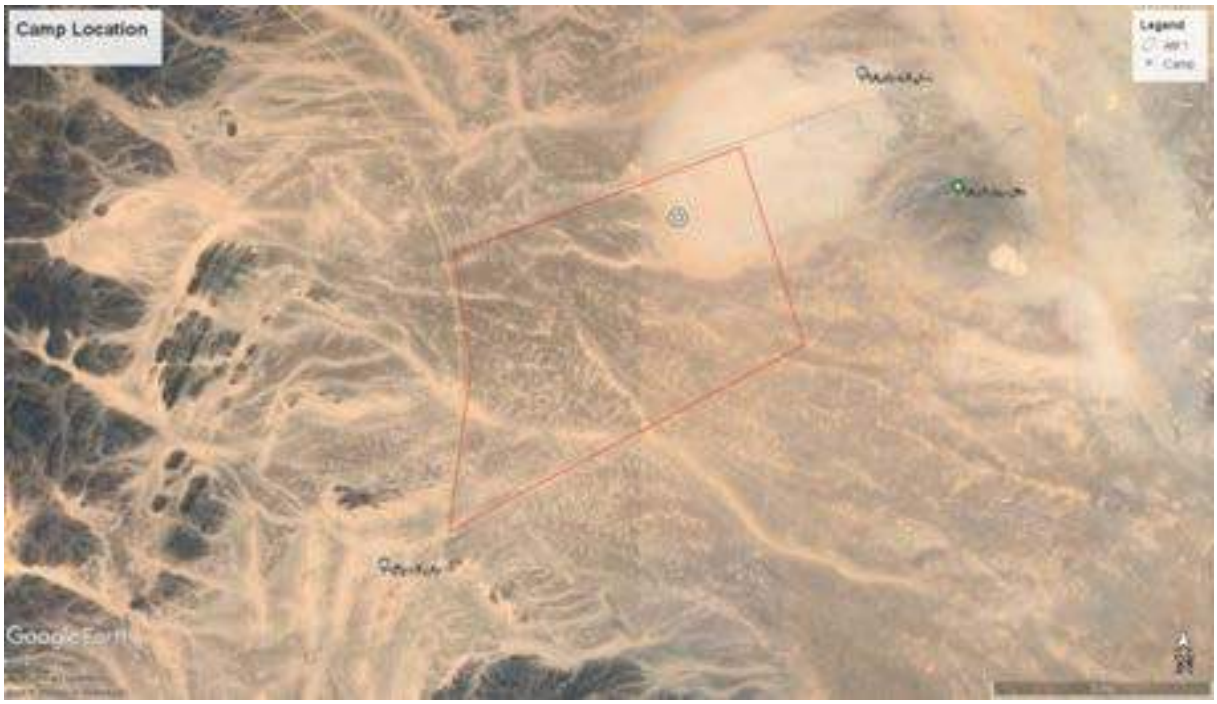


Figure 137. Nomadic camp location. Source: Environmental Baseline Survey Report for Afif 1 PV Plant

Figure 138. Nomadic camp and a camel´s enclosure within the project site. Source: TYPSA´s site visit

There is no remarkable land use at the moment, described as barren in the web service of Landuse Open Street Map (OSM). The exception is some grazing activity, mainly camels, although some sheep were also seen within an enclosure. The following figures present the findings of TYPSA´s site visit.

Figure 139. Cattle within the project site. Source: TYPSA´s site visit

There is also a road that connects routes 50 and 80 through Almardamah and runs through the west limit of the project site. Photographs were taken of this road during TYPSA´s site visit. Since it had rained the night before the visit, the photographs show flooding areas at both sides.

Figure 140. Road adjacent to the Solar Power Plant plot. Source: TYPSA´s site visit

c. Environmental degradation

During the baseline survey, some wheels and plastic wastes were recorded onsite. All these features can be considered as environmental degradation of the area.

TYPSA´s team also encountered scarce wastes onsite. The photographs below show some abandoned litter within the plot boundaries.

Figure 141. Abandoned garbage within the Solar Power Project boundaries. Source: selfmade

d. Land ownership

Regarding land ownership, expropriations are unnecessary, as the land is property of the kingdom.

The terrain will be managed by leasing. The land will be under the management of the Ministry of Municipal, Rural Affairs and Housing.

4.4. Antiquities and Cultural Heritage

4.4.1. Relevant legislation and standards

4.4.1.1. National regulations

Law of Antiquity (Royal Decree M/3 dated 9/1/1436 AH). This regulation is developed in more depth in Section 2.2.1.

4.4.2. Baseline condition

No bibliographic information about the local archaeology and heritage in Saudi Arabia has been found.

No features of archaeological or cultural heritage significance were observed during the initial site visit and the Environmental Baseline Survey.

According to the current UNESCO (United Nations Educational, Scientific and Cultural Organization) World Heritage Sites list, no World Heritage Sites are located within the project site boundaries or in its vicinity. All heritage sites are located far from the location of the project site (see figure below). The closest heritage sites are the At-Turaif District in ad-Dir'iyah (359 km away from the project site), Jabal al-Manor and Jabal Raat (417 km northwest of the project site), and Historic Jeddah (476 km southwest of the project site).

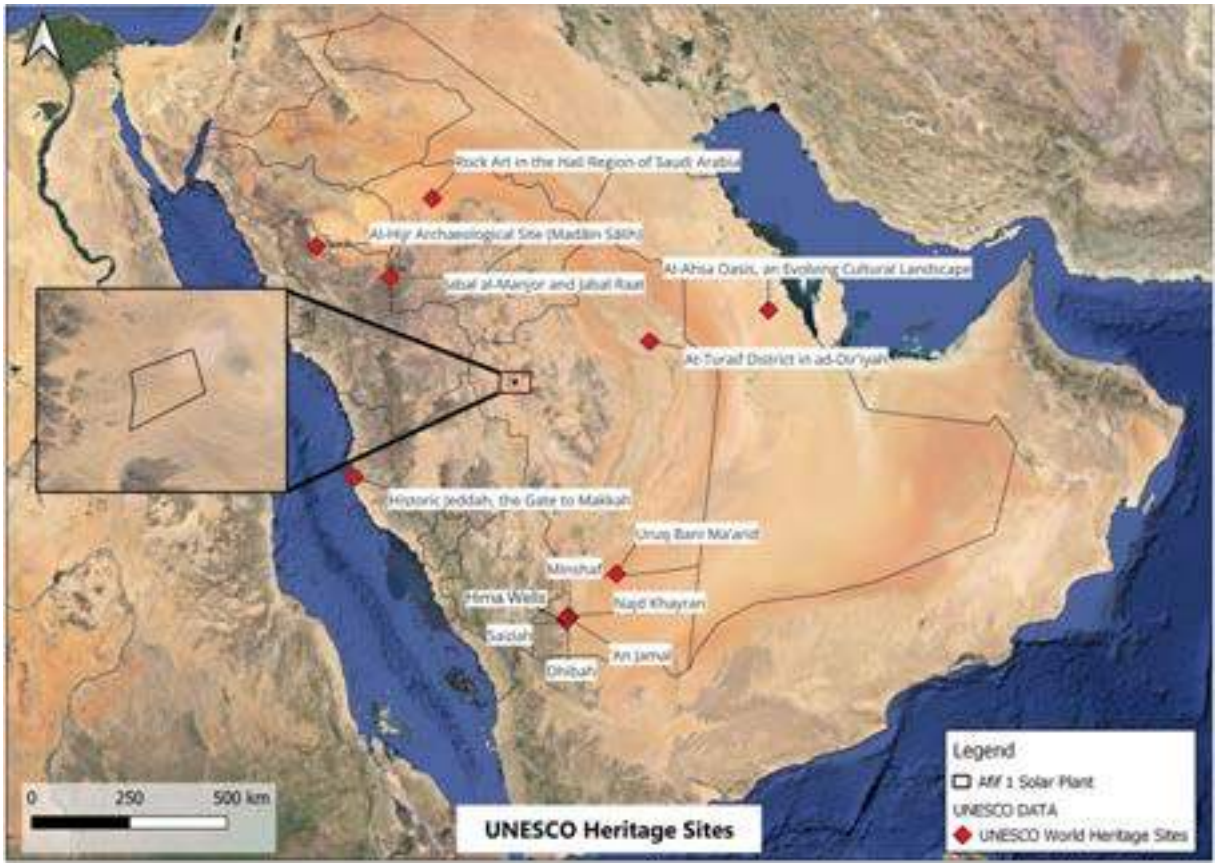


Figure 142. World Heritage Sites of UNESCO and Afif 1 Solar PV Plant. Source: UNESCO

No archaeological or historical features have been recorded at the project site. A review of the database revealed no other nationally registered sites or previously identified sites of endemic importance in the proposed PV solar plant area.

4.5. Sensitive Receptors

Sensitive areas are considered as those areas existing near the Project and where occupants are more susceptible to the exposure of pollutants, chemicals, traffic, noise, and vibration as a result of the project construction and operation. Sensitive receptors include schools, universities, hospitals, housings, mosques, libraries, parks, Government buildings, cemeteries, museum, investigation centres, natural reserves, etc.

No sensitive receptors such mentioned above were identified close to the project site except some seasonal shepherds/herders and temporary settlements whom main activity is grazing. The nearest large city, which is Afif, is 23 km away from the project.

Figure 143. Inhabited areas inside the project site. Mobile homes and camels' enclosure. Source: TYPSA´s site visit

The project site itself is evaluated to have a minor ecological value. No ecological sensitive receptor close to the project activities was remarked.

4.6. Climate Change Adaptation

4.6.1. Climate Trend Analysis for Saudi Arabia

For this analysis TYPSA has retrieved data from The Climate Change Knowledge Portal (CCKP), https://climateknowledgeportal.worldbank.org/, which provides global data on historical and future climate, vulnerabilities, and impacts.

Saudi Arabia, covering the majority of the Arabian Peninsula in Western Asia, spans approximately 2.25 million km², with around 38% comprising desert lands. This arid country's sand deserts make many regions prone to flooding and desertification. With a population of about 35 million as of 2020, Saudi Arabia's economy relies heavily on oil, being the world's top petroleum exporter. The absence of permanent water resources compels reliance on groundwater and seawater desalination for water supply. The country faces increasing water security risks due to climate change impacts, including reduced frequency and amount of precipitation and rising temperatures. Characterized primarily by a desert climate, except for its semi-arid southwestern part, Saudi Arabia experiences extreme hot and dry summers. Central regions see temperatures ranging from 27°C to 43°C inland and 27°C to 38°C along the coast. Winter temperatures vary from 8°C to 20°C in inland areas and 19°C to 29°C along the Red Sea coast. Most of the country receives less than 150 mm of annual rainfall, except the southwest, where it ranges between 400 – 600 mm.

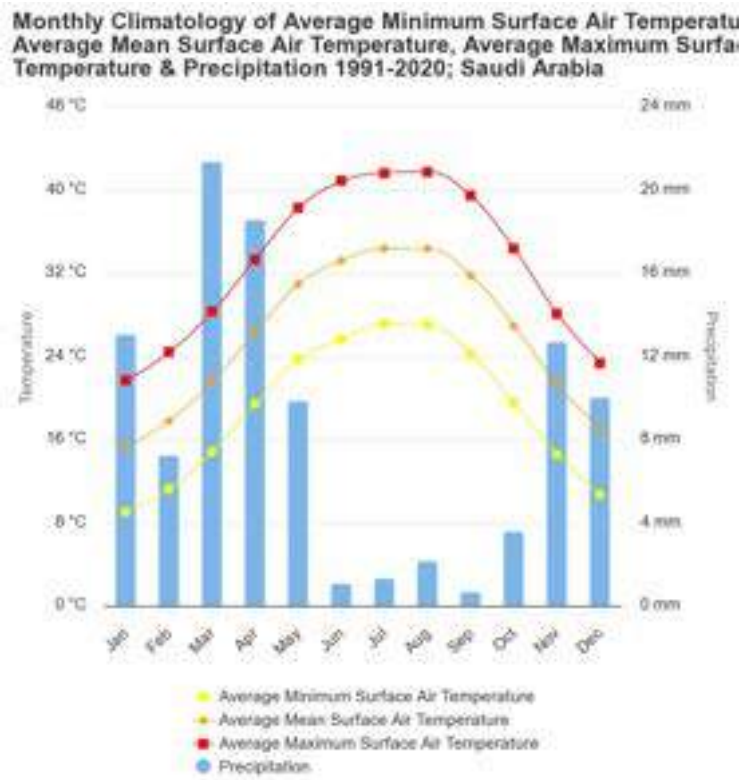
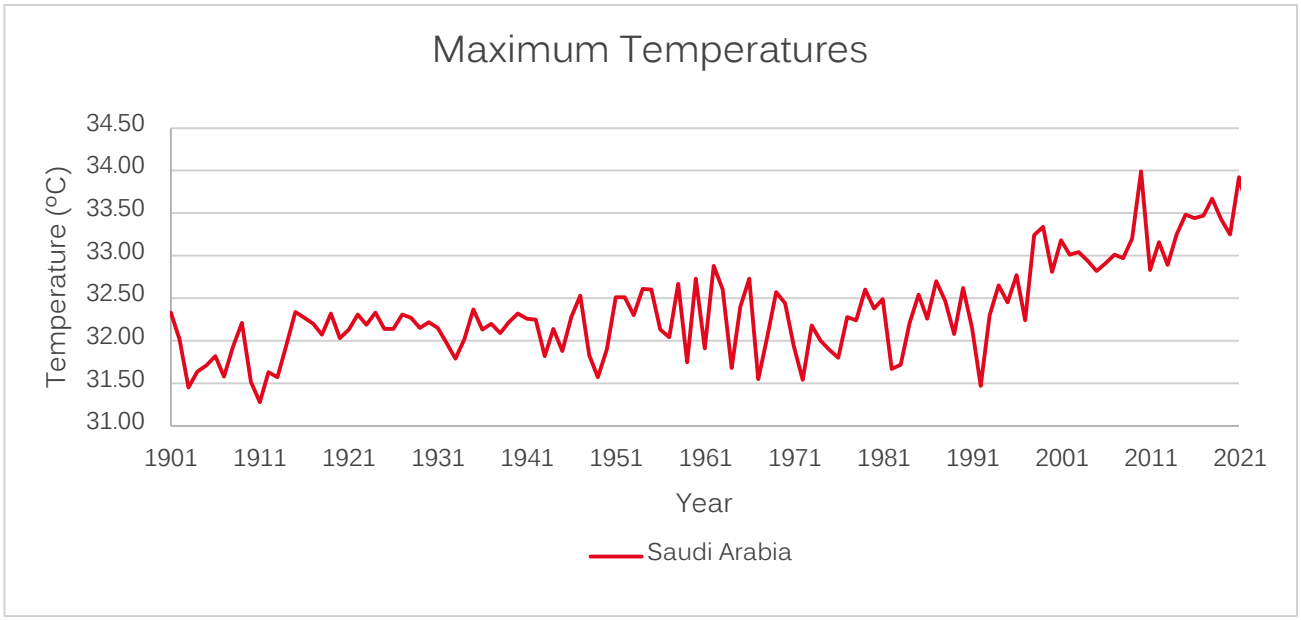


Figure 144. Monthly mean temperature and precipitation for Saudi Arabia during the 1991-2020 period Source: World Bank

Using the Climate Change Knowledge Portal, historical climate data from 1901 to 2020 was examined. The following section shows the most relevant variables for Saudi Arabia. This section aims to establish a baseline for future climate projections.

Temperature

The accompanying figure illustrates the time series for maximum and minimum temperatures during the historical reference period from 1901 to 2021.



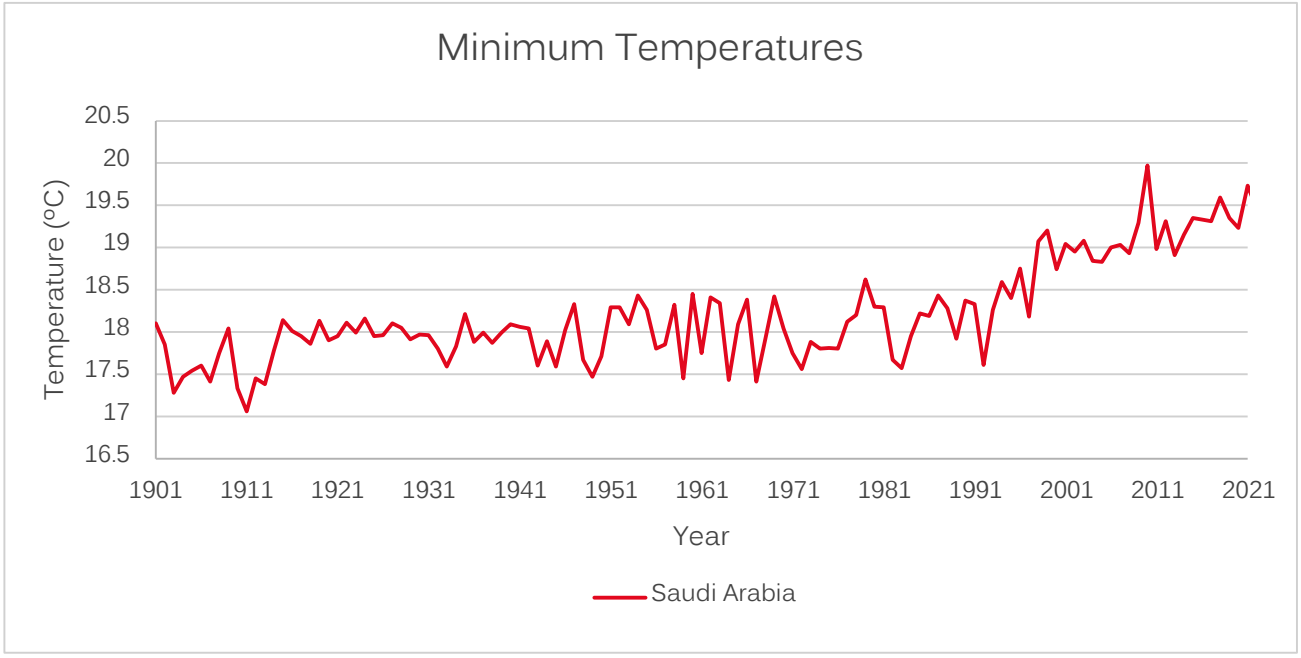


Figure 145. Maximum and minimum temperatures for Saudi Arabia for the 1901-2020 period. Source: World Bank

Both graphs demonstrate a distinct trend of increasing maximum and minimum temperatures over the studied period. The data series reveal a mean maximum temperature of 32.5ºC for Saudi Arabia with a mean minimum temperature of 18.3ºC.

Additionally, a preliminary analysis of temperatures in different regions show a clear trend, where landlocked regions have higher temperatures than the average for Saudi Arabia whilst those near the coast see their average temperatures reduced by up to 2ºC from the national average. For example, in Ar Riyad, lacking the moderating influence of the sea the mean maximum temperature is 1ºC higher than the national average, whilst the seaside province of Ash Sharqīyah has a mean maximum temperature 1.3ºC lower than the average for the kingdom for the same period. In this case, the Afif 1 PV Plant is located in an inland region, specifically in the Ar Riyad province.

Precipitation

The available historical data corresponding to the precipitation variable in mm has been analyzed. The study period goes from 1901 to 2021.

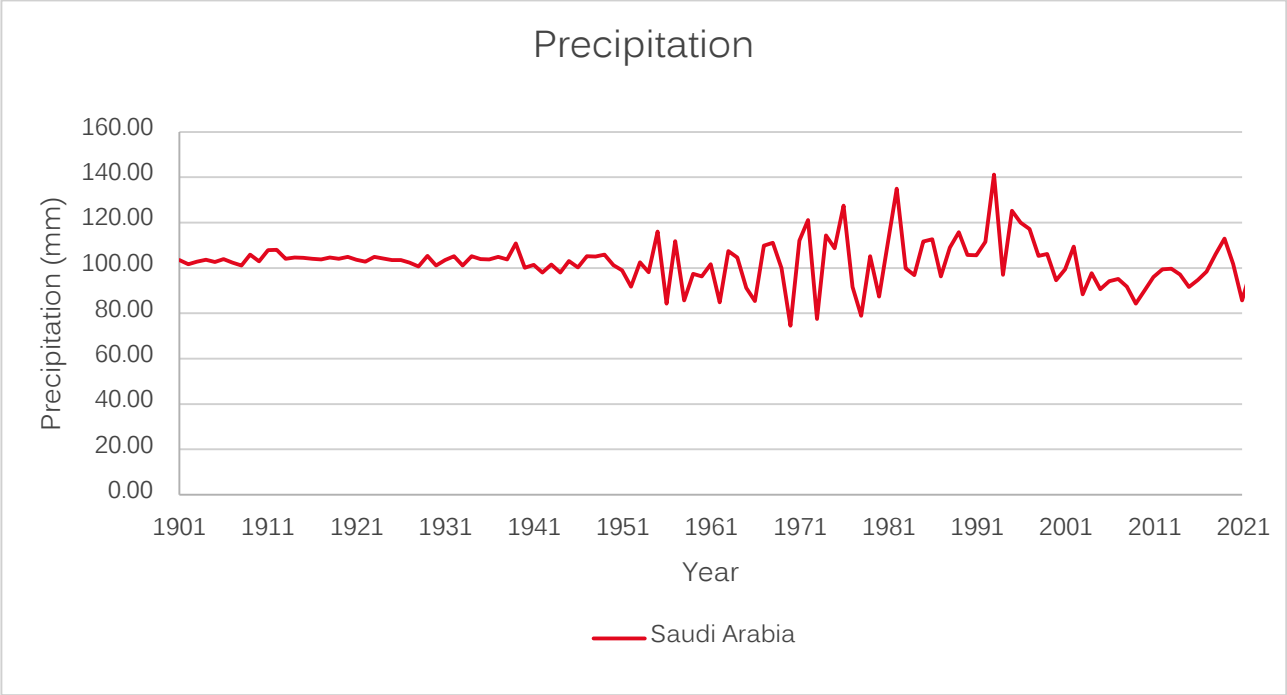


Figure 146. Precipitation for Saudi Arabia for the 1901-2022 period. Source: World Bank

The data series determine a mean value for the average of the individual models of 102,41 mm in Saudi Arabia. There is no significant variation between provinces when it comes to precipitation.

Analysis of future climate scenarios

The climate scenarios approach characterizes a range of plausible climate futures, illustrating the consequences of various pathways like policy choices and technological changes. These scenarios act as 'what if' cases, spanning a wide range without linking to likelihood. Over the past three decades, this method has shifted from a climate-centric to a more societal development-centric perspective. The CMIP5 employed Representative Concentration Pathways (RCPs), while CMIP6 introduced Shared Socio-economic Pathways (SSPs), maintaining the core aim of exploring plausible climate outcomes. In CMIP6, each SSP generates future projections of greenhouse gas emissions and land-use changes based on the baseline SSP storyline. Designed to work with an updated version of RCPs, the SSPs enable the modeling of different climate policy futures. These include, for instance, transitions from fossil fuels to renewable energy, affecting the radiative forcing levels by the end of the century as specified in an RCP. Different policy scenarios result in varying radiative forcing values, with higher values indicating stronger warming effects. These values facilitate comparisons with the RCPs of CMIP5 and IPCC AR5. CMIP model outcomes, informed by these scenarios, are essential references for climate change science, impact assessment, vulnerability, adaptation, and mitigation. Scenarios serve as tools for understanding emerging climate signals, aiding decision-making. In summary, the AR6 offers a more current and detailed assessment of climate change, incorporating a range of socio-economic, technological, and environmental factors, with increased focus on climate justice, risk communication, and health impacts.

CMIP6

The SSPs outline potential paths for societal development and policy strategies aimed at achieving specific radiative forcing targets by the end of the century. In CMIP6, scenarios encompass a range from high to very high GHG emissions (SSP3-7.0 and SSP5-8.5), where CO2 emissions could roughly double from current levels by 2100 and 2050, respectively. There are also intermediate scenarios (SSP2-4.5), with CO2 emissions stabilizing at current levels until mid-century, and scenarios with very low to low GHG emissions (SSP1-1.9 and SSP1-2.6), where CO2 emissions are projected to decline to net zero around or after 2050, followed by various degrees of net negative emissions. These emissions vary across scenarios based on socio-economic assumptions, the extent of climate change mitigation efforts, and air pollution control measures, especially for aerosols and non-methane ozone precursors.

Narrative description for the shared socio-economic pathways:

- **SSP1 "Sustainability" (Low challenges to mitigation and adaptation).** The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity. The combination of directed development of environmentally friendly technologies, a favorable outlook for renewable energy, institutions that can facilitate international cooperation, and relatively low energy demand results in relatively low challenges to mitigation. At the same time, the improvements in human well-being, along with strong and flexible global, regional, and national institutions imply low challenges to adaptation.
- **SSP2 "Middle of the Road" (Intermediate challenges to mitigation and adaptation).** The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals.

Environmental systems experience degradation, although there are some improvements and overall, the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain. These moderate development trends leave the world, on average, facing moderate challenges to mitigation and adaptation, but with significant heterogeneities across and within countries.

- **SSP3 "Regional Rivalry" (High challenges to mitigation and adaptation).** A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions. Growing

resource intensity and fossil fuel dependency along with difficulty in achieving international cooperation and slow technological change imply high challenges to mitigation. The limited progress on human development, slow income growth, and lack of effective institutions, especially those that can act across regions, implies high challenges to adaptation for many groups in all regions.

- **SSP5 "Fossil-fueled Development" (High challenges to mitigation, low challenges to adaptation).** This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary. While local environmental impacts are addressed effectively by technological solutions, there is relatively little effort to avoid potential global environmental impacts due to a perceived tradeoff with progress on economic development. The strong reliance on fossil fuels and the lack of global environmental concern results in potentially high challenges to mitigation. The attainment of human development goals, robust economic growth, and highly engineered infrastructure results in relatively low challenges to adaptation to any potential climate change for all but a few.

To compile this report, the team utilized the Climate Change Knowledge Portal (CCKP) and focused on the AR6 scenarios. These projections are developed under various scenarios, influenced by the conservation index. For this case study, both the most pessimistic scenario (SSP5-8.5) and a moderate scenario (SSP2-4.5) were considered.

4.6.2. Future climate trend analysis for Afif 1 Solar Park

Maximum Temperatures

As can be seen in the following figures, maximum temperatures are expected to increase significantly during the period studied (2014-2100)

The following graph shows the projected increase in yearly average maximum temperatures in the Ar Riyad province. It shows a significant increase for all scenarios. As it only shows the average maximum temperatures, it is important to note that absolute maximums are projected to reach values of approximately 50ºC.

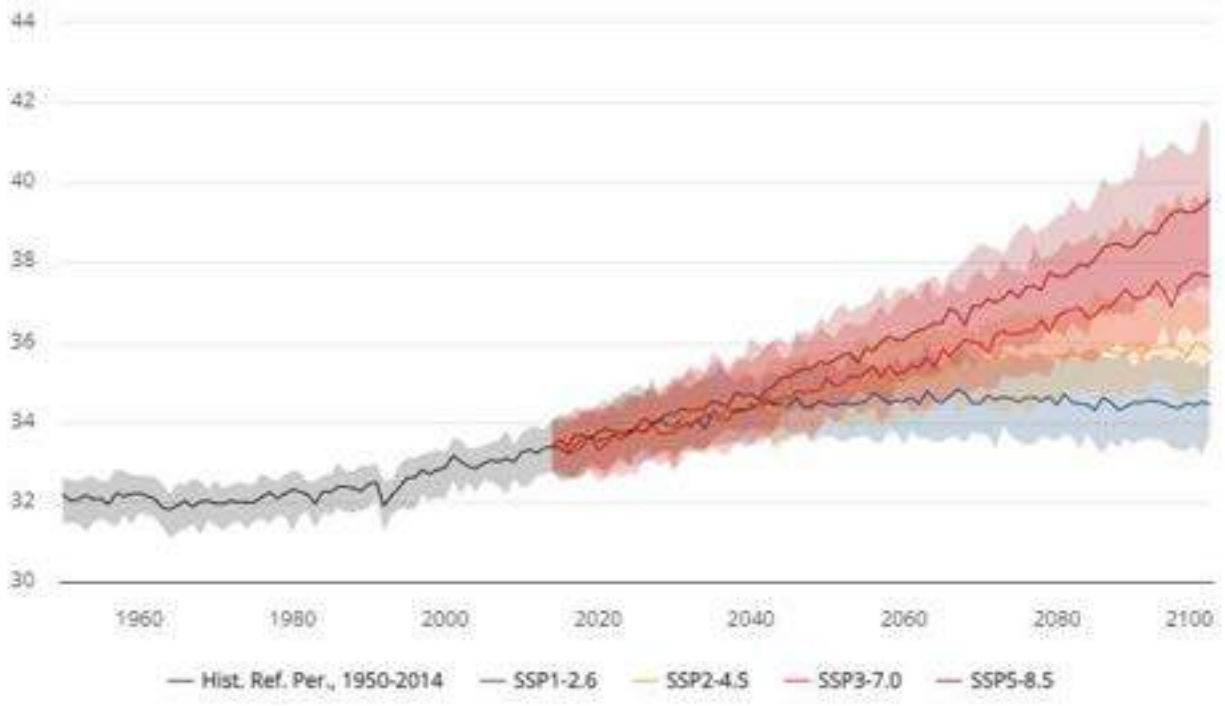


Figure 147. Projected average maximum temperature in Ar Riyad for all SSP scenarios (Reference period: 1950-2014). Source: World Bank

The accompanying figure presents data for scenarios SSP2-4.5 and SSP5-8.5. It forecasts an increase of 0.9 ºC by the near future (2040) under SSP2-4.5, while SSP5-8.5 anticipates a rise of 1.2 ºC for the same period. In the intermediate future, maximum temperatures are projected to continue rising, with an increase of 1.5 ºC under SSP2-4.5 and 2.5 ºC under SSP5-8.5. Furthermore, minimum temperatures are expected to escalate more significantly, with a rise of 3ºC in SSP2-4.5 and 4.3ºC in SSP5-8.5. By the year 2100, maximum temperatures could rise by up to 2.3 ºC in SSP2-4.5 and a substantial 6.1ºC in SSP5-8.5.

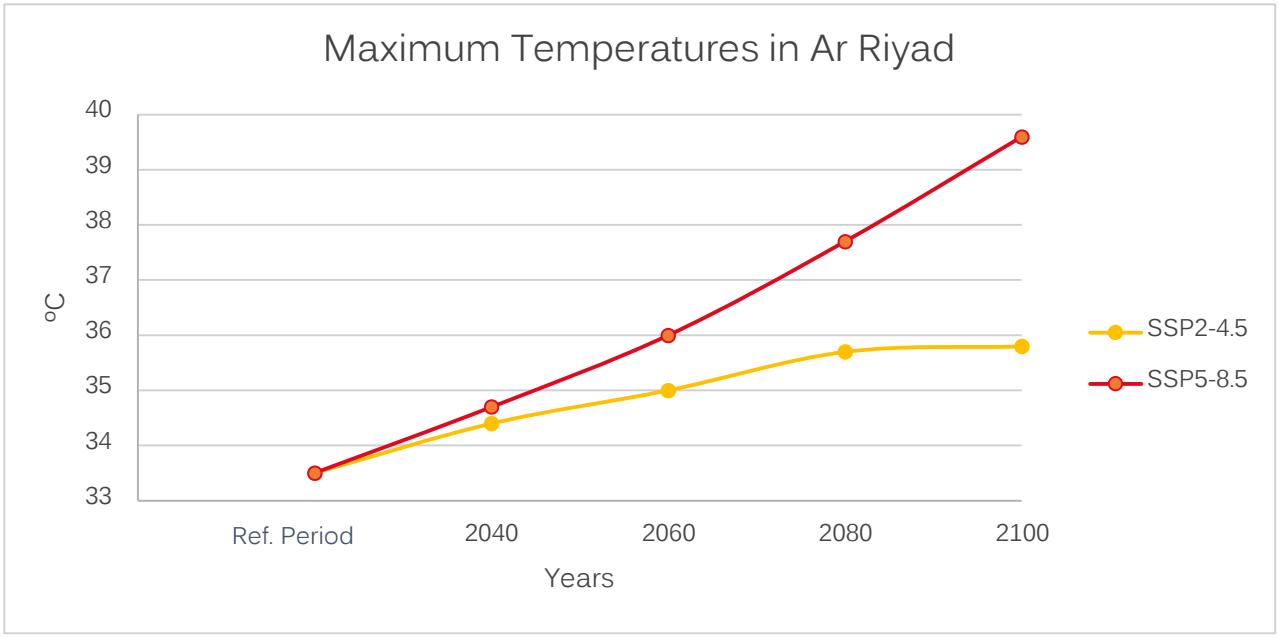


Figure 148. Projected maximum temperatures in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank

Temperature maximum	Ref. period	2040	2060	2080	2100
SSP2-4.5	33,5	34,4	35	35,7	35,8
SSP5-8.5	33,5	34,7	36	37,7	39,6

Figure 149. Table with projected maximum temperatures in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank

The following graphs illustrate the changes in maximum temperatures for the near, intermediate, and far future periods. These graphs clearly depict the monthly variations in temperature changes throughout the year.

These graphs demonstrate that the most significant changes in maximum temperatures occur during the summer months (June to September). They also show a continuous increase in temperature anomalies over time.

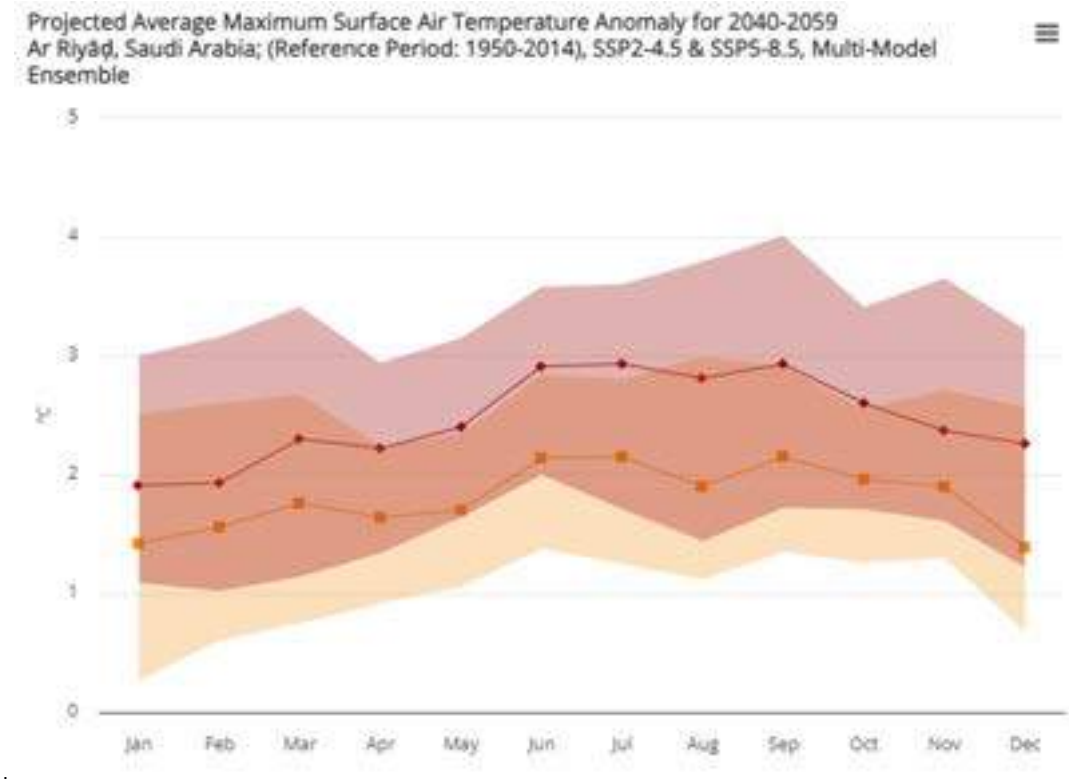


Figure 150. Projected Average Maximum Surface Air Temperature Anomaly for the 2040-2059 period (SSP2-4.5 and SSP5-8.5S).ource: World Bank

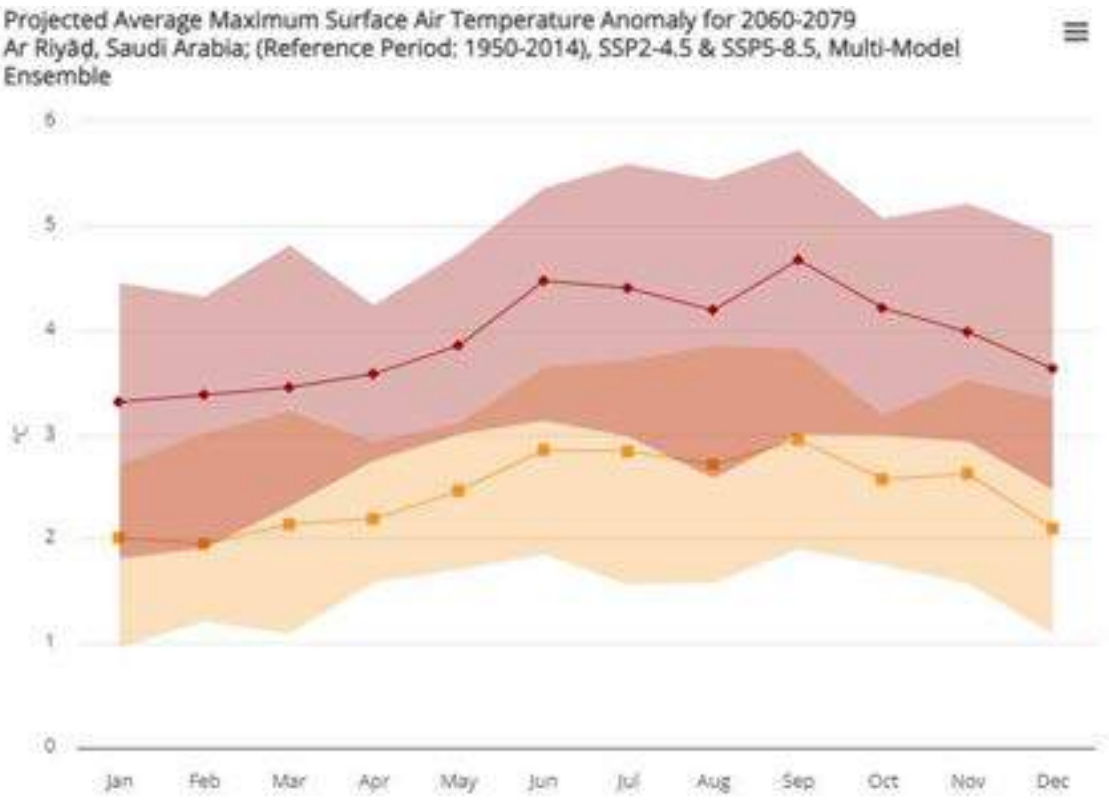


Figure 151. Projected Average Maximum Surface Air Temperature Anomaly for the 2060-2079 period (SSP2-4.5 and SSP5-8.5). Source: World Bank

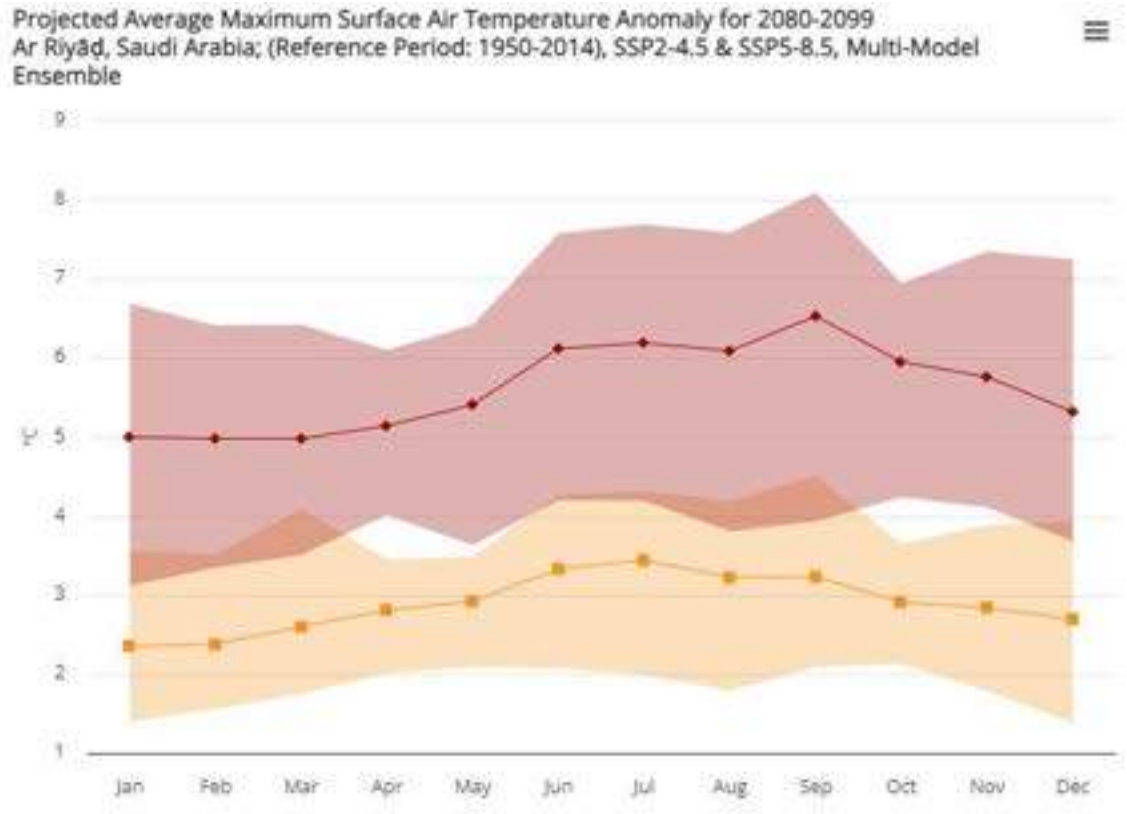


Figure 152. Projected Average Maximum Surface Air Temperature Anomaly for the 2080-2099 period (SSP2-4.5 and SSP5-8.5). Source: World Bank

Minimum temperature

The figures below demonstrate a significant expected increase in minimum temperatures during the period studied (2014-2100). The subsequent graph presents the projected yearly average increase in maximum temperatures for the Ar Riyad province.

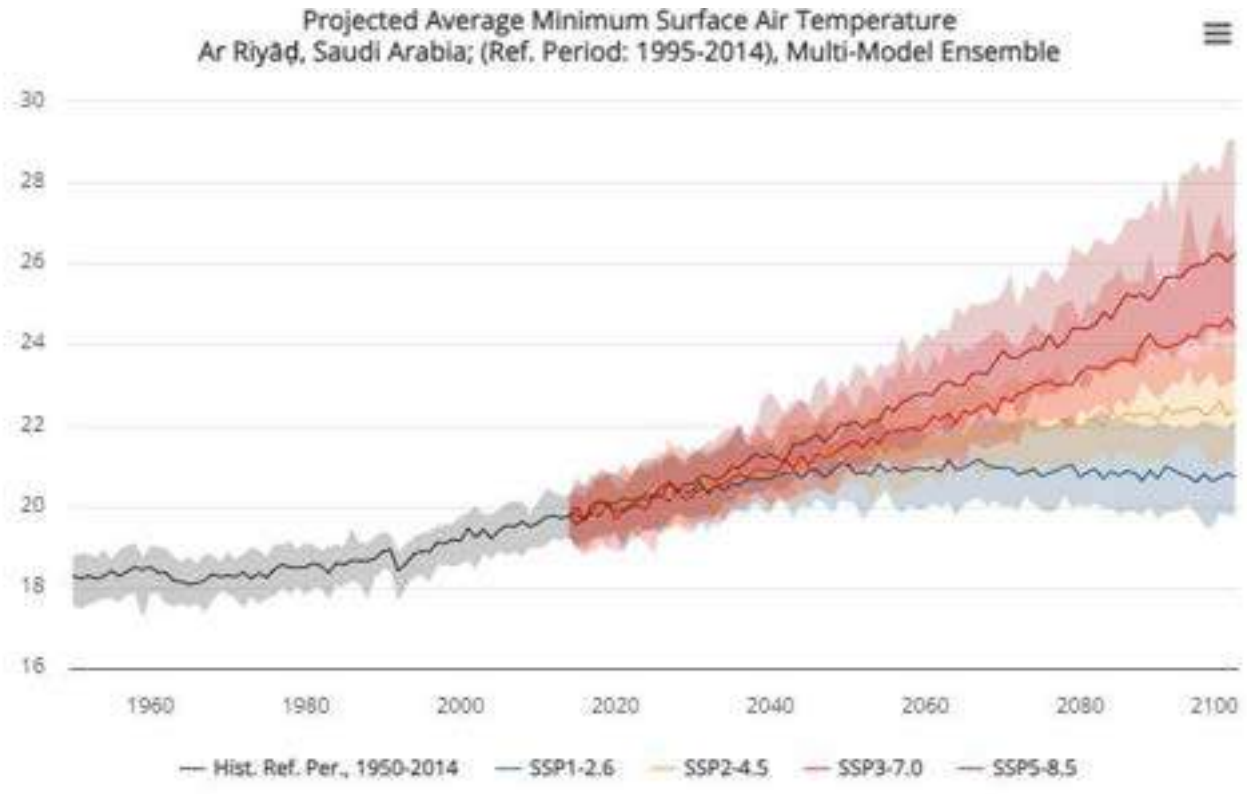


Figure 153. Projected average minimum temperature in Ar Riyad for all SSP scenarios (Reference period: 1950-2014. Source: World Bank

The figure only displays data for scenarios 4.5 and 8.5, predicting an increase of 0.9 ºC in the near future (2040) for SSP2-4.5, while SSP5-8.5 indicates an increase of 1.2 ºC for the same period.

For the intermediate future, minimum temperatures are projected to rise further, reaching 3ºC for SSP 4.5 and 4.3ºC for SSP 8.5.

By the year 2100, minimum temperatures are anticipated to increase by 4ºC for SSP 4.5 and 7.75ºC for SSP 8.5.

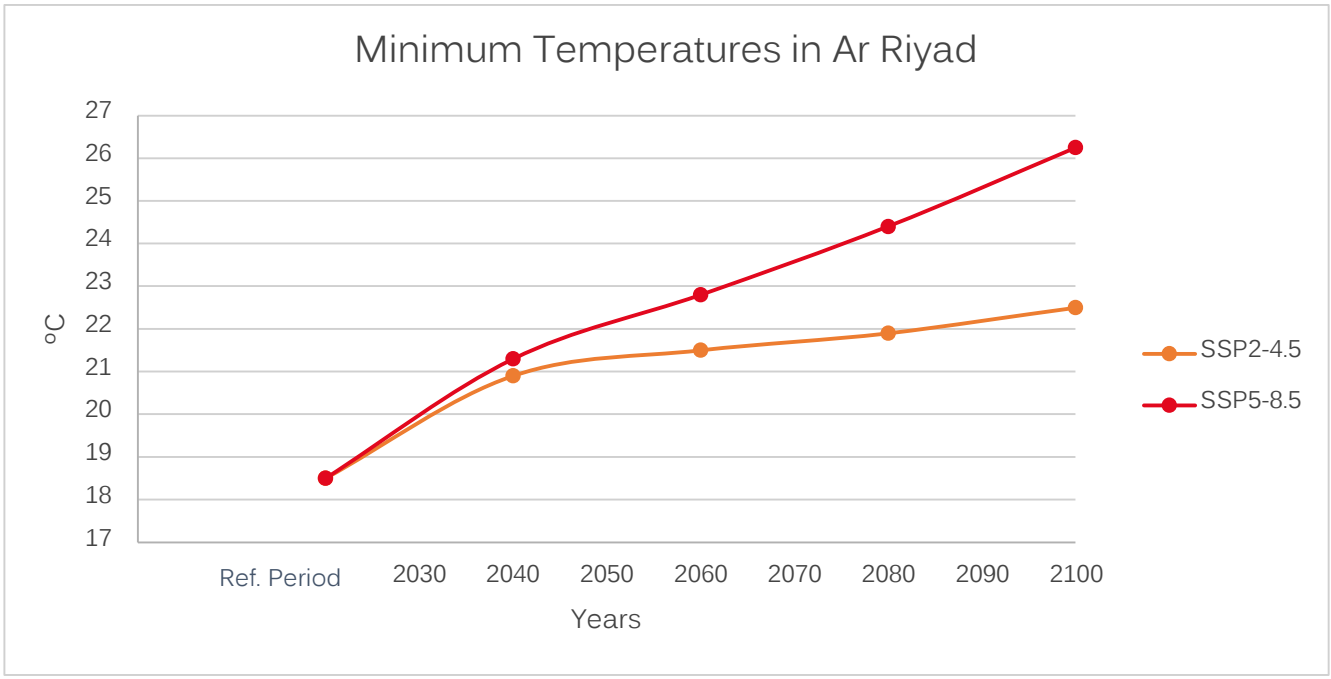


Figure 154. Projected minimum temperatures in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank

Temperature minimum	Ref. period	2040	2060	2080	2100
SSP2-4.5	18,5	20,9	21,5	21,9	22,5
SSP5-8.5	18,5	21,3	22,8	24,4	26,25

Figure 155. Table with projected minimum temperatures in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014.). Source: World Bank

The following graphs depict changes in minimum temperatures for the near, intermediate, and far future periods, clearly showing monthly temperature variations throughout the year.

These graphs highlight that the most significant changes in minimum temperatures will occur during the summer months (June to September), with anomalies expected to increase progressively over time.

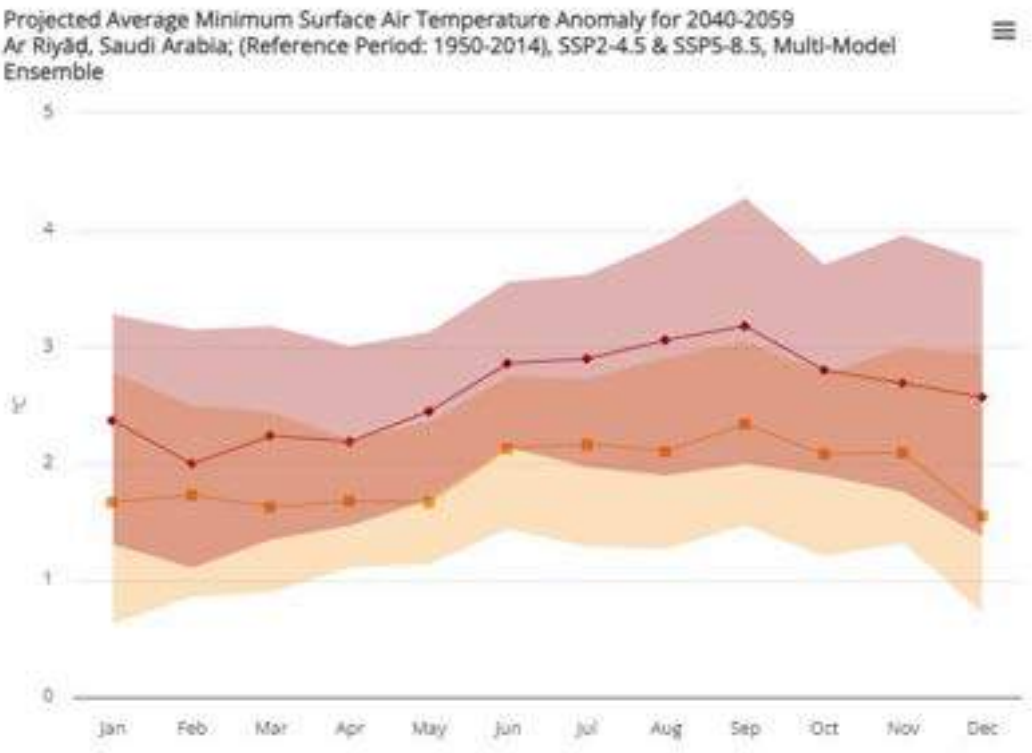


Figure 156. Projected Average Minimum Surface Air Temperature Anomaly for the 2040-2059 period (SSP2-4.5 and SSP5-8.5), Source: World Bank

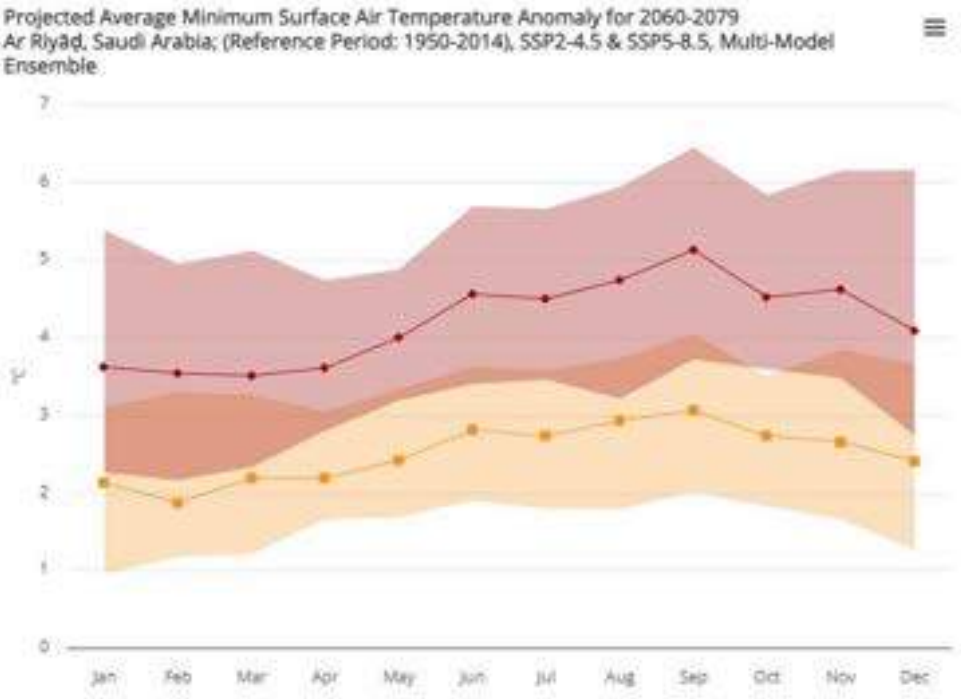


Figure 157 Projected Average Minimum Surface Air Temperature Anomaly for the 2060-2079 period (SSP2-4.5 and SSP5-8.5). Source: World Bank

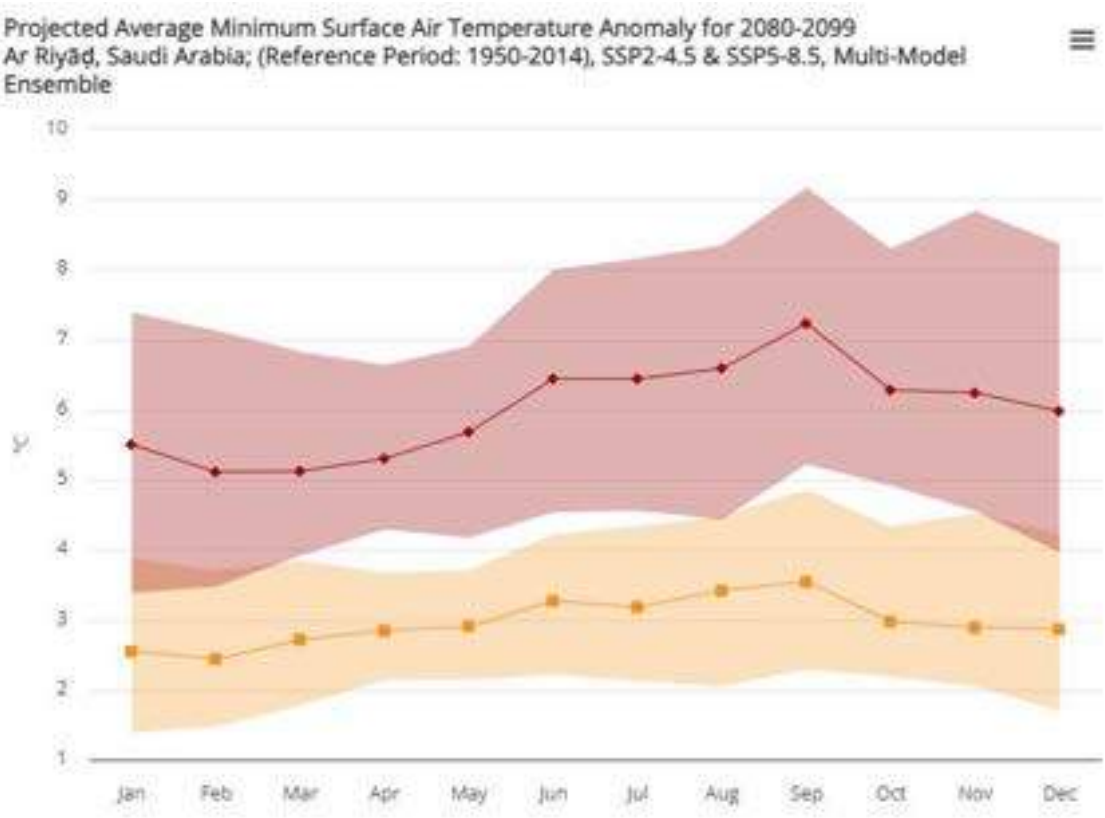


Figure 158. Projected Average Minimum Surface Air Temperature Anomaly for the 2070-2099 period (SSP2-4.5 and SSP5-8.5. Source: World Bank

Number of hot days per year (Tmax>40ºC)

The figure indicates a sharp increase in days with temperatures exceeding 40ºC in Ar Riyad for the period 2014-2100."

The subsequent graph projects an increase in yearly hot days in Ar Riyad. It reveals a significant rise across all scenarios, with SSP5-8.5 indicating an increase of 98 days by the year 2100.

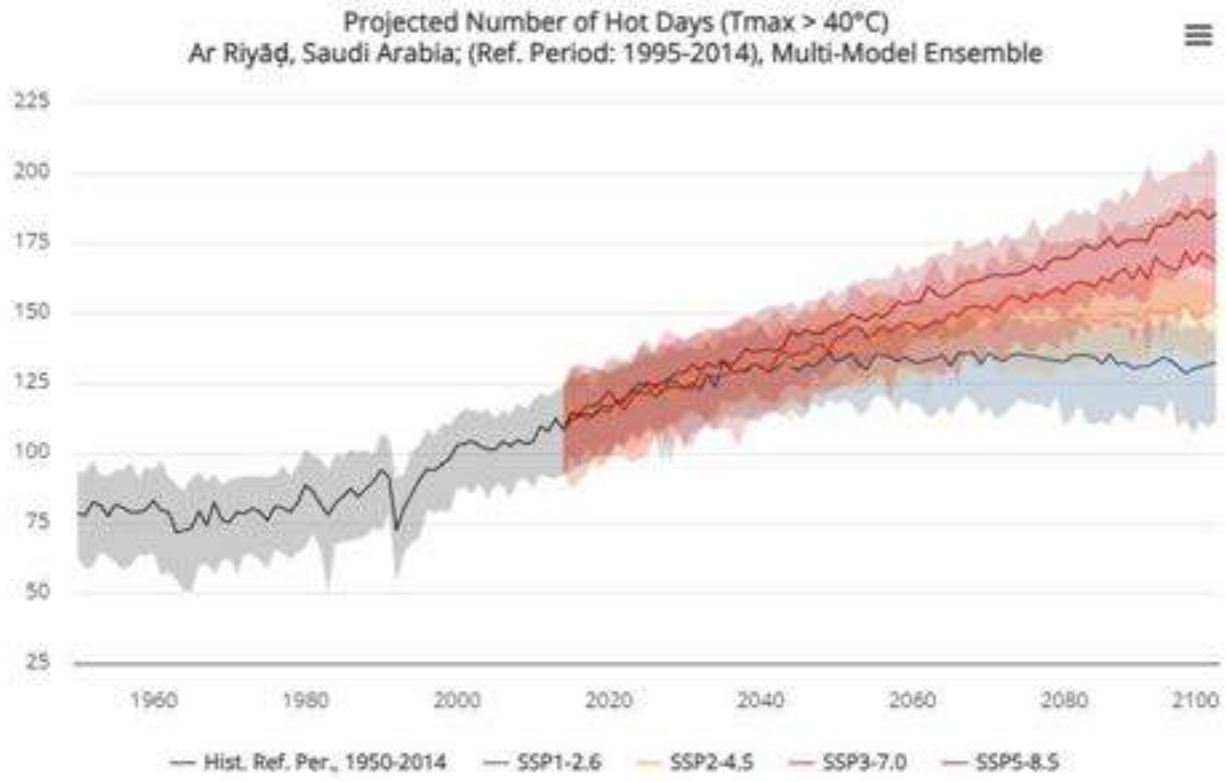


Figure 159. Projected hot days (>40°C) in Ar Riyad for all SSP scenarios (Reference period: 1950-2014. Source: World Bank

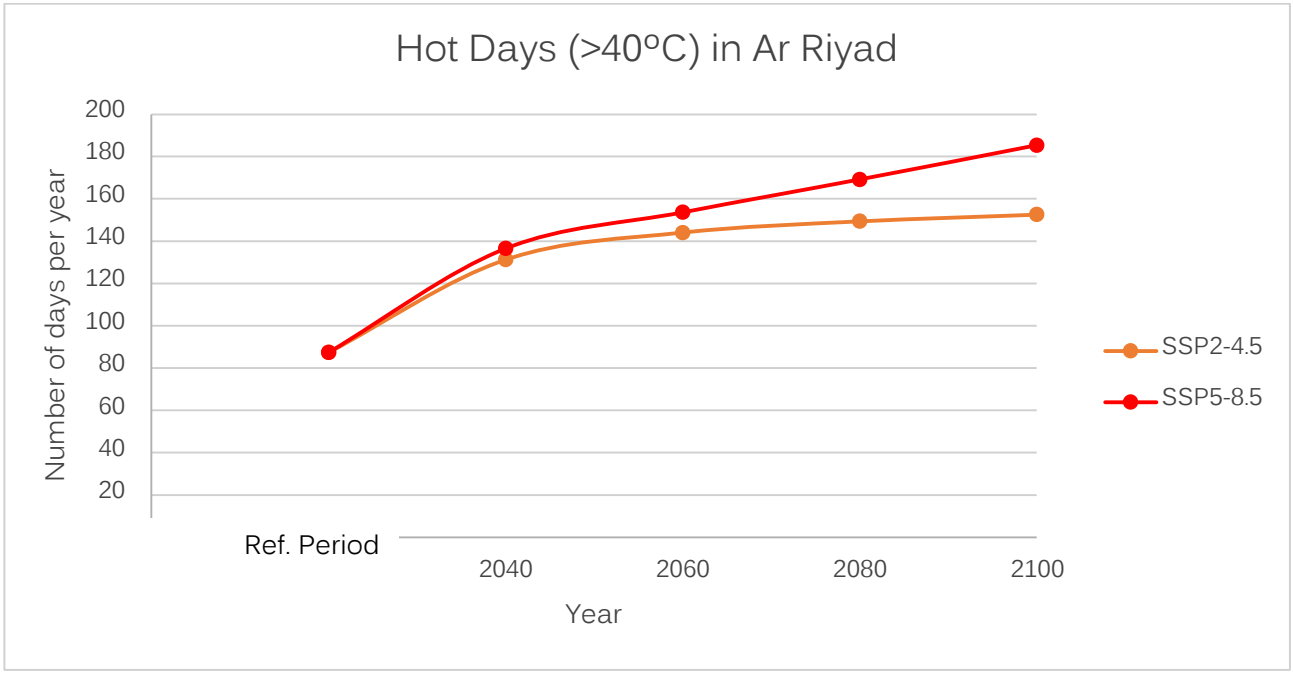


Figure 160 Projected hot days (>40°C) in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank

Hot Days (>40ºC)	Ref. period	2040	2060	2080	2100
SSP2-4.5	87,4	131,3	144,1	149,4	152,6
SSP5-8.5	87,4	136,6	153,7	169,2	185,4

Figure 161. Table with projected hot days (>40ºC) in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank

The following graphs illustrate how hot days over 40ºC will increase mainly before and after summer months, as days over 40ºC are already common. The months of May and September are where this increase will be the sharpest, with an increase of up to 18 days per month during the 2080 and 2100 period for SSP5-8.5.

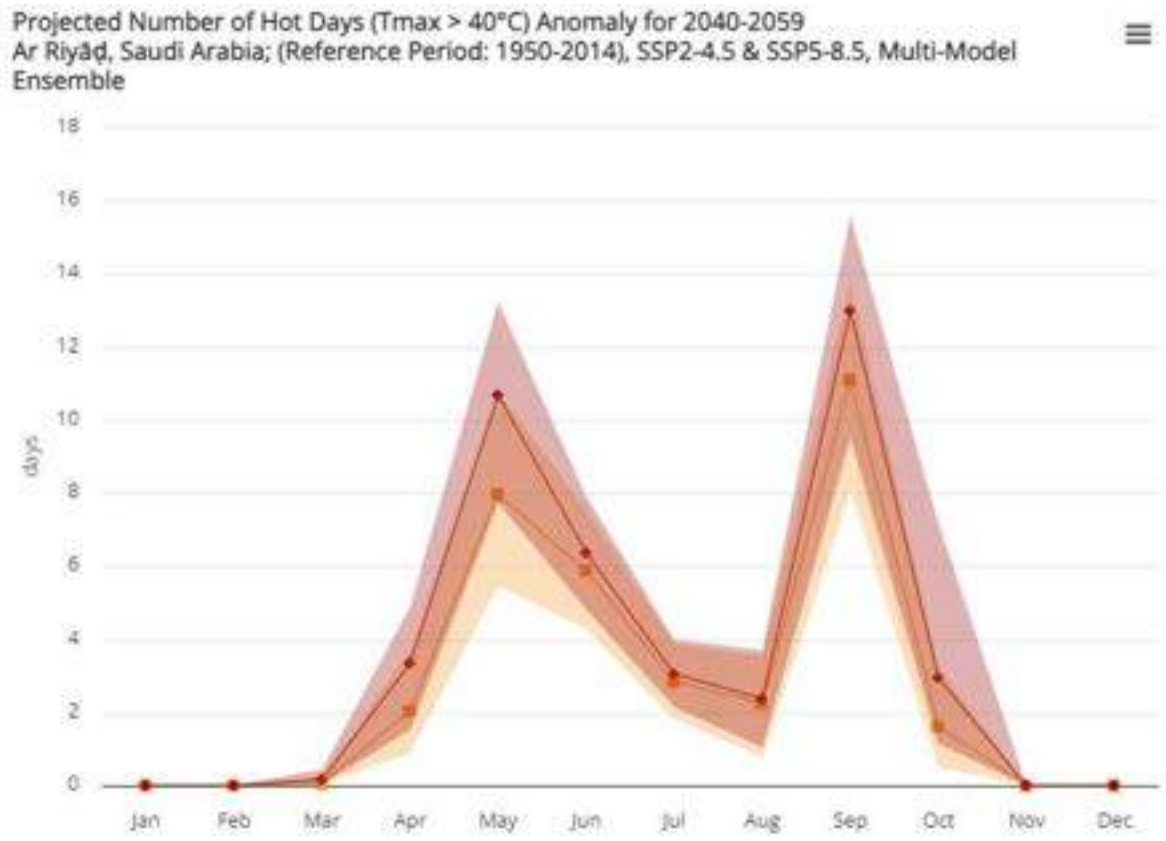


Figure 162. Projected Hot Days Anomaly for the 2040-2059 period (SSP2-4.5 and SSP5-8.5). Source: World Bank

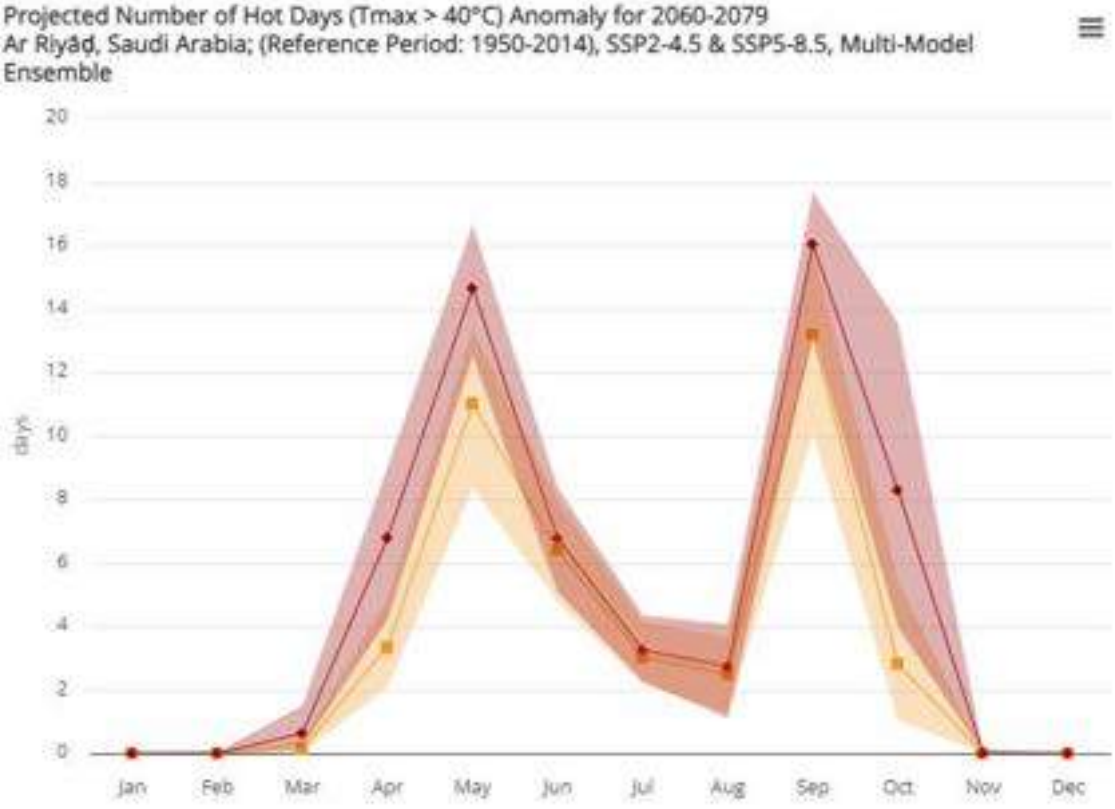


Figure 163. Projected Hot Days Anomaly for the 2060-2079 period (SSP2-4.5 and SSP5-8.5). Source: World Bank

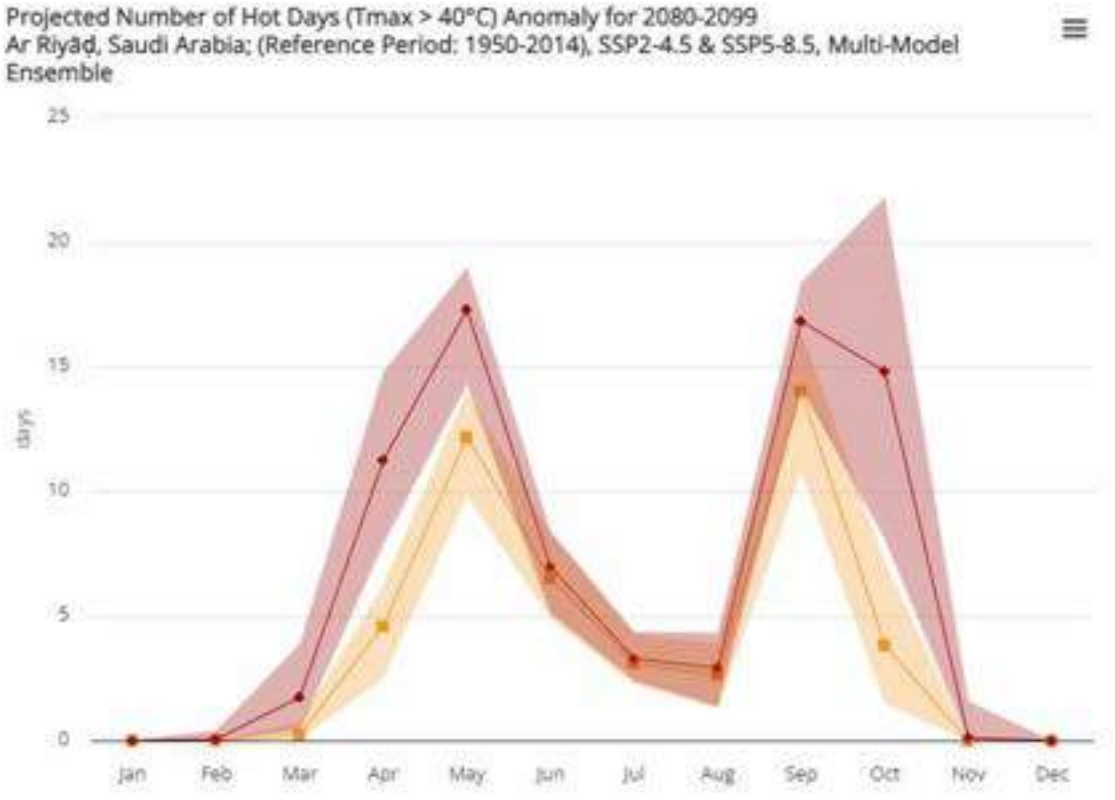


Figure 164. Projected Hot Days Anomaly for the 2080-2099 period (SSP2-4.5 and SSP5-8.5). Source: World Bank

Number of tropical nights per year (Tmin>29ºC)

The figures below indicate a significant expected increase in tropical nights during the period studied (2014-2100). Tropical nights are defined as nights with minimum temperatures exceeding 29ºC. The subsequent graph projects a marked increase in yearly tropical nights in Ar Riyad. This increase is significant across all scenarios.

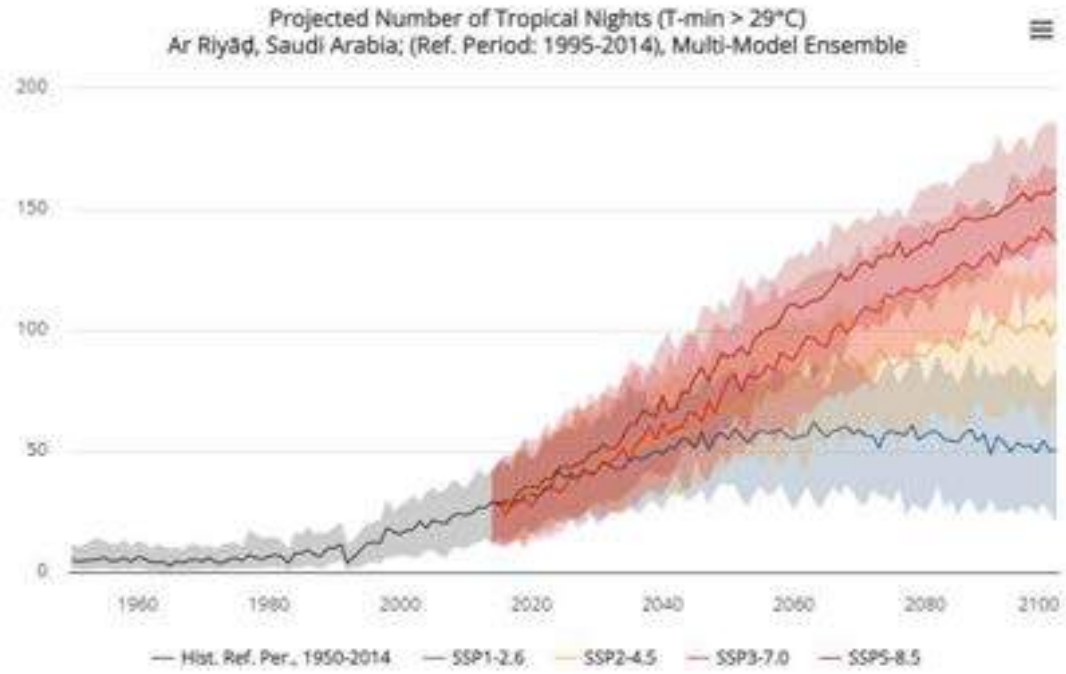


Figure 165. Projected number of tropical nights (Tmin >29ºC) in Ar Riyad for all SSP scenarios (Reference period: 1950-2014). Source: World Bank

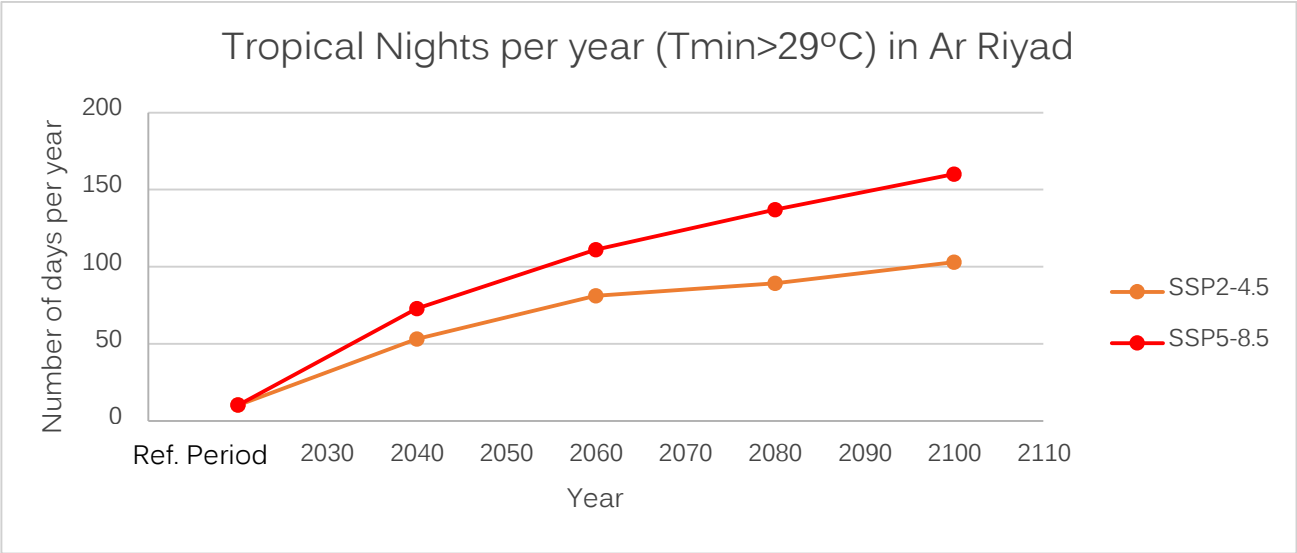


Figure 166. Projected tropical nights in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank

Number of tropical nights per year (Tmin>29ºC)	Ref. period	2040	2060	2080	2100
SSP2-4.5	10,25	53,07	81,1	89,2	102,9
SSP5-8.5	10,25	72,9	110,9	136,9	160

Figure 167. Table with projected tropical nights in Ar Riyad for SSP 2-4.5 and SSP 8.5 (Reference period: 1950-2014). Source: World Bank

"As indicated by the table above, tropical nights are projected to increase sharply under both SSP2-4.5 and SSP5-8.5 scenarios. Specifically, under SSP5-8.5 for 2100, nearly half of the year is expected to experience nights with temperatures over 29ºC."

"The subsequent graphs illustrate variations in tropical nights over the years for both SSP2-4.5 and SSP5-8.5. They reveal a clear trend of increasing tropical nights during the summer months (May to September) in the near future, with this increase extending into the far future.".

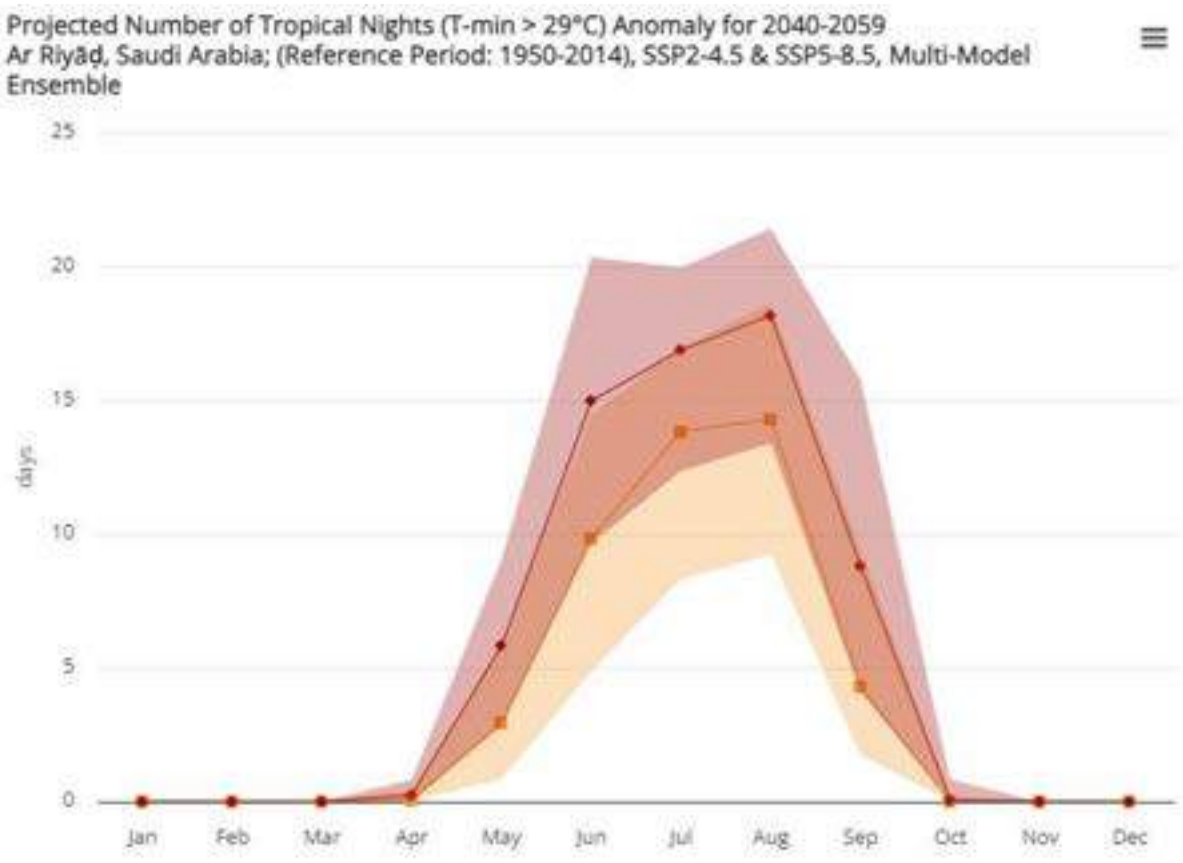


Figure 168. Projected Tropical Nights Anomaly for the 2040-2059 period (SSP2-4.5 and SSP5-8.5). Source: World Bank

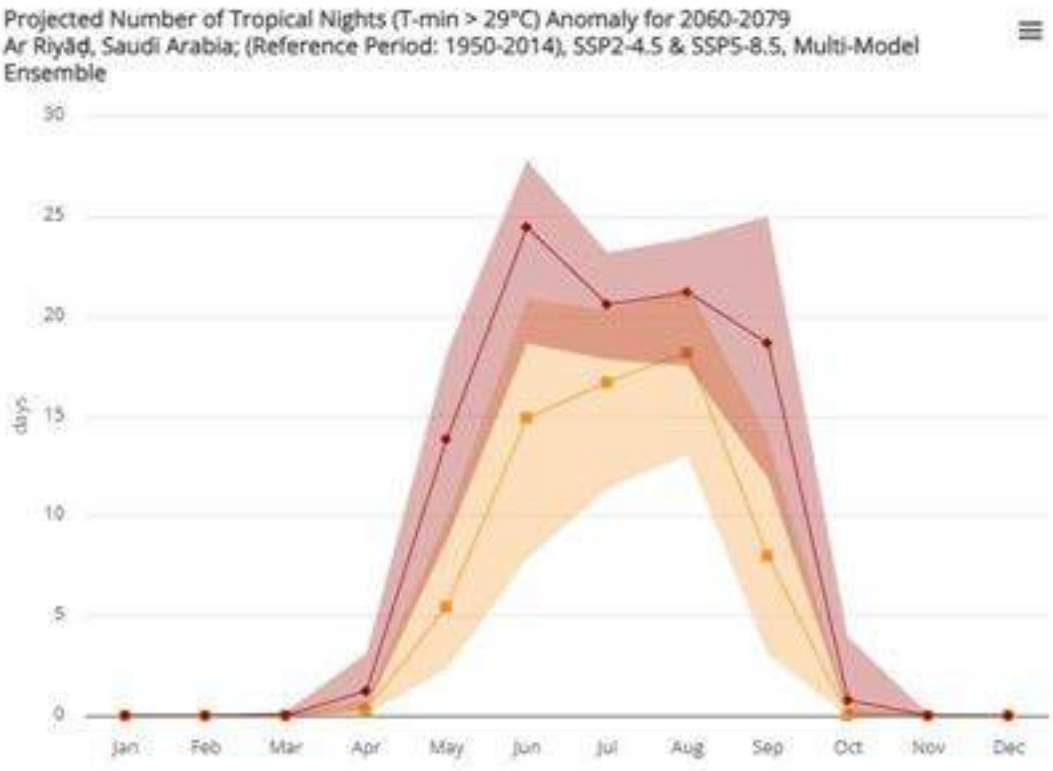


Figure 169. Projected Tropical Nights Anomaly for the 2060-2079 period (SSP2-4.5 and SSP5-8.5). Source: World Bank

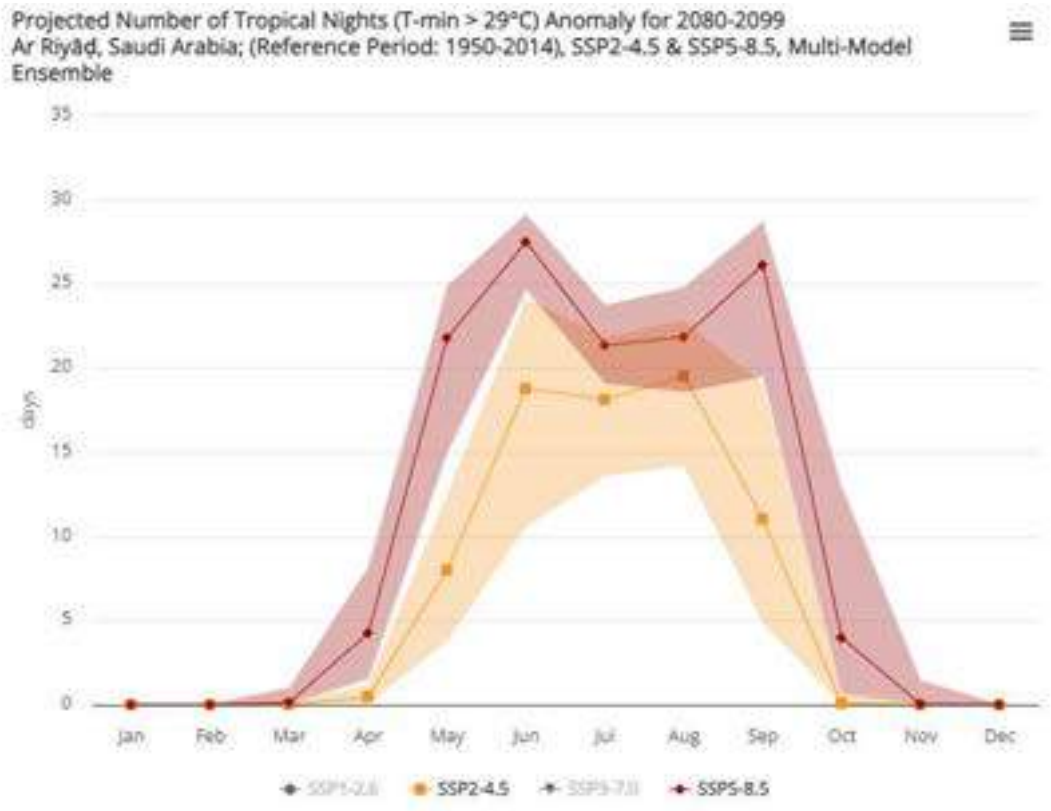


Figure 170. Projected Tropical Nights Anomaly for the 2070-2099 period (SSP2-4.5 and SSP5-8.5). Source: World Bank

4.6.3. Analysis of other climate related risks

There are additional climate-related risks not shown in the IPCC climate projections viewer, including floods, cyclones, and soil stability issues.

To assess these risks, TYPSA utilized the UNISDR (United Nations International Strategy for Disaster Reduction) mapping platform, based on the GAR Atlas (Global Assessment Report on Disaster Risk Reduction - Risk Data Platform). This platform provides information on climate-related risks not covered by the Climate Change Knowledge Portal.

The platform enables visualization of various natural threat layers and climate change impacts for the project's geographic location, identifying areas at high or moderate threat levels.

As noted in the GAR Atlas by the UN[34], the GIS layers are based on global data and models with coarse resolution. Similar to climate projection viewers, they offer general trends for analyzed threats, aiding decision-making process considerations.

The application includes a total of 21 layers covering both geophysical and hydrometeorological hazards spanning a range of sources and resolution levels that respond to the diverse nature of each hazard and the methods used to model them.

An overview of the GAR viewer data for the study area revealed information on variables absent in the World Bank viewer. While some selected threats lack probabilistic representation, they are quantified by the GAR using indices and historical data. Combined with simulation models, these provide threat and risk maps for various return periods. Our analysis of earthquakes, landslides, fires, and flooding indicated no potential risks for return periods up to 1000 years. The only risk which showed positive values were fires, which have shown an upwards trend. However, most of the terrain affected by the fires has been classified as bare.

Sea rise levels were also not a concern.

Although not included in the GAR Atlas viewer, an increase in the intensity and frequency of sandstorms is also a concern. As explained by Almujibah, H et al in 2022, higher average temperatures, more extreme heatwaves, and further reductions in precipitation, especially during the already parched summer months could mean more frequent dust storms and sandstorms, exacerbated by decreasing vegetation cover and soil moisture.

4.6.4. Conclusions

Summarizing the previous analysis of past, current and future climate, TYPSA has identified that the main climate threats to the project are those related to extreme temperatures, which, in some moments, are expected to surpass 45ºC. These temperatures might impact on the specifications of most materials used in construction, which must be adapted to these future conditions.

[34] *https://www.undrr.org/publication/gar-atlas-unveiling-global-disaster-risk*

Increased sandstorms can also have an impact on panel soiling, reducing production and increase the need of cleaning.

Furthermore, higher ambient temperatures could reduce the yield in the long term.

All those issues have been considered in the Consultant's project requirements by selecting the most suitable systems and designs to overcome and compensate this issue.

4.7. Future Activities within the geographic scope of the project

No information has been found about similar future projects in the same geographic scope.

4.8. Checklist of the project environment characteristics

A checklist is included below in relation to the characteristics of the environment, adapted from the European economic community check list (source: Guidance on EIA. June 2001. Environmental Resources Management) to the study area.

QUESTION	YES, or NO?

Question - Are there features of the local environment on or around the Project location which could be affected by the Project?
• Areas which are protected under international or national or local legislation for their ecological, landscape, cultural or other value, which could be affected by the project? No
• Other areas which are important or sensitive for reasons of their ecology e.g.
  • Wetlands, No
  • Watercourses or other waterbodies, No
  • Mountains, No
  • Forests or woodlands No
• Areas used by protected, important or sensitive species of fauna or flora e.g., for breeding, nesting, foraging, resting, overwintering, migration, which could be affected by the project? No
• Areas or features of high landscape or scenic value? No
• Routes or facilities used by the public for access to recreation or other facilities? No
• Transport routes which are susceptible to congestion, or which cause environmental problems? No
• Areas or features of historic or cultural importance? No
	NO, the project will not affect areas or features of environment, historic or cultural importance. Sensitive areas are located away from the project area. There are not key landscape features in the project site. There are not archaeological remains in the plot.

Question - Is the Project in a location where it is likely to be highly visible to many people?	NO, the project will be visible only from the road that connects routes 50 and 80 (Almardamah road) through the west limit of the Project site, adjacent to the plot.
Question - Is the Project located in a previously undeveloped area where there will be loss of greenfield land?	**YES,** the project will be located in an undeveloped area
Question - Are there existing land uses on or around the	**NO**

QUESTION	YES, or NO?
Project location which could be affected by the Project? For example: • Homes, gardens, other private property, • Industry, • Commerce, • Recreation, • Public open space, • Community facilities, • Agriculture, • Forestry, • tourism, • mining or quarrying	
Question - Are there any plans for future land uses on or around the location which could be affected by the Project?	NO
Question - Are there any areas on or around the location which are densely populated or built-up, which could be affected by the Project?	NO
Question - Are there any areas on or around the location which are occupied by sensitive land uses which could be affected by the Project? • hospitals, • schools, • places of worship, • community facilities	NO
Question - Are there any areas on or around the location which contain important, high quality or scarce resources which could be affected by the Project? For example: • groundwater resources, • surface waters, • forestry, • agriculture, • fisheries, • tourism, • minerals.	NO, the project will not adversely affect any resource.
Question - Are there any areas on or around the location of the Project which are already subject to pollution or environmental damage e.g., where existing legal environmental standards are exceeded, which could be affected by the project?	NO
Question - Is the Project location susceptible to earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions e.g., temperature inversions, fogs, severe winds, which could cause the project to present environmental problems?	NO, the project is not susceptible to natural disasters.
Question - Is the Project likely to affect the physical condition of any environmental media? • The atmospheric environment including microclimate and local and larger scale climatic conditions? • Water - e.g., quantities, flows or levels of rivers, lakes, groundwater. Estuaries, coastal waters, or the sea?	NO

QUESTION	YES, or NO?
• Soils - e.g., quantities, depths, humidity, stability, or erodibility of soils? • Geological and ground conditions?	
Question - Are releases from the Project likely to have effects on the quality of any environmental media? • Local air quality? No • Global air quality including climate change and ozone depletion? No • Water quality – rivers, lakes, groundwater. Estuaries, coastal waters, or the sea? No • Nutrient status and eutrophication of waters? No • Acidification of soils or waters? No • Soils. No • Noise? Yes. Temporary during construction • Temperature, light, or electromagnetic radiation including electrical interference? No • Productivity of natural or agricultural systems? No	There are areas around the project where noise or PM10 particles will be temporary increased during construction phase. There are not sensitive receptors
Question - Is the Project likely to affect the availability or scarcity of any resources either locally or globally? • Fossil fuels? • Water? • Minerals and aggregates? • Timber? • Other non-renewable resources? • Infrastructure capacity in the locality - water, sewerage, power generation and transmission, telecommunications, waste disposal roads, rail?	**NO**
Question - Is the Project likely to affect human or community health or welfare? • The quality or toxicity of air, water, foodstuffs, and other products consumed by humans? • Morbidity or mortality of individuals, communities, or populations by exposure to pollution? • Occurrence or distribution of disease vectors including insects? • Vulnerability of individuals, communities, or populations to disease? • Individuals' sense of personal security? • Community cohesion and identity? • Cultural identity and associations? • Minority rights? • Housing conditions? • Employment and quality of employment? • Economic conditions? • Social institutions?	**NO,** the project will positively affect the economy and employment, because of the people that will be hired during the construction and operation phases of the project.

Impact identification, analysis, and evaluation

5. Impact identification, analysis, and evaluation

5.1. The methodology used for impact identification, analysis, and evaluation

The ESIA process has considered the different elements of the proposed development and their effects on the environment and society. This process has incorporated significant interaction between the ESIA team and project design functions, thereby enabling a high level of mitigation to be incorporated into the fundamental design and implementation of the project. The major outputs of the ESIA process are the identification and assessment of environmental and social effects of the proposed project activities and the recommendation of mitigation measures to be implemented by Afif 1 Project to prevent or minimize such effects.

The ESIA methodology follows a structured process to identify all real and perceived environmental impacts that can result from the construction and operation of the project.

In summary, the EIA process has comprised the following steps:

- Definition of the proposed development across the various project phases and identification of the infrastructure, processes and activities that will be involved.
- Description of the existing geographical, environmental, social and policy contexts of the project site and its surrounds.
- Identification of impacts.
- Assessment of environmental and social impacts that may arise from the project activities and processes.
- Development of a framework environmental management plan (EMP) that identifies actions to be implemented to achieve commitments aimed at mitigating adverse environmental and social impacts. The framework EMP includes a program for monitoring to ensure the effectiveness of the commitments and mitigation measures proposed.

The environmental impact assessment follows a systematic and interactive process of examining the environmental, socio-economic, and regulatory context within which the project is situated. The key steps in environmental impact assessment (ESIA) process can be considered in terms of phases as described below:

1. Pre-study activities: such as screening, preliminary assessment, and scoping. This phase establishes the environmental and social considerations in advance of detailed studies.
2. The ESIA study: which results in the identification and assessment of impacts. Integral to this study is the development of measures to mitigate and reduce or remove adverse impacts.
3. The post-study stage: which includes steps undertaken for review and monitoring to ensure that mitigation measures are implemented, and that they are effective during construction and operations.

In summary, the ESIA follows a systematic and interactive process of examining the environmental, socio-economic, and regulatory context within which the project is situated.

A tested and universally accepted evaluation method for impact identification, analysis and evaluation has been used and has been focus on project construction, operation/maintenance, and decommissioning stages.

The methodology to assess 'effect significance' follows an International Best Practice based on the assumption that the significance of an impact on resources or receptors is considered to result from an interaction between three factors:

- The nature (negative or positive) and magnitude of the impact (i.e., a change in the environment, social and/or health baseline conditions).
- The number of resources or receptors affected (i.e., humans and the environment).
- The environmental value or sensitivity of those resources or receptors to the change.

A three-step approach has been used to determine the significance of environmental effects, as follows:

- Step 1 – Evaluation of value/sensitivity of resource or receptor.
- Step 2 – Assessing the magnitude of the impact on the resource or receptor.
- Step 3 – Determining the significance of effects (importance).

The significance of effects is a combination of the environmental value (or sensitivity) of a receptor or resource and the magnitude of the project impact value (change). In other words, it is this product of the impact acting on the receptor that produces an environmental effect.

The most important potential impacts have been described in terms of nature of impacts, magnitude, extent, timing, duration, reversibility, likelihood, and importance.

The risks of negative impacts have been also taken into account.

5.1.1. Identification and Evaluation of Receptors

Receptors are defined as:

- Elements of the environment that are of value to the functioning of natural systems (i.e., areas or elements of ecological, landscape or heritage value, species, habitats and ecosystems, soil, air and water bodies or land-use patterns).
- Human receptors, such as stakeholders (i.e., users of dwellings, places of recreation, places of employment, community facilities or household relocation) and human systems (e.g., employment

market, population disease susceptibility and disease communicability, exposure to toxicity of chemicals).

The environmental value (or sensitivity) of the resource or receptor will be defined by using the criteria below.

Value (sensitivity)	Description of Value
Very High	• High importance and rarity on an international scale and limited or no potential for substitution. • The receptor has already reached it carrying capacity, so any further impact is likely to lead to an excessive damage to the system that it supports. • Locations or communities that are highly vulnerable to the environmental impact under consideration or critical for society (e.g., indigenous peoples, hospitals, schools).
High	• High importance and rarity on a national scale, and limited potential for substitution. • The receptor is close to reaching it carrying capacity, so a further impact may lead to a significant damage to the system that it supports. • Locations or communities that are particularly vulnerable to the environmental impact under consideration (e.g., residential areas, vulnerable/marginalized groups).
Medium	• High or medium importance and rarity on a regional scale, limited potential for substitution. • The receptor is already significantly impacted, but it is not close to reaching it carrying capacity. Further impacts will get increase the stress of the underlying system, but evidence does not suggest that it is about to reach a critical point. • Locations or groups that are relatively vulnerable to the environmental impact under consideration (e.g., commercial areas).
Low (or Lower)	• Low or medium importance and rarity on a local scale. • The receptor is not significantly impacted and shows a large spare carrying capacity. Impacts are not likely to generate any noticeable stress in the underlying system. • Locations or groups that show a low vulnerability to the environmental impact under consideration (e.g., industrial areas).
Very Low	• Very low importance and rarity on a local scale. • The receptor is not impacted and shows a very large spare carrying capacity. Impacts are very unlikely to generate any noticeable stress in the underlying system. • Locations or groups that show a very low vulnerability to the environmental impact under consideration (e.g., industrial areas).

Table 51. Environmental value of receptor or resource

The existence of receptors that are legally protected (e.g., designated areas, protected habitats, or species) will be taken into consideration for the assessment of the sensitivity of the receptors.

The environmental value (or sensitivity) in general of the resource or receptor in the study area is Low.

No sensitive receptors were identified close to the project site except some **seasonal shepherds/herders and temporary settlements** whom main activity is grazing.

The project site itself is evaluated to have a minor ecological value. No ecological sensitive receptor close to the project activities was remarked.

No vegetation species recorded are listed as IUCN threatened species or as KSA High Conservation Priority (HCP) species.

Limited fauna species were observed during the site visit due to the lack of vegetation and key landscape features. Only one of them is classified as threatened or HCP species, the Steppe Eagle which is currently listed as Endangered according to the IUCN Red List of Threatened Species, also listed as a KSA High Conservation Priority species, and its local status is nonbreeding for the study area. The value for this species is high.

No live reptiles were recorded within the project area during the survey period, although some burrows of Spiny Tailed Lizard (STL) without any clear signs of activity (tracks) were observed. STL is listed as Vulnerable (V) according to UICN categories and is included in KSA HCP Species. The value for this species is medium.

5.1.2. Nature and Magnitude of Impacts

The following types of impacts have been considered according to its Nature:

- Positive Impacts – Impacts that have a positive, desirable, or favourable effect on the sensitive resources or receptors (e.g., landscape providing artificial habitat for a variety of species, creating jobs during the construction and/or occupation phases of a project).
- Negative Impacts – Impacts that are detrimental and have a negative influence on sensitive resources or receptors.

The Magnitude of the impact is defined where possible in quantitative terms. The magnitude of an impact has a number of different components, for example: the extent of physical change, the level of change in an environmental condition, its spatial footprint, its duration, its frequency and its likelihood of occurrence where the impact is not certain to occur. The criterion that has been used for assessing the magnitude of impacts includes the geographical scale of the impact, the permanence of impact and the reversibility of the impacted condition. A brief description of the magnitude of the impacts is provided in the table below.

Magnitude of Impact	Description of Magnitude
Major	*Adverse:* Loss of resource and/or quality and integrity; severe damage to key characteristics, features, or elements. A major impact is usually large scale, permanent and irreversible. *Beneficial:* Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality.
Moderate	*Adverse:* Significant impact on the resource, but not adversely affecting the integrity; Partial loss of/damage to key characteristics, features, or elements. Moderate impacts usually extend above the site boundary, and are usually permanent, irreversible, or cumulative. *Beneficial:* Benefit to, or addition of, key characteristics, features, or elements; improvement of attribute quality.

Magnitude of Impact	Description of Magnitude
Minor	*Adverse:* Some measurable change in attributes quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristic, features or elements. Minor impacts usually are only noticeable within the site and are temporary and reversible. *Beneficial:* Minor benefit to, or addition of, one (maybe more) key characteristics, features, or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring.
Negligible	*Adverse:* Very minor loss or detrimental alteration to one or more characteristics, features, or elements. *Beneficial:* Very minor benefit to or positive addition of one or more characteristics, features, or elements.
No change	No loss or alteration of characteristics, features, or elements; no observable impact in either direction.

Table 52. Criteria for magnitude of impacts

5.1.3. Extension of the Impact

Depending on the characteristics of the action, the extension of the area affected by the impact varies from a Punctual extension to a Total one.

Magnitude of Impact	Description of Extension
Local	The area affected by the impact is located in a specific zone or the impact partially affects a local area
Regional	The impact affects the Region.

Table 53. Criteria for extension of impacts

5.1.4. Timing between the action and its effect

The time elapsed between the occurrence of the action and the appearance of the effect varies according to the type of impact. Immediate to less than one year; Medium term, 1 to 5 years; Long term, more than 5 years.

Magnitude of Impact	Description of Timing
Short term	The effects of the action appear immediately or within 1 to 5 years.
Long term	The effects appear in more than 5 years. This attribute can also be considered within this category when the timing is inopportune in the sense that the action occurs at a critical time for the factor under consideration

Table 54. Criteria for timing of impacts

5.1.5. Duration of the effect from its appearance

This attribute is based on the time the effect would last from the occurrence of the corresponding action. It must be considered that the return to the initial conditions may be natural or by applying corrective measures.

Magnitude of Impact	Description of Duration
Temporal	The effects of the action last less than 10 years

Magnitude of Impact	Description of Duration
Permanent	The effects of the action last more than 10 years

Table 55. Criteria for duration of impacts

5.1.6. Reversibility of the effect

This attribute indicates the possibility to reconstruct by natural means, without applying corrective measures, the initial conditions after the effect has occurred.

Magnitude of Impact	Description of Reversibility
Reversible	The alteration produced by the impact can return to natural initial conditions in a short or medium term
Irreversible	The alteration of the initial conditions caused by the impact is irrecoverable.

Table 56. Criteria for reversibility of impacts

5.1.7. Criteria for Likelihood of Occurrence of Environmental and Social Effects

'Event related impacts' are potential unplanned impacts that are dependent on the occurrence of an event that has a finite probability such as an accidental, uncontrolled release of hydrocarbons that might occur under non-routine operating condition. Because event-related impacts may not occur, assessment of potential impacts that are event-related may take into consideration the **'likelihood of occurrence· (**See table below).

Likelihood of an unplanned event can be derived from historical information, modelling, industry data, stakeholder interviews and professional judgment. In addition, likelihood considers anticipated or planned mitigation measures, engineering controls and procedures in place to prevent or reduce the probability of the identified event taking place.

Magnitude of Impact	Description of Likelihood
Likely	The consequence can reasonably be expected to occur on this project during the lifecycle of the facility.
Occasional	The consequence may occur on this project during the lifecycle of the facility.
Seldom	The consequence could occur on this project during the lifecycle of the facility but only under exceptional conditions.
Unlikely	The consequence has occurred in the industry in the past but is not likely to occur on this project during the lifecycle of the facility (e.g., construction, operation, decommissioning).
Remote	The consequence has occurred once or twice in the industry

Table 57. Criteria for likelihood of impacts

5.1.8. Determination of Significance of Effects. The Importance of Impacts

The significance of effects is a combination of the environmental value (or sensitivity) of a receptor or resource and the magnitude of the project impact value (change). In other words, it is this product of the

impact acting on the receptor that produces an environmental effect. Table below shows the criterion used for determining the significance of environmental effects.

		Magnitude of impact (degree of change)				
		No change	Negligible	Minor	Moderate	Major
Sensitivity of Receptor	Very High	Neutral	Minor	Moderate or Major	Major	Major
	High	Neutral	Minor	Minor or Moderate	Moderate or Major	Major
	Medium	Neutral	Negligible or Minor	Minor	Moderate	Moderate or Major
	Low	Neutral	Negligible or Minor	Negligible or Minor	Minor	Minor or Moderate
	Very Low	Neutral	Negligible	Negligible or Minor	Minor	Minor

Table 58. Criteria for determining significance of effects (the importance of impacts)

Note: All predicted impacts with a beneficial impact (positive impacts) will be colour coded dark green. Definitions of each significance categories are provided below.

Significance Category	Criteria
Major	Permanent widespread or Persistent, regional effects that cannot be remediated but maybe compensable. Only adverse effects are assigned this level of importance as they represent key factors in the decision-making process. Effects are associated with sites and features of national or regional importance. Effects exceed statutory limits. Mitigation measures are unlikely to remove such effects.
Moderate or Major	Permanent, local or persistent, widespread effects that may be managed are likely to be compensable. Important considerations at a local scale but, if adverse, are potential concerns to the project and may become key factors in the decision-making process. Mitigation measures and detailed design work are unlikely to remove all of the effects upon the affected communities or interests.

Significance Category	Criteria
Moderate	Long-term, local or medium-term, widespread effects that can be managed, mitigated or remediated or may be compensable. Moderate impacts usually extend above the site boundary, and are usually permanent, irreversible, or cumulative. These effects, if adverse, while important at a local scale, are not likely to be key decision-making issues. Nevertheless, the cumulative effect of such issues may lead to an increase in the overall effects on a particular area or on a particular resource. They represent issues where effects will be experienced but mitigation measures and detailed design work may ameliorate or enhance some of the consequences upon affected communities or interests. Some residual effects will still arise.
Minor	Medium-term, local or short-term widespread effects that can be easily managed, mitigated or remediated and unlikely to require compensation. Local issue unlikely to be of importance in the decision-making process. Effects do not exceed statutory limits. Nevertheless, they are of relevance in enhancing the subsequent design of the project and consideration of mitigation measures. Minor impacts usually are only noticeable within the site and are temporary and reversible.
Negligible	Minimal or no detectable effects, Effect that is beneath the level of perception, within normal bounds of variation or within the margin of forecasting error. No mitigation is required.
Neutral	No effect. No mitigation is required.

Table 59. Definition of significance of effects (Importance)

The significance of the effect (importance) is determined by comparison, wherever possible with company, locally, nationally, or internationally accepted standards. If no standards are available then it is necessary to develop project specific limits, based on guidance or best practice, as necessary. Such standards or limits are referred to as the **Significance Threshold**. If the size and type of effect is greater that the significance threshold, then this is termed a **Significant Effect**. Potential significant effects need to be avoided and are therefore prioritized by identifying mitigation measures to reduce the effect to an acceptable level. Significant effects are considered 'Major' or 'Moderate'.

5.1.9. Risk Matrix

A risk matrix has been developed for negative impacts, combining the significance of the effect with the likelihood factor.

RISK		Significant of effects					
		Major	Moderate or Major	Moderate	Minor	Negligible	Neutral
Likelihood	Likely	Very High	Very High	High	High	Medium	Medium
	Occasional	Very High	High	High	Medium	Medium	Low
	Seldom	High	High	Medium	Medium	Low	Low
	Unlikely	High	Medium	Medium	Low	Low	Very Low
	Remote	Medium	Medium	Low	Low	Very Low	Very Low

Table 60. Risks Matrix for Negative impacts

The risks for negative impacts have been classified as:

- Very High: Is Intolerable and the associated risk is eliminated or substituted with an inherently safer option.
- High: Probably require further design or planning and the associated activity should be revised through further engineering designs or identified risks managed using a specific management plan to mitigate potential risks
- Medium: Require Best Practice Controls to proceed. This means that for the associated activity, mitigation measures and best practice operational controls should be applied for the Activity to be considered as Tolerable.
- Low: Is considered Tolerable but may still need to have best practice applied to them to ensure they comply.
- Very Low: Is considered Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2. Analysing and evaluating the potential impacts that are expected to be achieved during the different phases of the project

This chapter contains the identification and analysis of key effects of the project on the following aspects: natural vegetation cover, terrestrial biodiversity fauna & flora, air quality, noise & vibration, odour, surface water & groundwater quality and availability, hydrology and flood risk, soils quality, health & safety, landscape and visual comfort, land use, waste generation, glint and glare, climate change, economic and social aspects, traffic and transport, archaeological and cultural heritage and unplanned events.

5.2.1. Natural Vegetation Cover. Impact assessment

There is scarce vegetation in the project site. Only one tree species (*Acacia tortilis).* was encountered during field survey (Least Concern according to UICN) These trees have been preserved to avoid impacts. Where disturbances cannot be avoided, relocation of plants have been considered.

The vegetation distribution on the area is not uniform. There are in some places with vegetation cover and some other places with total absence of vegetation. Most of the species will be preserved. The trees to be removed will be conserved and replanted. The impact is assessed to be minor, and the likelihood is occasional then the risk is evaluated to be “Medium”.

The impact on vegetation during construction phase (habitat loss, habitat degradation and disturbance) is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Minor.

Extent: Local.

Timing: Short-Term.

Reversibility: Irreversible.

Duration: Temporal.

Likelihood: Occasional.

Potential Impact Significance: Negligible or Minor

Risk: Medium.

The significance of the impact is Negligible or Minor, The Risk Is considered Medium, require Best Practice Controls to proceed. Mitigation measures (conservation of trees, relocation of affected trees, restauration of degraded areas, etc.) and best practice operational controls described in section 6 will be applied for the Activity to be considered as Tolerable. **The impact is acceptable after that mitigation measures are applied.**

Due to the minimal earthworks, it is not foreseen affection to the flora by dust.

5.2.1.1. Operation phase

It is expected that the effect on plants and vegetation on the site to be minimal. As such, the only activities that could negatively affect the environment of the site would be through indirect project activities, related to poor management practices in any project area. Poor management practices are considered: damage surrounding vegetation and transit with equipment & vehicles out of the stablished paths.

The impact on vegetation during operation phase (vegetal cover removal) is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible or Minor.

Extent: Local.

Timing: Long-Term.

Reversibility: Irreversible.

Duration: Temporal.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor

Risk: Low/Very Low.

The significance of the impact is Negligible or Minor, The Risk Is considered Low/Very Low. Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.1.2. Decommissioning

Potential impacts associated with the decommissioning phase are the following:

- Destruction of vegetation cover, bad manipulation of equipment.

These impacts will be remote and incidental.

5.2.1.3. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with vegetation cover, during construction, operation, and decommissioning phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Vegetation cover	Destruction of vegetation cover due to earthworks, excavation, levelling.	Negligible or Minor	Occasional	Medium
Operation				
Vegetation cover	Destruction of vegetation cover due to poor management practices	Negligible or Minor	Remote	Low/Very Low
Decommissioning				
Vegetation cover	Destruction of vegetation cover due to bad manipulation of equipment	Negligible or Minor	Remote	Low/Very Low

Table 61. Risk Assessment Summary for vegetation cover,

5.2.2. Terrestrial Biodiversity. Fauna & Flora. Impact assessment

Surveys have taken place to identified protected species of flora and fauna, and land of high ecological value. No invasive or injurious species have been recorded.

The survey data has reflected the environmental features and other features as observed at the time of the survey:

- The area is poorly vegetated, with scarce tree specimens found during the field survey. The site has low flora coverage, with the sandy and gravel plain biotopes almost completely devoid of vegetation. A total of just five flora species were recorded at the Project Site, one of which, the *Acacia tortilis*, is listed as Least Concern (LC) according to IUCN categories. None is included in KSA HCP Species.
- Fauna is scarce and with a limited richness and abundance because of the ecosystem conditions of the study area. Limited fauna species were observed (few mammals and birds) during the site survey, due to, at least partially, the lack of vegetation and key landscape features.
- Four mammals were recorded during the survey (camels, goats, sheep, and a cat), none of them are classified as threatened or HCP species. No species of bats were recorded onsite during the site survey. The habitats identified in the study area are not optimal for bat species. The project site is settled in a low richness area of mammals according to the Digital Observatory for Protected Areas.
- There are not Important Bird and Biodiversity Areas (IBAs) in the project site or vicinity. The nearest IBAs - Mahazat As-Sayd -SA019 is located approximately 166 km far from the project site, southwest direction. The project site does not fall in one of the main corridors of the migratory birds. Ten bird species were recorded during site survey. Only one of these ten, the Steppe Eagle (observed due to the presence of a dumping site near Afif city, 18 km away from the project site) is currently listed as Endangered according to the IUCN Red List of Threatened Species, also listed as a KSA High Conservation Priority species, and its local status is nonbreeding for the study area., The rest of the species are categorized as Least Concern (LC) according to IUCN classification. Usual mitigation measures in design and operation will be more than enough to minimize the impact of the project on the birds.

The project site is settled in a low richness area of birds according to the Global Biodiversity Facility (GBIF) so the occurrence of this taxa is scarce probably because of the absence of wet ecosystems and the low vegetation coverage.

- No live reptiles were recorded within the project area during the survey period, although some burrows of Spiny Tailed Lizard (STL) without any clear signs of activity (tracks) were observed. STL is listed as Vulnerable (V) according to UICN categories and is included in KSA HCP Species.
- No Key Landscape Features have been found in the study area as ecologically important for flora or fauna.

The assessment methodology has been the following:

- Examination and discussion of the baseline existing conditions.
  To assess the sensitivity of vegetation cover, fauna, and its management, it has been considered that species counted the area and their status at International and KSA level have been a key factor.
- The following hierarchy have been followed when managing negative impacts of the site preparation and construction works:
  1. Avoid negative impacts on habitats and features of ecological value of the site. If it is not possible to avoid negative impacts, then:

  2. Protect habitats and features of ecological value from damage in accordance with best practice guidelines during development works. If it is not possible to avoid all negative impacts or to protect habitats and features of ecological value, then:

  3. Reduce, limit or control negative impacts as far as possible. Where it is not possible to avoid, protect, limit, or control the negative impacts on features of ecological value on site, then:

  4. Compensate to ensure the existing ecological value.

Acacia tortilis, listed as Least Concern (LC) according to IUCN categories, have been taken into consideration during development and construction. These trees have been preserved to avoid impacts. Where disturbances cannot be avoided, relocation of plants have been considered.

Regarding avifauna, the vulnerability of the Steppe Eagle to collision incidents with overhead lines has been considered and incorporate steps to protect.

With regard to reptiles, although no live reptiles were recorded within the project area, conservation measures in situ have been incorporated to protect HCP species. Where in situ conservation is not possible, trap and relocate HCP species have been considered.

Impacts have been assessed in the context of the described baseline conditions within the Area of Influence during the lifetime of the development. Impacts have been considered in two stages: the construction phase and the operation phase.

Construction phase impacts are predominantly concerned with site clearance and construction activities and include, but are not limited to:

- Habitat loss, habitat degradation and disturbance. Collision risk of fauna with site vehicles. Hunting. Fauna disturbance by the increase of noise levels and vibration.
- Introduction or spread of invasive species (flora and fauna).

Operation phase impacts which will be considered relevant to ecology include, but are not limited to:

- Habitat fragmentation. Barrier effect between habitats.
- Electrocution risk from overhead transmission lines (associated facilities off-site); and Collision risk with maintenance vehicles and fence. Increase of Birds' mortality.
- Introduction or spread of invasive species (flora and fauna).

5.2.2.1. Construction phase

Habitat loss, habitat degradation and disturbance

Prior to the start of the works, the presence of HCP bird species in the surroundings of the infrastructures will be checked; in the event that nuptial flights or nesting are detected in the area, the calendar of the work must be readjusted in order not to affect its reproduction. In addition, the potential presence of HCP reptiles species in the surroundings of the infrastructures will be checked; in the event that nesting are detected in the area, the calendar of the work must be readjusted in order not to affect its reproduction.

Potential impacts on fauna during construction will be limited to the direct loss of habitat because of the footprint of the plant and the construction laydown area as well as disturbance and/or damage to habitats and species because of construction activities e.g., movement of vehicles and construction workers to and from the site.

Construction vehicles including delivery trucks and minimal excavation equipment may increase noise disturbance. Heavy duty machinery and vehicular movement, friction between vehicles and the road surface, driver behaviour, vehicles' horns, resonance of traffic and piling increase ambient noise levels and vibration that may disturb fauna life.

There are no special habitats for endangered fauna in the site. There are not sensitive habitats within the PV site that would need to be protected. There is not land with high ecological value.

Therefore, although a large area of habitat will be permanently lost the overall significance of the impact is low due to the low conservation value of the habitats within the site area.

There will be no overall loss of ecological value on the site as a result of activities to avoid, reduce, limit and control for impacts in line with the hierarchy set out in the assessment criteria. The project has avoided to affect areas with presence of protected flora and fauna.

The impact on fauna and biodiversity during construction phase (habitat loss, habitat degradation and disturbance) is considered:

Nature: Negative.

Sensitivity of receptor: Low. Only Steppe Eagle is considered as high value but is nonbreeding in study are and STL (not observed during the field survey) is considered as medium value and this species, if it is found in the study area, will be relocated.

Magnitude: Minor.

Extent: Local.

Timing: Short-Term.

Reversibility: Irreversible.

Duration: Temporal.

Likelihood: Occasional.

Potential Impact Significance: Negligible or Minor

Risk: Medium.

The significance of the impact is Negligible or Minor, The Risk Is considered Medium, require Best Practice Controls to proceed. Mitigation measures (conservation of key ecological features, restauration of degraded areas, spiral bird protector devices in transmission lines, implementation of STL Relocation Plan, etc.) and best practice operational controls described in section 6 will be applied for the Activity to be considered as Tolerable. **The impact is acceptable after that mitigation measures are applied.**

Measures taken to control loss of biodiversity will include clearing and grading the ground surface within approved work limits, stripping the topsoil layer from the subsoil, stockpiling the removed soil in approved areas to be retrievable for landscaping and site restoration around the building structure, clearing the nearby drainage systems and replanting the original vegetation after construction is completed. The soil removed from the building site will be used in landscaping around the paved areas for enhancement of environmental quality. The affected plants will be relocated inside the study area, in the available zones.

The STL Relocation Plan will be implemented by the Contractor if reptiles are found by the expert in the study area before the construction phase. Following the establishment of the relocation site, the STLs relocation will be completed by suitably trained and qualified ecologists with experience of STLs in the Middle East and internationally. The areas of activity will be targeted daily until the STLs burrows are captured and successfully removed. Following capture, the burrows will be monitored for a further three days via camera trap and visual assessments to ensure that no additional animals are utilising the STLs prior to demolition. All relocation will be conducted prior to any clearing activities within each site.

Introduction of invasive species

During construction phase, the back-and-forth movement of heavy machinery, trucks and vehicles can accidentally bring and introduce seeds of invasive species into the site. Disturbance of soil and vegetation is likely to create opportunities for seeds to germinate and the establishment of alien invasive species. Alien invasive species can outcompete natural vegetation, decreasing indigenous species abundance and diversity. If allowed to seed before control measures are implemented, alien plans can easily colonise and impact on vegetation communities on site and in the surrounding areas. Alien invasive plants could also be distributed through vehicles leaving the site.

In terms of alien fauna several urbanised alien faunal species are already present in the greater area. If food and food waste is not managed appropriately it could attract additional alien faunal species or individuals to site.

If equipment and/or fill material from other areas is imported during the construction and operation phases there is a high risk that alien invasive plants may be introduced and could spread into adjacent areas where

they may replace indigenous vegetation and/or reduce grazing potential for wild animals, camels, sheep, and goats' herds.

The impact on fauna, flora, and biodiversity during construction phase (introduction of invasive species) is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor

Risk: Low.

The likelihood of the impact is Unlikely. The significance of the impact is Negligible or Minor. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

The following mitigation measures have been considered for the invasion of alien species:

- Machinery and vehicles will be cleaned upon entry/exit, and any soil brought on or off site screened for invasive species or plant pathogens.
- Disturbed areas will be rehabilitated at the earliest opportunity with native and endemic species to minimize the establishment of invasive plant species.
- Source areas such as vehicle parking and construction lay down areas will be kept clean of invasive plants to minimize the presence of seeds that can be dispersed unintentionally.
- Regular and ongoing monitoring of the presence of invasive plant species will be conducted within construction and rehabilitated sites and removal operations implemented according to the results.

5.2.2.2. Operation phase

Habitat fragmentation, birds´ collision and electrocution risk

There will be minimal impacts on fauna (disturbance) during the operation phase as there will be no additional land take. Night works will be avoided.

Photovoltaic panels can provide artificial shades to protect livestock against intense solar radiation while serving as a clean energy source.

The risk of avian collisions with photovoltaic modules has received little attention until now. A key finding from the study by Walston et al. (2016), along with other similar research (e.g., McCrary et al. 1986; Lovich &

Ennen 2011; Hernández et al. 2014; Kagan et al. 2014), suggests that fatalities due to collisions with these modules likely do not pose a significant issue initially. The incidents seem to happen because solar panels reflect polarized sunlight, making them appear as water bodies. This illusion can attract certain birds and their prey (e.g., insects), raising the risk of collisions with these structures (Lovich & Ennen 2011; Kagan et al. 2014; Bureau of Land Management 2012; Horváth et al. 2009). Yet, as of now, studies assessing bird fatalities at large solar energy installations are sparse (Walston et al. 2016).

Considering the lack of significant water bodies in the study area to attract large numbers of waterbirds, bird collisions with the project's photovoltaic modules are not expected to pose a major concern initially. Also, there is no anticipated diversion of migratory paths of species that might fly over the photovoltaic modules due to reflection. Furthermore, the proposed solar plant is unlikely to attract waterfowl and migratory birds significantly, given the panel angles.

The majority of bird deaths in photovoltaic parks are due to collisions with evacuation infrastructure.

The project has minimized the barrier effect and the electrocution risk and mitigation measures have been included. The fence has been marked with high visibility elements (plates) to prevent birds from collision Spiral bird protector devices have been installed in the transmission lines to avoid electrocution risk.

The impact on fauna, flora, and biodiversity during operation (habitat fragmentation and fauna mortality) is considered:

Nature: Negative.

Sensitivity of receptor: Low. Only Steppe Eagle is considered as high value and spiral birds protector devices have been installed in the transmission lines to avoid electrocution risk.

Magnitude: Negligible.

Extent: Local.

Timing: Long-Term.

Reversibility: Reversible.

Duration: Permanent.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor

Risk: Low.

The significance of the impact is Negligible or Minor. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

Introduction of invasive species

There is a risk that alien invasive plants may be introduced and could spread into adjacent areas If equipment and/or fill material from other areas is imported, where they may replace indigenous vegetation and/or reduce grazing potential for wild animals, camels, sheep, and goats' herds.

The impact on fauna, flora, and biodiversity during operation phase (introduction of invasive species) is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Long-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The likelihood of the impact is Unlikely. The significance of the impact is Negligible or Minor. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

The following mitigation measures have been considered for the invasion of alien species:

- Machinery and vehicles will be cleaned upon entry/exit, and any soil brought on or off site screened for invasive species or plant pathogens.
- Regular and ongoing monitoring of the presence of invasive plant species will be conducted and removal operations implemented according to the results.

5.2.2.3. Decommissioning phase

Potential impacts associated with the decommissioning phase are the following:

- Destruction of vegetation cover, bad manipulation of equipment.
- Harm or destruction of habitat.

These impacts will be Unlikely and Negligible.

5.2.2.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with vegetation cover, fauna and biodiversity during construction, operation, and decommissioning phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Fauna Flora Habitats	• Loss of habitats • Degradation of habitats • Disturbance, harm, and displacement for the fauna.	Negligible or Minor	Occasional	Medium
	• Introduction of invasive species	Negligible or Minor	Unlikely	Low
Operation				
Fauna Flora Habitats	• Disturbance, harm, • Habitat fragmentation • Birds 'collision • Introduction of invasive species	Negligible or Minor	Unlikely	Low
Decommissioning				
Fauna Flora	Harm, destruction of habitat	Negligible	Unlikely	Low
	Destruction of vegetation cover, bad manipulation of equipment	Negligible	Unlikely	Low

Table 62. Risk Assessment Summary for flora, fauna, and biodiversity

5.2.3. Air quality. Impact assessment

Air quality impact has been assessed based on the closest existing sensitive air quality receptors which consist of isolated camps, sheep, and camel herders. The number of fauna and flora species is low. The workers attending the site during the construction phase are also considered to be sensitive receptors with respect to the potential construction impacts of increased dust and exhaust emissions from vehicles.

So, receptors in both phases are the following: Site workers (construction and operation), campers and herders. Dust during construction can also affect fauna and flora.

The Construction phase impacts principally concern with site preparation, construction activities and transport, and include, but not be limited to the following activities:

- Site preparation.
- Earthworks. The earthworks foreseen are minimal. They are concentrated in the buildings and substations to make the foundations. This is a minimal surface inside the project boundaries.
- Stockpiling.
- Building construction; and
- Construction vehicle movement. Transport routes.

The potential impacts have been qualitatively assessed based on the current air quality conditions at site, the few sensitive receptors in the study area and the activities foreseen in the project.

Operation phase activities, which could affect air quality, include but not be limited to the following:

- Maintenance of the PV Panels; and
- Maintenance vehicle movement.

The potential impacts have been qualitatively assessed based on the activity during operation phase. Solar Energy Parks are not recognized to be an air polluting activity. For this reason, no air modelling has been undertaken.

5.2.3.1. Construction phase

The current air quality is generally good given that the area is predominantly desertic. In addition, the absence of any industries or human activity, contributes to the good air quality of the area.

Dust generation during construction phase

Activities such as stockpiling of soil and construction of buildings as well as digging of tower foundations for the associated sub-transmission line will result in dust generation. The generation of dust is expected to be short term and only last for the duration of the construction period.

Taking into consideration of the existence of few sensitive receptors through the site represented by occasional camel and sheep herders and some temporary campers, the impact from increased dust is evaluated to be minor. Dust impacts will be brief and discernible at these receptors.

Apart from vehicle movements on unpaved (or dusty) surfaces, dust due to the movement of trucks and material transportation should only occur where mitigation measures are not effectively implemented, or by contractors bringing materials to the site (i.e., the sheeting/containment of truck loads, wheel washing).

Uncontained and/or un-sheeted trucks may be subject to losses of material where the containment is not effective (i.e., spills), or when wind, or other air turbulence, may disturb the content and result in dispersion of material. Such impacts have the potential to degrade local air quality in the immediate area of such movements.

Unnecessary vehicle movements must be restricted and certain works, such as excavation, should be curtailed during windy conditions. Surfaced roads and public roads used to access the site should be regularly cleaned, and unsurfaced tracks watered for dust suppression.

Anyway, the contractor will ensure that the construction activities do not give rise to any exceedances of the air quality limit values (Air quality Standards).

The impact on air quality during construction phase (air quality degradation: dust) is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Minor.

Extent: Local.

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Occasional.

Potential Impact Significance: Negligible or Minor.

Risk: Medium.

The impact from increased dust is evaluated to be Negligible or Minor. The Risk Is considered Medium, require Best Practice Controls to proceed. Mitigation measures and best practice operational controls described in section 6 will be applied for the Activity to be considered as Tolerable. The impact is acceptable after that mitigation measures are applied.

Gaseous emissions from construction equipment & vehicles during construction phase

Vehicles and equipment, such as generators, trucks, excavators, etc., that operate on liquid fuel will result in the emission of gases to air due to the combustion of fossil fuels. The magnitude of the emissions will depend on the number and type of vehicles used; details of the type and operating time of vehicles and machinery and the transport routes are not currently available at this initial stage of the development.

Air quality impacts related to the use of machineries are minor in magnitude for individual sources. However, when old or poorly maintained equipment is operating, there is potential for noticeable and/or cumulative impacts to occur. So, the adequate maintenance of the vehicles and machinery, including the brakes and tyre wear, during construction phase is very important to avoid gaseous emissions.

Impacts relating to gaseous emissions, may not be discernible at the project site. At distant receptors, gaseous emissions will mix sufficiently with ambient air (within a short-range), so emissions are not expected to be distinguishable from background concentrations. Furthermore, the volume of vehicle traffic is not expected to be exceptionally high (i.e., compared to typical road or highway flows, as the road that connects routes 50 and 80 through Almardamah runs through the west limit of the Project site, adjacent to the plot.).

The impact on air quality during construction phase (air quality degradation: gaseous emissions) is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Minor.

Extent: Local.

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Occasional.

Potential Impact Significance: Negligible or Minor.

Risk: Medium.

The impact from increased dust is evaluated to be Negligible or Minor. The Risk Is considered Medium, require Best Practice Controls to proceed. Mitigation measures and best practice operational controls described in section 6 will be applied for the Activity to be considered as Tolerable. The impact is acceptable after that mitigation measures are applied.

5.2.3.2. Operation phase

It is expected that the project may be assigned a limited number of vehicles during the operation phase. No dust generation is expected to occur during the operation phase of the project, except for minimal dust created by this and other maintenance vehicles along the dusty roads, which is expected to be insignificant and infrequent. The significance of the impact is Negligible or Minor.

Furthermore, the volume of vehicle traffic is expected to be very low compared to the current road flows.

In operation, there are no permanent fuel combustion requirements or any other associated air emissions directly from the Project. The operation of the plant is considered to be a benefit.

The impact on air quality during operation phase (air quality degradation) is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local.

Timing: Long-Term.

Reversibility: Reversible.

Duration: Permanent.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.3.3. Decommissioning phase

Potential impacts on air quality associated with the decommissioning phase are the following:

- Demolition activity is anticipated to generate dust and exhaust emissions which can be carried downwind to receptors around.

These impacts will be Unlikely and Negligible.

5.2.3.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with air quality during construction, operation, and decommissioning phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Air Quality Site workers Campers Herders Fauna and Flora	Air quality degradation due to dust/ emissions	Negligible or Minor	Occasional	Medium
Operation				
Air Quality Site workers Campers Herders	Air quality degradation due to emissions	Negligible or Minor	Unlikely	Low
Decommissioning				
Ambient air	Risk of air quality degradation	Negligible	Unlikely	**Low**

Table 63. Risk Assessment Summary for air quality

5.2.4. Noise & Vibration. Impact assessment

The potential for noise disturbance is normally greatest during the construction phase of a project. During the construction phase, construction vehicles including delivery trucks and minimal excavation equipment may produce a slight increase in noise disturbance.

Construction noise guidelines within the KSA are understood to restrict the use of loud construction equipment between 8h00 pm and 7h00 am, except some cases specifically approved by the NCEC.

At this initial stage of the development, exact details of the equipment to be used during construction (i.e., makes & models, quantities and schedules, operating time, machinery location, etc.) are yet to be established. Consequently, assumptions will be made regarding equipment usage based on a typical construction methodology. It has been assumed that the main construction phases will be as follows:

- Site preparation.
- Civil works.
- Supply and installation of plant and equipment.
- Mechanical, Electrical and Plumbing works.
- Construction vehicle movement. Transport routes.

The assumed equipment used during each of these construction phases is presented in table below, along with the corresponding noise data. This table should not be interpreted as a comprehensive list of all equipment likely to be used during these activities; only items that produce significant levels of noise are considered for the noise assessment impact. Quantitative noise estimation will be made by the Contractor in the CEMP.

Type of Machinery/Equipment	Typical Noise Level during Major Construction Activity (Noise Level in dB(A) at 50 Feet)
CLEARING	
Bulldozer	80
Front end loader	72 – 84
Dump truck	83 – 94
Jack hammer	81 – 98
Crane with ball	75 – 87
EXCAVATION AND EARTH MOVING	
Bulldozer	80
Backhoe	72 – 93
Front end loader	72 – 84
Dump truck	83 – 94
Jack hammer	81 – 98
Scraper	80 – 93
STRUCTURE CONSTRUCTION	
Crane	75 – 77
Welding generator	71 – 82
Concrete mixer	74 – 88
Concrete pump	81 – 84
Concrete vibrator	76
Air compressor	74 – 87
Pneumatic tools	81 – 98
Bulldozer	80
Cement and dump trucks	83 – 94
Front end loader	72 – 84
Dump truck	83 – 94
Paver	86 – 88
GRAND AND COMPACTING	
Grader	80 -93
Roller	73 – 75
PAVING	
Paver	86 – 88
Truck	83 – 94
Tamper	74 – 77
LANDSCAPING AND CLEAN UP	
Bulldozer	80
Backhoe	72 – 93
Truck	83 – 94
Front end Loader	72 – 84
Dump Truck	83 – 94
Paver	86 – 88

Table 64. Typical noise levels of principal construction equipment. Source: India ministry of environment and climatic change

During operation phase, solar PV systems are static generators of electricity and therefore PV modules do not generate any audible sound. The potential impacts have been qualitatively assessed based on the activity

during operation phase. Solar Energy Parks are not recognized to be a noise polluting activity. For this reason, no noise modelling has been undertaken.

Receptors in both phases are the following: Site workers (construction and operation), fauna, campers, and herders.

5.2.4.1. Construction phase

Site transport and construction machinery

Construction activities will likely result in temporary and short duration increases in the noise levels emanating from the project site, construction basecamp and the laydown areas.

During the construction phase, construction vehicles including delivery trucks and minimal excavation equipment may produce a slight increase in noise disturbance. Heavy duty machinery and vehicular movement, friction between vehicles and the road surface, driver behaviour, vehicles' horns, resonance of traffic and piling increase ambient noise levels and vibration. Impacts are likely to be minimal due to the methods of construction to be used.

The site, however, is in a desert setting with few or no receptors considered sensitive within proximity.

As noise levels dissipate with distance, the effects from the construction site on receptors are likely to be imperceptible.

Anyway, the contractor will ensure that the construction activities do not give rise to any exceedances of the noise objectives/limit values of recognized threshold criteria (Noise Level Standards).

Noise is likely to have an impact on workers directly involved in site activities. Noise will be dealt with under appropriate provisions of the contractors' HSSE manual. These will comprise a combination of engineering and administrative controls including the use of mufflers and logging, noise reduction apparatus as recommended by equipment manufacturers, the relative siting of plants and offices, and the timing of the noisiest operations not to take place at night. Whilst all workers will be issued with PPE, including ear protectors, appropriate to the tasks to be undertaken, PPE should be viewed as the last resort for noise reduction.

Certain construction processes, particularly those involved with site preparation and civil works have the potential to create vibration within the vicinity of the works.

As vibrations dissipate quickly (due to losses of energy radiating 360 degrees from their source) its impact at the project construction site will likely be negligible and it is not expected to be discernible at receptors.

The impact on noise during construction phase (noise environment disturbance from site transport and construction machinery) is considered:

Nature: Negative.

Sensitivity of receptor: Low

Magnitude: Minor.

Extent: Local.

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Occasional.

Potential Impact Significance: Negligible or Minor.

Risk: Medium.

The impact from increased noise (site transport, and construction machinery) is evaluated to be Negligible or Minor. The Risk Is considered Minimum, require Best Practice Controls to proceed. Mitigation measures and best practice operational controls described in section 6 will be applied for the Activity to be considered as Tolerable. **The impact is acceptable after that mitigation measures are applied.**

Road transport

Delivery vehicles will also create some noise and vibration along access routes. The site however is in a desert setting with few, or no receptors considered sensitive within proximity. For traffic noise, overall daily traffic movements are predicted to be low as the delivery requirements for men and materials are low and will be restricted to daytime only. As such, the noise increases over the current baseline along these routes will be adverse but temporary in nature and Minor in significance.

The impact on noise during construction phase (noise environment disturbance from road transport) is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Minor.

Extent: Local.

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Occasional.

Potential Impact Significance: Negligible or Minor.

Risk: Medium.

The impact from increased noise (road transport) is evaluated to be Negligible or Minor. The Risk Is considered Minimum, require Best Practice Controls to proceed. Mitigation measures and best practice

operational controls described in section 6 will be applied for the Activity to be considered as Tolerable. **The impact is acceptable after that mitigation measures are applied.**

5.2.4.2. Operation phase

Increased noise levels are not anticipated during the operation phase of the development either at the power plant site or the transmission line. Emissions of noise during the operation of the solar power plant will not be significant enough to generate noise nuisance.

It is expected that the project may be assigned a limited number of vehicles during the operation phase. The volume of vehicle traffic is expected to be very low compared to the flows of the road that connects routes 50 and 80 through Almardamah.

The impact on noise during operation phase (noise environment disturbance) is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local.

Timing: Long-Term.

Reversibility: Reversible.

Duration: Permanent.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The significance of the impact is Negligible or Minor. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.4.3. Decommissioning phase

Potential impacts on noise associated with the decommissioning phase are the following:

- The decommissioning activities of dismantling or removing the solar PV power plant and removing the ancillary facilities can lead to increased noise levels.

These impacts will be Unlikely and Negligible.

5.2.4.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with ambient noise during construction, operation, and decommissioning phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Ambient noise Site workers Campers Herders Fauna	Noisy environment will be created	Negligible or Minor	Occasional	Medium
Operation				
Ambient noise Site workers Campers Herders Fauna	Noisy environment will be created	Negligible or Minor	Unlikely	Low
Decommissioning				
Ambient noise	Noise level rising	Negligible	Unlikely	Low

Table 65. Risk Assessment Summary for noise

5.2.5. Smells. Impact assessment

Odours are resulting essentially from bad management of sanitary facilities. Odours' impact has been assessed based on the closest existing sensitive air quality receptors which consist of isolated camps, sheep, and camel herders. The workers attending the site during the construction phase are also considered to be sensitive receptors with respect to the potential impacts of increased odours. The assessment considers the potential resultant changes to the receptor and assess the overall significance of the impact.

Receptors in both phases are the following: Site workers (construction and operation), seasonal shepherds/herders and temporary settlements whom main activity is grazing, and scarce fauna,

5.2.5.1. Construction phase

There is the potential for release of associated odour to the immediate surrounding areas associated with inappropriate containment and coverage associated with wastewater chemical toilets. Any such impacts are likely to be fleeting and limited to the immediate surrounding area.

Impacts may only occur in the vicinity of the construction camp or laydown areas and are likely to affect only working nearby.

The odour impact during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local.

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The significance of the impact is Negligible or Minor. The likelihood is Unlikely. Anyway, the good maintenance of the chemical toilets will avoid this impact. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.5.2. Operation phase

A holding tank will be used for wastewater management during operation phase. The holding tank will be periodically emptied by licensed company.

There is the potential for release of odour to the immediate surrounding areas associated with inappropriate containment and coverage associated with wastewater holding tanks.

The odour impact during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local.

Timing: Long-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The significance of the impact is Negligible or Minor. The likelihood is Unlikely. Anyway, the good maintenance of the holding tanks will avoid this impact. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.5.3. Decommissioning phase

Odours' impacts will be Remote and Negligible.

5.2.5.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with odour environment.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Odour Site workers Campers Herders Fauna	Bad smells environment will be created	Negligible or Minor	Unlikely	Low
Operation				
Odour Site workers Campers Herders Fauna	Bad smells environment will be created	Negligible or Minor	Unlikely	Low
Decommissioning				
Odour	Bad smells	Negligible	Remote	Very Low

Table 66. Risk Assessment Summary for smells

5.2.6. Surface water quality. Impact assessment

There is no existing water body close to the solar power project site. The impact could be expected in the surface bodies far from the site in case of exceptional rainfall and runoff. Due to desertic nature of the climate of the region and the scarcity of precipitation and the nature, the impact would be assessed with very low significance.

5.2.6.1. Construction phase

Uncontrolled spills of fuels and lubricants during the construction phase could persist in the soil and be driven by surface water runoff to surface water bodies downstream the site and pollutes them.

The impact on surface water quality during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Long-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Very Low.

The impact on surface water quality during construction phase is considered Negligible or Minor. The likelihood is Remote. The Risk Is considered Very Low, Tolerable but may still need to have best practice operational controls applied to them to ensure they comply.

5.2.6.2. Operation phase

The uncontrolled spills and leaks from machinery and chemical materials from solar panels cleaning and changing is likely a potential source of pollution that could be brought by water runoffs to nearest water bodies.

The impact on surface water quality during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Long-Term.

Reversibility: Reversible.

Duration: Permanent.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Very Low.

The impact on surface water quality during operation phase is considered Negligible or Minor. The likelihood is Remote. The Risk Is considered Very Low, Tolerable but may still need to have best practice operational controls applied to them to ensure they comply.

5.2.6.3. Decommissioning phase

No impacts are foreseen.

5.2.6.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with surface water quality.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Surface water quality Local communities Site workers Campers Herders Fauna Aquatic receptors	Surface water contamination	Negligible or Minor	Remote	Very Low
Operation				
Surface water quality Local communities Site workers Campers Herders Fauna Aquatic receptors	Surface water contamination	Negligible or Minor	Remote	Very Low

Table 67. Risk Assessment Summary for surface water quality

5.2.7. Surface water availability. Impact assessment

There is no existing water body close to the solar power project site. Water will be provided by tankers in both phases. The impact could be expected in the surface bodies far from the site, where the water will be obtained. Few waters volume will be required in construction and operation phases.

5.2.7.1. Construction phase

There are no water sources available on site and water will be supplied using:

- Potable water: Bottles of water from the nearest markets.
- Domestic uses: Water will be brought to project site by tankers.
- Water for dust suppression and for civil works: Water will be brought to project site by tankers.

During the project construction phase, water is required for preparing RCC foundations for module mounting structures, building control room and security rooms, and domestic purpose such as drinking and washing by the construction workers and staff. Water is also used for dust suppression. A licensed water supply company will supply the water required to cover the water demand to the Project to the site via water tanker trucks. At this initial stage the total volume of water required by the Project has not been finalised. No impacts are foreseen in the surface water availability at local and regional level. The likelihood is Remote.

The impact on surface water availability during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Short-Term.

Reversibility: Irreversible.

Duration: Temporal.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Very Low.

The impact on surface water availability during construction phase is considered Negligible or Minor. The Risk Is considered Very Low, Tolerable but may still need to have best practice operational controls applied to them to ensure they comply.

5.2.7.2. Operation phase

There are no water sources available on site and water will be supplied using:

- Water for panels 'cleaning and domestic uses: Water will be brought to the site by tankers.

The total volume of water required by the operation phase will be minimum. No impacts are foreseen in the surface water availability at local and regional level. The likelihood is remote.

The impact on surface water availability during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Short-Term.

Reversibility: Irreversible.

Duration: Permanent.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Very Low.

The impact on surface water availability during operation phase is considered Negligible or Minor. The Risk Is considered very Low, Tolerable but may still need to have best practice operational controls applied to them to ensure they comply.

5.2.7.3. Decommissioning phase

During the project decommissioning phase, water is required for domestic purposes such as drinking and washing by the construction workers and staff.

Impacts on surface water availability will be Remote and Negligible during decommissioning phase.

5.2.7.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with surface water availability.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Surface water quality Local communities Site workers Campers Herders Fauna Aquatic resources	Surface water resources exhausting	Negligible or Minor	Remote	Very Low
Operation				
Surface water quality Local communities Site workers Campers Herders Fauna Aquatic resources	Surface water resources exhausting	Negligible or Minor	Remote	Very Low
Decommissioning				
Surface water quality Local communities Site workers Campers Herders Fauna Aquatic resources	Surface water resources exhausting	Negligible or Minor	Remote	Very Low

Table 68. Risk Assessment Summary for surface water availability.

5.2.8. Groundwater quality. Impact assessment

5.2.8.1. Construction phase

The potential for groundwater contamination is associated with uncontrolled spills of fuels and lubricants during the construction phase.

The risk of contamination of certain areas is unlikely. This risk could come from liquid discharges, solid waste generated during construction work and from camps or accidental spillage / leakage.

Storage and usage of fuels, chemicals and sanitary provision during the construction phase will introduce risks to ground water associated with spills and leaks. Such instances may potentially result from poor storage, handling, transfer, or containment of such materials.

The extent and impact of potential groundwater contamination is largely dependent on the nature of the subsurface soil conditions, their transmissivity and susceptibility to erosion. Apart from the permeability of the

soil substrate, groundwater contamination could also occur through joints, fractures and contact zones associated with the geology.

According to geotechnical study, given the nature of the soils, the geology at the site, and the groundwater depth, the contamination of the aquifer is very unlikely to occur. However, measures to prevent the possibility of contamination of aquifer from this will be implemented. The risk of contamination is incidental and with low probability, but it could take place.

The impact on ground water quality during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible or Minor.

Extent: Local-Regional.

Timing: Long-Term.

Reversibility: Irreversible.

Duration: temporal.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The impact on groundwater quality during construction phase is considered Negligible or Minor. The Risk Is considered Low, Tolerable but may still need to have best practice operational controls applied to them to ensure they comply.

5.2.8.2. Operation phase

The potential for groundwater contamination during the operation phase is associated with uncontrolled spills of fuels and lubricants from operation of maintenance and changing the solar panel. Associated with rainfall and process of infiltration these materials could reach and contaminate the aquifer if appropriate measures are not taken. The risk of aquifer contamination is considered to be remote but could take place.

The impact on ground water quality during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local.

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Very Low.

The impact on groundwater quality during operation phase is considered Negligible or Minor. The Risk Is considered Very Low, Tolerable but may still need to have best practice operational controls applied to them to ensure they comply.

5.2.8.3. Decommissioning phase

Impacts on groundwater will be Remote and Negligible

5.2.8.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with ground water quality.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Ground water quality Local communities Site workers Campers Herders Fauna Aquifers	Ground water contamination	Negligible or Minor	Unlikely	Low
Operation				
Ground water quality Local communities Site workers Campers Herders Fauna Aquifers	Ground water contamination	Negligible or Minor	Remote	Very Low
Decommissioning				
Ground water quality Local communities Site workers Campers Herders Fauna Aquifers	Ground water contamination	Negligible or Minor	Remote	Very Low

Table 69. Risk Assessment Summary for groundwater quality

5.2.9. Hydrology and flood risk. Impact assessment

The methodology of impact assessment on hydrology and flood risk analysis is based upon the collection of information from a wide variety of data sources including published material and consultation with statutory bodies.

A hydrology study report has been prepared by TYPSA (The study has been included in section 8.3.3). The goal of this study is to analyze and identify existent natural flow streams at site, obtaining watersheds that have important influence inside and outside the site area. Finally, estimate the peak flows for different return periods (25, 50 and 100 years), that might have influence around Afif 1 PV Plant area. The areas identified as high flood hazard have been avoided for the design of the layout of the PV project.

From a hydrological point of view, the AFIF1 area does not pose any major risk for the development of photovoltaic installations. Analyzing the results, slopes in the area are very low, between 0 to 3%. As a result, surface water runoff slowly flows over the ground into the main surface water overland flow paths (streams) where it drains away. Additionally, surface water is stored in some parts at the low points of the ground before it drains away through infiltration and evaporation. The hydraulic modeling shows similar results for all rainfall events with surface water flowing through the existing streams with maximum depths between 0.20m to 0.40m and maximum velocities between 0.8m/s to 1.20m/s at the existing overland flow paths.

Some of the water basins that drain into the site are large, that result in moderate to large volumes of water flowing through the existing streams. However, the identified surface runoff streams have a very low slope with values between 1.0% and 0.10%, so concentration times are relatively high. Moreover, the local terrain has a low runoff coefficient. Altogether these factors moderate the impact that any extreme rainfall event might have on the site. Thus, rainfall and runoffs in the site will have a low velocity or erosive potential and therefore hydrological severe impacts are unlikely to occur. Moreover, the erosion of the area is expected to be very low as the small and diffuse runoffs detected are not strong enough to wash away soil particles.

The hydrological model shows that areas subjected to flood hazard risk are entirely located within the existing streams, where the hydraulic modeling shows maximum water velocities around 1.0m/s and maximum water depths around 0.5m and have been found.

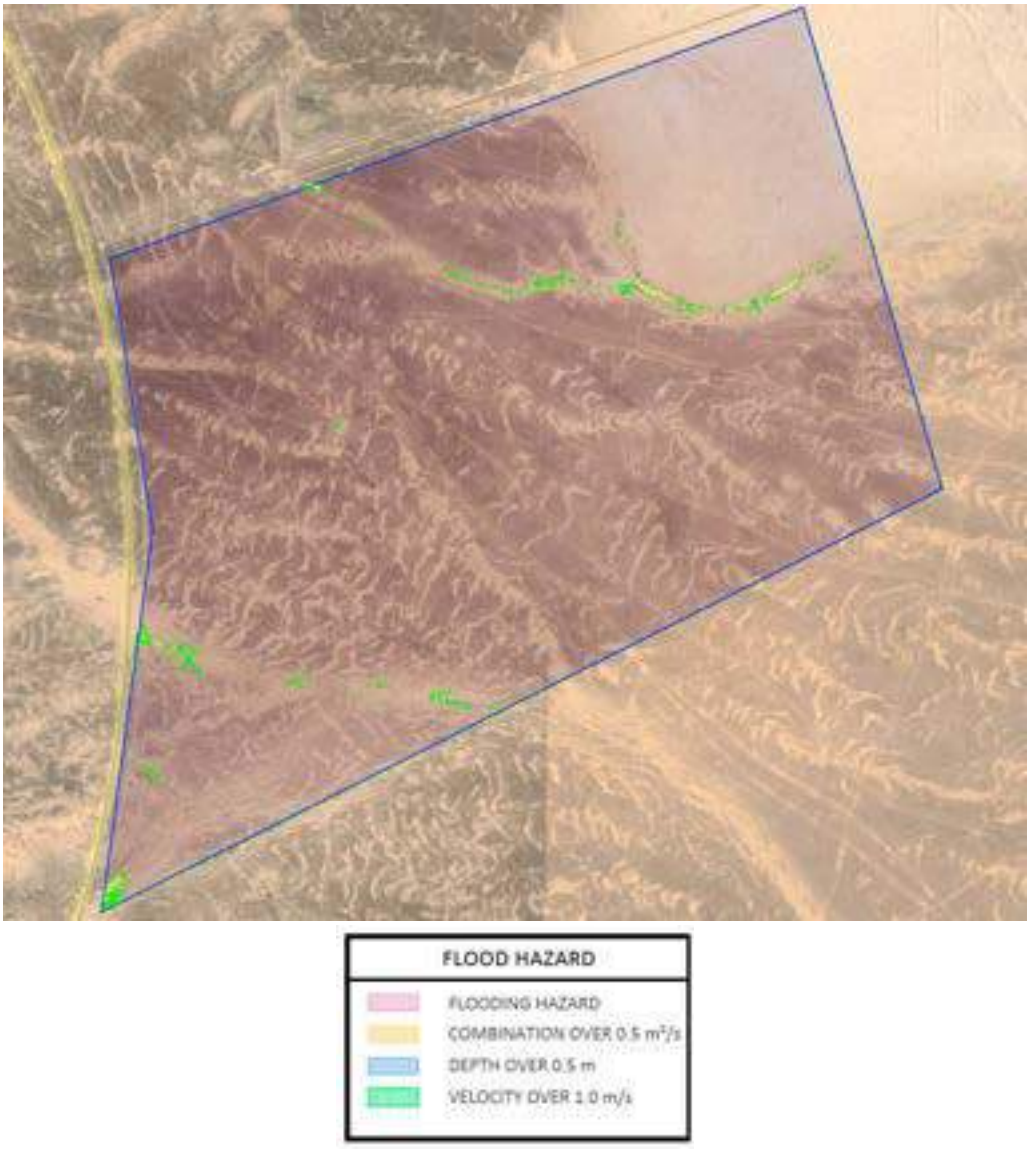


Figure 171. Flood Hazard for Afif 1 project

The impact on hydrology and flood risk during construction and operation phases is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Long-Term.

Reversibility: Irreversible.

Duration: Temporal.im construction and permanent in operation

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

According to the assessment, the impact on hydrology and flood risk in both phases (construction and operation) is considered Negligible or Minor. The likelihood is Unlikely. The Risk Is considered Low, Tolerable but may still need to have best practice operational controls applied to them to ensure they comply. The puddles do not show any risk over the projected facilities. However, a series of mitigation measures have been proposed (section 6.3.7) with the aim of minimizing the impact of water on the facilities, thereby maximizing the performance of the installations.

5.2.9.1. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with hydrology and flood risk.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction & Operation				
Workers	Wadi flows and floods	Negligible or Minor	Unlikely	Low
Campers and local communities	Diversion of wadi flows by emplacement of hydraulic structures	Negligible or Minor	Unlikely	Low
Soil/Water quality and biodiversity	Pollution caused by mobilization of contaminants by wadi flows	Negligible or Minor	**Unlikely**	Low

Table 70. Risk Assessment Summary for hydrology and flood risk

5.2.10. Soils quality. Impact assessment

IFC General EHS Guidelines (2007) defines 'exposure pathway(s)', as; 'a combination of the route of migration of the contaminant from its point of release and exposure routes, which would allow receptor(s) to come into actual contact with contaminants.

Contaminated soils can leach toxic chemicals into nearby ground, where these materials can be taken up by plants and animals, contaminate a human drinking water supply, or volatilize and contaminate the indoor air. Potential sources of contamination must be identified and assessed. Pathways must be evaluated and potential impacted identified.

There is not a potential risk of soil contamination in the study area because the site is undeveloped.

The potential impacts on soils are soil compaction and soil contamination by accidental spills.

5.2.10.1.Construction phase

Topsoil compaction

The crossing of machines and vehicles through the project site can create changes in the soil structure through compaction. Excavated areas can generate movements that show surface deformation. This will have the effect of promoting soil erosion and deformation.

The preparation of the solar plant site could have an adverse impact on soils through topsoil compaction, rutting and mixing because of:

- Excavation of the site for civil works, trenching for cable laying and access roads.
- Temporal disposal of excess soils from excavation.
- The movement of equipment on site during construction; and
- Excavation for the tower foundations for the internal transmission line.

The impact on soil quality during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local.

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

Given the temporary duration of the construction work and their local extent, the significance of the impact is considered Negligible or Minor. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

Regarding erosion, the project maintains the current runoff and the main flows will not be diverted. The areas with flora are maintained, so the construction of the plant is not expected to increase current erosion.

Soil contamination

Contamination of soils may also arise through the spillage of lubricants, oils, and machine fuel during construction activities. This risk could come from liquid discharges, solid waste generated during construction work and from camps or accidental spillage / leakage.

Storage and usage of fuels, chemicals and sanitary provision during the construction phase will introduce risks associated with spills and leaks to ground. Such instances may potentially result from poor storage, handling, transfer, or containment of such materials.

The impact on soil quality during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local.

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

Given the temporary duration of the construction work, the likelihood of the impact (unlikely), and their local extent, the significance of the impact is considered Negligible or Minor. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.10.2. Operation phase

There are potential impacts to soil quality from the operation of the facility because of the possibility of minor uncontrolled releases as a result of maintenance activities during operation. The likelihood is Remote.

The impact on soil quality during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Very Low.

The impact is considered Negligible. or Minor. The Risk Is considered Very Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.10.3. Decommissioning phase

Potential impacts on soil quality associated with the decommissioning phase are the following:

- Improper disposal of demolition waste and obsolete machinery will lead to contamination of soil.
- Improper management of hazardous waste will lead to contamination of soil.

These impacts will be Unlikely and Negligible.

5.2.10.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with ambient soils quality during construction, operation, and decommissioning phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Soil Local communities Site workers Campers Herders Fauna /flora	Topsoil compaction	Negligible or Minor	Unlikely	Low
Operation				
Soil Local communities Site workers Campers Herders Fauna /flora	Soil contamination (spills, leakage, hazard waste)	Negligible or Minor	Remote	Very Low
Decommissioning				
Soil	Soil contamination (spills, leakage, hazard waste)	Negligible	Unlikely	**Low**

Table 71. Risk Assessment Summary for soils quality

5.2.11. Health & Safety. Impact assessment

The assessment considers the potential impacts, that the solar park may have on the health, safety both the employees and the local communities.

The receptors are the local communities, herders/campers, and the workers (construction and operation).

5.2.11.1.Construction phase

All construction projects have potential risks relating to public safety that could arise, particularly regarding the use of high-powered equipment, excavations, transportation, and traffic among others, in addition to fire and pollution releases.

Public risks during construction have the potential to result in isolated incidents, which could be of a devastating magnitude to a person or group of people in the wrong place at the wrong time.

The impact on health and safety during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The impact is considered Negligible. or Minor. Risks to public safety will be appropriately addressed and prepared in the construction phase 'Emergency Preparedness and Response Plan' and training, reported in section 6.

The construction phase may present an unwanted opportunity for local communities to access the site, in terms of trespassing, with associated risks to those working at the site and those who are trespassing. Under such circumstances there is potential for incidents to occur particularly as a construction site is a risk area. The area will be guarded during construction phase and a fence will avoid this kind of incidents.

As with any construction project, there are potential impacts on human health and safety because of accidents and unplanned events that may occur during the construction of the PV power facility (physical injury, exposure to hazardous materials, including waste, etc.). The risk of injury associated with the construction of the PV power facility will be mainly limited to the workers (as the site will be secured to avoid public incursion into the active development area), but there remains some risk of injury to other site users (i.e., camel and sheep herders).

5.2.11.2.Operation phase

During operation phase, there are potential impacts on human health and safety because of accidents and unplanned events that may occur during the operation of the PV power facility (physical injury, exposure to hazardous materials, including waste, etc.).

The impact on health and safety during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional

Timing: Long-Term.

Reversibility: Reversible.

Duration: Permanent.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Very Low.

The impact is considered Negligible. or Minor. Risks to public safety will be appropriately addressed and prepared in the operation phase 'Emergency Preparedness and Response Plan' and training, reported in section 6.

5.2.11.3. Decommissioning phase

During decommissioning phase, the following impacts and risks are considered:

- Risks associated with health and safety issues such as trip and fall, electrical hazard etc.
- The decommissioning activities of dismantling or removing the solar PV power plant and removing the ancillary facilities can lead to increased noise levels that could affect receptors.
- Demolition activity is anticipated to generate dust and exhaust emissions which can be carried downwind to receptors around.

These impacts will be Unlikely and Negligible.

5.2.11.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with health and safety during construction, operation, and decommissioning phases.

These impacts will be Unlikely and Negligible.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Local communities Herders/campers Workers	Risk Injury and incidents during construction phase	Negligible or Minor	Unlikely	Low
	Exposure to hazardous material	Negligible or Minor	Unlikely	Low
Operation				
Local communities Herders/campers Workers	Risk Injury and incidents during operation phase	Negligible or Minor	Remote	Very Low
	Exposure to hazardous material	Negligible or Minor	Remote	Very Low
Decommissioning				
Health and Safety	Risk Injury and incidents and exposure to hazardous material	Negligible	Unlikely	Low

Table 72. Risk Assessment Summary for health and safety

5.2.12. Landscape & Visual comfort. Impact assessment

Visual receptor means an element - or group of elements - that will be directly or indirectly affected by the proposed development. These would include viewpoints available to users of public roads; viewpoints from landscape features and beauty spots and viewpoints available to people travelling through the landscape.

There are few visual receptors in the study area: The helders/campers, and the users of the road that connects routes 50 and 80 through Almardamah.

5.2.12.1.Construction phase

The visual receptors in construction phase will be the helders/campers and the users of the road that connects routes 50 and 80 through Almardamah.

The construction of associated infrastructure of the solar energy facility (i.e., the substation, associated power line, access road to the site, internal access roads within the site) has the potential of visual impacts on local campers or passers-by. There is the potential visual impact of the construction of ancillary infrastructure on observers residing near of the facility (helders/campers). Such potential visual impacts during the construction phase on observers near the solar plant are expected to be of a short duration and limited to the site.

Various aspects of the construction phase that will contribute to visual impacts caused by the proposed development include:

- Construction activities and equipment associated with construction of the proposed development, including access roads and buildings.
- A slight increase in traffic can be expected on roads, particularly large construction, and freight vehicles.
- Construction of the overhead distribution lines and the onsite substation are likely to be visible against the skyline in places.

The proposed development will result in a change to the local landscape character. The development is likely to impact the overall sense of place of the wider area. The site is in a rural area and is relatively flat and as such the visual impact of the PV power facility is regarded as a potentially important consequence of the proposed development. The affected areas (construction camps) will be restored.

The impact on landscape and visual comfort during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Minor.

Extent: Local.

Timing: Short-Term.

Reversibility: Irreversible.

Duration: Temporal.

Likelihood: Occasional.

Potential Impact Significance: Minor.

Risk: Medium.

The impact on landscape and visual comfort during construction phase is considered Temporary and Minor. The Risk Is considered Medium, require Best Practice Controls to proceed. Mitigation measures (restoration

of the affected areas) and best practice operational controls described in section 6 will be applied for the Activity to be considered as Tolerable. **The impact is acceptable after that mitigation measures are applied**.

5.2.12.2.Operation phase

During the operation phase, a few elements of the proposed PV solar park will potentially intrude on the existing views of visual receptors (helders/campers, users of the road that connects routes 50 and 80 through Almardamah, and possible visitors). These elements are the following: the very large solar field (with solar panels covering the area), tall structures such as the on-site substation, and overhead transmission lines connecting the plant with the SEC power grid.

Once in operational phase, the project will continue its contribution to the feeling of developing the project area. Given the size of the proposed project, it is anticipated that the solar plant will remain the most prominent landscape feature in the vicinity.

The design of the project and the related buildings have been developed focusing on the combination of operational suitability and efficiency while ensuring minimization of the environmental and visual impact.

The impact on landscape and visual comfort during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local.

Timing: Long-Term.

Reversibility: Irreversible.

Duration: Permanent.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Very Low.

The impact on landscape and visual comfort during operation phase is considered Negligible or Minor. The Risk Is considered Very Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.12.3.Decommissioning phase

During the dismantling or removing of the solar PV plant, with the removal of ancillary facilities, visual intrusions will be temporal. The land will be restored increasing the landscape quality.

5.2.12.4.Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with landscape and visual comfort during construction, and operation phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Local communities/ Campers/herders	Temporary modification of natural landscape and nuisance to visual amnesty caused by working machinery, disturbance of lands	Minor	Occasio-nal	Medium
Operation				
Local communities Campers/herders Visitors	Permanent modification of natural landscape by installing of solar panels	Negligible or Minor	Remote	Very Low

Table 73. Risk Assessment Summary for landscape & visual comfort

5.2.13. Land Use. Impact assessment

The assessment of land use effects identifies the existing conditions of the area surrounding the Project and predicts the likely effects arising from the Project.

5.2.13.1.Construction phase

Construction activities cannot hinder or affect the actual use of land on the site, as these lands are not of agricultural value for the population around excepting grazing activity.

The impact on land use during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Minor.

Extent: Local.

Timing: Short-Term.

Reversibility: Irreversible.

Duration: Temporal.

Likelihood: Occasional.

Potential Impact Significance: Minor.

Risk: Medium.

The significance of the impact is Minor. The Risk Is considered Medium, require Best Practice Controls to proceed. Mitigation measures (Government Affairs for change of land use) and best practice operational controls described in section 6 will be applied for the Activity to be considered as Tolerable. The impact is acceptable after that mitigation measures are applied.

5.2.13.2. Operation phase

The operation will not cause disturbance or affect the use of the land as it will no more used for grazing by the temporary residing communities. Thus, the project cannot have a negative impact regarding this aspect.

The impact on land use during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local.

Timing: Long-Term.

Reversibility: Irreversible.

Duration: Permanent.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Very Low.

5.2.13.3. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with land use during construction, and operation phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Campers/herders	Change of land use - occasionally or permanently	Minor	Occasional	Medium
Operation				
Campers/herders	Change of land use	Negligible or Minor	Remote	Very Low

Table 74. Risk Assessment Summary for land use

5.2.14. Waste Generation. Impact assessment

The waste management for the project will follow the waste management hierarchy as a guiding principle. A strategy for waste management has been considered on Afif 1 solar park project.

This assessment focuses on key waste management issues associated with the project that could have an impact upon the environment. The assessment also aims to identify opportunities which may reduce the likelihood or severity and subsequently the degree of significance of the environmental impacts.

5.2.14.1.Construction phase

Afif 1 solar park construction will generate a minimal quantity of spoil.

The construction camp will generate domestic wastes. Due to the nature of the project type and the construction works being undertaken, there will be a few hazardous materials used, and only expected in low volumes (i.e., without major stores on the site). Such materials may result in fuel containers waste, oily residues, paints, paint cans and wastes from chemical cleaning products.

The inappropriate management, storage, handling, transfer, or transportation may lead to accidental spills or leaks to the soil or groundwater and potentially could result as a pollution source to receptors. The downstream pollution may also occur off-site, when transportation and management by waste contractors is not effective, or when unlicensed companies are engaged. The likelihood is occasional.

Wastewater generation on site during the construction phase will include chemical toilets. These chemical toilets will be removal by a licensed wastewater contractor.

The impact on waste during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Short-Term.

Reversibility: Irreversible.

Duration: Temporal.

Likelihood: Seldom.

Potential Impact Significance: Negligible or Minor.

Risk: Medium-Low.

The significance of the impact is Negligible or Minor. The Risk Is considered Medium-Low, require Best Practice Controls to proceed. Mitigation measures and best practice operational controls described in

section 6 will be applied for the Activity to be considered as Tolerable. The impact is acceptable after that mitigation measures are applied.

5.2.14.2.Operation phase

The operation of the proposed project will generate small amounts of non-hazardous domestic waste from the operation of the solar plant activities. This waste can be classified as both recyclable and non-recyclable. Recyclable waste includes paper, tin, cans, plastics, cartons, rubber, and glass, while non-recyclables will consist mainly of food residues and other organic waste. The quantity of domestic waste will be minor given the required number of personnel employed onsite.

The inappropriate management, storage, handling, transfer, or transportation may lead to accidental spills or leaks to the soil or groundwater and potentially could result as a pollution source to receptors. The likelihood is occasional.

Wastewater generation during the operation phase will include the following key streams: sanitary and domestic wastewater. Wastewater generated on-site area will be stored within holding tanks for removal by a licensed wastewater contractor.

The impact on waste during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Long-Term.

Reversibility: Irreversible.

Duration: Permanent.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The significance of the impact is Negligible or Minor. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.14.3.Decommissioning phase

Waste (hazardous and non-hazardous) will be generated during decommissioning phase. This waste will be managed in a good manner. These impacts will be Seldom and Negligible or Minor.

5.2.14.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with waste during construction, operation, and decommissioning phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Local communities Campers/herders Workers Soil environment Water environment	Bad management of generated solid/liquid will lead to soil /water contamination. Nuisance to local communities	Negligible or Minor	Seldom	Medium-Low
Operation				
Local communities Campers/herders Workers Soil environment Water environment	Bad management of generated solid/liquid will lead to soil /water contamination. Nuisance to local communities.	Negligible or Minor	Unlikely	Low
Decommissioning				
Local communities Campers/herders Workers Soil environment Water environment	Bad management of generated solid/liquid will lead to soil /water contamination. Nuisance to local communities	Negligible or Minor	Seldom	Medium-Low

Table 75. Risk Assessment Summary for waste

5.2.15. Glint & Glare. Impact assessment

Dawadmi Domestic Airport is located approximately about 120 km away from the PV plant. Almardamah Road is about 60 m away from the PV Solar Plant and Haraniga Road is about 150 m away.

Afif 1 glint and glare assessment report has been prepared and has been included in the EsIA Report (section 8.3.4). The conclusions of the potential impacts (visual impact due to solar radiation reflection) from Afif 1 glint and glare assessment report have been included and analysed in section 8.3.4.

5.2.15.1. Operation phase

The conclusions of the potential impacts from Afif 1 glint and glare assessment report are summarized below.

No glare caused by the future Afif 1 Solar Power Plant is expected at any of the Flight Paths studied and the ATCT of the Dawadmi Domestic Airport.

The simulation reveals little glint and glare during a few hours of the day on both roads that run parallel to Afif 1 Solar Power Plant. In no cases the level of glare is significant, and it only occurs during shot periods at sunrise and sunset of some months.

These results are not of concern due to the distance between the roads and the PV plant and the low number of glint and glare hours occurring during the entire year.

However, it is possible to eliminate almost all the glint and glare effects by implementing a vegetation barrier.

A simulation was carried out by placing a vegetation barrier. The simulation including a vegetation barrier around the PV plant shows that the amount of yellow glare is almost completely reduced in the roads that run parallel to the site:

- Almardamah Road (road 1): Yellow glare is reduced from 229 minutes to 4 minutes.
- Haraniga Road (road 2): Yellow glare is completely reduced.

The impact on glint and glare during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local.

Timing: Long-Term.

Reversibility: Irreversible.

Duration: Permanent.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The significance of the impact is Negligible or Minor. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply. A vegetation barrier will be implemented around the PV Plant.

5.2.15.2. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with glint and glare during operation phase.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Operation				
Local communities Campers/herders Road users	Glint and Glare	Negligible or Minor	Unlikely	Low

Table 76. Risk Assessment Summary for glint and glare

5.2.16. Climate Change. Impact assessment

Climate change impact assessment during construction is based on embodied carbon as an indicator of the amount of greenhouse gases (GHG) equivalent emissions associated with the solar plant materials and construction processes.

However, during operation, benefits (positive impact) have been calculated by estimating the greenhouse gas (GHG) equivalent emissions associated with the same annual output of the solar plant through fossil fuel-based power generation.

5.2.16.1.Construction phase

Carbon dioxide (CO_2) equivalent emissions associated with materials and construction processes is called Embodied Carbon. It includes any CO_2 equivalent created during the manufacturing of all solar plant material required (extraction, transport to manufacturer, manufacturing), the transport of those materials to the job site, and the construction practices used. Put simply, embodied carbon is the carbon footprint of the solar plant before it becomes operational.

Some papers have been published that investigate how the embodied carbon of solar photovoltaic technology is changing over time and conclusions evidence embodied carbon of solar plants has fallen rapidly. Taking into consideration date sources such as Environmental Product Declarations with long-term studies, Louwen et al (2016, Reassessment of net energy production after 40 years of PV development) indicates that the embodied carbon of solar plants in 2020 is around 615 kgCO2/kWp of installed capacity.

It is worth to mention that Afif 1 PV plant presents some favourable conditions for construction as the site is very flat and minor civil works will be necessary. Besides of that, the site presents good access. All the components to be applied are commercially standard and manufactured under high optimized processes.

Using this average emissions factor for solar plant construction and taking into account an approximate peak capacity of 2,636 MWp, the total embedded carbon of the project for the construction has been estimated to be approximately of 1,845,000t of CO2 equivalent, which is a minor adverse effect on climate change.

The impact on climate change during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Long-Term.

Reversibility: Irreversible.

Duration: Temporal.

Likelihood: Seldom.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The significance of the impact is Negligible. The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.16.2. Operation phase

Operational carbon of a solar plant is very low as its energy yield production essentially is basically results from dependent on the incident solar energy, requires minor very little inputs and very little maintenance activities. IPCC for example refers an average life-cycle CO2 equivalent emissions for solar plants of 48 gCO2/kWh.

However, the real benefice comes from substitution of fossil fuel-based energy generation with renewable energy generation. Effectively greenhouse gases (GHG) production would substantially be reduced.

- With the annual generating capacity of the planned plant (2,636 MWp) and the estimated equivalent hours of production (2,492.41 kWh/kWp), Afif 1 plant total energy production has been estimated on 7,477.23 GWh/year.
- Emissions intensity from electricity generation in Saudi Arabia from 2012 to 2021 is indicated in the figure included in section 3-8.

Taking into account this Afif 1 plant total energy production and this GHG emission factor for electricity generation with hydrocarbons it is estimated that the operation of the planned solar power plant will avoid the emission of 4,254,319.55 tCO2 GHG annually. This supposes an appreciable reduction and so on an appreciable **Positive Impact**.

The impact on climate change operation phase is considered:

Nature: Positive.

Sensitivity of receptor: Low.

Magnitude: Major.

Extent: Local-Regional.

Timing: Long-Term.

Reversibility: Irreversible.

Duration: Permanent.

Likelihood: Likely.

5.2.16.3. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with climate change during construction and operation phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construtions				
Human receptors Air quality Climate	Rising of GHG emissions	Negligible	Seldom	Low
Operation				
Human receptors Air quality Climate	Reduction of GHG emissions	Positive Impact	Likely	-

Table 77. Risk Assessment Summary for climate change

5.2.17. Economic and Social Aspects. Impact assessment

5.2.17.1.Construction phase

Construction activities can potentially have a positive socio-economic impact by the provision of temporary employment opportunities and an improvement in local economy of the region generated by an increased demand for local goods and services. Conversely, construction activities can also have a negative impact on local communities through the impact of an influx of construction workers, which may place pressure on local resources, affect social dynamics and culture, and exacerbate health problems, etc.

Positive impacts

Based on the status and conditions of the project area and the nature of the proposed development, the following socio-economic positive impacts are anticipated:

- Creation of temporary jobs during construction (including local jobs) and local economy benefits.

  The principal economic impact during construction is likely to result from employment creation during this phase. As well as the direct monetary uplift to the families of those employed, money paid to workers will also stimulate the local economy via the multiplier effect, whereby money earned on the project expended locally will re-circulate within the local economy.

  The impact of employment created during construction is considered a positive effect from the project. However, most of employment during construction is likely to be relatively short-term and significant employment opportunities for local communities may be limited to the people with low levels of education, skills, and limited experience. This can result in a large percentage of skilled and semi-skilled workforce being sourced on a temporary or permanent basis from outside the region. At this stage in the project development, the origin of workers is unknown.

- Skills training for local workers during construction.

  As excepted, the project will bring in employment opportunities for the local inhabitants. Construction crews will constitute mainly skilled and semi-skilled workers. Unskilled jobs will be offered mainly to the local people particularly during the construction phase. It will be necessary for the EPC Contractor and project parties to ensure appropriate labour and working conditions and facilities are in place for their workforce. These conditions will need to meet national and international requirements.

Negative impacts

Based on the status and conditions of the project area and the nature of the proposed development, the following socio-economic negative impacts are anticipated:

- Workers conflicts with local communities.

  The influx of expatriate workers into the receiving environment is likely to cause a disturbance in the order of the existing social structure and might also lead to increases in social deviance. The likelihood is seldom. The significance of the impact is Negligible or Minor.

- Influx workers and increase of diseases.

  Due to the required workforce during the construction phase, there is the potential for additional influx to the local area and for associated impacts such as spread of disease to any local communities. The likelihood is seldom. The locations of worker accommodation areas have not been confirmed at this stage; however, it is expected that the majority of site staff will be sub-contractor workers who will be in the local area, and therefore may come into contact with local populations.

Coinciding with the influx of migrant workers is typically a raise in demand for goods and services during the construction period which can result in a rapid expansion in supply chain businesses operating in the area. This expansion may result in migration into the area. The impacts that may arise from the presence of migrant and/or expatriate employees are largely comprised of:

  - Inappropriate behaviour and lack of respect for local leadership and cultural norms on the part of expatriate workers.
  - Conflict resulting in part from resentment by skilled nationals and residents if they perceive that expatriates have been hired into jobs for which they are suitably qualified.
  - Spread of transmissible diseases both within the workforce and between the workforce and the local community.
  - Resentment of non-local nationals by residents if they are perceived to have taken jobs that could be successfully filled by local people, or due to non-integration with the local community.
  - Increased local demand for consumer goods and housing with resulting encouragement for improved supply resulting in financial hardship and benefits for local people; and,
  - Increased pressure on infrastructure, services (such as healthcare) and roads, particularly with the establishment of informal settlements.

  The significance of the impact is Negligible or Minor.

- Traffic increase during construction phase.

  This impact has been assessed in the following section “traffic and transport”.

5.2.17.2. Operation phase

Positive Impacts

The installation of the Solar Power Plant will improve the renewable energy sector in the Kingdom and SEC service. This will result in benefits to Kingdom economy by providing a more reliable electricity supply and

decrease the reliance on fossil fuel energy. This will have a positive impact on air quality through the reduction of air emissions from Thermal Power plants and may reduce the cost of electricity.

Working opportunities will be created by hiring technical workers for operations at the solar power plant during operation phase. In addition to technical workers, other people will be engaged at site for security and administrative duties expected. So, the operation of the plant may also result in employment opportunities, indirectly through creating free energy source in a non-urbanized area which would enhance the emergence and development of small businesses e.g., suppliers/distributors of foodstuff, among other service providers. The development could increase income in the future due to people who will go to that area to trips and excursions.

Negative impacts

Operation of the solar plant could have an impact on land use by disturbing access of camel and sheep herders to grazing areas, creating conflicts with local communities. The likelihood is seldom. The significance of the impact is Negligible or Minor. Movement of traffic to and from the site will be limited primarily to that of workers vehicles. This impact has been assessed in the following section "traffic and transport".

5.2.17.3. Decommissioning phase

- Job losses at the end of the project life cycle. The impact will be Negligible and Likely.

5.2.17.4. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with economic and social aspects during construction, operation, and decommissioning phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Local communities Herders/ campers Workers	Job opportunities creation	Positive Impact	Likely	-
	Workers conflict with local communities	Negligible or Minor	Unikely	Low
	Influx or workers, and spread of diseases	Negligible or Minor	Unikely	Low
	Local economy benefits	Positive Impact	Likely	-
Operation				
Local communities Herders/ campers Workers	Job opportunities creation	Positive Impact	Likely	-
	Workers conflict with local communities	Negligible or Minor	Unikely	Low
	Influx or workers, and spread of diseases	Negligible or Minor	Unikely	Low
	Local economy benefits	Positive Impact	Likely	-
Decommissioning				
Workers	Job losses	Negligible	Likely	Medium

Table 78. Risk Assessment Summary for economic and social aspects

5.2.18. Traffic and Transport. Impact assessment

5.2.18.1.Construction phase

The key reason for vehicle uses during construction will be the transfer of employees on the site on a daily basis, as well as the delivery of materials and equipment for construction activities.

It is anticipated that traffic levels will increase temporarily on local roads during the construction phase. The volume of traffic will vary over the course of construction, depending on the phases of construction and the demand for materials, removals, and construction personnel on site. The main factors that will affect the number of vehicles on the roads will be related to manpower needs, material usage and waste generation. There will be the potential for increased road traffic accidents from increased construction traffic. During construction, non-local employees are typically employed on a 'single' basis, they will not come with their families. Often, they can be housed close to the construction sites in purpose- built accommodation of within the nearby communities, which will most be likely in this case.

The impact on traffic and transport during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Short-Term.

Reversibility: Reversible.

Duration: Temporal.

Likelihood: Seldom.

Potential Impact Significance: Negligible.

Risk: Low.

The impact due to the traffic movement during construction is assessed as Negligible and Seldom. The Risk is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.18.2.Operation phase

There may be some alterations in the existing road traffic movements associated with the operation of the project. However, these impacts will be considerably less than during construction. During operation and maintenance trips to and from the solar plant will be limited to the trips of maintenance stuff with their machinery and using access tracks which are less frequent than in construction phase and daily trips of operations workers to get to work.

The impact on traffic and transport during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Long-Term.

Reversibility: Reversible.

Duration: Permanent.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Low-Very Low.

Impact during operation phase is Negligible and Remote. The Risk is considered Low-Very Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.18.3. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with traffic and transport during construction, and operation phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Local communities Campers/herders Workers Ambient Noise Air quality	Rising of traffic volume on local roads Risk of accidents/ injuries Rise of ambient noise Air quality degradation	Negligible	Seldom	Low
Operation				
Local communities Campers/herders Workers Ambient Noise Air quality	Rising of traffic volume on local roads Risk of accidents/injuries Rise of ambient noise Air quality degradation	Negligible or Minor	Remote	Low-Very Low

Table 79. Risk Assessment Summary for traffic and transport

5.2.19. Antiquities and Cultural Heritage. Impact assessment

5.2.19.1. Construction phase

The project site is not located in a designated archaeological priority area nor contains any scheduled ancient, and recognized monuments. There were no archaeological and heritage features recorded within the Project Site.The impact on antiquities and cultural heritage during construction phase is considered:

Nature: Negative.

Sensitivity of receptor: Low

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Short-Term.

Reversibility: Irreversible.

Duration: Temporal.

Likelihood: Unlikely.

Potential Impact Significance: Negligible or Minor.

Risk: Low.

The Risk Is considered Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.19.2. Operation phase

Once built, it is unlikely that operation of the facility would impact on any areas of cultural interest. The operation will not adversely impact paleontological resources because the ground disturbed during these activities have been already disturbed during construction phase. The impact on antiquities and cultural heritage during operation phase is considered:

Nature: Negative.

Sensitivity of receptor: Low.

Magnitude: Negligible.

Extent: Local-Regional.

Timing: Long-Term.

Reversibility: Irreversible.

Duration: Temporal.

Likelihood: Remote.

Potential Impact Significance: Negligible or Minor.

Risk: Low-Very Low.

The impact is considered Negligible. The Risk Is considered Low-Very Low. Tolerable but may still need to have best practice applied to them to ensure they comply.

5.2.19.3. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with antiquities and cultural heritage during construction, and operation phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Cultural Heritage	Risk destruction of archaeological and cultural heritage	Negligible or Minor	Unlikely	Low
Operation				
Cultural Heritage	Risk destruction of archaeological and cultural heritage	**Negligible or Minor**	**Remote**	Low-Very Low

Table 80. Risk Assessment Summary for antiquities and cultural heritage

5.2.20. Unplanned Events. Impact assessment

Unplanned events include a range of unintended activities and accidental events during construction and operational processes as well as a result of improper handling of hazardous materials and wastes (storage, transport and final disposal) and vehicle accidents.

These accidental events may produce fire and explosions, atmospheric pollutant emissions, leaks, and spills, between others. They can negatively affect several receptors, including primarily air, soil, and water quality. Indirectly this also can produce adverse effects on fauna and flora as well as workers and communities.

Receptor	Risk Factor
Air quality	Fire and explosions. Atmospheric accidental emissions
Soil	Soil pollution from leak and spills
Water quality	Water pollution from leak and spills
Ecosystem	Harm, habitats destruction
Workers /population	Accidents/ injuries/loss of lives

Fire, explosions, and atmosphere pollutant emissions

Air quality can be affected as a result of explosions and fires and accidental pollutant emissions. This type of event can also produce indirect adverse effects on water and soil quality, fauna, flora and population. It can occur because of accidents during construction and maintenance operations but also from a deficient handling of hazardous materials and wastes and vehicle accidents (transport and worker journeys).

A large concentration of various air pollutants such as sulfur dioxide and particulate matter results from fire and/or explosion. The type of air pollutants emitted depends on the properties of the flammable substance as well as temperature.

The effect of fire and explosion on ambient air quality is highly dependent on various factors such as the type and size of the flammable substance and the duration of the fire.

Atmospheric pollutant emissions that may severely affect air quality are remote as vehicles and machinery usually used in construction and transport have their preceptive inspection and emissions limitations. Operation of the plant otherwise does not produce significant emissions.

Project include a wide range of prevention measures that reduce likelihood of the event occurrence to remote. In the event of a large fire, given the low sensitivity of the potentially affected receiver, the magnitude of the effect is expected to be Moderate and the significance of the impact Minor.

The Risk Is considered Tolerable but need to have best practice applied to them to ensure they comply.

Leaks and spills

During construction, potential soil contamination may occur from materials such as: fuel, engine oil, paint, solvents, and chemical additives, which are expected to be stored and circulated at the construction site. Also, improper management of hazardous materials and solid waste, vehicles accidents or failure in the human sewage facilities may lead to the same results. Accidental spills may reach the soil, resulting in contamination.

Soil quality can be affected with a wide range of consequences. However, as project include specific prevention measures Magnitude has been assessed as Moderate, the Likelihood Remote and the significance of the effect Minor. The Risk Is considered Tolerable but need to have best practice applied to them to ensure they comply.

Once soil affected, indirectly groundwater quality may be also affected by leaks and spills. Groundwater was found only in two boreholes in the study area during the geotechnical campaign. A water table is present at an approximate depth of 27.5 m in BH-01 and another at approximately 14.0 m in BH-73. With this information in mind the overall impact on the quality of the groundwater due to various non-routine events can be categorized as Minor and its likelihood as Remote.

Biological environment includes flora and fauna as well as its ecosystem values. These resources may also be adversely affected indirectly after soil and groundwater pollution. The extent and magnitude of the effect is highly dependent on the substance/chemical released in terms of composition and quantity. Due to the low sensitivity of potentially affected environmental receptors, significance of the effect has been rated as Minor and Likelihood as Remote. The Risk Is considered Tolerable but need to have best practice applied to them to ensure they comply.

Finally indirect adverse effects on the human environment can also result from leaks as spills derived from non-routine incidental events. Adverse effects may result on health of construction and maintenance workers but also of the communities nearby. Increasing of traffic volume may also increase risk of vehicle accident and then risk of serious injuries /death to workers and community. However, as project includes specific prevention measures, Magnitude has been assessed as Moderate, the Likelihood Remote and the significance of the effect Minor. The Risk Is considered Tolerable but need to have best practice applied to them to ensure they comply.

5.2.20.1. Summary of Risk Assessment

Table below provides a summary of the significant risks that the proposed project presents to key or sensitive receptors associated with unplanned events during construction, and operation phases.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Construction				
Workers/Population Water quality Air quality Soils Ecosystem	Risk of fire, explosions, pollutants. Leaks and spills.	Minor	Remote	Low
Operation				
Workers/Population Water quality Air quality Soils Ecosystem	Risk of fire, explosions, pollutants. Leaks and spills.	Minor	Remote	Low

Table 81. Risk Assessment Summary for unplanned events

5.2.21. Human Rights. Impact assessment

International human rights law provides a clear and universal framework for the promotion and protection of the right to development. It states that the creation of conditions of stability and well-being are necessary for peaceful and friendly relations among nations.

The Universal Declaration on Human Rights contains the concepts of promotion of social progress and better standards of life, recognizes the right to non-discrimination, the right to participate in public affairs and the right to have an adequate standard of living. It also refers to the principle of equal rights and self-determination of peoples, solutions to international economic, social, health, employment and related problems, international cultural and educational cooperation; and universal respect for, fundamental freedoms for all without distinction as to race, sex, language, or religion.

The main objective of the human rights impact assessment is to identify, understand, assess, and address the potential adverse effects of the project on workers and community members. The human right assessment is also intended to prevent or mitigate risks of adverse impacts from the project operation. A proactive approach was taken to ensure that right of workers and community members are to be respected and promoted.

Risks may mostly occur during the construction phase. Construction phase is the stage in which most people will be involved. Maintenance of a solar plant manpower requirements are very low.

Adverse effects during this phase will mainly be related to workers labor conditions even if they relationship with local community must also be carefully considered.

Risks factors identified may be summarized in the following subjects:

- Labour Rights issues.
- Human Resources (HR) Policy and Procedures.
- Gender, race, language, or religion equality.
- Condition of Work.
- Employment contract.
- Accommodation.

- Environmental, Safety & Health issues at workplace.
- Child labour and forced labour.

The impact is considered Negligible and Remote. The Risk is considered Very Low, Tolerable but may still need to have best practice applied to them to ensure they comply.

Receptor	Risk Factor	Significant of effects	Likelihood	Risk Ranking
Workers	Labour rights issues Human Resources (HR) Policy and Procedures Gender, race, language, or religion equality	Negligible	Remote	Very Low
	Bad work conditions Employment contract. Accommodation. Environmental, Safety & Health issues at workplace.	Negligible	Remote	Very Low
	Child labour and forced labour	Negligible	Remote	Very Low

Table 82. Risk Assessment Summary for human rights

5.2.22. Cumulative Impacts

Cumulative Impacts are the additive potential impacts that may result from the incremental potential impacts of the planned project plus the potential impacts of reasonably anticipated future projects or future phases of a same development.

The assessment of cumulative impacts must be based upon solid documented development plans/strategies and announced projects. International guidelines recommend a study area between 10 and 15 km from the project site to assess cumulative impacts to occur with other future developments.

Cumulative impacts from operation of project have been considered in relation to proposed developments in the surroundings of study area. A radius of 15 km from the project site has been considered in this assessment.

There is not available information of the future development plans around the project area (15 km radius).

5.3. Summary of the expected impact evaluation

The table below presents a summary of the expected impacts during the construction and operation phases of the project. It provides a description of the most important potential environmental impacts in terms of the nature of the impact, magnitude, extent, timing, duration, reversibility, likelihood, and importance.

Environmental aspect	Potential Impact	Phase	Sensitivity of Receptor	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Likelihood	Potential Impact Significance
Natural vegetation cover	Vegetal cover removal	Construction	Low	Negative	Minor	Local	Short-term	Temporal	Irreversible	Occasional	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor	Local	Long - term	Temporal	Irreversible	Remote	Negligible or Minor
Terrestrial Biodiversity. Fauna and flora	Ecosystem disturbance and habitat destruction	Construction	Low	Negative	Minor	Local	Short-term	Temporal	Irreversible	Occasional	Negligible or Minor
	Habitat fragmentation, birds collision and electrocution	Operation	Low (High for Steppe eagle)	Negative	Negligible	Local	Long - term	Permanent	Reversible	Unlikely	Negligible or Minor
	Introduction of invasive species	Construction	Low	Negative	Negligible	Local-Regio-nal	Short-term	Temporal	Reversible	Unlikely	Negligible or Minor
		Operation	Low	Negative	Negligible	Local-Regio-nal	Long-term	Temporal	Reversible	Unlikely	Negligible or Minor
Air quality	Air quality degradation	Construction	Low	Negative	Minor	Local	Short-term	Temporal	Reversible	Occasional	Negligible or Minor
		Operation	Low	Negative	Negligible	Local	Long - term	Permanent	Reversible	Unlikely	Negligible or Minor

Environmental aspect	Potential Impact	Phase	Sensitivity of Receptor	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Likelihood	Potential Impact Significance
Noise and vibration	Noise disturbance	Construction	Low	Negative	Minor	Local	Short-term	Temporal	Reversible	Occasional	Negligible or Minor
		Operation	Low	Negative	Negligible	Local	Long - term	Permanent	Reversible	Unlikely	Negligible or Minor
Odours (smells)	Air quality disturbance. Bad smells	Construction	Low	Negative	Negligible	Local	Short-term	Temporal	Reversible	Unlikely	Negligible or Minor
		Operation	Low	Negative	Negligible	Local	Long - term	Temporal	Reversible	Unlikely	Negligible or Minor
Surface water quality	Surface water quality degradation	Construction	Low	Negative	Negligible	Local-regio-nal	Long-term	Temporal	Reversible	Remote	Negligible or Minor
		Operation	Low	Negative	Negligible	Local-regio-nal	Long - term	Permanent	Reversible	Remote	Negligible or Minor
Surface water availability	Surface water resources exhausting	Construction	Low	Negative	Negligible	Local-regio-nal	Short-term	Temporal	Irreversible	Remote	Negligible or Minor
		Operation	Low	Negative	Negligible	Local-regio-nal	Short-term	Permanent	Irreversible	Remote	Negligible or Minor
Ground-water quality	Ground-water quality degradation	Construction	Low	Negative	Negligible or Minor	Local-regio-nal	Long-term	Temporal	Irreversible	Unlikely	Negligible or Minor
		Operation	Low	Negative	Negligible	Local-regio-nal	Long - term	Temporal	Irreversible	Remote	Negligible or Minor

Environmental aspect	Potential Impact	Phase	Sensitivity of Receptor	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Likelihood	Potential Impact Significance
Hydrology and flood risk	Natural hydrologic system disturbance	Construction	Low	Negative	Negligible	Local-regio-nal	Long - term	Temporal	Irreversible	Unlikely	Negligible or Minor
		Operation	Low	Negative	Negligible	Local-regio-nal	Long - term	Permanent	Irreversible	Unlikely	Negligible or Minor
Soil Quality	Potential soil contamina-tion and compaction	Construction	Low	Negative	Negligible	Local	Short-term	Temporal	Reversible	Unlikely	Negligible or Minor
		Operation	Low	Negative	Negligible	Local	Short-term	Temporal	Reversible	Remote	Negligible or Minor
Health and safety	Risk of accidents and injuries during construction and operation	Construction	Low	Negative	Negligible	Local-regio-nal	Short-term	Temporal	Reversible	Unlikely	Negligible or Minor
		Operation	Low	Negative	Negligible	Local-regio-nal	Long - term	Permanent	Reversible	Remote	Negligible or Minor
Landscape and visual comfort	Degradation of general landscape of the site	Construction	Low	Negative	Minor	Local	Short-term	Temporal	Irreversible	Occasional	Minor
		Operation	Low	Negative	Negligible	Local	Long - term	Permanent	Irreversible	Remote	Negligible or Minor
Land use	Modification of land use	Construction	Low	Negative	Minor	Local	Short-term	Temporal	Irreversible	Occasional	Minor
		Operation	Low	Negative	Negligible	Local	Long - term	Permanent	Irreversible	Remote	Negligible or Minor

Environmental aspect	Potential Impact	Phase	Sensitivity of Receptor	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Likelihood	Potential Impact Significance
Waste generation	Non-hazardous and hazardous waste generation Contamination of water and soil if managed badly	Construction	Low	Negative	Negligible	Local-regio-nal	Short-term	Temporal	Irreversible	Seldom	Negligible or Minor
		Operation	Low	Negative	Negligible	Local-regio-nal	Long - term	Permanent	Irreversible	Unlikely	Negligible or Minor
Glint and Glare	Visual impact due to solar radiation reflection	Operation	Low	Negative	Negligible or Minor	Local	Long - term	Permanent	Irreversible	Unlikely	Negligible or Minor
Climate change	Reduction/ increasing of GHGs	Construction	Low	Negative	Negligible	Local-regio-nal	Long-term	Temporal	Irreversible	Seldom	Negligible or Minor
		Operation	Low	Positive	Major	Local-regio-nal	Long - term	Permanent	Irreversible	Likely	Positive impact
Economic and social aspects	Creation of job opportunities	Construction	Low	Positive	Minor	Regio-nal	Short term	Temporal	Reversible	Likely	Positive impact
		Operation	Low	Positive	Minor	Regio-nal	Long-term	Permanent	Reversible	Likely	Positive impact
	Growth of regional economy	Construction	Low	Positive	Minor	Regio-nal	Long-term	Temporal	Reversible	Likely	Positive impact
		Operation	Low	Positive	Moderate	Regio-nal	Long-term	Permanent	Reversible	Likely	Positive impact

Environmental aspect	Potential Impact	Phase	Sensitivity of Receptor	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Likelihood	Potential Impact Significance
	Workers conflict with local communities	Construction	Low	Negative	Negligible	Local-regio-nal	Short-term	Temporal	Reversible	Unlikely	Negligible or Minor
		Operation	Low	Negative	Negligible	Local-regio-nal	Long-term	Temporal	Reversible	Unlikely	Negligible or Minor
	Infectious disease spread	Construction	Low	Negative	Negligible	Local-regio-nal	Short-term	Temporal	Reversible	Unlikely	Negligible or Minor
		Operation	Low	Negative	Negligible	Local-regio-nal	Long-term	Temporal	Reversible	Unlikely	Negligible or Minor
Traffic and transport	Volume of traffic rise and risk of accidents	Construction	Low	Negative	Negligible	Local-regio-nal	Short term	Temporal	Reversible	Seldom	Negligible
		Operation	Low	Negative	Negligible	Local-regio-nal	Long - term	Permanent	Reversible	Remote	Negligible or Minor
Antiquities and cultural heritage	Risk destruction of archaeologi-cal and cultural heritage	Construction	Low	Negative	Negligible	Local-regio-nal	Short-term	Temporal	Irreversible	Unlikely	Negligible or Minor
		Operation	Low	Negative	Negligible	Local-regio-nal	Long - term	Temporal	Irreversible	Remote	Negligible or Minor

Environmental aspect	Potential Impact	Phase	Sensitivity of Receptor	Nature	Magnitude	Extent	Timing	Duration	Reversibility	Likelihood	Potential Impact Significance
Unplanned events	Risk of fire, explosions, pollutants. Leaks and spills	Construction	Low	Negative	Moderate	Local-regio-nal	Short/ Long term	Temporal	Reversible	Remote	Minor
		Operation	Low	Negative	Moderate	Local-regio-nal	Long/ Short term	Permanent	Reversible	Remote	Minor

Table 83. Summary of Impacts

5.4. Checklist: Significance of the impacts

A checklist is included below in relation to the significance of the impacts, adapted from the European Economic Community Check list (source: Guidance on EIA. June 2001. Environmental Resources Management) to the study area.

Questions to be Considered:

a. Will there be a big change in environmental conditions? No

b. Will new features be out-of-scale with the existing environment? No

c. Will the effect be unusual in the area or particularly complex? No

d. Will the effect extend over a large area? No

e. Will there be any potential for transfrontier impact? No

f. Will many people be affected? No

g. Will many receptors of other types (fauna and flora, businesses, facilities) be affected? No

h. Will valuable or scarce features or resources be affected? No

i. Is there a risk that environmental standards will be breached? No

j. Is there a risk that protected sites, areas, features will be affected? No

k. Is there a high probability of the effect occurring? No

l. Will the effect continue for a long time? No

m. Will the effect be permanent rather than temporary? No

n. Will the impact be continuous rather than intermittent? No

o. If the impact is intermittent, will it be frequent rather than rare? No

p. Will the impact be irreversible? No

q. Will the impact be difficult to avoid, or reduce or repair or compensate for the effect? No

Plans

6. Plans

6.1. Emergency preparedness and response plan

Emergencies in the construction and operation phases may result from natural disasters, pollution, or chemical spills and other environmental risks.

The emergency preparedness and response plan will include, but is not limited to, the following measures:

- Procedures for dealing with emergencies and environmental disasters,
- Emergency preparedness and response planning,
- Training and awareness raising,
- Corrective action plan after the accident.

6.1.1. Emergency procedures for accidents in construction phase

Construction contractor will draw up an Occupational and Community Health and Safety Plan and an Emergency Response Plan. The Plan will contain the following aspects:

- Strictly implement approved Occupational and Community Health and Safety Plan, and approved Emergency Response Plan.
- Appoint an environment, health, and safety manager to look after implementation of required environmental mitigation measures, and to ensure that health and safety precautions are strictly implemented for the protection of workers and the general public in the vicinity of construction areas.
- Conducting suitable and effective staff training and awareness activities to ensure the project employees understanding, appreciation and adherence to the suggested environmental and social management requirements.
- Provide first aid facilities that are readily accessible by workers.
- Provide firefighting equipment at the work areas, where appropriate, and at construction camps.
- Appropriate Personal Protective Equipment (PPE) shall be provided for the workforce.
- Establish clean canteen/rest area.
- Provide sufficient lighting in construction areas to enable safe equipment operation. Provide emergency lighting system of adequate intensity that is automatically activated upon failure of the principal artificial light source to ensure safe equipment operation, safe shut-down, evacuation, etc.

- Confined spaces will be provided with safety measures for venting, monitoring, and rescue operations, to the extent possible.
- Implement precautions to ensure that objects (e.g., equipment, tool, debris, etc.) do not fall onto or hit people, vehicle, and properties in adjoining areas.
- Fencing of construction sites and excavation sites and guarding such areas to restrict public access.
- Prior to excavation work, provide fencing on all sides of areas to be excavated.
- Provide warning signs at the periphery of the construction site.
- Strictly impose speed limits on construction vehicles along sensitive areas.
- Educate drivers on safe driving practices to minimize accidents and to prevent spill of hazardous substances and other construction materials during transport.
- Provide adequate drainage in workers camps to prevent water logging.
- Provide potable water, hygienic sanitation facilities/toilets with sufficient water supply.
- Construction contractor will strictly implement approved Occupational and Community Health and Safety Plan, and approved Emergency Response Plan.

6.1.2. Emergency procedures for accidents in operation phase

Prior to operation of the project, Principal Buyer will ensure Emergency Procedures for Accidents have been developed and adequately resourced, as well as shall ensure strict implementation of plan provisions throughout operational phase:

- Occupational Health and Safety Plan for project facilities and train staff in the implementation of such plan.
- Security and Emergency Response Plan (SERP) (e.g., in case of fire, floods, equipment breakdown, accidents, security issues, etc.) covering operational phase. Staff will be trained in the implementation of such plan.

6.2. Environmental rehabilitation and addressing plan

6.2.1. Environmental Rehabilitation Plan

The Environmental Rehabilitation Plan details a framework which aims to address environmental issues related to the rehabilitation, decommissioning and closure of the Solar Plant.

This plan will be developed as per the requirements of National regulations and describes the manner in which environmental rehabilitation will be implemented during the various phases of the proposed infrastructure and activities.

Recommendations and commitments relating to rehabilitation will be included based on the Project plans. It is expected that this Environmental rehabilitation plan will be updated when Project designs are finalised. Accordingly, this plan will be regularly reviewed and updated to reflect revised Project design and learning experienced during its implementation.

The objectives of the Environmental Rehabilitation Plan will be the following:

- Reintegrate the site into the surrounding area, increasing landscape quality.
- Restore the affected ecosystem, enhancing site biodiversity.
- Ensure that all areas are stable, and that there are not erosion risks.
- Ensure that all applicable environmental regulations and best practices are followed and implemented.
- Contribute to the economic increase.
- Comply with the stakeholders' requirements.
- Rehabilitate the site for a new land use after decommission phase. Return the site to a condition as similar as possible to the natural environment or to the end use.

The Environmental Rehabilitation Plan will include the following measures:

- Removal, stockpiling, conservation of topsoil and reuse for revegetation works.
  The topsoil will be piled and conserved for their further utilization, in the restoration works. To maintain the stockpile in optimal conditions, erosions caused by rain will be restored. This topsoil will be stockpiled within an area delimited by the marking out, without affecting the existing vegetation.
  The stockpiled topsoil must be extended over the areas to be restored after morphological correction. A layer of 30 cm of topsoil must be spread.
- Restoration of the construction camps
  On completion of the project the camp will be suitably decommissioned, and all construction debris, wastes or scraps shall be removed. The area will be rehabilitated after decommissioning.
  The contractor will restore the construction camps to its condition prior to commencement of the works or to an agreed condition with the landowner.
  The contractor will dismantle and remove from the site all facilities establish within the construction camp including the perimeter fence.
  Recycling or reuse of demolish material will be promoted during demolition of construction camps.
- Remediation any compacted soils. Scarification of the terrain. It will proceed to the scarification of all the areas to be restored, preparing the surfaces for the subsequent spread of topsoil, thus ensuring a better subjection of this surface layer, and avoiding its sliding, also favouring the infiltration of water and a better rooting of the roots.
- Restoration of the terrestrial ecology habitats within the Project footprint including access roads e.g., re-seeding and re-vegetation using local indigenous species. Natural areas with native species will be created in study area. Plantation for environmental balance, ecosystem development, and conservation site for wildlife,
  Planting, as part of mitigation measures, will increase the ability of the landscape to accommodate the project. Different criteria will be used to select the most suitable species to achieve a balanced and sustainable plantation scheme. The selected species will have the purpose of contributing for the integration of the new buildings and structures with the surrounding environment. Some of the criteria for planting selection will be the following:
  - Climate: Plants are adapted in diverse ways to climate. Tolerances to sun, drought, wind, and salinity will be identified for each species. Selected species will be adapted to study area conditions.
  - Water and soil requirements: In order to limit the need for irrigation, native species and drought tolerant species will be mainly selected. Selected species will be adapted to site's soil.

- Sun exposure: Knowing about this aspect is necessary to locate plants in the proper place. In general, north-facing exposures are cooler and receive less sunlight, just the opposite of south-facing exposures.
- Availability in local nurseries: The species will be available and accessible locally.
- Maintenance level: A lower maintenance level is associated with less costs and optimized upkeep.

- After decommissioning and closure of the Solar Plant, removal of all Project related components and wastes and appropriate disposal method that adopts the waste hierarchy and maximises re-use and recycling of materials.

6.2.2. Environmental Remediation Plan

The Environmental Remediation Plan is a document in which is formulated the course followed to address a case of environmental contamination. The purpose of a remediation plan is to identify and treat the contamination so that the contaminated area will be restored and be usable again.

No polluted soils have been observed during field surveys. No Environmental Remediation Plan is necessary.

6.3. The proposed plan to reduce environmental impacts for each environmental component

Mitigation measures are defined as the approved practices that avoid, prevent, reduce, or eliminate the negative environmental impacts associated with any development project.

Prevent and avoid the impact is better than minimize, reduce, mitigate or compensate it.

Preventive measures are more effective when applied at an early stage of project (planning).

During first stages, the environmental component is a key factor in the design of the elements of a project. Sustainable design can enable to avoid risks and impacts, reducing costs and improving benefits.

The overall objective of the environmental infrastructure design criteria will be to ensure that the project will be developed in an environmentally sustainable manner ensuring that all negative effects are mitigated as well as practical and positive impacts are enhanced.

Mitigation hierarchy has been considered during the design of the project: Avoid, Minimize / Reduce, Mitigate, and Compensate. See figure below; that is:

- Anticipate and avoid risks and impacts.
- Where avoidance is not possible, minimize or reduce risks and impacts to acceptable levels.
- Once risks and impacts have been minimized or reduced, mitigate such risks and impacts.
- Compensate where significant impacts occur.

Preference Order	Migration Hierarchy
1	Avoid/Prevent
2	Minimize/Reduce
3	Mitigate
4	Compensate

Figure 172. Mitigation hierarchy in the Design of the Project

This section presents the mitigation measures that must be adopted during the construction, operation and decommission phases to avoid, reduce and minimize associated negative environmental impacts as much as possible. These mitigation measures are based and aligned with the Environmental and Social Codes Practice for Construction and Operation.

6.3.1. Flora

6.3.1.1. Construction phase

The area is poorly vegetated, with low vegetation coverage. However, the EPC Contractor will implement the following mitigation measures to preserve the scarce natural vegetation cover:

- The Contractor will avoid unnecessary plants removal or disturbances.
- To avoid impacts near the zones with flora, before the construction works start, the Contractor will proceed to protect them, marking the outer limits. The marking out will consist of steel rods of 30 mm wide and one meter in length, with the lower 30 cm nailed to the ground. These supports will be embedded into the ground and placed every 8 meters and will be joined to each other by a plastic tape (see figure below).

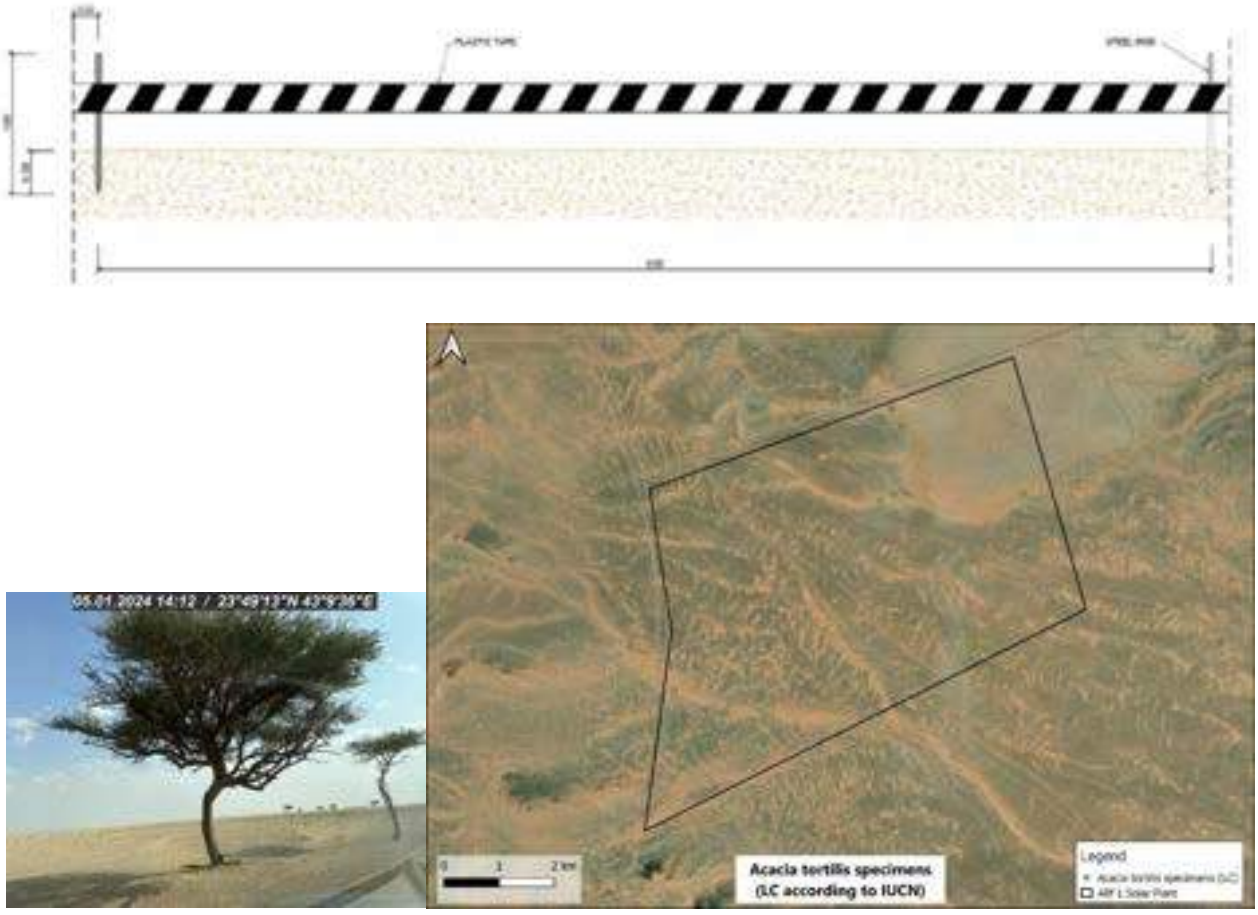


Figure 173. Temporary marking out to protect the trees (Acacia tortilis).

- The marking out will be continuously reviewed to ensure its functionality and it will be replaced when it is damaged. The marking out will be temporary, and it will be extended during the period in which

the works are carried out. Once the work has been completed, the tape and steel rods will be removed, as well as any other element foreign to the environment related to this work unit.

- The Contractor will ensure that only vegetation within the work boundary is removed. Vegetation outside the proposed project layout will not be removed or disturbed. An emergency response plan will be in place in the case of any event of additional or modified vegetation removal outside the scope of the project.
- The Contractor must comply with the requirements of the Executive Regulation for Vegetation cover development and Combating Desertification (Ministerial Decision No. 354566/1/1442).
- The minimum number of trees (acacias) should be removed from the project site in order to achieve the minimal impact possible on the biodiversity at the Project Site. The trees removed should be replaced by other trees to be planted in the vicinity of the project site in order to act as an offset for the removed trees and as a new refuge for the species affected.
- Vegetation must not be removed with herbicides without the approval of the project manager.
- The Contractor will ensure that machinery can only move within site boundaries, auxiliary site facilities and other items that are maintained within designated areas.
- Machinery and vehicles will be cleaned upon entry/exit, and any soil brought on or off site screened for invasive species or plant pathogens.
- The Contractor must obtain the necessary approvals to remove some plants. In case of removing plants, the Contractor will develop and implement the Plant Transplanting Plan.
- The Contractor will consider seeds collection as an option, in order to obtain local genetic material which could be used in further plantations.
- The Contractor will not burn plants, and residues will be disposed in approved landfill.
- The Contractor will install informational signs with specific legends that constitute system information to operators and site personnel regarding standards and behaviours to prevent environmental impact on plants.
- The Contractor will be responsible for informing and training all employees of the need to prevent any adverse effects on the natural vegetation on or around the construction site as a result of their activities.
- The Contractor shall implement fire prevention measures and avail fire extinguishers on all equipment.

6.3.1.2. Operation phase

During operation phase, the Operator will Implement proper management measures to prevent damage to the biodiversity of the site. This could include establishing a proper code of conduct and awareness raising/training of personnel and good housekeeping. The scarce vegetation will be preserved.

The Operator should check periodically the vegetation preserved areas to ensure that day by day activities are not negatively affecting them.

6.3.1.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.2. Fauna and Biodiversity

6.3.2.1. Construction phase

- The Contractor will Implement proper management measures to prevent damage to the biodiversity of the site. This could include establishing a proper code of conduct and awareness raising/training of personnel and good housekeeping.
- Prohibit hunting at any time and under any condition by construction workers onsite.
- The Contractor will ensure proper storage, collection, and disposal of waste streams generated.
- The Contractor will restrict activities to allocated construction areas only, including movement of workers and vehicles to allocated roads within the site and prohibit off-roading to minimize disturbances.
- The Contractor will avoid unnecessary elevated noise levels at all times. In addition, he will apply adequate general noise suppressing measures.
- The Contractor will prohibit the use of alarm sounds, specially near the zones where active burrows of HCP species (STL) have been located.
- Machinery and vehicles will be cleaned upon entry/exit, and any soil brought on or off site screened for invasive species or plant pathogens.
- Disturbed areas will be rehabilitated at the earliest opportunity with native and endemic species to minimize the establishment of invasive plant species.
- Source areas such as vehicle parking and construction lay down areas will be kept clean of invasive plants to minimize the presence of seeds that can be dispersed unintentionally.
- The Contractor will prohibit the use of pesticides or herbicides on site.
- A regular and ongoing monitoring of the presence of invasive plant species will be conducted within construction and rehabilitated sites and removal operations implemented according to the results.
- The Contractor will ensure that complies with all national and local legislation and by-laws regarding the protection of flora and fauna. No flora or fauna may be removed without the approval of the Project Director.
- The minimum number of trees should be removed from the project site in order to achieve the minimal impact possible on the biodiversity at the Project Site. The trees removed should be replaced by other trees to be planted in the vicinity of the project site in order to act as an offset for the removed trees and as a new refuge for the species affected.
- Contractor must mark the fence has with high visibility elements (plates) to prevent birds from collision.

Figure 174. Plates in the fence to avoid birds´ collision.

- Regarding avifauna and considering the vulnerability of the Steppe eagle to collision incidents with overhead lines, Contractor will incorporate steps to protect them (Spiral bird protector devices to avoid electrocution risk).

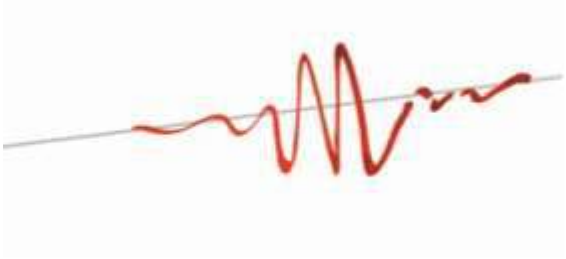


Figure 175. Spiral bird protector devices in transmission lines.

- The Contractor will not permit to destroy any active nest/burrow or eggs of birds or reptiles.
- The Environmental Engineer will be in charge of all environmental issues, including the check of active nest/burrows or eggs before the starting of construction works.
- As there were locations where likely reptile burrows were recorded, the Contractor will check its possible presence and adopt the proper mitigation measures if needed.
- During the breeding and nesting season of the HCP avifauna (Steppe eagle), that is between April and Jule, although this specie is nonbreeding in the study area, the Contractor should avoid noisy works and minimize disturbing activities then where susceptible avifauna have been identified.
- Regarding HCP reptile's species (STL), reproduction is seasonal, with mating in early spring (March), oviposition in late spring (May-June) and hatching in summer (July). The Contractor will avoid minimize disturbing activities then where susceptible reptiles have been identified. In case of HCP reptiles' presence, the relocation plan will be implemented by Contractor (capture and relocation of each specimen).
- Incidents of animals spotted at construction areas must be reported immediately. The Environmental Engineer will check the site for animals trapped in, or in danger from site works, and he will relocate the animal.
- Strick housekeeping in the accommodation camp and other site areas to avoid attracting wildlife.
- Night time driving must be restricted to emergencies only.
- The Contractor will avoid loose and unnecessary strings, cables, and rubbish.
- The Contractor will include plates in fences to prevent birds from collision.
- The Contractor will include spiral bird protector devices in the transmission lines to avoid electrocution risk.

6.3.2.2. Operation phase

The following identifies the mitigation measures to be applied by the Project Operator during the operation phase and which include:

- Implement proper management measures to prevent damage to the biodiversity of the site. This could include establishing a proper code of conduct and awareness raising/training of personnel and good housekeeping.
- Prohibit hunting at any time and under any condition by workers onsite.
- Ensure proper storage, collection, and disposal of waste streams.
- Restrict activities to allocated areas only, including movement of workers and vehicles to allocated roads within the site and prohibit off-roading to minimize disturbances.

6.3.2.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.3. STL Relocation Plan

6.3.3.1. Introduction

Following the completion of the Works sites ecological surveys, it is recommended that a relocation program (RRP) is implemented to minimise impacts to the flora / fauna currently residing within the proposed project site. In accordance with IFC Performance Standard 6, in particular Paragraph 16, the presence of some trees / shrubs and the Spiny-tailed Lizard (STL) and their habitat is of ecological importance to which protection should be afforded. Further support of this implementation is in the form of STL being recognized by Saudi Wildlife Authority as a High Conservation Priority species, an IUCN Red List Vulnerable species and a CITES Appendix II species.

The following provides an overview of Tree / shrubs / STL within the project, along with a proposed methodology for relocation, receptor site assessment and trapping. It is based on the Species Relocation Action Plan for the Spiny-tailed Lizard.

6.3.3.2. Requirement for the Plan

Egyptian Spiny-tailed Lizard (Uromastyx sp) is a large, robust terrestrial lizard with a thick spiny tail, easily distinguishable from any other lizard species. It can reach up to 75 cm of total length. The head is cordiform, with short, rounded snout. Body is robust, dorsoventrally flattened. Extremities are remarkably strong, toes relatively short, with robust claws. Ground colour uniform, usually greyish, brownish, or yellowish, but vary considerably according to temperature. Head and neck are often dark.

The most productive period for reptiles in Saudi Arabia is generally late spring and early autumn. It is the opinion of some authors that the heightened reptile breeding and feeding activity brought about by warm weather in spring, followed by an evenly increasing temperature gradient, is by far the most productive time to conduct field surveys. Midday temperatures remain in the mid-30s, allowing diurnal species to remain active throughout the daylight hours.

STL reproduction is seasonal, with mating in early spring (March), oviposition in late spring (May-June) and hatching in summer (July).

Figure 176. Relocation Plan for STL.

Spiny-tailed Lizards within Arabia face a multitude of threats. These threats, in combination with continued urban sprawl and development, place irreversible strain on the distribution and genetic variability amongst remnant lizard populations. A brief overview of key threats to STL populations are outlined below.

Spiny-tailed Lizard (*Uromastyx sp*) are a species of diurnal agamid found throughout mountain, rock, gravel and sand-based habitats within Arabia (Kingdom of Saudi Arabia, Yemen, Sultanate of Oman, United Arab Emirates, Qatar and Kuwait). However, the existing populations are under threat from pressures inclusive of rapid urban and industrial expansion, over grazing, development of infrastructure, genetic isolation, hunting and increased predation levels.

Overgrazing by livestock, such as camels and goats, reduces the food availability for populations of Uromastyx in Arabia.

Competition for food plants between lizards and livestock can threaten the populations of the spiny-tailed lizards living near farms.

Whilst definitive information on the species presence is yet to be confirmed, active burrows indicate the likely presence of some species belonging to the genus Uromastyx.

This Species Action Plan (SAP) provides and overview of the species Uromastyx along with management techniques for the conservation and relocation of STLs within the development.

6.3.3.3. Relocation strategy

Following the establishment of the relocation site, the STLs relocation will be completed by suitably trained and qualified ecologists with experience of STLs in the Middle East and internationally. The areas of activity will be targeted daily until the STLs burrows are captured and successfully removed. Following capture, the burrows will be monitored for a further three days via camera trap and visual assessments to ensure that no additional animals are utilising the STLs prior to demolition. All relocation will be conducted prior to any clearing activities within each site.

At each identified active Spiny-tailed Lizard, the following methodology for capture and relocation will be employed:

- All STL burrows will be recorded by GPS and subsequently marked with a colour coded flag.
- At each burrow, appropriately sized nets will be placed and secured to a 30 cm metal rod inserted into the ground to ensure that lizards cannot retreat to their burrow once caught.
- During the trapping procedure, all burrows will be checked every 30 minutes to maintain animal welfare and minimize potential stress on the animals.
- On capture of a STL, the animal will be placed into an individual calico/transport bag and then placed in to a lockable, breathable container within an airconditioned vehicle.
- Such handling techniques minimise stress and allow for the animals to reduce body heat, thus limiting the possibility of death.

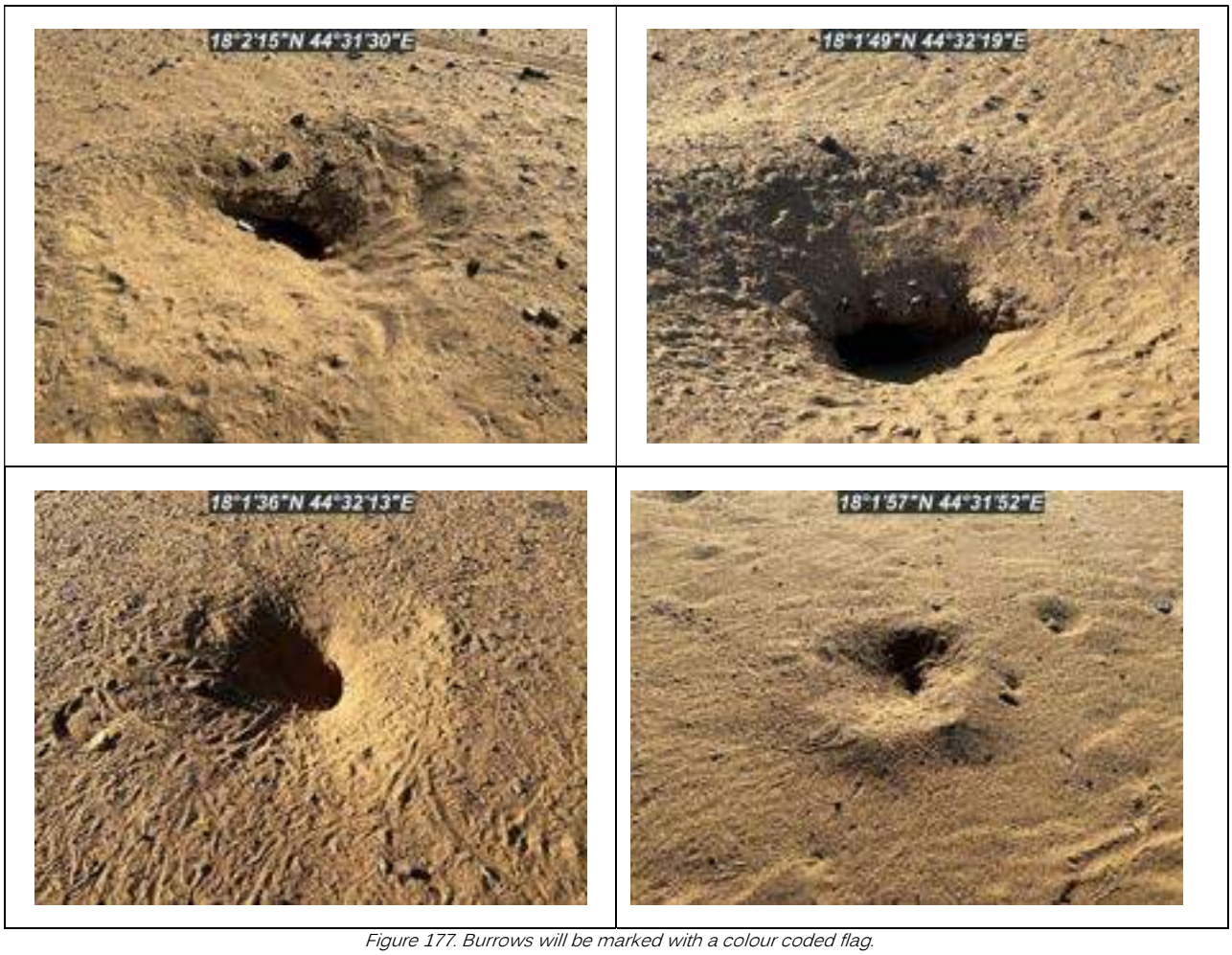


Figure 177. Burrows will be marked with a colour coded flag.

Following the completion of the relocation program, post relocation monitoring will be conducted to ascertain the activity levels of Spiny-tailed Lizard released. Monitoring will be conducted for a minimum of one calendar year post relocation within the receptor site only. Monitoring will assist in determining the success of the relocation program and whether additional measures need to be implemented.

A key attribute to the success of the monitoring is being able to differentiate between captured animals, and existing animals in the receptor site. Whilst it is envisaged that the release location will unlikely contain an existing population of STL, released animals will be marked to allow for quick identification in the field during monitoring.

Following the completion of each relocation period, all animals marked will be catalogued with photographic evidence clearing showing the mark, and the location of the mark. In the instance that multiple capture programs are required, new colours will be utilised to ensure that animals are easily distinguishable from a distance correlating with that capture period.

6.3.3.4. Relocation methodology

This Plan for the conservation and relocation of STLs/ trees / shrubs is structured as follows:

- Section 2: Species Assessment.
- Section 3: Management Objectives.
- Section 4: Relocation Strategy.

- Section 5: Relocation Methodology.
- Section 6: Post Relocation Monitoring.

The Contractor will develop the relocation plan as follow:

1. Introduction

2. Species Assessment

2.1 Conservation Status

2.3 Speciation

2.4 Habitat

2.5 Diet

2.6 Activity Patterns

2.7 Reproduction

2.8 Conservation Issues

3. Relocation Strategy

3.1 Release Site

3.2 Quarantine Facility

3.3 Security

3.4 Artificial refugia

3.5 Timing of release

4. Relocation Methodology

4.1 Reptile Relocation

4.2 Spiny-tailed Lizard Capture

4.3 Record Keeping

5. Post Relocation Monitoring

5.1 Monitoring Best Practice Guidance

5.2 Monitoring Regime

5.3 Marking of Animals

The contractor is invited to provide a detailed STL relocation plan based and aligned with the Species Relocation Action Plan – Spiny-tailed Lizard.

6.3.4. Air Quality

6.3.4.1. Construction phase

- Fulfilment of legal framework and standards.
- Good construction practices about air quality and implement duly mitigation measures will significantly reduce impacts.

a. Dust

- Dust generating materials stockpiled and transported by road vehicles will be covered with suitable sheets or dampens with water to prevent dispersal of particulates.
- Paving or regular dampening with water on haul roads.

Figure 178. Worksites will be irrigated with water.

- Provision of wheel washing bay at project site exits to prevent materials offsite. During construction, the approach road will be kept clean, free from mud and slurry.
- Land grading, excavations and movement of uncovered waste/materials should be undertaken during periods of low winds (<15 km/h wind speed is recommended as a threshold to review the situation on-site for these works).
- Idling of vehicles and equipment will be prevented.
- Waste from construction will not be burned.
- Dusty materials will be removed from construction sites as soon as possible.
- Implementation of a Dust Control Plan: The construction contractor will draw up a Dust Control Plan in accordance with Air National Standards. The construction contractor:
    - Shall instigate effective dust suppression measures as may be necessary to avoid creating dust nuisance arising as a result of the Works on site.
    - Shall clearly identify proposed dust control measures intended to be implemented in detail as a part of a general method statement to be issued.
    - Shall ensure that all temporary construction shall be such that it will not allow the infiltration of any biological or chemical pollutants into the works.

- The Dust Control Plan shall provide details of mitigation measures, specific location and schedule where such measures will be implemented to minimize impacts to sensitive receptors due to construction works, sourcing and transport of construction materials, and other project-related activities.
- The construction contractor shall designate a person or several persons to monitor the Dust Control Plan, with authority to order additional sprinkling when needed to avoid dust problems around the construction site and on external roadways. This monitoring includes weekends and holidays when there is no work on the construction site.
- The Dust Control Plan Report shall have at least the following content:

  1.DUST CONTROL PLAN

  1.1. Purpose.

  1.2. Air Standards and other National Legislation. Acceptable levels.

  1.3. Time for completion.

  1.4. Quality assurance.

  1.5. Site working conditions.

  1.6. Local conditions.

  1.7. Material Support.

  2.SCOPE OF THE WORK

  2.1. Measures to minimize dust and other emissions.

  2.2. Measures to monitor dust and other emissions.

  3.DELIVERABLES

  Appendix: Monitoring Control Points.

b. Gaseous emissions

- To reduce air pollutant emissions from fixed and mobile sources during construction, it will be used cleaner fuels such as ultra-low sulphur fuels. The construction contractor will also ensure that fuels will be burned more efficiently by using machinery and vehicles according to manufacturer's specifications. In addition, a preventive and regular maintenance program will be undertaken by the construction contractor to ensure that machinery and vehicles are in good condition through the entire duration of the project construction and meet national emission standards.
- Burning of wastes generated at the construction sites is strictly prohibited. No bonfires.
- Setting appropriate speed limits onsite (not exceed a speed of 20-30 km/hr).

Figure 179. Speed limits onsite

- Implementation of an Engine Emission Management Program: According to Mobile Source Emissions Standard (The Executive Regulations for Air Quality), the owner or operator of a large site or facility (the construction contractor) must develop an internal management program. Large sites are those that have 5 or more engines, equipment and/or vehicles that have the potential to be operational at the same time. This engine emission management program shall include the following:
    - A list of all applicable engines.
    - Engine maintenance procedures.
    - Procedures to ensure best available environmental technology are used where economically feasible.
    - Potential hazards and emergency response procedures.
    - It is the responsibility of the site owner or his designated site manager to ensure the implementation and maintenance of the engine emission management program.
    - All engine emission management program documentation will be organized carefully and made available to the Competent Agency when required.
    - Failure to submit internal management program documentation to the Competent Agency, within a 30-day period, will be deemed as a failure to comply with Mobile Source Emissions Standard of the Executive Regulations for Air Quality.

6.3.4.2. Operation phase

Solar Park operation have no emissions except few ones from the limited number of vehicles serving operating personnel on the site. The main mitigation measures that should be conducted in this phase are:

- Fulfilment of legal framework and standards.
- Periodic maintenance of machinery and vehicles used on the site.
- Vehicles traveling on gravel roads should not exceed a speed of 30 km/hr.
- Regular water spray is required on unpaved road as the dust not move during heavy wind.
- Use clean fuel in vehicle as the exhaust emission will be low.

6.3.4.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.5. Odours (Smells)

6.3.5.1. Construction phase

To reduce impacts from odours:

- Sewage treatment/handling facilities and waste storage facilities will be operated properly and monitored for operational performance, including odours.
- Adequate and sufficient sanitary facilities for site workers must be provided.
- Effective cleaning and maintenance of toilets to be undertaken to avoid odour dispersion and cleaning records/inspection sheets displayed in the toilets.
- All holding tanks must be sealed and fully functioning. Holding tanks must be operated and maintained according to manufacturer recommendations.
- Sanitary waste will be removed from site by licensed contractors and disposed in wastewater treatment facilities approved by the applicable regulator.
- Project facilities will incorporate appropriate waste storage and handling procedures.

6.3.5.2. Operation phase

During the operational phase of the Solar Plant, the potential for release of odours is related with the inappropriate containment and coverage associated with wastewater holding tanks, and its correct maintenance will avoid the impact. All mitigation measures listed before, at Construction phase section, will be also implemented while the Solar Plant is functioning, adapting them to the operational phase requirements.

6.3.5.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.6. Noise

6.3.6.1. Construction phase

The following mitigation measures will be implemented to minimize potential noise impacts during the construction phase in all periods:

- Fulfilment of legal framework and standards.
- Good construction practices and duly implement noise mitigation measures that will significantly reduce noise levels:
- During construction phase, the contractor will employ only approved vehicles and machinery. All the vehicles and machinery must work properly avoiding malfunctioning that may increase noise levels. Equipment will be serviced regularly and operated as each manufacturer's specifications.

- Night works should be avoided to reduce noise nuisance.
- Truck drivers and equipment operators will minimize the use of horns.
- All construction equipment and vehicles will be well maintained and will be fitted with appropriate noise suppression equipment consistent with applicable national noise standards.
- Standard sound reduction devices such as silencers or mufflers will be installed in construction equipment.
- Speed limits will be imposed on construction vehicles to minimize noise emission (not exceed a speed of 30 km/hr).
- The number of equipment operating simultaneously should be reduced as far as practicable.
- The personnel involved in high noise generating activities shall be provided with personal protective devices to minimize their exposure to high noise levels.

6.3.6.2. Operation phase

Operation of solar plant doesn't lead to significant rise of noise levels in the surrounding environment however some mitigation measures should be implemented:

- Fulfilment of legal framework and standards.
- Periodic maintenance of machinery and vehicles used on the site.
- Periodic monitoring of noise near to the sources of generation, like transformers, to ensure compliance with design specification.

6.3.6.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.7. Hydrology and Flood Risk Control

6.3.7.1. Construction phase

Mitigation Strategies

Based on the results of the hydrological simulations for the different return periods, the hydrological trend of the site shows that surface water is drained through the existing overland flow paths (streams). Additionally, some surface water is stored in the low areas of the ground before it drains away through infiltration and evaporation. Apart from some very localized flood hazards areas within the overland flow paths, that show maximum water depths above 0.5m and maximum water velocities above 1.0m/s, surface water runoff at the project site does not denote any potential danger for the project.

Although these localized flood hazards areas do not indicate any potential danger for the project, the mitigation measures described in this section should be included to remove any potential risk. These mitigation measures are common in the photovoltaic plants projects.

The hydraulic modeling results and subsequent hazard analysis shows that the most restrictive factor is the velocity along some sections of the existing streams. Therefore, it is important to introduce materials such as rocks or breakwater in those sections of the existing streams where the results show velocities above 1 m/s. This strategy will increase the roughness and head losses of the stream channels (n-manning), decreasing

the velocities and hazards accordingly. These sections should include a localized management and maintenance to ensure that the applied mitigation measures remain operational over time.

Critical design elements such as transformation centers, panel inverters, substations or other any equipment should be placed and installed outside the flood hazards sections. Additionally, the electrical facilities trenches at the flood hazards areas should be concreted. For other electrical equipment located over zones where floods and high-water depths are more prone to happen, the recommendation is to place the equipment at certain level over ground level and, additionally, some waterproof protections to avoid damages.

The solar panel piles at the flood hazards sections should include local protections such as rocks surrounding them.

It is important to improve the terrain drainage capacities. The proposals must focus on enhancing the superficial water flow and shorten up the amount of water logged within the plot boundaries. The aim is to reduce the water retention time and minimize any possible damage to the facilities equipment.

Attending to the topography and the elevations of the low points where the water remains after the heavy rainfall episodes, carry out some grading could be a good technical option to increase the drainage capacity. These earthworks will reduce the differences between the highest and the lowest points. The purpose is not only to generate a homogeneous slope, as this would be very expensive, but reducing the water that can remain stored. Eventually, if the water level is lower, the evaporation effect will be faster.

To get the continuous slopes, balancing masses is relatively simple by filling the lower parts with the material of the highest parts.

Along the internal roads that will be defined within the park, a specific drainage system should be designed to protect the road from suffering damages by the water runoff during the heavy rainfall episodes. For the roads or linear works, a system of ditches and ford will be sufficient since the ditches are expected to collect the water and direct it to the natural channels. The road arranged over low zones where the water level is expected to be high, a minimum elevation for the road surface should be set to prevent the water from passing over the roads and avoid damages on shallow layers of the road.

In all scenarios, it can be assured that the drainage solution implemented in the park to protect the roads or the earthworks leveling to enhance the soil's drainage capacity will not result in any adverse effects on the downstream facilities. Due to the park topography, the water behavior has a well-defined path, catching the water from the north-west area and conduct it to the south-east part. Any change on the water behavior that can occur due to the drainage works inside the park will improve the drainage capacity, that means: less water or lower velocity runoffs.

Other mitigation measures

To reduce the potential for disturbance of existing hydrographic network and potential erosion of drainage channels during construction, the following mitigation measures should be implemented:

- The EPC contractor will be instructed to avoid any unnecessary changes in the topography.
- Keep all natural channels to the extent possible at their original state.
- Routes will be selected to avoid ephemeral drainage channels where possible.

- Design structures should consider the natural functioning of the of drainage channels.
- Adequate drainage systems will be provided to reduce and control erosion/erosion.
- Culverts or other drainage control features will be installed where crossings of drainage routes are unavoidable.
- The excavated materials will be kept in stocks for the shortest possible time.
- Introduction of flows to conserve natural hydrology and surface water resources downstream.

Mitigation works to reduce/minimize impacts for flood risk include:

- Surface water will be controlled with appropriate drainage and bunded areas as appropriate.
- No storage of hazardous chemicals, materials, oils, or fuels within areas of water drains and wadi channels.
- Infrastructure that is most vulnerable to flooding, is located in areas of lowest flood risk (i.e., areas of solar PV panels to be located outside of the main flood risk corridors).

7.3.5.2 Operation phase

- Surface water will be controlled with appropriate drainage and bunded areas as appropriate.
- Rainwater sewers will be connected and directed to a confined area in order to avoid flooding area.

7.3.5.3 Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.8. Surface Water, Groundwater, and Soil quality preservation

6.3.8.1. Construction phase

During the construction phase, the following measures will be implemented to preserve the soil and water quality:

- Adequate location for the construction camps and auxiliary facilities which will be placed at zones that are acceptable from environmental, cultural, and social point of view. The sites will be marked to be visible day and night and will present all the necessary safeguards for environmental protections and safety of workers. Once construction phase is over, camps will be suitable decommissioned and all materials, wastes, or scraps, will be removed.
- Where possible, the quantity of chemicals and fuels stored on site will be kept to a minimum practicable level. Infrequently used chemicals should be ordered in appropriate quantities only when needed.
- Construction vehicles and equipment will be serviced regularly. Repair work, service and maintenance of machinery and vehicles shall be carried out in authorized garages. If this is not possible, the Contractor will use designated areas for vehicles' repair and maintenance (which will be previously conditioned). Washing of equipment, machinery and vehicles will only be permitted in designated areas, with impermeable surfaces and dedicated drainage systems leading to separate treatment facilities and/or lined evaporation ponds. Use of evaporation ponds will require removal of sludge residues as hazardous solid waste by a licensed waste contractor.

- A waterproof area will be considered in the construction camps, to avoid any volume of water could be polluted with fuels, oils, etc. An area for the location of the machinery, waterproof, will avoid soil pollution by a potential spill.
- A Plan for Storm Water Runoff Management will be design as the water could contain fuels and oils. Around the areas designed for storing and parking machinery and ancillary facilities a network perimeter drainage for retaining surface water runoff will be built before work operations start.
- Contractor will take into account the provision of appropriate storage of hazardous materials and waste. Implement good management practices during construction activities including procedures and requirements for proper handling, storage and transportation of hazardous materials and waste.
- All hazardous materials or waste that are temporarily used or stored outside their designated storage areas must be kept in well-equipped, leak-tight containers with drip protection to avoid leakage on the floor.
- Training related to the management, transport and handling of hazardous materials and waste will be provided - as per established procedures to direct the on-site management of such activities.
- All permanent or temporary hazardous materials/fuel/chemical storage areas will have a roof and sealing barriers sufficient to contain the total volume stored, in the event of a spill or leakage.
- A Spill Prevention Plan and Spill Response Plan will be created. The plan will identify ways to prevent accidents, respond and address any contamination. Where relevant to the applicable risks, this should be consistent with the Sites Emergency Preparedness and Response Plan.
- Appropriate spill kits will be available wherever hazardous materials or waste are stored. All contaminated cleaning materials will be disposed of as hazardous waste.
- Refuelling of mobile equipment and fuel tanks (e.g., in unloading areas) will only take place in designated areas following specified refuelling procedures, and not at worksites to reduce potential spills.
- Damaged / deformed secondary containment drip trays shall be immediately removed from site and replacement secondary containment spill/leakage trays shall be provided to the item of equipment it served.
- Additional mitigation involving the provision for drip trays/plant nappies for all static plant (dozers/graders/dumpers) and equipment should be included by Contractor. Environmentally friendly biodegradable lubricating and hydraulic oils should be selected by Contractor for use in vehicle & equipment unless there are practicable reasons which would preclude their use.
- If contaminated soil is observed during construction activity, the identified contaminated soil should be separately excavated, stored, handled, and disposed of according to the waste management plan, to avoid cross-contamination situations. Collected waste or contaminated drilling material will be disposed of through licensed waste contractors at licensed facilities.
- The construction contractor will implement a training program to familiarize staff with emergency procedures and practices related to contamination events.

6.3.8.2. Operation phase

During the operation phase, the following measures will be implemented:

- All drainage systems will be disconnected and directed to a confined basin.
- Spills and cleaning supplies will be well located and visible in key areas of the site.

- Effective waste management controls will be implemented through the site's waste management plan. The waste management plan will include measures to reduce the incidence of soil and groundwater contamination.
- Hazardous and non-hazardous waste storage areas will be well constructed with impermeable soil barrier protection, separate drainage system and rain shelter to avoid any possible case of runoff, or runoff intrusion.
- Collection and treatment of grey water for car washes and dust suppression.
- Periodic maintenance of the rainwater drainage system must be carried out to avoid blockages, sedimentation and the risk of flooding resulting from water collection.

6.3.8.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.9. Spill Prevention and Control Management Plan

Any project may face a wide range of emergencies resulting from different environmental risks in the construction and operation phases, varying in their scope, complexity, and repercussions. These emergencies may have wide environmental, social, and public health impacts, with the possibility of long-term repercussions lasting years after the emergency. Emergencies may result from natural disasters, pollution, chemical or radiological leaks, and other hazards. Thus, preparing and responding to emergencies effectively becomes one of the urgent challenges facing the Kingdom.

The likelihood of an accident can be reduced through effective planning and development of a site pollution incident response plan or a Spill Prevention and Control Management Plan as part of the Environmental Management System.

All risk assessments and method statements should include consideration of the potential for environmental accidents. Appropriate incident response equipment must be maintained at appropriate locations on the site and project personnel should be appropriately trained in the use of such equipment and in responding to such emergencies.

The Environmental Manager should be responsible for preparing a customized pollution prevention and response plan for the site to include requirements for coordination with relevant external agencies (e.g., emergency services and the National Center for Environmental Compliance), affected stakeholders and legal authorities in the event of a pollution incident.

The plan should specify procedures for emergency situations associated with explosion, fire, etc. and specify the requirements for pollution response materials and where they should be placed within the project area.

When developing an emergency response plan, the following should be considered:

- The most appropriate to respond to an emergency.
- The process of internal and external communication.
- Action required to prevent or mitigate environmental impacts.
- Mitigation and response actions to be taken for different types of emergencies.

- The need for a post-emergency assessment to identify and implement corrective and preventive actions.
- Periodic testing of planned emergency response procedures.
- Emergency response training.
- A list of key personnel and assistance agencies, including contact details (e.g., fire department, spill cleanup services).
- Evacuation routes and assembly points.
- Possibility of needing mutual assistance from neighbouring organizations/projects.
- Spill Prevention and Control Management Plan for construction and operation shall specify all reasonable steps to be taken to prevent contamination of land or water contamination from spills of fuel or other hazardous liquids and an appropriate method for communicating spill response actions to site personnel.
- All permanent or temporary hazardous materials/fuel/chemical storage areas shall have a roof cover and bounds sufficient to hold 110% of the total volume stored, in the event of a spill or leakage.
- A Spill Prevention Plan and Spill Response Plan will be created. The plan will identify ways to prevent accidents, respond and address any contamination., this should be consistent with the Sites Emergency Preparedness and Response Plan.
- Any spills or leaks will be cleaned up by spill absorbents, which are available at all on-site fuel, hazardous materials and hazardous waste storage locations (e.g., spill kit). Other absorbents/cleaning materials will be contained in an easily accessible and clearly marked spill kit. Spill response training will be provided to site staff and will be covered in the Toolbox. All contaminated cleaning materials will be disposed of as hazardous waste.
- Refuelling of mobile equipment and fuel tanks (e.g. located in unloading areas) will only take place in designated areas following specified refuelling procedures, and not at worksites to reduce potential spills.
- Implement good management practices during construction and operation activities including procedures and requirements for proper handling, storage and transportation of hazardous materials and waste.
- If contaminated soil is observed during construction activity, the identified contaminated soil should be excavated separately, stored, handled, and disposed of according to the waste management plan, to avoid cross-contamination situations.
- Collected waste or contaminated drilling material will be disposed of through licensed waste contractors at licensed facilities.
- Washing of equipment, machinery and vehicles will only be permitted in designated areas, with impermeable surfaces and dedicated drainage systems leading to separate treatment facilities and/or lined evaporation ponds. Use of evaporation ponds will require removal of sludge residues as hazardous solid waste by a licensed waste contractor.
- All hazardous materials or waste that are temporarily used or stored outside their designated storage areas must be kept in well-stocked, airtight containers with drip protection to avoid spillage onto the floor.
- Where possible, the amount of chemicals and fuels stored on site will be kept to a minimum practicable level. Chemicals used infrequently should be ordered in appropriate quantities only when needed.
- Adequate drainage systems will be provided to reduce and control erosion/erosion. Sediment traps (i.e., filter cloth) will be installed at designated runoff points. Where possible, road slope (perimeter

and slopes) will be reduced in order to reduce erosion caused by runoff. Regular inspection of sedimentation/erosion controls will be conducted to prevent flooding/pooling.

- Training related to the management, transportation and handling of hazardous materials and waste will be provided - as per established procedures to direct the on-site management of such activities.
- Introduce flows to maintain natural hydrology and surface water resources in the direction of natural flow.

6.3.10. Health and Safety

6.3.10.1. Construction phase

The contractor will be required to have a Health and Safety Management System (HSMS)to systematically eliminate risks or if this is not possible, reduce them as low as reasonably practicable. The HSMS should include, at least the following aspects:

- The workers (both regular and contractual) on the project will be provided with training on the Health and Safety policy in place, and their role in the site and refresher courses will be provided throughout the life of the project.
- Establish a grievance redressal mechanism in place, to allow for the employees and workers to report any concern or grievance related to work activities.
- Operation of loading-unloading equipment should be undertaken under the guidance/supervision of trained professional.
- The contractor should ensure that no person is engaged in driving or operating construction machinery unless he is sufficiently competent and reliable, possess the knowledge of risks involved in the operation and is medically examined periodically.
- Contractor should prepare a site Emergency Preparedness and Response Procedure, which should be followed for the subjected project.
- Adequate training should be provided to staff about raising awareness about use of Personal Protection Equipment (PPE) and emergency response measures.
- Job responsibility and shifting chart should be prepared so that no person shall be over exhausted, which will ultimately lead to the accident or injuries.
- Safety sign should also be marked at appropriate places.
- It shall also be ensured that good housekeeping at the construction site is maintained to avoid slips and falls.
- Excessive waste debris and liquid spills will be cleaned up regularly, while electrical cords and ropes will be placed along identified corridors marked for the attention of everyone at the site.
- Use of personal fall arrest system, such as full body harnesses as well as fall rescue procedures to deal with workers whose fall has been successfully arrested shall also be carried out.
- Dropping/lowering of construction material or tool will be restricted and undertaken only under strict supervision if required. PPEs such as safety glasses with side shields, face shields, hard hats and safety shoes shall be mandatory at a construction site. Earplugs shall be provided for workers placed in high noise areas.

6.3.10.2. Operation phase

The following mitigation measures will be taken to minimize the health impact during operation phase:

- Workers handling electricity and related components will be provided with shock resistant gloves, shoes, and other protective gears.
- Adequate training regarding health and safety will be provided to the workers.
- A health, safety, and environment (HSE) management system will be developed, rolled out and implemented. This system which will be reviewed annually or after a major accident or incident.
- The switchyard building will be provided with fire extinguishers and sand buckets at all strategic locations to deal with any incident of fire.
- Safety incidents will be recorded and monitored with an aim that numbers are never significant, and gradually reduce.
- Workers at site handling broken solar panels shall be provided with adequate PPEs (safety gear, goggles, and gloves).
- The workers at the site are also on regular basis shall be appraised about the potential health risks associated with the handling of solar panels.
- Ensure use of safety belt and need for safety net as required.
- All work at height to be undertaken during daytime with sufficient sunlight except emergency (with proper illumination arrangement).
- Fixtures shall be installed on tower components to facilitate the use of fall protection systems.
- Only workers trained in climbing techniques and use of fall protection measures; inspection, maintenance, and replacement of fall protection equipment shall be engaged for work at height.
- Workers handling electricity and related components will be provided with shock resistant gloves, shoes, and other protective gears. Adequate training regarding health and safety will be provided to the workers.
- Access to areas containing exposed electrical equipment (such as transformers) shall be fenced and locked. Warning signs shall be posted at hazardous locations.
- Firefighting equipment such as fire extinguishers and sand buckets shall be provided at appropriate locations.
- Workers involved in electric operations shall be provided with Protective Equipment such as rubber gloves etc.
- Employees involved in electrical works shall be trained in and familiar with the safety- related work practices, safety procedures, and other safety requirements that pertain to their respective job assignments.
- First aid box/ arrangement to be ensured.

6.3.10.3. Decommission phase

Once the Solar Plant operation will be over, it decommissions will take place. This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.11. Landscape and Visual Confort

Landscape integration and visual impact have been taken into account during project design. Buildings have been designed in a sensitive manner to the local landscape character within the area including the use of neutral colours and materials.

6.3.11.1. Construction phase

The project will include these considerations about landscape mitigation measures during construction phase:

- Minimize impacts on landscape and restoration of altered areas.
- Reduce working areas as much as possible.
- Careful consideration of the form and finish of structures so they fit in with existing landscape.
- The finished surfaces of earthworks will be protected against erosion.
- Disposal of excavated unacceptable material will be minimized, where possible.
- Restriction of stockpiling heights.
- Dust control.
- Tidy storage of materials and machinery.
- Duly manage all work sites at the end of the construction period.
- Appropriate storage and reuse of topsoil for final landscaping.

6.3.11.2. Operation phase

The solar panels will be installed at a low height and will be kept closer to the ground so that it does not prop out of the general landscape of the area.

- The panels will be arranged in a systematic manner which will give an aesthetic sense to it.
- The proposed solar PV power project will include a boundary wall around the perimeter of the project to further obscure the peripheral view of the project and any indirect reflection. Impacts from glare will be minor.
- All cables and power lines will be located underground as far as possible.
- The substation, gatehouses and maintenance and storage buildings will be grouped as far as possible to avoid the scatter of buildings in the open landscape.
- Vegetation barrier around the PV plant will avoid visual impacts.

6.3.11.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.12. Land Use and Local People

The actual area of land use impact would be limited to some grazing lands in immediate vicinity of the solar plant.

6.3.12.1. Construction phase

The following mitigation measures will be implemented:

- Minimize land take as far as possible.
- Construction camps will be located at areas which are acceptable from environment, cultural and social point of view. On completion of construction activities, land used for temporary facilities will be restored to the extent possible.

- Any existing useful road will be widened and developed for access to the project site.
- Construction activities will be restricted to designated area.
- The land use in and around permanent project facilities will not be disturbed.
- After-construction work, any land taken for a temporary basis for storage of material will be restored to their original form.

6.3.12.2. Operation phase

During operation phase, no mitigation measures are planned to avoid/mitigate negative affections on land use.

6.3.12.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.13. Waste Generation and Management

6.3.13.1. Construction phase

The contractor will develop and implement a Waste Management Control Plan. In addition, the project will comply with all legal requirements (Law of Waste Management. Royal Decree M/3 dated 5/1/1443 AH) and National standards (Waste 2012 Standards).
To achieve a proper management of construction waste, the following measures must be taken into account:

- Contractor will design, develop, and implement the Waste Management Control Plan. All workers shall be instructed.
- The Plan will be monitored during all construction phase and updated/change if necessary.
- Contractor will assure proper handling, storage, tracking, label, transportation, and disposal of all types of waste, as well as the correct records custody.
- Contractor will also ensure emergency procedures to solve, as quickly as possible and with as little damage as possible, any problem that may occur.
- Although spoils volume is scarce in the project (excavations are only necessary for the solar panel structures and the buildings), excavation spoils will be reused for levelling, etc.
- Wastewater will be generated from human uses and chemical toilets and will be collected and regularly emptied and cleaned by an approved contractor.

a. Waste Management Strategy

Waste will be managed in a manner that will be safe and without risks to the health of workers, the community, or the environment.
Waste management for the project will follow the waste management hierarchy as a guiding principle. The preferred order of waste management for the waste streams generated from the project will be as follows:

- Reduce waste by optimising construction methods (ordering materials in bulk to reduce packaging waste; proper planning and ordering of what is needed for the project; requesting suppliers to minimally but adequately pack orders to reduce waste volume, ordering chemicals in returnable drums; optimising changing of filter systems through regular cleaning and maintenance, etc.,).

- Re-use waste by identifying sources in the actual works that can utilise the waste (Use of refillable containers for collection of waste fluids, such as waste oil, hydraulic oil, used grease; sending used oil and oil from drip trays to a licensed recycling company for filtering and reuse; reusing single sided paper, where appropriate by printing rough drafts on the clear side, or using them as note pads; using wooden pallets and other packaging materials for creating warning, hazard and safety signage, etc.).
- Recycle waste by identifying facilities that are able to recycle waste (Use of recyclable materials when packing orders to increase recycling opportunities, avoiding ordering and using disposable materials such as non-rechargeable batteries, plastic cups, etc. Instead, use recyclable paper cups, rechargeable batteries, etc.). All recyclable wastes will be transported to an approved facility by an approved sub-contractor.
- Disposal of residual waste at appropriate landfills.

Figure 180. Waste hierarchy. Source: The centre of waste management

Consideration of sustainable options such as renewable, reusable, or recyclable materials and implementation of waste management options integrating international best practices shall reduce waste generation thereby minimising the load on existing landfills. In addition, waste could be segregated at source to readily facilitate sorting of waste when transferred to the designated central waste holding area to ensure recycling and reuse of materials. Waste separation and recycling shall be introduced at the main construction areas where practical. The reuse and the recycle of the waste will be beneficial and positive.

b. Guidelines for Waste Management

Handling and Storage

The following measures are designed to improve waste handling and storage:

- The contractor must containerize and pack hazardous waste in a proper and environmentally sound manner placing warning labels on each package in accordance with the specifications and standards applicable in the kingdom.
- The effective handling and storing of waste shall prevent and minimise spills and leakages.
- The procedure for the correct waste storage is regulated by Section 5 of Implementing Regulations of the Waste Management Law (MWAN, 2021). The standard establishes the need for waste segregation, to reduce the risk of waste being incorrectly classified and to ensure that the correct procedures are followed from the point of generation through to final disposal.
- The Waste Producer and the Service Provider shall store waste at Waste storage sites, maintain housekeep such storage sites in a manner consistent with the environmental health and safety requirements specified by the technical controls on waste storage issued by the Centre and in accordance with conditions and provisions of the relevant License.
- Waste Producers and Service Providers shall store separately the different categories of Hazardous Waste, depending on the physio-chemical properties, compatibility and nature of the extinguishing agents that can be used for each category of such Waste in the event of fire, so as to ensure the highest degree of protection of the general health, Environment, and public and worker health and safety.
- Storage areas shall be located as far as practically possible from sensitive receptors.

Tracking Form

The waste generator is responsible for ensuring the accuracy of the classification of waste on the Waste Tracking Form.

- The information that must be provided on the form includes: the Generator's name, address, municipality and contact details; name, address and contact details of the person to whom the waste is to be transported; day and time the Generator gives the waste to the transporter for transporting; type and number of containers if the waste is hazardous; type of waste, its amount, physical nature, waste code.
- The Generator is required to record and keep for a minimum period of five years the following information: The information detailed in the Waste Tracking Form and the Transporter's name, address, and contact details.
- An approved form, known as a waste tracking form, provides details of the waste tracking information to be provided. The form, available from the competent agency, is a five-copy docket which travels with the waste from its point of generation to the site of storage, recycling, treatment, or disposal. The form records proof of actions for all persons involved in the handling of the waste for regulatory purposes.

Waste transportation

The transportation of waste will be undertaken in a responsible manner to safeguard the protection of the environment and the community against potential accident, spills, and pollution.

- The necessary arrangements shall be made with both the transporter who will carry the waste and the receiving landfill designated in the transportation documents as the destination for the waste.

- The transporter must be registered with the competent agency for approval to operate as a waste transporter, covering hazardous, non-hazardous, and inert waste. Registration must be approved by the competent agency who will issue to the transporter a registration certificate.
- The transporter must have a license to operate from the authority. Transporters for hazardous wastes are not allowed to work without acquiring an operational permit for the vehicle from the concerned agency as well as an identification code and work permit from the competent authority.
- A waste transporter may not accept waste from a generator unless it is accompanied by a waste tracking form completed.
- Before transporting the waste, the waste transporter must sign and date the waste tracking form acknowledging acceptance of the waste from the generator.
- Once a transporter receives waste, they are liable for the proper handling and movement of the waste and must take all necessary measures to avoid potential risks to human health and the environment. This liability continues until the waste is disposal at a waste landfill.
- The waste transporter must use vehicles with proper specifications and placards and ensure that the correct labelling and marking is being employed for the waste in transit.
- Transporters are obliged to prepare a contingency plan to respond to emergency and hazardous waste leakage incidents during delivery or transportation activities. Transporters shall be committed to implement this plan after being approved by the Competent Authority.

Disposal of Waste to Landfill

Where landfill is the only disposal option identified for all or part of the waste, the Generator (the construction contractor) must consider the appropriate treatment options:

- Identify the landfill that may be able to accept the treated waste.
- Establish whether the waste will meet the relevant WAC (Waste Acceptance Criteria Standard). Landfills are divided into three categories: Class 1 Hazardous, Class 2 Non-hazardous (include municipal waste) and Class 3 Inert.
- Where all the limit values for WAC are met, the waste will be acceptable for final disposal at a waste landfill site. Where the limit values are not met, then the waste must be treated to bring it within the required acceptance limits, or an alternative disposal route must be sought.
- Generators may liaise with the landfill operator to determine what techniques or methods might be available to reduce the hazardousness of the waste such that it is suitable for disposal at the lowest class of landfill possible.
- If the waste fails to meet the requirements of WAC, the waste transporter must establish with the Generator whether to deliver the waste to an alternate facility or return the waste to the Generator.

Keeping of records and reports

A hazardous waste generator shall comply with the following for keeping of records:

- Keep one copy of each transport document it has generated pending receipt of the signed copy from the hazardous landfill designated in the document. It shall also keep the signed copy for at least 5 years as of the date of receipt of the waste by that landfill.
- Retain, for at least five years from the last date of handling of such waste, copies of the results of all tests and analysis performed on the hazardous waste as well as copies of all pertinent reports, correspondence, and documents.

- Submit to the competent authority an annual report on all hazardous waste generated during the year. Copies of such reports shall be retained for at least five years from the date of completion.
- Submit on demand to the competent authority or the agencies designated by it, all documents, records, and reports related to the waste.

6.3.13.2. Operation phase

Operator must detail and implement a Waste Management Control Plan. To achieve a proper management of waste in operation phase, the following measures must be taken into account:

- Operation waste management will incorporate reduction, recycling, and reuse principles. All workers will be instructed.
- The Plan will be monitored and updated/change if necessary.
- Operator will assure proper handling, storage, tracking, label, transportation, and disposal of all types of waste, as well as the correct records custody.
- Operator will also ensure emergency procedures to solve, as quickly as possible and with as little damage as possible, any problem that may occur.
- Material Safety Data Sheets for all applicable materials present on Site will be readily available to on-site personnel.
- First, inspection of PV modules for defects that can appear in the form of burn marks, discoloration, or broken glass is to be undertaken. An authorized person will walk the site to confirm that there are no broken modules (shattered glass) and broken modules should not be sprayed with water.
- Broken or damaged solar panels are required to be immediately shifted to a designated area in a scrap yard to avoid any type of land contamination. A photograph is to be taken of the broken panel at the site to cater to Insurance settlement claims.
- Once the PV panels have reached the end of their life cycle, the manufacturer of the PV panels will collect and recycle the PV panels and recover any hazardous substances in the PV modules. This provision forms part of the supply agreement between the proponent and the selected PV panel manufacturer.
- Wastewater will be generated from human uses in holding tanks and will be collected and emptied and cleaned by an approved contractor.

6.3.13.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.14. Glint and Glare

A specific glint and glare assessment report for the project has been carried out. The report has been included in section 8.3.4. The conclusions of the glint and glare assessment report have been taken into account in the EsIA.

No glare caused by the future Afif 1 Solar Power Plant is expected at any of the Flight Paths studied and the ATCT of the Dawadmi Domestic Airport. In addition, It is possible to eliminate almost all the glint and glare effects by implementing some mitigation measures.

A simulation was carried out by placing a vegetation barrier. The simulation including a vegetation barrier around the PV plant shows that the amount of yellow glare is almost completely reduced in the roads that run parallel to the site:

- Almardamah Road (road 1): Yellow glare is reduced from 229 minutes to 4 minutes.
- Haraniga Road (road 2): Yellow glare is completely reduced.

If any further deep analysis or test still show any harmful glare in key locations, there are some commentary simple measurements to eliminate or reduce the glare:

- Using a vegetative barrier.
- Selection of PV modules with special Anti-Reflective (AR) coating and surface texturing.
- Shading the ATCT from the glare
- Variation in PV module orientation: The information provided by the Annual Glare Occurrence Plot and the PV Footprint Glare - Spot Heatmap Plot with a modification of the backtracking algorithm (or simply a deactivation of the backtracking) during the brief time intervals of the year when glare is a concern would be very effective in eliminating glare.

Figure 181. Vegetation barrier example for reducing glint and glare

6.3.15. Climate Change

The project itself has a positive impact by contributing KSA shifts its energy mix towards a more sustainable future.

6.3.16. Employment and Social aspects

6.3.16.1. Construction phase

Below are briefly described measures to be implemented:

- The local community is preferred by the project for the requirement of skilled, semiskilled, and unskilled workers to the extent possible.
- The sourcing of local labour wherever possible should be made obligatory for the sub- contractors and in all major procurement activities.
- Preference should be given to the vulnerable population.
- The EPC Contractor and Principal Buyer will establish a mechanism to audit subcontractors and suppliers with respect to compliance of utilizing local labour and resources.
- Provision of infrastructure and amenities for migrant labour in construction camp to avoid dependence on limited local resources.
- Adequate sanitation facility at labour camps to maintain hygiene and minimize spread of diseases.
- Proper disposal of wastes generated from the camp and construction activity to maintain general hygiene in the area.
- Creating awareness about different traditions and cultures and encourage respect for them.
- Avoid unnecessary movement of vehicles through near settlement areas to avoid disturbance and traffic safety related issues.

6.3.16.2. Operation phase

Measures mentioned before at Construction phase section, when applying to operational phase, must be also implemented.

6.3.16.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.17. Traffic and Transport

6.3.17.1. Construction phase

- Designation of suitable transport routes and schedule for truck movements to minimize traffic disruption/congestions.
- The contractor should ensure that all PV module and mounting structure components are transported in appropriate vehicles that adhere to the axle load limits.
- Only trained drivers with valid license shall be recruited by the construction contractor.
- Training programs shall be conducted at regular intervals for all the drivers for raising awareness about road safety and adopting best transport and traffic safety procedures once in every month.
- Additionally, speed limits for all construction related vehicles shall be adhered to at all times to prevent damage to roads and other infrastructure.
- Mitigation measures to avoid traffic congestion and access problems in Road Transport
- High visibility colours should be used during the transportation of PV panels to the project site.
- Regular maintenance of vehicles and use of manufacturer approved parts should be adopted to minimize potentially serious accidents caused by equipment malfunction or premature failure.
- The villagers will be made aware of the schedule prior to the movement of trucks and transportation of power plant equipment in the project area.

- Movement of heavy equipment and construction materials will be regulated during peak hours (09:00 AM to 06:00 PM).
- Depute traffic escorts as and when required near project site and major settlements to guide movement of project vehicles.
- Collaboration with local communities and responsible authorities to improve signage, visibility, and awareness of traffic and pedestrian safety.
- Notify the governing body and local area responsible person prior to start the construction work and put adequate signage around the construction area.
- Coordination with emergency responders to ensure that appropriate first aid is provided in the event of accidents.
- Movement of the project traffic should be limited to the planned route only.
- The traffic movement in the settlement areas should be limited for the daytime only.

6.3.17.2. Operation phase

No operational impacts to traffic are expected during Operation phase.

6.3.17.3. Decommission phase

This phase of the project will require the removal of all installations and structures. The dismantling works will imply presence of machinery and workers, which will carry out similar actions that the ones occurred in the Construction phase.

6.3.18. Unplanned events

Unplanned events include a range of unintended activities and accidental events during construction and operational processes as well as a result of improper handling of hazardous materials and wastes (storage, transport and final disposal) and vehicle accidents.

These accidental events may produce fire and explosions, atmospheric pollutant emissions, leaks, and spills, between others. They can negatively affect several receptors, including primarily air, soil, and water quality. Indirectly this also can produce adverse effects on fauna and flora as well as workers and communities.

Mitigation measures for these unplanned events will depend on the type of incident occurred. The Emergency Preparedness and Response Plan, as well as the Waste Generation and Management Plan, would refer the necessary mitigation measures and actions to be carry out for most of unplanned events.

6.3.19. Archaeology and Cultural Heritage

6.3.19.1. Construction phase

- An archaeological 'Chance Find Procedure' will be developed prior to construction and the start of site earthworks, as part of / or alongside the CESMP. This will include protocols and procedures to stop work and methods to preserve potential finds, as well as reporting requirements and co-ordination with the Ministry of Culture.
- Where archaeological remains are encountered, the site will be clearly signed/delineated with high visibility flagging to impede access and prevent any damage or loss of the artefacts which have been found.

- All direction concerning the management of potential archaeological finds must only be taken from the Ministry of Culture.
- The EPC Contractor will receive training about the Chance Finds Procedure and key processes to follow concerning any suspected archaeological finds to avoid disturbance.
- The removal of any archaeological artefacts from the site is strictly prohibited.

6.3.20. Human rights

Implementation of mitigation measures may avoid negative impacts of the project on workers and external communities. Among the proposed recommendations are:

- Implementation of HR Policy & Procedures.
- Prohibition of child labour and forced labour.
- Ensure that foreign workers are not discriminated during the recruitment process as well as in the workplace.
- Establish and develop policies of gender equality.

6.4. Proposed Environmental Management and Monitoring Plan

6.4.1. Environmental Management Plan (EMP)

6.4.1.1. Objectives, scope, and content of the CEMP/OEMP

Both Construction and Operational phase Environmental Management Plan will need to incorporate mitigation and monitoring requirements as well as all future requirements defined by NCEC and the project lenders.

The Framework for the EMP will provide a framework for the development of CEMP / OEMP by the EPC / O&M Contractors respectively. The intention is that the Framework for the CEMP / OEMP will be used by the EPC and O&M Contractor for the development of specific environmental and social management plans, based on the specific findings and recommendations of this ESIA.

Chapter 2 of this Report outlines the national, regional, and international legislative commitments that are applicable to the Project.

Construction Phase

A Framework for the Construction Environmental Management Plan (FCEMP) will be prepared as part of the Construction Documentation. This report intends to establish a Framework for the Construction Environmental Management Plan (CEMP). The FCEMP will have the following content:

- Introduction.
- Project Description.
- Environmental Management.
- Environmental Impacts.
- Environmental Mitigation Measures.
- Monitoring and Auditing.

The Construction Environmental Management Plan (CEMP) is a site-specific plan developed to ensure that appropriate environmental management practices are followed during the construction phase to avoid or mitigate environmental or nuisance impacts. The construction environmental mitigation measures will be included in the Construction Environmental Management Plan (CEMP). The Construction Environmental Management Plan (CEMP) will be developed by the Contractor.

The main purpose of the CEMP is to:

- Support the management bodies to minimize environmental effects.
- Document environmental concerns and appropriate protection measures.
- Provide instructions to relevant project personnel regarding procedures for protecting the environment and minimizing environmental effects, thereby supporting the project goal of least incidents.

The main goals of the CEMP are to specify the roles and responsibilities of personnel involved with all aspects of the construction activities; identify potential environmental impacts and the mitigation measures that will be used to address them; establish procedures for audits, monitoring, and inspections; and specify training, recordkeeping, and documentation requirements. The CEMP will be use by all personnel involved with construction activities.

Prior to starting works, Contractor will provide the following control plans in the CEMP:

- Air Quality Control Plan
- Soil and Groundwater Contamination Control Plan
- Landscape, Erosion and Sediment Control Plan
- Terrestrial Ecology Control Plan
- Water Protection Plan
- Wastewater Management Plan
- Noise Control Plan
- Traffic Control Plan
- Waste Management Control Plan
- Chemical and Hazardous Materials Control Plan
- Contingency Plan
- Emergency Management Plan
- Security Plan
- Infrastructure Plan.
- Archaeological Chance Find Procedure

A set of mitigation and monitoring measures will be undertaken by contractor during the construction of the Solar Plant. These measures will be performed and will be audited to determine their effectiveness:

- Standard construction practices for avoiding and minimizing environmental effects.
- Measures to comply with the requirements of environmental legislation.
- Measures designed to specifically address the remaining negative (adverse) effects of the final development proposals.

Mitigation strategies will be based on the best available management practices and technologies that will eliminate or minimize adverse impacts to health, safety, amenity, traffic, or the environment in the surrounding area.

Contractor will thoroughly address site-specific mitigation measures for the applicable environmental components in study area. Contractor will develop and will implement the CEMP. Control plans will be applicable to the whole project.

Operation Phase

Operation Environmental Management Plan (OEMP) will be prepared by Operator according to the regulations issued by NCEC as well as other practices in similar fields.
During the development of the OEMP all mitigation and/or management measures relevant to the operation phase of the project should be identified from the EIA and the method of compliance with these mitigation measures detailed within the OEMP.
During the development of the OEMP, the requirements associated with the following should be identified and documented:

- National legislation.
- International Treaties and Conventions.
- Client/Contractual requirements.

The OEMP will need to clearly define all associated plans and procedures that are required to define and control potential adverse environmental and social risks.

Prior to starting operational works, Operator will provide the following control plans in the OEMP:

- Waste and Wastewater Management Plan.
- Occupational Health & Safety Plan.
- Site Inspection & Audit Plan & Procedure.
- Emergency Management Plan.
- Environmental Monitoring Plan.
- Human Resources and Policies Procedures.

6.4.1.2. Organisational Structure

An overview of the organisational structure of all parties involved in the implementation of the CEMP and OEMP is outlined below:

- NCEC: As the Competent Authority in KSA, NCEC is responsible for issuing the required Environmental Permit and ensuring all construction and operational conditions related to the Environmental Permit are met. Other general responsibilities include:
  - Enforcement of KSA laws and regulations.
  - Provision of guidelines on compliance with environmental requirements.
  - Strategic overview of environmental issues.
  - Review and approval of the ESIA Report.
  - Issue of the Environmental Permit and any associated conditions; and,
  - Undertake inspections, audits etc. to ensure compliance with the Environmental Permit.
- Project Company (Principal Buyer): The Project Company is responsible for the financing and development of the Project and will assume all responsibility for ensuring all environmental and social commitments of the Project are met.

- EPC Contractor: The EPC Contractor is responsible to the Project Company for ensuring all environmental and social commitments of the Project are met. The EPC Contractor will produce and implement the detailed CEMP.
- Sub-Contractors: All sub-contractors undertaking works on behalf of the EPC Contractor will be responsible for undertaking works in line with the CEMP and all approve method statements and management plans.
- O&M Contractor: The appointed O&M Contractor is responsible to ensure that all requirements and permit conditions are adhered to and reported to the Project company during routine operation.

6.4.1.3. Key Roles and Responsibilities

The roles and key responsibilities related to the implementation of the CEMP and the OEMP are outlined below.

Role	Key Responsibilities
Project Company/ Executive Managing Officer	▪ Review and approve environmental and social management budgets, resourcing, and staffing. ▪ Attend and actively input to environmental and social management review meetings. ▪ Formal sign off and approval of all EMS documentation produced by the EPC and O&M Contractor, including their detailed management plans.
Project Company / HSE Manager	▪ Follow up, review and internal approval off EMS documentation produced by the EPC and O&M Contractor. ▪ Inspect and audit EPC and O&M Contractor. ▪ Liaise with regulators and/or other authorities on environmental and social matters. ▪ Be responsible for communications regarding environmental and social reporting and third-party audits.
EPC and O&M Contractor: Project Director	▪ Review and approve environmental and social management budgets, resourcing, and staffing.
EPC and O&M Contractor: HSE Manager	▪ Review and approve environmental and social management budgets, resourcing, and staffing. ▪ Ensure sufficient resources for the management of environmental and social matters. ▪ Undertake regular site inspections. ▪ Monitor and report on environmental management and performance, including compliance with the CEMP/OEMP. ▪ Undertaken regular inspections and audits to assess compliance and manage implementation of corrective and preventative actions.
EPC and O&M Contractor: HSE Engineer/ Environmental Engineer	▪ Monitor and report on environmental management and performance, including compliance with the CEMP/OEMP. ▪ Prepare and monitor site bulletin boards. ▪ Undertake daily site walkovers and inspection of works. ▪ Maintain applicable environmental and social records. ▪ Act as point of contact for any sub-contractor with regard to environmental issues.

Table 84. CEMP and OEMP Roles and Responsibilities

6.4.1.4. Key Roles and Responsibilities

All Project staff must be fully competent to perform their tasks based on appropriate education, training, or experience. To minimize potential impacts of the Project on the environment, all Project Company, EPC Contractor, and sub-contractor as well as the O&M Contractor staff will be adequately trained to understand and comply with the environmental requirements and commitments of the Project.

All staff will be required to undertake a site-specific Environmental Training prior to commencing any works. The initial training should include the following:

- Site layout.
- Safety procedures.
- Hazardous materials and their safe use.
- CEMP/OEMP and environmental considerations.
- Environmental emergency response procedures.
- Firefighting.
- Fuel-handling and spillage; and,
- Incident reporting procedure.

Outside of the Initial Environmental raining, the level of training will vary depending on staff roles and responsibilities. Example training requirements are outlined in the table below. The CEMP and OEMP will provide further detail on the training requirements in line with the construction and operational activities.

Example/ training	Project staff	Content	Timing
Initial Environmental Training	All project staff and visitors	▪ Environmental policy and CEMP/ OEMP. ▪ Legal commitments and requirements. ▪ Environmental aspects and impacts associated with: ▪ Construction/operational activities. ▪ Role and responsibilities of site environmental management. ▪ Communication procedures; and ▪ Emergency procedures.	Prior to the involvement in any construction/ operational activities.
Environmental Induction for Supervisors	Site Supervisors HSE Managers Environmental Managers	▪ Importance of toolbox talks and how to conduct toolbox talks. ▪ Management of training records and grievances.	Prior to the involvement in any construction/ operational activities.
Spill&Emergency Response Training	All Project Staff	Detailed training on the response and procedures in the event of a spill of emergency.	Prior to the involvement in any construction/ operational activities.
Toolbox Talks	All Project Staff	Toolbox Talk environmental training sessions may be focused on the following subjects: ▪ Dust control measures. ▪ Air quality control measures. ▪ Hazardous materials management, handling, and transportation. ▪ Spill prevention and response for personnel involved in the storage of fuel and other hazardous materials.	Weekly – additional bulletins and alerts as required.

Example/ training	Project staff	Content	Timing
		▪ Storage, handling, and use of chemicals. ▪ Ecologically significant fauna and mitigation measures. ▪ STL Relocation Plan ▪ Transplanting Plan ▪ Noise control measures. ▪ Traffic control measures. ▪ Chance Find Procedure. ▪ Waste management; and ▪ Emergency incident response.	

Table 85. Example of Training Requirements

Records of training delivered by internal and external providers shall be maintained by the EPC and O&M Contractor. These records should include a training register which details the name and date of the training and list of all attendees.

6.4.1.5. Internal and External Communications

The CEMP and OEMP will be required to establish, implement, and maintain processes needed for internal and external communications relevant to the environmental and social performance of the Project.
All Project staff, including Project Company, EPC/O&M Contractor and sub-contractors will be responsible for the communication of any potential environmental issues to the appropriate person.
The CEMP/OEMP will develop a communication plan which will establish:

- What will be communicated.
- When it will be communicated.
- With whom to communicate.
- How to communicate.

Formal modes of internal communications relevant to the environmental and social management of the Project may include:

- Management meetings.
- Progress meetings.
- Monthly reports (e.g., monitoring, inspection, incident reports).

6.4.1.6. Auditing and Inspection

Internal Audits

Internal audits will be undertaken to assess the compliance and conformance of the Project Company and the EPC/O&M Contractors with the CEMP/OEMP. Internal audits will involve the observation of project activities, meetings with key Project staff and a review of records i.e., monitoring reports, management meetings, complaints, etc.
Should any non-compliances or opportunities for improvement be identified during the internal audit, corrective action requests will be issued to the responsible party. These requests will take the form of a short document / form setting out the following information, as a minimum:

- The nature of the non-compliance (date, location, description).
- The nature of the recommended / investigative / remedial / corrective action.
- The individual responsible for the action.
- The timeframe for undertaking and completing the action; and,

- A record and sign-off of the action undertaken.
- The CEMP/OEMP will detail the frequency, scope, and personnel responsible for the internal audits.

External Audits

As the Project is seeking finance from lenders who may (or may not) be signatories of the EP or have investment policies that are consistent with the IFC Performance Standards, the Project will be required to comply with lenders requirements.

In accordance with Equator Principle 9, an Independent Environmental & Social Consultant shall undertake monitoring and reporting activities on behalf of the lenders for the period of the project loan.

There is also the potential that Principal Buyer, as the project proponent, may undertake their own external audits. Further detail will be provided in the CEMP/OEMP.

Inspections

Daily inspections will be undertaken by the HSE Manager and/or Environmental Manager to monitor and record the general environmental performance of the Project. The daily walkover inspection will include of key areas i.e., construction activity locations, site offices, site compound / laydown/ storage areas and will cover the following as minimum:

- General site housekeeping.
- Dust management and air quality.
- Ecological observations.
- Noise and vibration.
- Waste storage and management.
- Chance Find Procedure.
- Lighting management; and,
- Traffic management.

All site inspections will be documented via an Environmental Inspection Record which will be submitted to the HSE Manager on a monthly basis.

In addition to the above, a more formal walkover with the HSE Manager and/or Environment Manager and the Construction Manager will be undertaken and documented.

6.4.1.7. Control of Documents

The CEMP and OEMP are intended to be an evolving 'live' document, which is regularly reviewed, revised, and developed, to ensure the depth of environmental management is compliant and complete.

It is recommended that the detailed CEMP/OEMP is reviewed throughout the construction and operation of the Project at regular intervals. Reviews of the detailed CEMP and OEMP should be undertaken in collaboration between Principal Buyer, EPC/O&M Contractor and their Environmental Advisor and should consider the following as a minimum:

- Any additional responses / comments from NCEC and/or Principal Buyer.
- Updated construction activity details.
- Outcomes of any environmental monitoring.
- Recorded incidences and non-conformances.
- Recorded enquiries and complaints.
- Changes in organization structure and responsibilities; and,
- Changes in environmental standards and legislation.

6.4.2. Monitoring Plan

Monitoring is an essential part of the overall environmental management activity. The overall objective of environmental monitoring is to ensure that all construction, operation, and decommissioning activities comply with legal and regulatory requirements so that all mitigation measures are effectively implemented. The elements that will be monitored will include, but are not limited to air quality, noise, waste, occupational health, and safety, visual and landscaping, etc. The key measurement indicators for these aspects will be defined in the Environmental Management Plan (EMP). The project developer will use various monitoring techniques including regular site supervision and inspection and the use of monitoring devices through the following monitoring software:

- Internal control.
- External monitoring.
- Evaluation and audit.

Monitoring and Auditing in Construction Phase: The monitoring and auditing section to be developed by the contractor of the works must include information regarding the monitoring and auditing of environmental performance, as well as information on reporting requirements, environmental checklists, and monitoring review.

Monitoring and Auditing in Operation Phase: Post-construction monitoring will take the form of routine site inspections to confirm that the Operator is operating properly. During the operation period there is need to ensure that the operating and performance standards are followed and achieved. Monitoring will be undertaken to ensure that proposed mitigation measures for negative impacts and enhancement measures for positive impacts are implemented. During this phase, environmental management will depend on Operator.

The EPC Contractor and Principal Buyer will be responsible for undertaking and reporting on the required monitoring during construction and operation phase respectively.

An Environmental Monitoring Plan for construction and operation of the project will be developed by the EPC Contractor and O&M Contractor respectively, which will detail the monitoring methodologies and specific detail on location, frequencies, duration, monitoring parameters etc. This Monitoring Plan will be part of the EMP (Construction and Operation approved by NCEC through the Permit for Construction. NCEC will ask for periodic reports to check the compliance with the document approved, and before issuing the Permit for Operation, will audit works.

The following tables outline the monitoring requirements related to the construction and operation phase of the project for the topics assessed in section 5.

Indicator	Project phase	Parameter monitored	Frequency and duration	Monitoring location	Source of Information	Monitoring responsibility
Air Quality						
Dust Generation	Construction	$PM_{2.5}$ and PM_{10}	Daily inspection. Visual observation for dust emissions and track out on nearby public road to be undertaken on a daily basis during dust generating activities by use of checklist. To be monitored quantitatively if generation is considered to be excessive (National Air Quality Standards) or complaints are received.	Access roads, construction sites and temporary facilities areas.	EMP	EPC contractor/HSE Manager
Emissions from engines and plant.	Construction	Vehicle Emissions	Pre-site authorization checks on vehicle status and health, including associated emissions. Weekly Visual assessment of emissions (e.g., black smoke) to be undertaken on a daily basis while vehicles and equipment are in use and annual inspection of vehicles.	All non-road vehicles and engines	EMP	EPC contractor/HSE Manager
Sanitary Facilities & Hazardous Material Storage Areas	Construction	Odour & VOCs	Daily visual and olfactory observations – as part of maintenance and inspection checks (for hygiene, safety, and appropriate storage/containment).	All sanitary facilities available within the laydown areas, sub-contractor camps and work fields. All hazardous material, chemical and fuel storage areas.	EMP	EPC contractor/HSE Manager
Noise and Vibration						

Indicator	Project phase	Parameter monitored	Frequency and duration	Monitoring location	Source of Information	Monitoring responsibility
Noise	Construction	Leq (A)	Daily inspection. To be monitored quantitatively if generation is considered to be excessive (National Noise Standards) or complaints are received.	Construction areas, site boundaries and around sensitive receptors	EMP	EPC contractor/HSE Manager
Soils						
Soil Quality	Construction	Visible spills & leaks of hydrocarbons and other potentially hazardous or chemical pollution sources	Daily visual observations as part of a checklist. Comply with National Soil Quality Standards	All construction areas, chemical and waste storage areas, temporary construction areas, associated facility construction and along the access roads during construction.	EMP	EPC contractor/HSE Manager
	Operation	Visible spills & leaks of hydrocarbons and other potentially hazardous or chemical pollution sources	Daily visual observations as part of a checklist. Comply with National Soil Quality Standards	Chemicals, hazardous materials, and waste storage areas.	EMP	Operator
Hydrology, Surface Water and Flood Risk						
Specific monitoring requirements related to hydrology and flood risk are not proposed, however, it will be necessary to take action in response to any realized flooding during both construction and operation. This would include determination of the cause of flooding and contributing factors that can be controlled. Actions related to contributing factors would then then be taken to limit future risk.						
Terrestrial Ecology						

Indicator	Project phase	Parameter monitored	Frequency and duration	Monitoring location	Source of Information	Monitoring responsibility
Flora	Construction	Any evidence of flora damaged	Daily visual inspection. Any change of baseline condition	All construction areas	EMP (Flora protection)	EPC contractor
Trees Transplanting	Construction	Success of Native Tree Transplanting	Every six months	All tree transplanting locations	EMP (Transplanting)	EPC contractor
Fauna	Construction	Any evidence of fauna, burrows and nests damaged	Daily visual inspection. Any change of baseline condition	All construction areas	EMP (Fauna protection)	EPC contractor
Fauna STL Relocation Plan	Construction	Success of STL Relocation Plan	Daily inspection during the relocation process	All construction areas	EMP (STL Relocation Plan)	EPC contractor
PV Site Bird Mortality Monitoring and Register	Operation	Any evidence of mortality will be recorded in the register	Any mortalities will be recorded (including the species, location of carcass, size/weight, age and cause of death) during site walkovers by management, HSE and security staff.	Fence and electrical lines	Fauna protection	Operator
Flora	Operation	Any evidence of flora damaged	Monthly visual inspection. Any change of baseline condition	Areas with vegetation	Flora protection	Operator
Landscape and Visual Amenity						
Monitoring is not proposed for Landscape character and visual impacts, however, any third-party complaints on this topic will be gathered via the project's construction and operational grievance mechanisms.						
Waste & Wastewater						

Indicator	Project phase	Parameter monitored	Frequency and duration	Monitoring location	Source of Information	Monitoring responsibility
Waste & wastewater	Construction and Operation	Ensuing engaged contractor, their vehicles and waste management facilities have applicable registrations/licenses at time of procurement	At procurement and annually thereafter	Construction areas, Project site, transport vehicles and waste management facilities	EMP	EPC contractor and Operator
Socioeconomics						
Employment	Construction and operation	Number of persons employyed from the local popularation	During both phases	N/A	Contractor and Operator Employment policy	EPC contractor and Operator (HR Dept).
Vehicles	Construction and operation	Traffic related issues & incidents, including near misses	During both phases	N/A	Contractor and Operator Employment policy	EPC contractor and Operator.
Third Party Grievances	Construction and operation	Grievances	During both phases	N/A	Contractor and Operator Employment policy	EPC contractor and Operator.
Climate Impacts						
Specific monitoring for climate impacts will not be conducted, however, resource consumption will be monitored and collated by the EPC Contractor						
Community, Health, Safety and Security						

Indicator	Project phase	Parameter monitored	Frequency and duration	Monitoring location	Source of Information	Monitoring responsibility
Record of any conflict between the workers and community members including any cases relating to sexual harassment.	Construction and Operation	N/A	Daily during construction	N/A	Complaints filed by community members or Project workers	EPC contractor
		N/A	quarterly during operations	N/A		Operator
Discharging of firearms by security personnel on site	Construction and operation	N/A	In the event the security personnel are armed	N/A	Security personnel/ local police	EPC contractor and Operator
Record of human rights violation/complaints from the local communities	Construction and operation	N/A	In the event of human rights violation/complaints	N/A	Complaints filed by community members in relation to the Project	EPC contractor and Operator
Record of any communicable diseases on site that could pose a risk to the local communities	Construction and operation	N/A	On-going	N/A	Project site clinic or HSE personnel	EPC contractor
Grievances	Construction and operation	Number of grievances received and closed out, average time for grievance proccessing	Quarterly / bi-yearly	Project site and any other grievances received from the public in reference to Project workforce including suppliers.	Grievance Management System	EPC contractor and Operator
Archaeology						

Indicator	Project phase	Parameter monitored	Frequency and duration	Monitoring location	Source of Information	Monitoring responsibility
Archaeology	Construction	Any evidence of findings damaged	Daily visual inspection. Any change of baseline condition	All construction areas	EMP (Heritage protection)	EPC contractor
Human Rights, Labour and Working Conditions						
Worker Contracts & HR	Construction and operation	Records of contracts, payments, receipt of benefits, etc.	During both phases	For all Project workers (direct staff) and oversight of sub-contractor staff dedicated to the project	Contractor and Operator Employment policy/ Saudi labour system	EPC contractor and Operator
Worker Welfare	Construction and operation	Sanitation Facilities, Office Spaces, Welfare and Rest Areas	During both phases	At all such facilities on- site	Contractor and Operator Employment policy/ Saudi labour system	EPC contractor
Quality of Accommodation	Construction and operation	Inspection/internal audit of worker accommodation facilities	Monthly	All accommodation facilities provided	Contractor Employment policy/ Saudi labour system	EPC contractor and Operator
Health of the workers	Construction and operation	Records of the illnesses the workers are suffering from and analysis of common diseases.	During both phases	Project site clinic or first aid facility	Contractor and operator Employment policy/ Saudi labour system	EPC contractor and Operator

Table 86. Environmental Monitoring Plan

6.5. Summary of Impacts Post-Mitigation

The following table summarizes the residual impacts identified for the construction and operation of the project after the application of the appropriate mitigation and management measures.

Environmental aspect	Potential Impact	Phase	Potential Impact Significance	Risk Ranking	Acceptance post mitigation
Natural Vegetation Cover	Vegetal cover removal	C	Negligible or Minor	Medium	TOLERABLE with the environmental measures in place
		O	Negligible or Minor	Low-Very Low	TOLERABLE
Terrestrial Biodiversity. Fauna & flora	Ecosystem disturbance and habitat destruction	C	Negligible or Minor	Medium	TOLERABLE with the environmental measures in place
	Habitat fragmentation. birds' collision and electrocution risk	O	Negligible or Minor	Low	TOLERABLE
	Invasive species introduction	C	Negligible or Minor	Low	TOLERABLE
		O	Negligible or Minor	Low	TOLERABLE
Air quality	Air quality degradation	C	Negligible or Minor	Medium	TOLERABLE with the environmental measures in place
		O	Negligible or Minor	Low	TOLERABLE
Noise and vibration	Noise disturbance	C	Negligible or Minor	Medium	TOLERABLE with the environmental measures in place
		O	Negligible or Minor	Low	TOLERABLE
Odours	Air quality disturbance. Bad smells	C	Negligible or Minor	Low	TOLERABLE
		O	Negligible or Minor	Low	TOLERABLE
Surface water quality	Surface water quality degradation	C	Negligible or Minor	Very Low	TOLERABLE
		O	Negligible or Minor	Very Low	TOLERABLE
Surface water availability	Surface water resources exhausting	C	Negligible or Minor	Very Low	TOLERABLE
		O	Negligible or Minor	Very Low	TOLERABLE

Environmental aspect	Potential Impact	Phase	Potential Impact Significance	Risk Ranking	Acceptance post mitigation
Ground-water quality	Ground-water quality degradation	C	Negligible or Minor	Low	TOLERABLE
		O	Negligible or Minor	Very Low	TOLERABLE
Hydrology and flood risk	Natural hydrologic system disturbance	C	Negligible or Minor	Low	TOLERABLE
		O	Negligible or Minor	Low	TOLERABLE
Quality of soil	Potential soil contamination and compaction	C	Negligible or Minor	Low	TOLERABLE
		O	Negligible or Minor	Very Low	TOLERABLE
Health and safety	Risk of accidents and injuries in construction& operation	C	Negligible or Minor	Low	TOLERABLE
		O	Negligible or Minor	Very Low	TOLERABLE
Landscape and visual comfort	Degradation of general landscape of the site	C	Minor	Medium	TOLERABLE with the environmental measures in place
		O	Negligible or Minor	Very Low	TOLERABLE
Land use	Modification of land use	C	Minor	Medium	TOLERABLE, with the environmental measures in place
		O	Negligible or Minor	Very Low	TOLERABLE
Waste generation	Non-hazardous & hazardous waste generation. Water & Soil contamination if managed badly	C	Negligible or Minor	Medium-Low	TOLERABLE with the environmental measures in place
		O	Negligible or Minor	Low	TOLERABLE
Glint & Glare	Visual impact due to solar radiation reflection	O	Negligible or Minor	Low	TOLERABLE
Climate change	Reduction/ increasing of GHGs		Negligible or Minor	Low	TOLERABLE
		O	Positive impact	-	Positive impact
Economic and social aspects	Creation of job opportunities	C	Positive impact	-	Positive impact
		O	Positive impact	-	Positive impact
	Growth of regional economy	C	Positive impact	-	Positive impact
		O	Positive impact	-	Positive impact
		C	Negligible or Minor	Low	TOLERABLE

Environmental aspect	Potential Impact	Phase	Potential Impact Significance	Risk Ranking	Acceptance post mitigation
	Workers conflict with local communities	O	Negligible or Minor	Low	TOLERABLE
	Infectious disease spread	C	Negligible or Minor	Low	TOLERABLE
		O	Negligible or Minor	Low	TOLERABLE
Traffic and transport	Volume of traffic rise and risk of accidents	C	Negligible	Low	TOLERABLE
		O	Negligible or Minor	Low-Very Low	TOLERABLE
Archaeology	Risk destruction of archaeological & cultural heritage	C	Negligible or Minor	Low	TOLERABLE
		O	Negligible or Minor	Low-Very Low	TOLERABLE
Unplanned events	Risk of fire, explosions, pollutants. Leaks and spills	C	Minor	Low	TOLERABLE
		O	Minor	Low	TOLERABLE

Table 87. Summary of Impacts Post-Mitigation

Notes:

- Phase

  C-Construction

  O-Operation

- Risk Ranking:

  Low and Very Low.: Tolerable but may still need to have best practice applied to them to ensure they comply.

  Medium: Mitigation Measures and Best Practise Controls will be applied for the activity to be considered as Tolerable. Acceptable with the mitigation measures in place.

Summary

7. SUMMARY

7.1. Summary of how the negative impacts on the environment or public health will be addressed and to what extent they will be reduced, improved, or controlled, and how the positive impacts will be enhanced

7.1.1. Summary of the environmental, social and economic losses and gains that justify the establishment of the proposed activity

The proposed project has a number of important positive impacts. A summary of the potential gains and losses associated with the project is shown below.

Aspect	Gains	Losses
Environmental aspect	• Reducing greenhouse gases (some millions of tons of carbon dioxide equivalent) • Energy production from renewable sources	Limited negative impacts on the environment (such as increase of noise levels) during the construction and operation phases. However, the application of proposed mitigation measures will further reduce or eliminate those impacts
Social aspect	• Energy production is equivalent to supplying energy to thousands of households. • Creating job opportunities during the different phases of the project • Purchasing items, especially during the phase construction, will have a positive indirect impact on the neighboring local communities due to the improvement of economic conditions	Limited negative impacts on the environment (such as increased noise levels) during the construction and operation. However, the application of the proposed mitigation measures will reduce more than those impacts.
Economic aspect	• Purchasing materials, especially during the construction phase, will have direct positive effects on the local economy. • Power generation from renewable source of energy	The biggest loss is 40.0 km^2 of a developed land to be offset against benefits of up to 2,636 MW of power generation

Table 88. Summary of gains and losses

7.1.2. Summary of the method of addressing the adverse impacts and the extent of their mitigation, improvement, or control

The ESIA report reveals that the major negative impacts of the proposed project will be during construction phase. These impacts are the following: increase of noise on receptors, air quality pollution due to gaseous and dust emissions, habitat destruction, ecosystem disturbance, modification of land use, landscape degradation and risk of heritage alteration. All environmental impacts are Negligible or Minor and can be mitigated and, in many cases, avoided by careful planning and compliance with Environmental Management Plan actions during the construction period. **All impacts will be acceptable after that mitigation measures are applied**. The negative Impacts will be monitored regularly during construction stage.

During the Operation Phases, some general environmental prevention measures have been considered to prevent negative impacts, and an effective environmental management.

During construction and operation stages there will be **positive impacts** on employment and livelihood. In the construction phase employment will be generated directly both for skilled and unskilled professionals at different levels. Indirectly, it will generate employment for many people in the project area and beyond. A big part of these employments will be from local sources. In addition, resources consumption during construction phase will produce an economic development both locally and nationally.

The most likely impacts and the potential impact significance are listed and summarized in table below.

Environmental aspect	Potential Impact	Phase	Receptor´s Sensitivity	Nature	Potential Impact Significance
Natural Vegetation Cover	Vegetal cover removal	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Terrestrial Biodiversity. Fauna & flora	Ecosystem disturbance and habitat destruction	Construction	Low	Negative	Negligible or Minor
	Habitat fragmentation, birds´ collision and electrocution risk	Operation	Low	Negative	Negligible or Minor
	Invasive species introduction	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Air quality	Air quality degradation	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Noise and vibration	Noise disturbance	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Odours	Air quality disturbance. Bad smells	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Surface water quality	Surface water quality degradation	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Surface water availability	Surface water resources exhausting	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Ground-water quality	Ground-water quality degradation	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor

Environmental aspect	Potential Impact	Phase	Receptor´s Sensitivity	Nature	Potential Impact Significance
Hydrology and flood risk	Natural hydrologic system disturbance	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Quality of soil	Potential soil contamination and compaction	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Health and safety	Risk of accidents and injuries in construction& operation	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Landscape and visual comfort	Degradation of general landscape of the site	Construction	Low	Negative	Minor
		Operation	Low	Negative	Negligible or Minor
Land use	Modification of land use	Construction	Low	Negative	Minor
		Operation	Low	Negative	Negligible or Minor
Waste generation	Non-hazardous & hazardous waste generation. Water & Soil contamination if managed badly	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Glint & Glare	Visual impact due to solar radiation reflection	Operation	Low	Negative	Negligible or Minor
Climate change	Reduction/ increasing of GHGs	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Positive	Positive impact
Economic and social aspects	Creation of job opportunities	Construction	Low	Positive	Positive impact
		Operation	Low	Positive	Positive impact
	Growth of regional economy	Construction	Low	Positive	Positive impact
		Operation	Low	Positive	Positive impact
	Workers conflict with local communities	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
	Infectious disease spread	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Traffic and transport	Volume of traffic rise and risk of accidents	Construction	Low	Negative	Negligible
		Operation	Low	Negative	Negligible or Minor
Archaeology	Risk destruction of archaeological & cultural heritage	Construction	Low	Negative	Negligible or Minor
		Operation	Low	Negative	Negligible or Minor
Unplanned events	Risk of fire, explosions, pollutants. Leaks and spills	Construction	Low	Negative	Minor
		Operation	Low	Negative	Minor

Table 89. Summary of Impacts

The negative impacts will be monitored regularly during construction stage. The main mitigation measures considered for addressing the adverse impacts have been:

- Air Control Plan.

- Noise Control Plan.
- Waste Management Control Plan.
- Terrestrial Control Plan (Marking out to protect groups of shrubs and trees; transplanting of trees, fence design with plates; spiral birds protector devises, relocation of STL, etc.).
- Integration measures to restore the affected surfaces during construction phase.
- Vegetal barrier around the PV plant.
- Selection of PV modules with special Anti-Reflective (AR) coating and surface texturing.
- Shading the ATCT from the glare
- Variation in PV module orientation

7.2. Summary of roles, responsibilities, and budget for the implementation of the environmental management plan

7.2.1. Roles and responsibilities of the different authorities concerned

Table below illustrates the Role and Responsibility of the main key stakeholders.

Items	Authorities	Roles and responsibilities in construction stage	Roles and responsibilities in operation stage
1	National Center for Environmental Compliance (NCEC)	The National Center for Environmental Compliance has been assigned responsibilities related to reviewing and approving environmental impact assessments for development projects and granting permits and licensing (i.e., environmental permit for construction and environmental permit for operation)	The National Center for Environmental Compliance acts as an enforcement agency for the enforcement of environmental laws, including licensing and environmental auditing.
2	Ministry of Environment, Water and Agriculture (MEWA)	Issuing a permit to drill groundwater wells if necessary	Attention to the environmental performance of the proposed project in general
3	Principal Buyer, the project owner	Performance monitoring. Liaise with relevant government agencies/ ministries as needed.	performance monitoring. Responsible for communicating with relevant government agencies/ministries as needed
4	Saudi Electricity Company (SEC)	Dealing directly with the common matters between the project and the assets of the Saudi Electricity Company (for example, the electrical connection)	An ongoing role related to project operation and grid power supply
5	Ministry of Culture	Potential supervision during the construction process to ensure that the discoveries do not overlook of archaeological, and the archaeological findings are preserved and protected	Attention to the environmental performance of the proposed project in general
6	National Center for Wildlife	Ensures that all procedures included in the ESIA are followed to protect biodiversity	Attention to the environmental performance of the proposed project in general

Items	Authorities	Roles and responsibilities in construction stage	Roles and responsibilities in operation stage
7	National Center for Vegetation Cover and Combating Desertification	Ensures that all procedures included in the EIA are followed to protect biodiversity	Attention to the environmental performance of the proposed project in general

Table 90. Roles and responsibilities of different authorities

7.2.2. Summary of the environmental management plan and budget for the implementation

Both Construction and Operational phases will need to incorporate in their Environmental Management Plans (EMP) mitigation and monitoring requirements as well as all future requirements defined by NCEC.

The objective of these documents is to carry out a detailed description of the environmental mitigation and monitoring measures to avoid, minimize or reduce the adverse environmental impacts identified to acceptable levels.

The EMP report intends to establish a Framework for the Construction Environmental Management Plan (CEMP) and the Operation Environmental Management Plan (OEMP). Both Management Plans will be prepared by Contractor/Operator according to the regulations issued by NCEC as well as other practices in similar fields.

The main goals of the CEMP and OEMP are to specify the roles and responsibilities of personnel involved with all aspects of the construction/operation activities; identify potential environmental impacts and the mitigation measures that shall be used to address them; establish procedures for audits, monitoring, and inspections; and specify training, recordkeeping, and documentation requirements. The CEMP/OEMP shall be use by all personnel involved with construction/operation activities.

Prior to starting works, Contractor will provide the following control plans in the CEMP:

- Air Quality Control Plan
- Soil and Groundwater Contamination Control Plan
- Landscape, Erosion and Sediment Control Plan
- Terrestrial Ecology Control Plan (including STL Relocation Plan)
- Water Protection Plan
- Wastewater Management Plan
- Noise Control Plan
- Traffic Control Plan
- Waste Management Control Plan
- Chemical and Hazardous Materials Control Plan
- Contingency Plan
- Emergency Management Plan
- Security Plan
- Infrastructure Plan.
- Archaeological Chance Find Procedure.

Prior to starting operational works, Operator will provide the following control plans in the OEMP:

- Waste and Wastewater Management Plan
- Occupational Health & Safety Plan
- Site Inspection & Audit Plan & Procedure
- Emergency Management Plan
- Environmental Monitoring Plan
- Human Resources and Policies Procedures

The cost for the implementation of the environmental management plan during construction phase (CEMP) will be included in the project budget.

The cost for the implementation of the environmental management plan during operation phase (OEMP) will be take into account during the stage of operation and maintenance.

7.2.3. CEMP and OEMP Roles and Responsibilities

The roles and key responsibilities related to the implementation of the CEMP and the OEMP are outlined below.

Role	Key Responsibilities
Project Company/ Executive Managing Officer	▪ Review and approve environmental and social management budgets, resourcing and staffing. ▪ Attend and actively input to environmental and social management review meetings. ▪ Formal sign off and approval of all EMS documentation produced by the EPC and O&M Contractor, including their detailed management plans.
Project Company / HSE Manager	▪ Follow up, review and internal approval off EMS documentation produced by the EPC and O&M Contractors. ▪ Inspect and audit EPC and O&M Contractors. ▪ Liaise with regulators and/or other authorities on environmental and social matters. ▪ Be responsible for communications regarding environmental and social reporting and third-party audits.
EPC/O&M Contractor: Project Director	▪ Review and approve environmental management budgets, resourcing and staffing.
EPC/O&M Contractor: HSE Manager	▪ Review and approve environmental and social management budgets, resourcing. and staffing. ▪ Ensure sufficient resources for the management of environmental and social matters. ▪ Undertake regular site inspections. ▪ Monitor and report on environmental management and performance, including compliance with the CEMP/OEMP. ▪ Undertaken regular inspections and audits to assess compliance and manage implementation of corrective and preventative actions.

Role	Key Responsibilities
EPC/O&M Contractor: HSE Engineer / Environmental Engineer	▪ Monitor and report on environmental management and performance, including compliance with the CEMP/OEMP. ▪ Prepare and monitor site bulletin boards. ▪ Undertake daily site walkovers and inspection of works. ▪ Maintain applicable environmental and social records. ▪ Act as point of contact for any sub-contractor with regard to environmental issues.

Table 91. CEMP and OEMP Roles and responsibilities

Annexes

8. Annexes

8.1. Annex nº 1. List of References

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8.2. Annex nº 2. Resumes of the Study Authors. Curriculum Vitae

8.2.1. Resume of National Team

Name of Expert	Educational Qualification	Experience	Organization
Local team from AH Environmental Consulting Office (AHEC)			
Ennacer BESGHAEIR	BEng in Chemical Engineering	16 years	AHEC
Abderrazzak ZEMZEMI	BEng in Hydraulic and Water Resources	14 years	AHEC
Bechir FRADJ	Bachelor's Degree in Earth and Life Sciences Master's degree in Environmental Sciences	6 years	AHEC
Nadia MEDIUONI	BEng in Hydrometeorological Sciences	13 years	AHEC
Marouane CHOUCHANE	BEng in Chemical Engineering	7 years	AHEC
Amer BEN SAAD	Chemical Process Engineering	16 years	AHEC
Muhammad LLYAS	Environmental Engineer	10 years	AHEC

8.2.2. Curriculum Vitae of National Team

General informations	
Last Name / First Name :	BESGHAIER Ennacer
Position:	PROJECTS MANAGER
Number of years' experience:	16 years
Qualification Degrees	Engineer in Chemical Engineering and Processes
Nationality:	Tunisian
IEMA associate Membership certificate :	IEMA Foundation Certificate in Environmental Management-154212
Saudi Council of Engineers	**membership Id** : 488956

Summary of Experience

Mr. Besghaier is an Engineer in Chemical Engineering and Processes graduated from National University of Engineers of Gabes (ENIG) in Tunisia and with proven Experience in the field of environmental investigations and studies, environmental permitting, EMP and risk assessment studies.That are Acquired through the various positions held within engineering services companies as well as good knowledge in water treatment and waste management field.

Ennacer had the opportunity to participate in the preparation of national and international tenders as well as in several of major projects. These projects include:

- ✓ Environmental permiting process for various project under Royal commission or / and GAMEP (NCEC).
- ✓ Environmental Management Audit.
- ✓ Conducting of environmental impact assessment studies for various projects**.**
- ✓ Carrying out Risk Assessment Studies and Emergency Responses Plans.
- ✓ Conducting air dispersion modeling by AERMOD
- ✓ Development of HSE procedures and manuals (emergency response plan, HSE manual, HSE policy, HSE good practice manual, risk assessment study, ...)
- ✓ Conducting waste management plan.
- ✓ Conducting solid wastes charachterization.
- ✓ Conducting feasibility study for solid waste management system (collect/transport/transfer station/landfill)

By conducting these project, Ennacer has acquired the following skills :

- ✓ Project Management (tender, contract, schedule, communication with the clients, site visit, meeting, technical advise, team)
- ✓ Be familiar with international regulations and laws relating to Environmental Protection and be in compliance (IFC Performance Standards, WORLD BANK OP, OMS Standards, EBRD Performance Requirements (PRs)…)
- ✓ checking compliance of environmental baseline parameters with the national and international standards.
- ✓ Conducting EIA Data collection,
- ✓ Environmental baseline assessment reporting
- ✓ having excellent background related to preparation and impelementation of waste management plan / Oil Spill Emergency Responses Plan / environmental management plan/ Environmental Monitoring Plan
- ✓ conducting air dispersion modeling from different sources (flare/stack/…)-AERMOD software.
- ✓ Coordination with laboratories to perform sampling/analysis for water, soil, wastewater, treated water, ...).
- ✓ participate in conducting qualitative and quantitative risk assessment and use DNV PHAST Software to perform risk consequences modeling

- ✓ familiar with HSE procedures/management system/policy
- ✓ familiar with the national and international environmental regulations (laws, standards, procedures)

key qualifications	
From august 2019 until now	Projects Manager / Sr. Environmental Engineer with AH ENVIRENMENTAL CONSULTING OFFICE
From July 2018 until July 2019	Head of Division "Solid Waste Management" in I2E (EPPM GROUP)-projects manager
From July 2014 to July 2018	Environmental / HSE Engineer - Projects Coordinator with I2E (EPPM Group). Project coordination of environmental / HSE / waste management studies.
From March 2013 to June 2014	Head of solid control /waste management division "ALAMIA OIL SERVICES GROUP" in Libya.
From October 2011 to February 2013	Environmental / HSE Engineer - Projects Coordinator with I2E (EPPM Group). Project coordination of environmental / HSE / waste management studies.
From May 2009 to September 2011	Environmental / HSE Engineer - Projects Coordinator with AMAL SERVICES & risk management & drilling wastes management & treatment.

Academic training

Chemical Engineering Process Engineer
with Honors

2004 - 2007	3-years chemical process engineering cycle in National Engineering university - Gabes (ENIG)-Tunisia .
2001 - 2003	2-years preparatory cycle in Preparatory Institute for Engineering Studies in Gabes - IPEIG
2000	Bachelor's degree in Experimental Sciences (with honors).

Professional Experiences

Project Title :
Environmental wastes and resources management audits for SAR - Riyadh and Nairyah Depot

Role: Project Manager - Environmental expert

Client (s): SAR	**Project duration** : January 2021- February 2021	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of wastes and resources management impact and proposal of necessary mitigation measures
- Wastes characterization and inventory
- Assessment of existing environmental issues ((soil contamination, air emission, noise pollution, fauna, flora, wastes generation,) – conducting sampling and monitoring for soil /air quality/noise.
- Environmental/ wastes and resources /Management Plan
- Recommendation in achieving the organization objectives in wide areas of environmental waste and resource management compliance
- QHSE Process / procedures review and analysis

- Preparation of the environmental audit report for each site including the aforementioned detailed tasks.

Professional Experiences

Project Title :
Environmental Assessment study of the Red Palace and Tuwaiq Place in Ryadh

Role: Project Manager - Environmental expert

Client (s): JLL-Boutique Hotels	**Project duration** : December 2020- February 2021	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of the current situation of the Palaces
- Assessment of existing environmental issues ((soil contamination, air emission, noise pollution, fauna, flora, wastes generation,) – conducting sampling and monitoring for soil /air quality/noise.
- Impact assessment of the proposed development of the palaces

Project Title :
Environmental Audit during construction for the 300MW SAKAKA SOLAR PLANT

role: Project Manager - Environmental expert

Client (s): MAHINDRA	**Project duration** Novembre 2019	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of wastes and resources management impact and proposal of necessary mitigation measures
- Wastes characterization and inventory
- Assessment of existing environmental issues ((soil contamination, air emission, noise pollution, fauna, flora, wastes generation,) – conducting sampling and monitoring for soil /air quality/noise.
- Environmental/ wastes and resources /Management Plan
- Recommendation in achieving the organization objectives in wide areas of environmental waste and resource management compliance
- QHSE Process / procedures review and analysis
- Preparation of the environmental audit report for each site including the aforementioned detailed tasks.

Project Title :

Environmental Impact Assessment Studies for Riyadh Sports Boulevards (5 EIA studies)

role: Project Manager - Environmental expert

Client (s): RCRC-TYPSA	**Project duration** March 2020-till now	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Preparation of an Environmental Monitoring and Management Plan
- Preparation of the Environmental impact assessment report
- Environmental Permitting from GAMEP (NCEC)

Project Title :

Environmental permitting services (permit application package / EIA / Environmental emergency response plan (EERP)) for Jubail Industrial Gas Hub in Jubail Industrial City

ROLE: Project Manager - Environmental expert

Client (s): AIR PRODUCTS	**Project duration** July 2020-Mars 2021	**country:** KSA

Project description :

- Site visit to the project
- Project Permitting process under Royal commission Jubail and Yanbu (RCJY) for the environmental permit to construct (EPC)
- Environmental baseline investigation (air quality and noise monitoring, soil & groundwater sampling and analysis ...)
- Air dispersion modeling / noise modeling / Best Available technology (BAT) Study
- Environmental Emergency response plan (EERP)
- Preparation of the Permit Application Package (PAP)
- Collection and analysis of project documents and other strategic documents
- Communication with local stakeholders mainly concerned by the project
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Project management (tender/ meeting /communication with client / RCJY/ Schedule/ coordination)

Project Title : Preliminary Environmental and Social Impact Assessment Studies for Rabigh 4 and Rabigh 5 Independent Water Project (IWP) seawater desalination plants-SWPC		ayesa الشركة السعودية لشراكات المياه Saudi Water Partnership Company
ROLE: Project Manager - Environmental expert		
Client (s): AYESA / SWPC	**Project duration** Dec 2019-Jan 2020	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Environmental baseline investigation (air quality and noise monitoring, soil & groundwater sampling and analysis ...)
- Collection and analysis of project documents and other strategic documents
- Communication with local stakeholders mainly concerned by the project
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Preparation of the Environmental Baseline detailed report (EBS): Current State Assessment.
- Preparation of the Preliminary Environmental and Social Impact Assessment Report (PESIA).

Project Title : Environmental permitting services (permit application package / EIA / Environmental emergency response plan (EERP)) for PETROKEMYA CLC PROJECT- China Tianchen Engineering Corporation Saudi Arabia Branch (TCC)-PETROKEMYA		TCC بتروكيميا
ROLE: Project Manager - Environmental expert		
Client (s): TCC-PETROKEMYA (SABIC)	**Project duration** Oct 2020-Ma 2021	**country:** KSA

Project description :

- Site visit to the project
- Project Permitting process under Royal commission Jubail and Yanbu (RCJY) for the environmental permit to construct (EPC)
- Environmental baseline investigation (air quality and noise monitoring, soil & groundwater sampling and analysis ...)
- Air dispersion modeling / noise modeling / Best Available technology (BAT) Study
- Environmental Emergency response plan (EERP)
- Preparation of the Permit Application Package (PAP)
- Collection and analysis of project documents and other strategic documents
- Communication with local stakeholders mainly concerned by the project
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Preparation of the Preliminary Environmental and Social Impact Assessment Report (PESIA).
- Project management (tender/ meeting /communication with client / RCJY/ Schedule/ coordination)

Project Title :		maaden معادن GOLD & PRECIOUS METALS SBU

Solid Waste Management Plan for MANSOURAH-MASSARAH GOLD PROJECT	

ROLE: Project Manager - Environmental expert

Client (s): MA'ADEN Gold-Gulf Consult	**Project duration** Sept 2020-Nov 2020	**country:** KSA

Project description :

- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Legal framework
- Project Solid Wastes (Waste classification, Waste Generation and General Characterization, The required wastes bins for the proposed residential units, Waste Storage and Collection Area)
- Environmental impact assessment / mitigation measures
- Waste management practices
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Preparation of solid waste Management Plan report

Project Title : Environmental Impact Assessment Study for 300MW SAKAKA SOLAR PLANT	

ROLE: Project Manager - Environmental expert

Client (s): SAKAKA	**Project duration** Oct 2020-Nov 2020	**country:** KSA

Project description :

- Environmental Permitting from GAMEP (NCEC)
- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Preparation of an Environmental Monitoring and Management Plan
- Preparation of the Environmental impact assessment report

Project Title :	

Environmental Impact Assessment Study for DAMMAM SHIPYARD -ALBALAGHA INDUSTRIAL	

ROLE: Project Manager - Environmental expert

Client (s): DAMMAM SHIPYARD	**Project duration** Jan 2021-Feb 2021	**country:** KSA

Project description :

- Environmental Permitting from GAMEP (NCEC)
- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Preparation of an Environmental Monitoring and Management Plan
- Preparation of the Environmental impact assessment report

Project Title : Environmental Impact Assessment Study for Al Nahda Entertainment Cluster Riyadh Project- EXIT 15 -SEVEN	

ROLE: Project Manager - Environmental expert

Client (s): SEVEN	**Project duration** Feb 2020 – June 2020	**country:** KSA

Project description :

- Environmental Permitting from GAMEP (NCEC)
- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Preparation of an Environmental Monitoring and Management Plan
- Preparation of the Environmental impact assessment report

Project Title : Environmental health program for the city of Tripoli: sustainable Management of Urban Solid Waste-Contract for Partner organization to conduct engineering study and design Engineered Landfill	

ROLE: Project Manager - HSE / Environment Engineer

Client (s): UNOPS	**Project duration** November 2018-March 2019	**country:** Tunisia

Project description :

- Environment Assessment: Conduct Environmental impact assessment / environment Initial evaluation / screening environment for Landfill Construction in Tripoli local regulation is based. (Time frame: January 2018 - December 2018)
- Engineering study: Conduct engineering study in order to design engineered landfill That will include but not limited to land boundary survey with outline in 5 meter interval, geological and hydrogeological investigations and other parameters Including but not limited to permeability, rainfall, wind speed, wind direction , sensitive areas are expected to be the carried out. (Time frame: November, 2018 - January 2019)
- Feasibility study: Conduct feasibility study on waste management system (Including but not limited to gender, social, waste characterization, policy, operations, capacity needs of stakeholders, existing waste management system in Tripoli, Libya, way forward to Reduce environment health issues.) (Time frame: November, 2018 and December 2018)
- Capacity Building: Conducting capacity building program for stakeholders are best waste management practices) (Time frame: November 2018 and March 2019)
- Design engineered landfill with amenities Necessary: This include structural, electrical and mechanical drawings with BOQ. (Time frame: December, 2018, and March 2019)

Project Title :
Environmental and Social Impact Assessment Study (ESIA) for Solar Thermal Power Plant, in Al Akarit in Gabes-Tunisia

Role: Environmental Engineer

Client (s): STEG	**Project duration** July 2013 - January 2014	**country:** Tunisia

Project description :

- ENVIRONMENTAL IMPACT ASSESSMENT (EIA)-**IFC Performance Standards /World Bank OP**

The EIS describe the various components of the project, the environmental baseline affected by the project, the potential environmental impacts, the mitigation measures. The EIA develop the following topics:

- Public consultation and communications program.
- Overview of political, legal and administrative framework.
- Analysis of the environmental baseline
- Analysis of project alternatives.
- Analysis of the potential environmental and social impacts.
- Risk assessment study.
- environmental and social management plan.

- ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The goal of the environmental management plan and monitoring program to ensure appropriate environmental management of the different project phases and minimize all potential aspects in compliance with the laws and regulations.

Project Title : Environmental and social study for the management of wastewater from the potable water treatment complex in Belli -**IFC Performance Standards/World Bank OP**		
Role: Project Coordinator - Environmental Engineer		
Client (s): SONEDE	**Project duration** December 2015- June 2016	**country:** Tunisia

Project description :

SONEDE proposes to develop an environmental and social assessment for the management of wastewater from the water treatment complex at Belli, to identify the potential impacts of releases drained water effluent to Wadi El Masri and to find solutions of waste management. This study is planned in the following two phases:

- Phase I: diagnosis of the current situation and impact analysis.
- Phase II: waste treatment solutions studies and proposed an action plan.

Project Title : ODC Project - Environmental and Social Impact Assessment study Tunisia- **EBRD Performance Requirements (PRs)/ IFC Performance Standards**		
role: Project Manager - Environmental and Waste Management Specialist		
Client (s): European Bank for Reconstruction and Development- EBRD		
Project duration October 2017- November 2017	**country:** Tunisia	

Project description :

- Summary of Key Findings - Within one week of the completion of the Site visit.
- Draft Environmental and Social Audit and Assessment Report, which includes a PR compliance table - Within 3 weeks of the Completion of the Site visit. **- EBRD Performance Requirements (PRs)- IFC Performance Standards**
- Draft Environmental and Social Action Plan (ESAP) - Within 3 weeks of the completion of the Site visit.
- Draft Stakeholder Engagement Plan (SEP) - Within 3 weeks of the completion of the Site visit.
- Draft Non-Technical Summary (NTS) for disclosure to the public - Within 3 weeks of the completion of the Site visit.
- Final documentation - Within 1 week of receiving send the Bank's comments on the draft versions.

Project Title : Risk Assessment study and emergency responses plan of the subsidiary biogas / cogeneration facility in the WWTP SE4 in Nabeul		
role: HSE / Environmental Engineer		
Client (s): ONAS	**Project duration :** November 2017 – November 2018	**country:** Tunisia

Project description :

Identify potential effects of BIOGAS Facility component / Cogeneration Project SE4 in Nabeul treatment plant (nearing completion of assembly work equipment of cogeneration component) on the physical environment, to estimate their likely magnitudes and identify the main measures that should accompany their implementation and address the identified environmental issues, safety and in accordance with regulations and requirements.

Project Title :	

Environmental impact assessment study with an environmental management plan and a risk assessment report of a landfill Ourhoud oil field

role: HSE Coordinator - Environmental Engineer

Client (s): EPPM & final Client OURHOUD SONATRACH

Project duration December 2016-August 2017

country: Algeria - Ouargla-HESSI MESSOUD

Project description :

- Site visit
- sampling mission and physico-chemical soil analysis
- Expose, evaluate and analyze the risks associated with the site, storage, and operation of the landfill and to determine their possible impacts on safety, health and safety of people (staff, neighbors) Health public and the environment.
- Set and justify preventive and protective measures to reduce the probability of accidents and limit their consequences.
- Analyze scenarios of potential accidents and their consequences in order to define intervention measures and adequate means to deal with so-called accidents.
- Conduct EIA in compliance with Algerian law.

Project Title :

Risk assessment study and an Emergency Responses Plan (ERP) EL GASSI oil field

role: Project Coordinator - HSE Engineer

Client (s): SONAHESS - Sonatrach

Project duration July 2012-July 2013

country: Ouargla - Algeria

Project description :

- Risk Assessment Study

  The study aims to:

  - Expose, evaluate and analyze the risks associated with the site, storage, processing, exploitation and production of oil El-Gassi and determine their possible impacts on safety, health and safety of people (staff, neighbors) on public health and the environment.
  - Set and justify preventive and protective measures to reduce the probability of accidents and limit their consequences.
  - Analyze scenarios of potential accidents and their consequences in order to define intervention measures and adequate means to deal with so-called accidents. (DNV PHAST MODELING)

- Emergency Response Plan (ERP)
  - Under the terms of reference established by Decree No. 09-335 of the Minister of Industry and Investment Promotion of 20 October 2009, the ERP is a tool of management and emergency planning and response, to protect workers, the public, property and the environment, and defining, in respect of the installation concerned, all risk prevention measures, the resources mobilized in this regard and the procedures to be implemented in the disaster triggered.

Project Title :

Conducting impact assessment studies for oil & gas facilities

role: HSE engineer

Client (s): Eni Tunisia BV	**Project duration** July 2016- June 2018	**country:** Tunisia

Project description :

Achievement of Environmental impact assessment Studies of the different projects and sites for Eni Tunisia to support compliance to the Tunisian regulations and international standards in this field.
These are onshore and offshore studies, noise measurement campaigns, vibration / air quality and air emissions, as well as analysis of samples of soil and water. Safety and health at work / work ergonomics.

Project Title :

Conducting impact assessment studies for oil & gas facilities

role: HSE/ environmental engineer

Client (s): Eni Tunisia BV	**Project duration** July 2013- June 2016	**country:** Tunisia

Project description :

Achievement of Environmental impact assessment Studies of the different projects and sites for Eni Tunisia to support compliance to the Tunisian regulations and international standards in this field.
These are onshore and offshore studies, noise measurement campaigns, vibration / air quality and air emissions, as well as analysis of samples of soil and water. Safety and health at work / work ergonomics.

Project Title :

Contract for conducting Environmental impact assessment for drilling and seismic operation on 5 oil &gas exploration permits (Boussada I, TIARET, EL OUABED, ATLAS II & I)

role: Environmental Engineer

Client (s): Sonatrach	**Project duration** June 2017-December 2017	**country:** Algeria

Project description :

- EIA Boussada I permit
- EIA TIARET permit
- EIA EL OUABED II permit
- EIA ATLAS I permit
- Site visit and data collection
- sampling and physico-chemical water analysis and soil
- Job training
- Staff training (GIS)

Project Title :

Environmental Impact assessment study for the drilling of 2 exploration well in Borj El Khadra South Tunisia permit.		
role: HSE / Environmental Engineer		
Client (s): Anadarko	**Project duration** February 2015-August 2015	**country:** Tunisia
Project description : EIA, EMP in compliance with Tunisian regulations.		

Project Title : Contract for conducting Environmental impact assessment studies for drilling and seismic operation on 29 oil &gas exploration permits for Sonatrach		
role: HSE Engineer / Environment		
Client (s): Sonatrach	**Project duration** April 2014-May 2016	**country:** Algeria
Project description : o Conducting 29 EIA in compliance with Algerian regulations o Site visit, Sampling, monitoring and physico-chemical water and soil analysis o Ambient air quality monitoring		

Project Title : Environmental Impact Assessment Study of the extension of the landfill of phosphogypsum slurry of Gabes decadmiation units.		
role: Environmental Engineer		
Client (s): GCT	**Project duration** February 2015-August 2015	**country:** Tunisia

Project description :

- ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The Environmental Impact Assessment Study assess, evaluate and measure the effects on the environment, direct and indirect, short, medium and long term, of a controlled landfill extension project of phosphogypsum slurry of decadmiation units in Gabes. The main objectives of EIA are:

- The identification and evaluation of impact affected the environment;
- The integration of project safeguards that are essential to reduce, eliminate or compensate for these violations;
- Air quality monitoring and air dispersion modeling
- The preparation of an Environmental Management Plan (EMP)

- ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The goal of the environmental management plan and monitoring program to ensure appropriate environmental management of the different project phases and minimize all potential aspects in accordance with the laws and regulations.
For each of the proposed measures, the EMP should define the technical content, the operational program, the organization to the place and the means to control the results.

Project Title : Risk assessment study and an emergency response plan for the head office of the company (TIC)

role: Environmental Engineer		
Client (s): TIC	**Project duration** October 2014- November 2014	**country:** Tunisia
Project description : Development of a risk assessment study and Development of an internal operation plan in compliance with Tunisian regulations.		

Project Title : Implementation of an Environmental and Social Management Plan for the control and monitoring of environmental indicators of waste water treatment plants operated by private companies LOT # 2: WWTP Enfidha-Hergla Chebba Hajeb EL Youn, Oueslatia, Bouhajla, Haffouz, Jelma,		
role: Project Coordinator - Environmental and Waste Management Specialist		
Client (s): ONAS	**Project duration** Feb 2018-Oct 2020	**country:** Tunisia

Project description :

As part of the water quality improvement program processed by treatment plants, ONAS launches the development and implementation of ESMP to ensure the control and monitoring of environmental and social indicators treatment plants operated by private companies. This mission and will ensure respect for private companies responsible for the operation of the treatment plants, the conditions and requirements of the operating contract (quality of treated water and sludge) and the implementation of good practices in these WWTP to mitigate operational impacts or improve them.

- The program also incorporates actions for capacity building of ONAS, covering: The development of an Environmental and Social Management Plan (ESMP) for wastewater treatment plant Improved control and monitoring of treatment plants;
- Capacity building of project management and operation of infrastructure;
- The services will be performed by three lots and each lot will consist of two phases:
  - Phase 1: Development of an Environmental and Social Management Plan (ESMP) for wastewater treatment plant
  - Phase 2: Implementation of ESMP of these treatment plants.
    - Periodic Sampling / monitoring program / reporting for sediments/soil/ treated water/wastewater/groundwater monitoring
    - Monthly monitoring of operation and safety parameters to ensure compliance with best practice and implement an action plan to protect workers and environment
    - Monthly Environmental and safety audit

Summary of others references studies and missions

- **Environmental Impact Assessment Studies for drilling wastes treatment operations for different drilling well**

site for different company such as OMV, BGT, PIONEER, SEREPT, TPS, PERENCO and CTKCP…

- **Environmental Hazard Identification (ENVID) - MA´ADEN SAUDI ARABIAN MINING COMPANY - UMM WU´AL PHOSPHATE PROJECT. FSA TREATMENT PACKAGE**
- **Emergency responses plan for oil spill in sea for Tunisia**
- **Emergency response plan for WINSTAR Tunisia**
- **Contaminated Soil Sampling mission –GCT –Gabes-Tunisia**
- **16 Environmental Impact Assessment Studies WWTP and sewage network for SKADO – GOCSA in KSA – El JAWEF -SAKAKA.**
- **Project coordinator and supervisor for drilling waste management for different drilling well site for different company such as: (OMV, PIONEER, TPS, British Gas Tunisia, CTKCP, ENI Tunisia, SEREPT, PA resources, Winstar Tunisia, LUNDIN Tunisia...);**
- **Quantitative risk assessment study oil and gas well development project –PERTAMINA and SONATRACH-ALGERIA**
- **Develop a series of matrixes (4) to compare the Algerian legislation on environmental, health and safety and social (EHSS) aspects relevant to the onshore O&G Industry against the IFC performance standards and sector-specific guidelines-RINA group-ITALY**
- **Environmental Impact Assessment Studies for drilling operations for different drilling well site for different company such as OMV, BGT, PIONEER, SEREPT, TPS, PERENCO and CTKCP…**

Personal skills and competences

Social skills and competences

- hardworking individual with excellent administration, technical and communication skills,
- Excellent ability to work hard on site, as well as, to perform Clients' satisfaction.
- Excellent ability to work under pressure and keep positive attitude.
- Comprehensive and collaborate individual,
- Keep good repetition in work and with Clients

Organizational skills and competences

- Expertise with written and verbal communications, including technical correspondences (report, letter, mail bid documents preparations…) and meeting communications.
- Ability to manage a team,
- Ability to coordinate in work,

Technical skills and competences

- Environment Impact Assessment Study for various projects (drilling well site, waste management (treatment, transport...) ;
- Environmental Audit
- Health and safety study (emergency plan, internal operation plan PIO, risk assessment management plan, …) ;
- Drilling waste management coordination and supervision.
- Air dispersion modeling

Linguistic and computer skills

Language skills

Arab	Read / written / spoken	Native language		
English	Read / written / spoken	Excellent	Excellent	Excellent
French	Read / written / spoken	Excellent	Excellent	Excellent

computer skills	
Developer - Applications	**software**
Air Dispersion modeling	Lakes AERMOD
Geographic Information System (GIS)	ArcGIS ArcMap
Qualitative and Quantitative Risk Assessment	DNV GL Phast
Microsoft Office	Word, Excel, PowerPoint, Project, Visio and Outlook

BESGHAIER Ennacer

GENERAL INFORMATION

Last Name / First Name:	ZEMZEMI Abderrazzak
Position:	Project Manager
Number of years' experience:	14 years
Qualification Degrees	Hydraulic and Water Resources Engineering
Nationality:	Tunisian Canadian
Saudi Council of Engineers	membership No.: 823716

CAREER OBJECTIVE

Graduated as Hydraulic Engineer from the National Agronomic School of Tunisia (INAT) in 2003, I have acquired, in over ١4 years working experience, a good knowledge in the field of environmental investigations and studies as well as in water/wastewater engineering field and waste management.

SUMMARY OF SKILLS

- Familiar with Environmental Impact Assessment studies for various projects including:
  - ✓ Recognition visits of the project site and site visit report preparation,
  - ✓ Mapping of the project site and the main elements and structures related to,
  - ✓ Gathering of relevant documents and data and preparation of baseline report,
  - ✓ Checking compliance of environmental baseline parameters with the national and international standards
  - ✓ description of legislative and institutional framework,
  - ✓ Full project process description
  - ✓ impacts analysis and identification of mitigation measures,
  - ✓ Elaboration of Environmental Management Plan and cost estimation
- familiar with the national and international environmental regulations (laws, standards, procedures)
- familiar with Coordination with laboratories to perform sampling campaign/analysis for water, soil, wastewater, treated water, ...)
- Demonstrated knowledge in domestic/industrial wastewater treatment plants and sludge treatment facilities; able to perform complete design and detailed engineering and waste disposal management.
- Working knowledge in water treatment including coagulation, flocculation, sedimentation filtration, reverse osmosis, UV disinfection and chlorination.

- Involved in preparation of technical and financial proposals for the new opportunities and contribute to business development.
- Very good team player and has the ability to manage time and resource effectively to meet deadlines.

WORK EXPERIENCE

Environmental Engineer **December 2021 – now**

ALI KHUDAIR AL-HARBI ENVIRONMENTAL CONSULTING OFFICE (AHEC), Khobar, Kingdom of Saudi Arabia

Main tasks

- Perform Environmental Impact Assessment studies of various projects
- Involved in coordination between the different disciplines, and cost-control of various projects.
- Conduct site visits and inspections; attend project meeting (internal and external).
- Prepare engineering reports and write project correspondence.

Achievements

- Environmental and Social Impact Assessment for Solar Plant of Haden on behalf of TYPSA, Final client: Ministry of Energy in Saudi Arabia.
- Environmental and Social Impact Assessment for Photovoltaic Solar Plant of Al-Mowyah on behalf of TYPSA, Final client: Ministry of Energy in Saudi Arabia.
- Environmental and Social Impact Assessment for Wind Power Plant of Starah on behalf of TYPSA, Final client: Ministry of Energy in Saudi Arabia.
- Environmental and Social Impact Assessment for Solar Plant of Sharifa on behalf of TYPSA, Final client: NEOM, Saudi Arabia.
- Environmental and Social Impact Assessment for Solar Plant of Airport West on behalf of TYPSA, Final client: NEOM, Saudi Arabia.
- Environmental and Social Impact Assessment for Solar Plant of Hasma on behalf of TYPSA, Final client: NEOM, Saudi Arabia.
- Environmental and Social Impact Assessment for Solar Plant of Airport West on behalf of TYPSA, Final client: NEOM, Saudi Arabia.
- Environmental and Social Impact Assessment for the Project ‘’Extract and Mix of sandy materials in Al-Qasab on behalf of “Diriyah Gate Development Authority”. Saudi Arabia.

- Ecology Survey for Shigry Solar Plant, Al-Aqaba wind farm and OHTL line on behalf of Air Product, Final client: NEOM Green Hydrogen. Saudi Arabia.
- Environmental Performance and compliance auditing for the Adobe processing facility in Jubailah, Riyadh Region on Behalf of "Diriyah Gate Development Authority", Saudi Arabia.
- Environmental Audit for the Dioxide of Titanium Plant on behalf of the Tronox Saudi Industries company in Jubail. Saudi Arabia.
- Environmental and Social Impact Assessment for sugar Refinery on Behalf of the Durrah Advanced Development Company, Saudi Arabia.

Environmental Engineer **Oct. 2008 –Oct. 2016**

COMPANY OF ENGINEERING FOR ENVIRONMENT AND ENERGY (I2E), Tunis**,** Tunisia

Responsibilities

- Perform Environmental Impact Assessment studies of various projects
- Involved in design and design works coordination between the different disciplines, and cost-control of various projects.
- Conduct site visits and inspections; attend project meeting (internal and external).
- Deliver complete design package including technical drawings, design calculations, specifications and bills of quantities.
- Prepare engineering reports and write project correspondence.

Achievements

- Environmental and social study for the management of wastewater from the potable water treatment complex in Belli on behalf of National Water Distribution Utility (SONEDE), Tunisia.
- Environment Impact Assessment of the project of the factory of phosphoric production of acid to the site of El MKHACHERMA in (Gabès governorate, Tunisia) on behalf of Tunisian Chemical Group "G.C.T".
- Environmental impact Assessment of projects of drinking water quality improvement of in southwestern Tunisia (Kébili and Tozeur Governorates) on behalf of the National Water Distribution Utility of Tunisia "SONEDE".
- Environmental Impact Assessment, Environmental Management Plan and Hazard Study for the Extension Project of the El-Arar Power Plant (Algeria).
- Study of depollution of Wadi Hamdoun (Sousse Governorate, Tunisia) on behalf of the Directorate-General of the Environment and the Quality of Life (DGEQV).
- Study of depollution of the Yeast Plant "Levurerie Béni-Béchir" (Jendouba Governorate, Tunisia) on behalf of Rayan Food Industries, Tunisia.

- Decontamination and Environment Impact Assessment of the refinery of the STIR located in Bizerte governorate, Tunisia on behalf of the Industrial Tunisian Company of Refinery " STIR "
- Environmental Impact Assessment, study and design of a pumping station of oily water with filtration chains and expedition pipeline (20 km) from South Industrial Centre to OMN77 Satellite Centre in Hassi-Messoud (Algeria) for the SONATRACH Company.
- Study of the implementation of a wastewater transfer system between the site of the Wastewater Treatment Plant (WWTP) of Sayada (Monastir Governorate, Tunisia) and a new WWTP site at the Monastir technopole (Monastir, Tunisia).
- Feasibility study of the oily water disposal at the Central Processing Facility (CPF) of Tazarka (Tunisia) for ENI Tunisia BV.
- Feasibility study of an Energy Efficiency Program of 15 wastewater treatment plants for the National Sanitation Office of Tunisia.
- Study of Rehabilitation and Extension of the Wastewater treatment plant (Capacity: 20,000 m3/day) of Gabès city (Tunisia) for the National Sanitation Office of Tunisia (ONAS).
- Preparation of technical and financial proposal of Wastewater treatment plant of Berrouaghia (Algeria) (capacity 17000 m3/day). Delivery of complete design of the plant, equipment datasheets, bills of quantities, technical report and plant operation manual for the Engineering Procurement and Project Management (EPPM) Company.
- Preparation of technical and financial proposal of six Wastewater treatment plants in Algeria (Azezga, Relizane, Aflou, Ain Sefra, Bayadh, Mechria with respective capacities of: 9,000 m3/d; 26,400 m3/d; 14,800 m3/; 11,700 m3/d; 19,700 m3/d and 12,800 m3/d): Delivery of complete design of the plant, equipment datasheets, bills of quantities, technical report and plant operation manual for the Engineering Procurement and Project Management (EPPM) Company.
- Preparation of technical and financial proposal of Drinking water treatment plant and facilities (capacity: 500 m3/hr) at Melut and Palogue Operational Base Camp (in Sudan) For the EPPM Company
- Environmental Impact Assessment, study and design of a pumping station of oily water with filtration chains and expedition pipeline (20 km) from South Industrial Centre to OMN77 Satellite Centre in Hassi-Messoud (Algeria) for the SONATRACH Company.
- Preparation of technical and financial proposal of a Build-Operate-Transfer project of an Industrial area situated in Al-Kharj (KSA) for the EPPM Company. Main tasks are design of the sewage network, the water supply and distribution system and the wastewater treatment plant.
- Feasibility study of the sewage treatment system upgrading at Hannibal gas plant for British Gas Tunisia
- Study of the Wastewater treatment plant and sewage transfer system of Ain-Bessem city for the Hydraulics Administration of the 'Wilaya' of Bouira in Algeria.

Run Plant Engineer **Nov. 2007 – Sept. 2008**

COMPANY OF EXPLOITATION AND MANAGEMENT OF STRUCTURES AND NETWORKS (SEGOR), Tunis, Tunisia

Responsibilities

- Monitor day-to-day operations of the plant (process: extended aeration, capacity: 15,000 m3/day) with the aim to maintain the treated effluent quality in conformity with the existing standards, improve the efficiency and reduce operation cost.
- Ensure Sludge Management and carrying it out effectively.
- Schedule and coordinate general plant work and assign tasks for employees.
- Monitor and control various equipment.
- Schedule and supervise preventive and corrective maintenance for equipment in accordance with client requirements and equipment manuals.
- Schedule and conduct water sampling and testing in accordance with the laboratory technician.
- Perform administrative duties such as data entry, writing correspondences and daily, monthly and yearly operation reports.
- Train new employees.
- Maintain standards of safety and comply with Company's Health, Safety & Environment Management System
- Take reasonable care of own health and safety and that of other employees in the plant space.
- Follow and maintain Company standards of Quality in accordance with Company Quality System.

Hydraulic Engineer **Oct. 2003 – Oct. 2007**

COMPANY OF TECHNICAL AND AGRICULTURAL STUDIES (SETA – TUNISIE), Tunis, Tunisia

Responsibilities

- Conduct site visits and inspections; attend project meeting (internal and external).
- Perform studies of water/wastewater projects; perform complete study from preliminary and detailed design to bill of quantities and tender documents.
- Notice of environmental and social impact assessment preparation
- Check engineering drawings for constructability, errors, omissions and consistency.

Achievements

- Study of duplication of the Chiba Dam transfer Pipeline (Ø800 mm) for 'the Regional Commissary for Agricultural development of Nabeul Governorate (Tunisia) and preparation of environmental and social Impact assessment notice.
- Study of safeguarding of Dar-Roufa and El-Mezraa irrigated areas for the 'Regional Commissary for Agricultural Development' of Nabeul governorate (Tunisia); design of irrigation networks, storage tanks, pumping stations and different structures.
- Study of the Sewage Treatment Master Plan in Nabeul Governorate for the National Sanitation Utility of Tunisia.
- Study of creation of a New irrigated area in the Rural District of Tejerouine for 'the Regional Commissary for Agricultural development of Kef governorate (Tunisia).
- Study of rehabilitation of the Irrigated Areas in The Rural Districts of Testour and Medjez-El-Bab for the 'Regional Commissary for Agricultural Development' of Beja governorate (Tunisia).
- Study of creation of three industrial areas in Al-Fejja (in Mannouba Governorate), El-Agba (in Tunis Governorate) and Garaat-El-Maleh (in Monastir Governorate) for the Industrial Land Agency of Tunisia; Design of the Drinking Water Networks, sewage collection networks and storm water networks and preparation of Environmental and Social Impact assessment notice
- Study of the Sanitation Master Plan of Oued-Mliz city in Jendouba governorate for the National Sanitation Utility of Tunisia.

LANGUAGES

Arabic: Native language

French: fluent

English: professional proficiency

SOFTWARE SKILLS

Microsoft Windows, Word, Excel, PowerPoint, MS Project**,** AutoCAD, Covadis, ArcGIS, HEC-RAS, HEC-HMS, BEL, AFT Impulse, Bentley Hammer, Carrousel, SewerGems, WaterGems, WaterCAD, Epanet, Stoat, OptiDesigner, Aspen Hysys.

EDUCATION

National Agronomic Institute of Tunisia, Tunis, Tunisia **1998 - 2003**

National Diploma of Engineering in Rural Engineering, Water and Forests

OTHER

Familiar with working in environment certified **ISO 9001**, **ISO 14001** and **ISO 27001**

General informations	
Last Name / First Name :	MEDIOUNI Nadia
Position:	Environmental Engineer
Number of years' experience:	12 years
Qualification Degrees	Engineer in Hydro-Meteorology
Nationality:	Tunisian
Saudi Council of Engineers	**membership Id** : 883434

Summary of Experience

Ms. Mediouni Nadia is an Engineer in Hydro-Meteorology graduated from National University of Engineers of Tunis (ENIT) in Tunisia and with proven Experience in the field of Meteorological and climatological studies. I gained good knowledge in the fields of meteorology and climate change, and my interests were based on climate change and studying the challenges and methods adopted to mitigate the effects of climate changes in order to preserve the environment and the characteristics of the atmosphere.

Nadia had the opportunity to participate in the national and international meteorological and climatological activities, such as:

- ✓ Weather analysis and forecasting.
- ✓ Ensure coordination with international forecasters.
- ✓ Analyzing weather forecasts by updating numerical models and verifying their validity using techniques and expertise.
- ✓ Conducting meteorological and climatological impact studies**.**
- ✓ Studying the challenges and methods adopted to mitigate the effects of climate changes in order to preserve the environment
- ✓ Studying the effect of climate change on the future environmental project.

By joining AH Environmental consulting office, Nadia has acquired the following skills :

- ✓ Environmental baseline assessment reporting
- ✓ Environmental impact assessment reporting
- ✓ Conducting environmental impact assessment of some projects
- ✓ Be familiar with the national and international environmental regulations (laws, standards, procedures)
- ✓ Checking compliance of environmental baseline parameters with the national and international standards.
- ✓ Having background related to preparation and impelementation of waste management plan / environmental management plan/ environmental monitoring plan
- ✓ Be familiar with HSE procedures/management system/policy

key qualifications

From September 2022 until now	Environmental Engineer with AH ENVIRENMENTAL CONSULTING OFFICE
From August 2010 until August 2022	Forecaster Leader in the General Forecasting Service, in National Institute of Meteorology - Tunisia

Academic training

Hydro-Meteorology Engineer
with Honors

2006 - 2009	3-years Hydro-Meteorology engineering cycle in National Engineering university - Tunis (ENIT)- Tunisia .
2004 - 2006	2-years preparatory cycle in Preparatory Institute for Engineering Studies in AL Manar Tunis - IPEIM
2003 -2004	Bachelor's degree in Technology (with honors).

Professional Experiences

Project Title :

The Eastern Railway network of the Saudi Railways- SAR

Role: Environmental Engineer

Client (s): SAR	**Project duration** : September 2022- till now	**country:** KSA

Project description :

- Collection and analysis of project documents and other strategic documents
- Environmental assessment of wastes and resources management impact and proposal of necessary mitigation measures
- Environmental/ wastes and resources /Management Plan
- Recommendation in achieving the organization objectives in wide areas of environmental waste and resource management compliance
- QHSE Process / procedures review and analysis
- Preparation of the environmental impact assessment report

Professional Experiences

Project Title :

The Northern Railway network of the Saudi Railways- SAR

Role: Environmental Engineer

Client (s): SAR	**Project duration** : September 2022- till now	**country:** KSA

Project description :

- Collection and analysis of project documents and other strategic documents
- Environmental assessment of wastes and resources management impact and proposal of necessary mitigation measures
- Assessment of existing environmental issues ((soil contamination, air emission, noise pollution, fauna, flora, wastes generation,).
- Environmental/ wastes and resources /Management Plan
- Recommendation in achieving the organization objectives in wide areas of environmental waste and resource management compliance
- QHSE Process / procedures review and analysis
- Preparation of the environmental impact assessment report

Project Title :

Construction villages within NEOM region

Role: Environmental Engineer

Client (s): NEOM , ELFANAR	**Project duration** Oct 2022-till now	**country:** KSA

Project description :

- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of wastes and resources management impact and proposal of necessary mitigation measures
- Wastes characterization and inventory
- Assessment of existing environmental issues ((soil contamination, air emission, noise pollution, fauna, flora, wastes generation,) – conducting sampling and monitoring for soil /air quality/noise.
- Recommendation in achieving the organization objectives in wide areas of environmental waste and resource management compliance
- Preparation of the environmental impact assessment report
- Preparation of the construction environmental and social management plan.

Project Title :

Aqaba Wind Farm, Shigry 2 PV plant and Electrical grid system

Role: Environmental Engineer

Client (s): L&T, NEOM, Air Products	**Project duration** November 2022-till now	**country:** KSA

Project description :

- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Preparation of an Environmental Monitoring and Management Plan
- Preparation of the construction environmental and social management plan.

Project Title :

Environmental impact study of the warehouse of the Saudi Tronox Manufacturing Company in Yanbu

ROLE: Environmental Engineer

Client (s): TRONOX	**Project duration** July 2022-October 2022	**country:** KSA

Project description :

- Project Permitting process under Royal commission Jubail and Yanbu (RCJY) for the environmental permit to construct (EPC)

- Environmental baseline investigation (air quality and noise monitoring, soil & groundwater sampling and analysis ...)
- Air dispersion modeling / noise modeling / Best Available technology (BAT) Study
- Environmental Emergency response plan (EERP)
- Collection and analysis of project documents and other strategic documents
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Project management (tender/ meeting /communication with client / RCJY/ Schedule/ coordination)
- Preparation of environmental impact assessment report

Project Title :

Wind Power Plant (WPP)- AL DAWADMI - Al Dawadmi Governorate- Riyadh Province

ROLE: Environmental Engineer

Client (s): TYPSA/Ministry of Energy	**Project duration** September 2022-till now	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Environmental baseline investigation (air quality and noise monitoring, soil & groundwater sampling and analysis ...)
- Collection and analysis of project documents and other strategic documents
- Conducting a meeting with those in charge of the project
- Environmental assessment of the impact of waste and resource management and proposing the necessary mitigation measures
- Recommend the achievement of project objectives in broad areas of environmental and resource waste management compliance
- Review and analyze QHSE process/procedures
- Preparing an environmental management plan
- Preparing the environmental impact report of the third category and submitting it to the environmental licensing system of the center
- Follow-up with the National Center until the environmental license is issued and delivered to the client.

Project Title :

An environmental impact study of the landfill of the Saudi Tronox Manufacturing Company in Yanbu

ROLE: Environmental Engineer

Client (s): TRONOX	**Project duration** June 2022-September 2022	**country:** KSA

Project description :

- Project Permitting process under Royal commission Jubail and Yanbu (RCJY) for the environmental permit to construct (EPC)
- Environmental baseline investigation (air quality and noise monitoring, soil & groundwater sampling and analysis ...)
- Air dispersion modeling / noise modeling / Best Available technology (BAT) Study
- Environmental Emergency response plan (EERP)
- Collection and analysis of project documents and other strategic documents
- Preparing the environmental impact report of the third category and submitting it to the environmental licensing system of the center
- Follow-up with the National Center until the environmental license is issued and delivered to the client. Environmental assessment of each component of the project facilities and proposal of necessary measures
- Project management (tender/ meeting /communication with client / RCJY/ Schedule/ coordination)

Project Title : BI 23-10885: Replace Saudi Aramco Built Government Schools in Eastern Province - Phase IV		aramco
ROLE: Environmental Engineer		
Client (s): Aramco	**Project duration** December 2022-till now	**country:** KSA

Project description :

- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Legal framework
- Project Solid Wastes (Waste classification, Waste Generation and General Characterization, Waste Storage and Collection Area)
- Environmental impact assessment / mitigation measures
- Waste management practices
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Preparation of environmental assessment impact reports for all the future schools
- Preparing the environmental impact report of the second category and submitting it to the environmental licensing system of the center
- Follow-up with the National Center until the environmental license is issued and delivered to the client.

Project Title :	

An environmental impact study for the design and construction of a mixed-use residential complex project in the city of Riyadh affiliated to Roshn Company - the Public Investment Fund	

ROLE: Environmental Engineer

Client (s): ROSHN/PIF	**Project duration** July 2022-October 2022	**country:** KSA

Project description :

- Environmental Permitting from GAMEP (NCEC)
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Preparation of an Environmental Monitoring and Management Plan
- Preparation of the Environmental impact assessment report

Project Title :

Study of the environmental impact of an estuary on the Red Sea belonging to the Saudi Tronox Manufacturing Company in Yanbu

ROLE: Environmental Engineer

Client (s): TRONOX	**Project duration** July 2022-September 2022	**country:** KSA

Project description :

- Project Permitting process under Royal commission Jubail and Yanbu (RCJY) for the environmental permit to construct (EPC)
- Environmental baseline investigation (air quality and noise monitoring, soil & groundwater sampling and analysis ...)
- Air dispersion modeling / noise modeling / Best Available technology (BAT) Study
- Environmental Emergency response plan (EERP)
- Collection and analysis of project documents and other strategic documents
- Preparing the environmental impact report of the third category and submitting it to the environmental licensing system of the center
- Follow-up with the National Center until the environmental license is issued and delivered to the client.
- Environmental assessment of each component of the project facilities and proposal of necessary measures
- Project management (tender/ meeting /communication with client / RCJY/ Schedule/ coordination)

Summary of others references studies and missions

Studies

- ✓ Flash flood situation from 22 to 23 September 2009 in the South Western Tunisia (Heavy rainfall and flooded regions occurred by deep convection).
- ✓ Analysis of the waterspout's formation on the Northern coast of Tunisia in October 2015.
- ✓ Study of the tornado's formation in the lowland of Jendouba in July 2018.
- ✓ Satellite Imagery: The different geostationary and orbital satellites around the globe, the sensers and their products related to meteorology and nowcasting.

Missions and Trainings

- ✓ From 14 to 18 February 2022 : Training on « The use of RADAR Novimet DATA » animated by experts from Novimet, France.
- ✓ From 12 to 16 April 2021: Online training on «Satellite Data Processing in African Francophone Countries», organized by la Direction Générale de la Météorologie du Maroc in collaboration with The European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) and METEO FRANCE.
- ✓ From 15 to 26 August 2020: Online training on «The International Distance Training Course on Nowcasting Techniques on Severe Convection Weather»,
- ✓ organized by the China Meteorological Administration Training Centre (CMATC) in Beijing, China in collaboration with the World Metrological Organization (WMO).
- ✓ 24 September 2020: An Online Seminar on «Earth Observation in Africa: Satellite data support for weather, hydrological and climate services», organized by The EUMETSAT and the African Development Bank (ADB) in participation with the five RCCs in Africa (ACMAD, AGRHYMET, ICPAC, SADC-CSC and CAPC-AC), it was focused on the benefits of SAWIDRA project in African countries.
- ✓ From 9 to 11 October 2019: Regional workshop «Remotely Sensed Observation of Precipitation Using Artificial Intelligence», held in the Faculty of Agricultural and Food Sciences (FAFS) at the American University of Beirut (AUB) in Lebanon, and organized by The UNESCO Regional Bureau for Science for the Arab States collaborating with the Center for Hydrometeorology and Remote Sensing (CHRS) at the University of California, Irvine (USA), the American University of Beirut AUB (Lebanon), IHP G-WADI and the United Nations Economic and Social Commission for Western Asia (ESCWA) through the RICCAR Regional Knowledge Hub for the preparation of this workshop.
- ✓ From 14 to 18 October 2019 : Workshop on « Satellite applications course », organized by EUMETSAT in collaboration with the Institute for Meteorological Training and Research/World Meteorological Organization Regional Training Center (IMTR/WMO-RTC), held in IMTR in Nairobi, Kenya.
- ✓ From 11 to 15 Mars 2019: Training on «Use of satellite images in weather forecasting», it was organized by EUMETSAT, held in the National Institute of Meteorology (INM) and led by different experts from different organizations: Mr. José Prieto (EUMETSAT), Mr. Hassan Bouksim (Meteo Maroc) and Mr. Hama Hamidou (EAMAC Niger).
- ✓ From 05 to 09 November 2018: Training on « Concepts and methods for forecasting» as part of a cooperation between Meteo France and INM, moderated by experts and forecasters leader from Meteo France : Mr.Joel CREMOUX, Mrs Nathalie Cerisier and Mr.Bruno Gillet Chaulet.
- ✓ October 2018: Professionnel training on «Winter Phenomena», in the National School of Meteorology of Toulouse (ENM), and organized by Meteo France.
- ✓ July 2018: Certificate of attendance of a training that was focused on «Social Networking practices», held in the National Institute of Meteorology INM and animated by Mr. Aymen Bouaben (consultant and digital trainer) from Streamerz Center, Tunis.
- ✓ From 08 to 10 May 2018: Training on « weather alert map » as part of the twinning between Meteo France and INM, it was animated by Meteo France experts: Mr.Joel CREMOUX and Mr.ALIAGA Philippe.
- ✓ From 05 to 09 Mars 2018: Training on « Handling the vigilance tool» as part of the twinning between Meteo France and INM, led by Meteo France experts: Mr.Joel CREMOUX and Mr.ALIAGA Philippe.
- ✓ From 26 to 28 February 2018: Training on « Management by objectives», moderated by Mr.Adel Guider (a Tunisian Public Administration Legal Advisor) and organised by Interface Training Center, Tunis.
- ✓ From 09 to 11 January 2018: Training on « Connection and communication with the media», animated by Mr.Adel Guider and organised by the International Office of Training, Studies and Assistance (CIFA), Montplaisir, Tunis.

- ✓ From 17 to 19 October 2017: Training on « Conduct of meetings and public speaking», led by Mr.Michel Assouline (Communication expert in Meteo France), INM.
- ✓ From 11 to 15 September 2017 : Workshop training on « Use of satellite information in nowcasting », organised by EUMETSAT and Aristotle University of Thessaloniki, held in Thessaloniki-Nei Epivates, Greece.
- ✓ December 2015: Professional training on « Weather forecasting in mid-latitude regions », organised by the National School of Meteorology of Toulouse (ENM), and moderated by different experts from Meteo France.
- ✓ May 2013: Professional training on « Concepts and methods for forecasting », it was organized by Meteo France and conducted by the National School of Meteorology of Toulouse (ENM), Meteo France.
- ✓ Mars 2013: Training on « Improvement of communication techniques» that was held in the African Center for the Development of Journalists and Communicators (CAPJC), Tunis.
- ✓ July 2012: Training on Numerical Models of Climate Change ‘‘Statistical DownScaling Model (SDSM)’’, moderated by Mr.Willby, expert from Loughborough University (UK), and held in The National Institute of Meteorology of Tunisia (INM).

Personal skills and competences

Social skills and competences

- Hardworking individual with excellent administration, technical and communication skills,
- Excellent ability to work hard on site, as well as, to perform Clients’ satisfaction.
- Excellent ability to work under pressure and keep positive attitude.
- Comprehensive and collaborate individual,

Organizational skills and competences

- Expertise with written and verbal communications, including technical correspondences (report, letter, mail bid documents preparations…) and meeting communications.
- Ability to coordinate in work,

Technical skills and competences

- Environment Impact Assessment Study for various projects;
- Health and safety study (emergency plan, internal operation plan PIO, risk assessment management plan, …) ;
- Air dispersion modeling
- Noise modeling

Linguistic and computer skills

Language skills

Arab	Read / written / spoken	Native language		
English	Read / written / spoken	Good	Good	Good
French	Read / written / spoken	Excellent	Excellent	Excellent

computer skills

Developer - Applications	**Software**
Air Dispersion modeling	Lakes AERMOD
Noise modeling	SoundPlan
The Weather Research and Forecasting (WRF) Model	WRF
Satellite images monitoring	EUMETVIEW
Microsoft Office	Word, Excel, PowerPoint, Project, Visio and Outlook

Nadia MEDIOUNI

General informations	
Last Name / First Name :	FRADJ Bechir
Position:	ENVIRONMENTAL AND ECOLOGY SPECIALIST
Number of years' experience:	6 years
Qualification Degrees	Master degree in environmental science
Nationality:	Tunisian

Summary of Experience

Mr. FRADJ Bechir Holder of a master's degree in environmental science, versatile, Reliable and passionate about the field of Environment Management, graduated from University of Carthage: Science Faculty of Bizerte in Tunisia and with proven Experience in the field of environmental investigations and studies, environmental permitting, EMP and risk assessment studies.That are Acquired through the various positions held within engineering services companies as well as good knowledge in water treatment and waste management field.

Bechir had the opportunity to participate in the preparation of national and international tenders as well as in several of major projects. These projects include:

- ✓ Environmental permiting process for various project under Royal commission or / and GAMEP (NCEC).
- ✓ Environmental Management Audit.
- ✓ Conducting of environmental impact assessment studies for various projects**.**
- ✓ Carrying out Risk Assessment Studies and Emergency Responses Plans.
- ✓ Development of HSE procedures and manuals (emergency response plan, HSE manual, HSE policy, HSE good practice manual, risk assessment study, ...)
- ✓ Conducting waste management plan.
- ✓ Conducting solid wastes charachterization.
- ✓ Conducting feasibility study for solid waste management system (collect/transport/transfer station/landfill)
- ✓ Ecology survey study

By conducting these project, Bechir has acquired the following skills :

- ✓ Project Management (tender, contract, schedule, communication with the clients, site visit, meeting, technical advise, team)
- ✓ Be familiar with international regulations and laws relating to Environmental Protection and be in compliance (IFC Performance Standards, WORLD BANK OP, OMS Standards, EBRD Performance Requirements (PRs)…)
- ✓ Checking compliance of environmental baseline parameters with the national and international standards.
- ✓ Conducting EIA Data collection,
- ✓ Environmental baseline assessment reporting
- ✓ Having excellent background related to preparation and impelementation of waste management plan / Oil Spill Emergency Responses Plan / environmental management plan/ Environmental Monitoring Plan
- ✓ Coordination with laboratories to perform sampling/analysis for water, soil, wastewater, treated water, ...).
- ✓ Familiar with HSE procedures/management system/policy
- ✓ Familiar with the national and international environmental regulations (laws, standards, procedures)

key qualifications	
From September 2022 until now	Environmental Specialist with AH ENVIRENMENTAL CONSULTING OFFICE

From July 2010 until August 2015	Environmental Specialist with PREVENTION PLUS

Academic training

Master degree in Environmental Science
with Honors

2010-2012	Specialized Master's degree in environmental sciences -Faculty of Sciences of Bizerte-FSB
2008- 2010	Master degree in Life and Earth sciences -Faculty of Sciences of Gabes-FSG.
2004-2007	University Diploma of Technology in Biological Engineering - Higher Institute of Applied Biological Sciences of Tunis-ISSBAT.
2004	Bachelor's degree in Experimental Sciences (with honors).

Professional Experiences

Project Title :

Environmental and Social Impact Assessment Studies of Shaqra Wind Power Plant

Role: Environmental Specialist

Client (s): Ministry of Energy-TYPSA	**Project duration** : September 2022- January 2023	**country:** KSA

Project description :

- Environmental Permitting from GAMEP (NCEC)
- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Environmental assessment of the current situation of the Palaces
- Assessment of existing environmental issues ((soil contamination, air emission, noise pollution, fauna, flora, wastes generation,) – conducting sampling and monitoring for soil /air quality/noise. Impact assessment of the proposed development of the palaces
- Preparation of the Environmental impact assessment report

Professional Experiences

Project Title :

Ecology survey Study of Al QASAB - Diriyah Gate Development Authority (DGDA) in Riyadh

Role: Environmental – Ecology Specialist

Client (s): DGDA	**Project duration** : September 2022- October 2022	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Provide technical support in verifying taxonomic identification of flora and fauna species and preparing biodiversity checklist for projects.

- Developing sampling techniques for ecological surveys to suit the local habitat and Ecosystems.
- Preparation of the Ecology survey report

Project Title :

Ecology survey Study of Shigry PV Plant-NEOM

Role: Environmental – Ecology Specialist

Client (s): NGHC-AIR PRODUCT	**Project duration** : Octoberber 2022- December 2022	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Provide technical support in verifying taxonomic identification of flora and fauna species and preparing biodiversity checklist for projects.
- Developing sampling techniques for ecological surveys to suit the local habitat and Ecosystems.
- Recording the coordinates of HCP and threatened species for relation later on.
- Preparation of the Ecology survey report

Project Title :

Ecology survey Study of AL AQABA Wind Power Plant-NEOM

Role: Environmental – Ecology Specialist

Client (s): NGHC-AIR PRODUCT	**Project duration** October 2022- December 2022	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Provide technical support in verifying taxonomic identification of flora and fauna species and preparing biodiversity checklist for projects.
- Developing sampling techniques for ecological surveys to suit the local habitat and Ecosystems.
- Recording the coordinates of HCP and threatened species for relation later on.
- Preparation of the Ecology survey report

Project Title : Overhead transmission lines terrestrial ecology survey of Shigry and AL aqaba OHT lines-NEOM		
ROLE: Environmental – Ecology Specialist		
Client (s): NGHC-AIR PRODUCT	**Project duration** October 2022- December 2022	**country:** KSA
Project description : ➢ Site visit to the project intervention areas ➢ Collection and analysis of project documents and other strategic documents ➢ Meetings with local actors mainly concerned by the project ➢ Provide technical support in verifying taxonomic identification of flora and fauna species and preparing biodiversity checklist for projects. ➢ Developing sampling techniques for ecological surveys to suit the local habitat and Ecosystems. ➢ Recording the coordinates of HCP and threatened species for relation later on. ➢ Preparation of the Ecology survey report		

Project Title : Ecology survey Study of 4 Construction Villages - NEOM.		
ROLE: Environmental – Ecology Specialist		
Client (s) : Al Fanar	**Project duration** October 2022-November 2020	**country:** KSA
Project description : ➢ Site visit to the project intervention areas ➢ Collection and analysis of project documents and other strategic documents ➢ Meetings with local actors mainly concerned by the project ➢ Provide technical support in verifying taxonomic identification of flora and fauna species and preparing biodiversity checklist for projects. ➢ Developing sampling techniques for ecological surveys to suit the local habitat and Ecosystems. ➢ Preparation of the Ecology survey report		

Project Title : Ecology survey Study of AL DAWADMI Wind Power Plant		
ROLE: Environmental – Ecology Specialist		
Client (s): Ministry of Energy-TYPSA	**Project duration:** November 2022-December 2022	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Provide technical support in verifying taxonomic identification of flora and fauna species and preparing biodiversity checklist for projects.
- Developing sampling techniques for ecological surveys to suit the local habitat and Ecosystems.
- Preparation of the Ecology survey report

Project Title : Roshn makkah township project Ecology Survey Study	

ROLE: Environmental – Ecology Specialist

Client (s): ROSHN	**Project duration:** October 2022-November 2022	**country:** KSA

Project description :

- Site visit to the project intervention areas
- Collection and analysis of project documents and other strategic documents
- Meetings with local actors mainly concerned by the project
- Provide technical support in verifying taxonomic identification of flora and fauna species and preparing biodiversity checklist for projects.
- Developing sampling techniques for ecological surveys to suit the local habitat and Ecosystems.

Preparation of the Ecology survey report

- Preparation of the Ecology survey report

Personal skills and competences

Social skills and competences

- Hardworking individual with excellent administration, technical and communication skills,
- Excellent ability to work hard on site, as well as, to perform Clients' satisfaction.
- Excellent ability to work under pressure and keep positive attitude.
- Comprehensive and collaborate individual,
- Keep good repetition in work and with Clients

Organizational skills and competences

- Expertise with written and verbal communications, including technical correspondences (report, letter, mail bid documents preparations…) and meeting communications.
- Ability to manage a team,
- Ability to coordinate in work,

Technical skills and competences

- Environment Impact Assessment Study for various projects (drilling well site, waste management (treatment, transport...) ;
- Environmental Audit
- Health and safety study (emergency plan, internal operation plan PIO, risk assessment management plan, …) ;

- Drilling waste management coordination and supervision.
- Provide technical support in verifying taxonomic identification of flora and fauna species and preparing biodiversity checklist for projects.
- Developing sampling techniques for ecological surveys to suit the local habitat and Ecosystems

Linguistic and computer skills				
Language skills				
Arab	Read / written / spoken	Native language		
English	Read / written / spoken	Excellent	Excellent	Excellent
French	Read / written / spoken	Excellent	Excellent	Excellent
Computer skills				
Developer - Applications			**software**	
Geographic Information System (GIS)			ArcGIS ArcMap	
Qualitative and Quantitative Risk Assessment			DNV GL Phast	
Microsoft Office			Word, Excel, PowerPoint, Project, Visio and Outlook	

FRADJ Bechir

General informations	
Last Name / First Name :	Chouchane Marouane
Position:	Environmental Engineer
Number of years' experience:	7 years
Qualification Degrees	Engineer in Chemical Engineering and Processes
Nationality:	Tunisian
Saudi Council of Engineers	**membership Id** : 352531

Summary of Experience

Mr. Marouane is an Engineer in chemical Engineering and Processe graduated from National University of Engineers of Gabes {ENIG} in Tunisia. I have a good Knowledge and experience in the environmental and testing field in different company in kingdom of Saudi Arabia(ETLCO, AIS, ACES).
I have a good technical and project management skills with the ability to successfully manage multiple projects and daily responsibilities.

key qualifications	
From January 2023 until now	Environmental Engineer with AH Environmental Consulting Office
From January 2021 to December 2022	Environmental and Chemical Engineer with ACES - Arab Company for Laboratory and Soil.
From August 2017 to December 2020	Environmental / Project Coordinator Engineer with AIS - Advanced Inspection Services and SWCC - Saline Water Conversion Corporation of Umluj.
From April 2017 to August 2017	Environmental Engineer with TIC – Technical Inspection and Testing (Tunisia).

Academic training

Chemical Engineering Process Engineer

2012 - 2015	Chemical process engineering cycle in National Engineering university in Gabes (ENIG) -Tunisia .
2010 - 2012	Cycle in Preparatory in Higher Institute of Applied Sciences and Technology of Gabes (ISSAT) - Tunisia
2009	Bachelor's degree in Mathematics Sciences - Tunisia

Professional Experiences

Project Title	
02 Environmental Impact Assessment studies / NCEC permitting for SAR – Eastern and Northern networks	SAR الشركة السعودية للخطوط الحديدية
Role: Environmental Engineer	
Client (s): SAR	**Project duration** : 6 months (ongoing) / **country:** KSA

Project description :

- EIA Study as Per NCEC regulation
- Site Visit
- Gathering project data
- Environmental Classification form
- Scoping report
- Ecology Survey
- Environmental Monitoring

Professional Experiences

- Environmental Emergency Response Plan (EERP)
- Environmental permitting process with NCEC

Project Title :

ENVIRONMENTAL PERMITTING AND MONITORING FOR TEMPORARY MUD BRICK / RIYADH LIMESTONE PRODUCTION AND CONSTRUCTION LAYDOWN AREAS – FACILITIES 1 & 2 AND MONITORING SERVICES

Role: Environmental Engineer

Client (s): DGDA	**Project duration** : 3 years (ongoing)	**country:** KSA

Project description :

- EIA Study as Per NCEC regulation
- Site Visit
- Gathering project data
- Environmental Auditing reports for constructions
- Environmental Monitoring
- Environmental Emergency Response Plan (EERP)
- Environmental permitting process with NCEC

Project Title :

Ministry of Energy -TYPSA- Preliminary Studies For Wind farm Projects In Shaqra Governorate- Environmental Impact Assessment studies / NCEC permitting - SHAQRA WIND FARM

Role: Environmental Engineer

Client (s): MoE / TYPSA	**Project duration** : 6 months (ongoing)	**country:** KSA

Project description :

- EIA Study as Per NCEC regulation
- Site Visit
- Gathering project data
- Environmental Classification form
- Scoping report
- Ecology Survey
- Environmental Monitoring
- Environmental Emergency Response Plan (EERP)
- Environmental permitting process with NCEC

Professional Experiences

Project Title :		وزارة الطاقة MINISTRY OF ENERGY
Ministry of Energy -TYPSA- Preliminary Studies For Wind farm Projects In ALDAWADMI Governorate- Environmental Impact Assessment studies / NCEC permitting -ALDAWADMI WIND FARM		
Role: Environmental Engineer		
Client (s): MoE / TYPSA	**Project duration** : 6 months (ongoing)	**country:** KSA

Project description :

- EIA Study as Per NCEC regulation
- Site Visit
- Gathering project data
- Environmental Classification form
- Scoping report
- Ecology Survey
- Environmental Monitoring
- Environmental Emergency Response Plan (EERP)
- Environmental permitting process with NCEC

Project Title :		
Providing Technical service and environmental support to Saline water conversion corporation (SWCC)		
Role: Environmental Engineer		
Client (s): MoE / TYPSA	**Project duration** : 3 years and 3 months	**country:** KSA

Project description :

- Ensure the implementation, establishment, maintenance, and updating of the Environmental Management System according to ISO 14001:2015 at Saline Water Conversion Corporation (SWCC).
- Implementing waste segregation in plant and monitoring the quality and performance of waste services, including contract management of external providers.
- Follow-up of environmental KPIs through the percentage of closing the actions taken and the extent to which the annual and monthly environmental testing (stack testing, quality ambient air, quality water, noise) are in line with the standards of the GAMEP.
- Program the periodic and annual Environmental checks and follow-ups (analysis of water (outfall, sea, product, sewage, and industrial wastewater), Stack testing, ambient air testing, noise measurement, marine survey).
- Assist the HSE team in the investigation and reporting of all accidents, incidents, and near misses and making sure of its closing out.

Professional Experiences

- Preparing daily inspections, monthly periodic reports and annual periodic reports for GAMEP.
- Conducting the periodic internal audit for Yanbu Plant and Al Wajah Plant.
- Conduct environmental training sessions for all SWCCs responsible.

Summary of others references studies and missions

Personal skills and competences

Social skills and competences

- hardworking individual with excellent administration, technical and communication skills,
- Excellent ability to work hard on site, as well as, to perform Clients' satisfaction.
- Excellent ability to work under pressure and keep positive attitude.
- Comprehensive and collaborate individual,
- Keep good repetition in work and with Clients

Organizational skills and competences

- Expertise with written and verbal communications, including technical correspondences (report, letter, mail bid documents preparations…) and meeting communications.
- Ability to manage a team,
- Ability to coordinate in work,

Technical skills and competences

- Environment Impact Assessment Study for various projects (drilling well site, waste management (treatment, transport...) ;
- Environmental Audit
- Health and safety study (emergency plan, internal operation plan PIO, risk assessment management plan, …) ;
- Drilling waste management coordination and supervision.
- Air dispersion modeling

Linguistic and computer skills

Language skills

Arab	Read / written / spoken	Native language

English	Read / written / spoken	Excellent	Excellent	Excellent
French	Read / written / spoken	Excellent	Excellent	Excellent

computer skills

Developer – Applications	**software**
Air Dispersion modeling	Lakes AERMOD
Noise modeling	Sound Plan
Geographic Information System (GIS)	ArcGIS ArcMap
Qualitative and Quantitative Risk Assessment	DNV GL Phast
Microsoft Office	Word, Excel, PowerPoint, Project, Visio and Outlook

CHOUCHANE Marouane

General informations	
Last Name / First Name :	Amer Ben Saad
Position:	Senior Environmental Engineer
Number of years' experience:	16 years
Qualification Degrees	Chemical Process Engineering
Nationality:	Tunisian

Summary of Experience

I'm a skilled Senior Process Engineer with 16 years in the chemical industry, specializing in production optimization and environment & safety compliance. My expertise includes technical operations oversight, project management, and proficiency in ISO standards. I have a successful track record of enhancing efficiency, maintaining high-quality standards, and excelling in team leadership with proven Experience in the field of environmental investigations and studies, environmental permitting, EMP and risk assessment studies.That are Acquired through the various positions held within engineering services companies as well as good knowledge in water treatment and waste management field.

Ennacer had the opportunity to participate in the preparation of national and international tenders as well as in several of major projects. These projects include:

- ✓ Environmental permiting process for various project under Royal commission or / and GAMEP (NCEC).
- ✓ Environmental Management Audit.
- ✓ Conducting of environmental impact assessment studies for various projects**.**
- ✓ Carrying out Risk Assessment Studies and Emergency Responses Plans.
- ✓ Conducting air dispersion modeling by AERMOD
- ✓ Development of HSE procedures and manuals (emergency response plan, HSE manual, HSE policy, HSE good practice manual, risk assessment study, ...)
- ✓ Conducting waste management plan.
- ✓ Conducting solid wastes charachterization.
- ✓ Conducting feasibility study for solid waste management system (collect/transport/transfer station/landfill)

By conducting these project, Ennacer has acquired the following skills :

- ✓ Project Management (tender, contract, schedule, communication with the clients, site visit, meeting, technical advise, team)
- ✓ Be familiar with international regulations and laws relating to Environmental Protection and be in compliance (IFC Performance Standards, WORLD BANK OP, OMS Standards, EBRD Performance Requirements (PRs)…)
- ✓ checking compliance of environmental baseline parameters with the national and international standards.
- ✓ Conducting EIA Data collection,
- ✓ Environmental baseline assessment reporting
- ✓ having excellent background related to preparation and impelementation of waste management plan / Oil Spill Emergency Responses Plan / environmental management plan/ Environmental Monitoring Plan
- ✓ conducting air dispersion modeling from different sources (flare/stack/…)-AERMOD software.
- ✓ Coordination with laboratories to perform sampling/analysis for water, soil, wastewater, treated water, ...).
- ✓ participate in conducting qualitative and quantitative risk assessment and use DNV PHAST Software to perform risk consequences modeling
- ✓ familiar with HSE procedures/management system/policy
- ✓ familiar with the national and international environmental regulations (laws, standards, procedures)

key qualifications	
From March 2021 **until September 2023**	Head of production division at Industries Chimiques du fluor ICF Gabes Tunisia
From January 2015 **-Feb 2021**	Chief Technical Officer at Energy&Environment Solutions Gabes Tunisia (Freelancer) :
From January 2016 - February 2021	Chief Production Officer at ICF
From January 2012 - December 2015	Head of Production Department
From October 2007 - December 2011	Production Engineer at ICF

Academic training

Chemical Process Engineering	
From 2004-2007	National Engineering School of Gabes, Tunisia Chemical Engineering Diploma
From 2002-2004	Preparatory institute for engineering studies of Secondary high school ofElguettar Gaf sa, Tunisia
From 2996-2002	Mathematics baccalaureate

Training Certificates

Technological innovation in relation to artificial intelligence

- Third party auditor of quality and environmental management systems iso 9001:2015 and iso 14001:2015
- Sea and Bracky water desalination by reverse osmosis: issues, methods and tools
- Water treatment technologies
- The cogeneration and the practical aspects of energy control

END of Study Projects Supervised

- Design and sizing of cooling tower (National Engineering School of Gabes)
- Sizing of a gas-solid heat exchanger for Partial Recovery of Outgoing thermal ener gy with aluminum fluoride (High Institute of Applied Sciences and Technology of Gabes)
- Modeling of an indirect heated rotary kiln for hydrofluoric acid production (National Engineering School of Gabes

A C H I E V E M E N T S

- Improving The Production Quality (2007-2009)
- Participation in Sizing and Ensuring the Startup of a Sequestration Unit to Reduce P205 Impurity Levels in the Aluminum Fluoride
- Increasing aluminium fluoride production volume by 2% (2019-2020)
- Adjusting Operating Parameter s for the Fluorspar Attack Reaction by the Sulfuric Acid

Summary of references studies and missions

- **Environmental Impact Assessment Studies for drilling wastes treatment operations for different drilling well site for different company such as OMV, BGT, PIONEER, SEREPT, TPS, PERENCO and CTKCP…**
- **Environmental Hazard Identification (ENVID) - MA´ADEN SAUDI ARABIAN MINING COMPANY - UMM WU´AL PHOSPHATE PROJECT. FSA TREATMENT PACKAGE**
- **Emergency responses plan for oil spill in sea for Tunisia**
- **Emergency response plan for WINSTAR Tunisia**
- **Contaminated Soil Sampling mission –GCT –Gabes-Tunisia**
- **16 Environmental Impact Assessment Studies WWTP and sewage network for SKADO – GOCSA in KSA – El JAWEF -SAKAKA.**
- **Project coordinator and supervisor for drilling waste management for different drilling well site for different company such as: (OMV, PIONEER, TPS, British Gas Tunisia, CTKCP, ENI Tunisia, SEREPT, PA resources, Winstar**

Tunisia, LUNDIN Tunisia...);

- **Quantitative risk assessment study oil and gas well development project –PERTAMINA and SONATRACH-ALGERIA**
- **Develop a series of matrixes (4) to compare the Algerian legislation on environmental, health and safety and social (EHSS) aspects relevant to the onshore O&G Industry against the IFC performance standards and sector-specific guidelines-RINA group-ITALY**

Environmental Impact Assessment Studies for drilling operations for different drilling well site for different company such as OMV, BGT, PIONEER, SEREPT, TPS, PERENCO and CTKCP…

Personal skills and competences

Social skills and competences

- hardworking individual with excellent administration, technical and communication skills,
- Excellent ability to work hard on site, as well as, to perform Clients' satisfaction.
- Excellent ability to work under pressure and keep positive attitude.
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Organizational skills and competences

- Expertise with written and verbal communications, including technical correspondences (report, letter, mail bid documents preparations…) and meeting communications.
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Technical skills and competences

- Environment Impact Assessment Study for various projects (drilling well site, waste management (treatment, transport...) ;
- Environmental Audit
- Health and safety study (emergency plan, internal operation plan PIO, risk assessment management plan, …) ;
- Drilling waste management coordination and supervision.
- Air dispersion modeling

Linguistic and computer skills

Language skills

Arab	Read / written / spoken	Native language		
French	Read / written / spoken	Good	Good	Good
English	Read / written / spoken	Good	Good	Good

computer skills

Developer - Applications	**software**
Air Dispersion modeling	Lakes AERMOD
Microsoft Office	Word, Excel, PowerPoint, Project, Visio and Outlook

AMEUR BEN SAAD

General informations	
Last Name / First Name:	Muhammad Ilyas
Position:	Senior Environmental and Ecology Engineer
Number of years' experience:	10 years
Qualification Degrees	Environmental Engineer
Nationality:	Pakistani

Summary of Experience

Dedicated senior environmental engineer with over 10 years of experience in assessing environmental risks, developing sustainable solutions, and ensuring compliance with government regulations. Committed to promoting environmental stewardship and achieving sustainability goals through the development and execution of eco-friendly practices.

✓ Managed construction site environmental management for major infrastructure projects, following regulations from NCEC, MEWA, Saudi Aramco, and the Royal Commission.

✓ Conducted environmental management, impact assessment (EIA) and compliance monitoring for major clients, i.e., NEOM, Saudi Aramco, RSG, CHEC, Saipem, JEC, PetroRabigh, and the Royal Commission.

✓ Expertise in monitoring air quality, noise, dust, solid waste management, wastewater treatment, and disposal, conducting ecology surveys, and water quality assessment related to projects.

✓ Assessment and management of environmental aspects, impacts, risks, and opportunities, oil and chemical spill, and hazardous and non-hazardous waste management at the construction site.

✓ Expertise in conducting offshore and onshore field works including site assessments, contaminants sampling, and laboratory analysis using various analytical techniques and tools.

✓ Conducting environmental audits by evaluating a company's operations, assessing resource use, waste management, and environmental regulations, and identifying improvements to sustainable practices.

✓ Preparation of assessment and audit reports and proposal preparations for projects and writing reports.

key qualifications

- Master of Chemical Engineering: Chemical Engineering Department (46th QS subject ranking), King Fahd University of Petroleum and Minerals (KFUPM) Dhahran, Saudi Arabia. (2012- 2014)
- Bachelor of Chemical Engineering: Institute of Chemical Engineering and Technology, University of the Punjab Lahore, Pakistan. (2007-2011)
- Sustainable Cities Specialization: Johns Hopkins University (4 Courses:Coursera: 2023).

Academic training &Training Certificates

Environmental and Sustainability Engineer

- **Envision SP** (Sustainability Professional) Credentials: Institute for Sustainable Infrastructure, (2023, USA).
- **Envision SP Training: Institute for Sustainable Infrastructure**, (Credentials: RCEP PDH #104185 USA).
- **ISO 14001 Lead Auditor**: Training and Certification from The Knowledge Academy UK (2023).
- **ISO 45001 Lead Auditor**: Training and Certification from The Knowledge Academy UK (2023).
- **ISO 14001:2015-Environmental Management Systems** (EMS): CPD Accredited Course (Alison: 2023).
- **Solid Waste Management:** Open Learning Campus World Bank Group Course (EDX:2023).
- **Introduction to ESG** (Environmental, Social, and Governance): Corporate Finance Institute (CFI: 2023)
- **The SDGs A global, transdisciplinary vision for the future**: University of Copenhagen (Coursera:2023).
- **Sustainable Regional Principles, Planning, and Transportation**: Johns Hopkins University (Coursera: 2023).
- **Transportation, Sustainable Buildings, Green Construction**: Johns Hopkins University (Coursera: 2023).
- **Sustainable Transportation Networks and Streetscapes**: Johns Hopkins University (Coursera: 2023).
- **Sustainable Neighborhoods: Johns Hopkins University**: (Coursera: 2023).

Professional Experience

1.Sr. Environmental Engineer at Center for Environment and Marine Studies, KFUPM from 2014 – Present. As an active participant in various construction, oil, and gas projects, my responsibilities include monitoring environmental compliance, conducting environmental impact assessments, and overseeing continuous monitoring projects. My expertise lies in data collection, environmental aspects, impact monitoring, and generating reports on containment assessment, cleanup, remediation, and waste disposal. I am well-versed in developing plans, proposals, and recommendations to eliminate contaminants and restore the environment, while also working alongside clients, local authorities, and experts to address environmental issues and promote sustainability.

My work involves the preparation of various environmental plans, including the CESMP, SMP, and sub-plans for dust suppression, noise, and vibration control, vehicle and equipment maintenance, chemical handling, nonhazardous and hazardous waste management, emergency response plans for oil and chemical spills, as well as flora and fauna management and erosion management plans to meet environmental requirements at the site. Conducting daily, weekly, monthly, and pre-audit inspections for fulfilling CEMP of projects.

- Experience in handling emergency conditions to control hazards like oil spills, chemical spills, and fires.
- Practicing 4Rs i.e., reduce, reuse, recycle, recovery, and life cycle assessment (LCA) approach methods.
- Identification and analysis of greenhouse gases and developing plans to reduce the carbon footprint.
- Experience in environmental incident investigation and reporting systems to prevent reoccurrence.
- Improving the environmental performance of the EMS with Plan, Do, Check, and Act model in place.
- Documentation and control for compliance with environmental regulations and project requirements.
- Experience in non-hazardous and hazardous waste management handling and disposal systems.
- Creating reports or presentations to effectively communicate the efficacy of environmental initiatives.
- Advising, developing, and reviewing environment and sustainability proposals, plans and policies. Implementing and monitoring environmental and sustainability initiatives for sustainable development.
- Introducing sustainable management systems at the project level to comply with EHS requirements.
- Playing a vital role in pollution control of air, water, soil, and noise, waste, by compliance monitoring.
- Investigating all environmental incidents to analyze the root causes for prevention of the same in the future.
- •Implementing and monitoring incident investigation-related recommendations within the stipulated time frame for continual improvement and compliance with legal, company, client, and other requirements.

2.Sheybarah-Ummahat Islands Construction Monitoring for RSG/CHEC from 2021-2023.

- Ensuring the implementation of the organization's environmental policy, developing and maintaining environmental key performances for set environmental objectives, and maintaining the Environmental Management System (EMS) ISO 14001:2015.
- Performing IER and internal audits to ensure the effective implementation of the ISO 14001:2015 management system and the Construction Environmental Management Plan (CEMP).
- Implementing Saudi Aramco Environmental Health Codes (SAEHC), relevant General Instructions (GIs), RCER, and General Environmental Regulatory Standards (GER) on project sites.
- Responsible for preparing environmental review and gap analysis reports, reporting for environmental objectives, and conducting periodic internal environmental audits as per CEMP.
- Reporting on environmental incidents and air quality and noise monitoring, dust control measures, terrestrial
- surveys, bird monitoring, mangrove surveys, water quality parameters, underwater noise recording, and marine biodiversity monitoring.
- Providing weekly water analysis reports, weekly statistics on waste management and ecological surveys, and control measures reports.
- Responsible for the implementation of a construction waste management plan (CWMP).
- Ensure the proper storage and segregation of waste as per its classification I, II, and II. Ensure the waste is correctly transported by an approved and authorized waste transporter.
- Ensure the correct waste disposal in approved and authorized waste management facilities as classification.
- Identify the opportunities to minimize waste by reducing, reusing, recycling, and recovering.
- Conduct audits and site inspections to ensure the effective implementation of the waste management plan.

3.Construction Phase Environmental Monitoring for Jazan Refinery & Terminal (JR&T), Jazan IGCC and Jazan Economic City (JEC) from 2017-2020.

- The role involves implementing an environmental management system, reviewing compliance reports, and supervising construction activities. It involves investigating and reporting environmental incidents, conducting audits, coordinating training, and developing policies.
- The role also involves participating in environmental safety campaigns, evaluating risks, and monitoring compliance efforts.
- The role of developing and coordinating an environmental assurance program and ensuring effective implementation of environmental and sustainability employer requirements during construction.
- Implementing an environmental management system (EMS) for continuous monitoring system aims to reduce environmental pollution and comply with legal requirements.
- It involves monitoring and evaluating environmental parameters, such as pH, temperature, conductivity, salinity, heavy metals, and hydrocarbons, to meet water quality standards.
- Also monitoring air pollutants, including particulate matter 2.5, 10, NOx, SO2, CO2, ozone, noise, and slid waste across construction sites.
- Monitoring the effectiveness of ecological barriers to avoid water pollution. It also ensures compliance with client, organizational, and legal register requirements.
- The EMS Management System is set up to set objectives and targets, identify Scope, and emissions, and implement control measures to reduce pollution effects.
- Providing technical planning advice, spot-checks of contractors, and managing on-board stakeholder management.
- Through effective EMS establishing and maintaining environmental programs and campaigns to raise awareness on environmental and sustainability issues.
- Reviewing and approving all environmental plans, procedures, and implementation to ensure 100% compliance with project, company, province, and country requirements.
- Also conducting review meetings for continual improvement of the company's environmental systems.

4.Related Projects Contribution

- NEOM: Development of Regional Baseline and Monitoring Standards and Conduction of Surveys for NEOM Environment: Cruise team leader responsible for water and sediment quality parameters. Participated in field operations involving equipment, chemicals, and logistics. Set up onboard lab for on-site sample processing, preservation, and transportation. (2021-2022)
- Environmental Monitoring for Seismic and Exploratory Drilling Operations in the LUKSAR Contract Area, North Rub-Al-Khali Desert Saudi Arabia (2015-2018: Task Leader).
- NEOM Soil Survey conducted at target locations for landscape observation and assessment of various environmental parameters (2022: Task Leader).
- Environmental Impact Assessment for Exploratory Drilling in The Shallow Waters of the Arabian Gulf (2018-2020 Team member).
- Environmental Assessment for Seismic and Exploratory Drilling Operations in SSG Contract Area, North Rub Al-Khali Dessert, Saudi Arabia (2015-2018: Task Leader).
- Environmental Compliance Monitoring and Post-Construction Monitoring for the Safaniya Marine Channel Dredging Project- Saudi Aramco (2019-2021 Team member).
- Annual Marine Environmental Compliance Survey and Bioaccumulation Study Petro Rabigh. (2019-2020, Task Leader)
- Environmental Impact Assessment for the replacement of 48” CLS-14 pipeline in Ras Tanura (BI-10- 15517). Saudi Aramco project (2020, Team member)
- Environmental Impact Assessment for ZULUF AM platforms Upgrade (BI-10-12741). Saudi Aramco project (2021 Team member)
- Consultancy Services to NEOM in the execution of fast-track environmental technical services. NEOM (2021, Team member)
- Environmental impact assessment for the installation of platforms and associated facilities in Safaniya and Manifa offshore oil fields (BI-12- 18000). Saudi Aramco project (2020-2021, Team member)

- Environmental Impact Assessment for the Construction of Offshore Facilities in Juaymah (BI-10-14164 & BI-10-14244). Saudi Aramco project (2020, Team member)
- 12 Projects: Environmental Monitoring Study for Exploratory Drilling in the Deep Waters of Red Sea- Saudi Aramco. (2014-2020, Team member).
- 05 Projects: Environmental Impact Assessment for Exploratory Drilling in the Deep Waters of Red Sea- Saudi Aramco. (2015-2020: Team member)
- Status Assessment and Monitoring of the Saudi Arabian Waters of The Arabian Gulf. (2015-2020 Team member, Task Leader).

5.Research Assistant at Chemical Engineering KFUPM from 2012-2014:

Led a funded project at KFUPM, establishing a microalgae cultivation, CO2 fixation, and wastewater treatment lab. Published research articles, managed safety and equipment, trained staff, and updated standard operating procedures for sample preparation and analysis.

Professional Trainings

•Hydrogen Sulfide (H2S) + SCBA from GTSC - Jan 2020.
•Hazard Communication Basic from OSHA Academy - Mar 2020.
•Personal Protective Equipment Basic (PPE) from OSHA Academy - Mar 2021.
•Introduction to job hazard analysis (JHA) from OSHA Academy - April 2021.
•Oil and gas safety management from OSHA Academy - April 2021.
•Professional development application CHEMCAD and MATLAB Mar 2011.
•Agilent-Germany Training Course R1893A QQQ-LC/MS - April 2016 Germany.
•Basic Chromatographic Trouble-Shooting from ACS - April 2017.
•GCMS, GCFID, TOC, HPLC, ICP-OES and ICP-MS Operational Training - Aug 2017.
•Introduction to Mass Spectrometry, Triple Quadrupole, and LIT MS – SCIEX -Mar 2018.
•Introduction to HPLC, Mobile Phase Prep. and Pump Overview – SCIEX -Mar 2020.
•The Basics of Tandem Mass Spectrometry and Quantitation by MS - SCIEX -Jun 2023.
•Laboratory Information Management Systems (LIMS) training – CEMS – Sep 2023.

Professional Skills

- Skilled at collecting, analyzing, and interpreting scientific and project data.
- Skilful at report writing and reviewing the reports prepared by the third party.
- Precise at meeting project deadlines and working under pressure.
- Adept at working with people from various disciplines towards a common goal.
- Technically inquisitive, with creative problem-solving skills.

Conference Presentations

1. **S. A. Razzak, M. Ilyas, M.M. Hossain**, Effect of different ratio of Air-CO2 mixing feed on the growth of Nannochloropsis Oculata in batch photobioreactor, AIChE 2013, USA.
2. **Razzak S.A., Ilyas M.,** Hossain M.M., CO2 Mitigation and carbon content analysis of Chlorella vulgaris culturing in synthetic wastewater media, CSChE 2014, Canada.
3. **Ilyas M., Razzak S.A, CO2** bio-fixation and pH-based optimization of Nannochloropsis oculata growth using photo-bioreactor for environmental remediation, LabTech-2014 Bahrain.
4. **Ilyas M., Shemsi A.M.**, Identification, evaluation and control mechanism of occupational hazards related to the production of engineered nanomaterials in research laboratories. CCPS-MEPSC-2015 Abu Dhabi, U.A.E.
5. **Ilyas M**, Evaluation of CO2 bio-fixation potential of microalgae culturing in closed photo-bioreactors: advancement toward addressing environmental challenge, MEPEC-2015 Bahrain
6. **Ilyas M**, Akeem A, Shemsi A.M. Estimation of TPHs in oil contaminated wastewater by adsorption on MWCNTs using solid-phase extraction. ChemIndix-2016 Bahrain
7. **Ilyas M**., Microalgae a non-edible source of biofuel production and wastewater treatment. LabTech **2017** 4th International Laboratory Technology Conference, Bahrain.

Workshops & Seminars

• Presented Seminar: Potential use of microalgae cultivation technology in biofuel production, CO2 fixation, and wastewater treatment. (CEMS, Feb 23, 2022)
• Attended workshop: blue economy forum. (CEMS, Dec 01, 2022)
• Fate of total petroleum hydrocarbons in the marine environment. (CEMS newsletter, 2022)
• EnvChem2020 conference: Chemistry of the whole environment research. (2022, RSC: Online)
• The Saudi green initiative: goals, targets and achievements. (CEMS newsletter, 2021)
• Workshop: Liquid chromatography: Advanced applications in the petroleum industry. (ACS 2021)
• Impact of daily activities on carbon footprint and ways to reduce it (CEMS newsletter, 2020)
• 24th Annual green chemistry & engineering virtual conference. (2020, ACS: Online)
• Petroleum hydrocarbons analysis at ECAL labs (CEMS newsletter, 2019)
• Impact of daily activities on carbon footprint and ways to reduce it (CEMS newsletter, 2020)
• Training of summer COOP students, staff, and newly hired personnel every year.

Professional Memberships

- 2023 - Present Institute for Sustainable Infrastructure (ISI #57021), USA 2023 - Present United States Green Building Council (USGBC), USA
- 2015 - Present Environmental Technology & Management Association (ETMA-SA) 2014 - Present Member of AIChE-Saudi Arabian Section (SAS-AIChE)
- 2011 - Present Member of Pakistan Engineering Council (PEC-Pakistan)

Community Service

2020 - Present	Participating in tree plantation campaign in KSA.
2015 - Present	Participating in environmental awareness campaigns.
2012 - Present	Participating in KFUPM "Volunteer Day" for distinct activities
2011 - Present	Founding member of Al-Rehman Welfare Society Pakistan

Linguistic and computer skills

Language skills

Arab	Read / written / spoken	Native language		
English	Read / written / spoken	Good	Good	Good

Muhammad Ilyas

8.2.3. Resume of International Team

Environment´s team from TYPSA			
Mª Luisa Villalmanzo	MSc Biological Science. 1987. Master's Degree in Environmental Impact Assessment and Mitigation Measures. 1989-1991.	37 years	TYPSA
Marta Muriel	BSc in Environmental Sciences 1998. Postgraduate course on Rural Planning related to the Environment 1999.	26 years	TYPSA
Patricia Rullán	BSc in Environmental Sciences 2002. Master's degree in Private Enterprise Environmental Management 2002.	22 years	TYPSA
Nuria Mesonero	BSc in Environmental Sciences 2001. Master's degree in environmental engineering and management 2002	23 years	TYPSA
Divyangi Singh	BSc in Technology, Mechanical Engineering 2019. MSc in Business and Management 2022. Master´s degree in International Management and Sustainability 2022.	5 years	TYPSA
Raúl Moral	BSc in Environmental Engineering 2023.	1 year	TYPSA
Support team from TYPSA			
Project´s team (Luis Trijueque and Alejandro Tolosa); geotechnics´ team (Pedro Adalia and Álvaro Barrero), and hydrolgy´s team (Javier Lopez and Samuel Perez) from TYPSA			

8.2.4. Curriculum Vitae of International Team

EXPERT ON ENVIRONMENTAL ASSESSMENT AND INTEGRATION

María Luisa Villalmanzo Sánchez

PERFIL

Both through her studies and her 35 years work experience, Mrs. Villalmanzo has acquired a wealth of experience in the field of Due Diligence, Environmental Audit, Strategic Environmental Impact Assessment, Environmental, Social and Biodiversity Impact Assessment, Mitigation Measures definition, natural resources management, waste, control, and environmental monitoring. She has managed and carried out more than 350 environmental impact studies and design recovery measures for projects related to civil engineering: linear infrastructures (roads and railways), dams, ports, airports, buildings, energy sector, etc. and she has also participated on planning and development important projects

UNIVERSITY DEGREE

DEGREE IN BIOLOGY (1987)
Complutense University of Madrid, Spain.

MASTER OF ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION MEASURES (1989-1991).
Polytechnic University of Madrid, Complutense University of Madrid, Autónoma University of Madrid, CIEMAT and University Foundation Company. Best Project award.

COMPLEMENTARY EDUCATION

Courses

- XVII Course on wastewater treatment and operation of treatment plants. CEDEX (Madrid 1999).
- Tool for quantifying the importance of habitat patches for landscape connectivity. (2013. Polytechnic University of Madrid).
- Sustainability CEEQUAL Project Assessor 6th Version (BREEAM Infrastructure certification). BREEAM Academy, 2022.
- Environmental and Social Performance Standard 6. Biodiversity Conservation and Sustainable Management of Living Natural Resources, BID. 2023

OTHER KNOWLEDGE

- Word processing (Microsoft Word)
- Database (Microsoft Access)
- Spreadsheets (Excel)
- Operating systems (MS-DOS)
- Geographic Information Systems (GIS)
- Measurement and Budget Programs (PRESTO).

LANGUAGES

	Spanish	English	French
Auditive comprehension	Mother tonge	B2	A1
Reading comprehension	Mother tonge	B2	A1
Oral interaction	Mother tonge	B2	A1
Oral expression	Mother tonge	B2	A1
Written expresión	Mother tonge	B2	A1

María Luisa Villalmanzo Sánchez

PROFESSIONAL CAREER

12.1992
Actual

- **PROJECT DIRECTOR**

TYPSA. Spain

Management, coordination and carrying out environmental impact studies and projects of protective and corrective measures. Environmental management and integration. Waste. Water. Environmental monitoring

12.1989
11.1992

- **FREE PROFESSIONAL PARTNER**

ESTUDIOS Y PROYECTOS MINEROS, POLYTECHNIC UNIVERSITY OF MADRID. ENVIRONMENTAL AGENCY, AMBIOTEC, EPTISA AND PICSA. SPAIN

Environmental impact studies and projects of protective and corrective measures. Environmental Audit.

07.1988
03.1990

- **ENVIRONMENTAL TECHNICAL**

Ministry of Public Works, Transport and Environment. Environmental Impact Area

Environmental impact statements, monitoring and controlling the condition of the said declaration, plans of corrective and protective measures and environmental monitoring programs.

MAIN PROJECTS

12.1992 To Present

Company: TYPSA.

Roads, Railways, Metro, Transport and Development Projects. Environmental Impact Assessment Studies and Projects of Mitigation Measures

Since 1992 until today she has led, and she has done more than 100 studies of environmental impact and projects of corrective measures of roads, railways, and metro throughout the Spanish geography and in other countries. The most relevant in the last years are:

- "FCEMP (FRAMEWORK FOR CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN) FOR THE MBS GLOBAL CENTRE FOR ARABIC CALLIGRAPHY PROJECT IN DETAIL DESIGN". 2024. | SAUDI ARABIA

DIRIYAH GATE DESIGN AUTHORITY (DGDA)

Project Director. Management, Coordination and Carrying out the FCEMP Report for the project.

- SINGLE AWARD TASK ORDER CONTRACT (SATOC) FOR THE OVERALL INTEGRATION OF THE P-563 PROGRAM. IT INCLUDES FACILITIES AND INFRASTRUCTURE TO SUPPORT THE OVERALL MINISTRY OF DEFENSE TRANSFORMATION INITIATIVES BEING DEVELOPED AS PART OF VISION 2030 IN SAUDI ARABIA. ITS MAJOR ELEMENTS ARE A NEW MILITARY CITY, A NATIONAL DEFENSE UNIVERSITY, AND A NEW JOINT FORCES COMMAND. 2023-2024 | SAUDI ARABIA

US ARMY CORPS OF ENGINEERS (USACE).

Environmental Coordinator. Development of environmental documents for environmental procedure (Scoping Report and EIA Report), and also carrying out the environmental mitigation measures and the FCEMP Report for the project

- ARCHITECTURAL AND ENGINEERING DESIGN CONSULTANCY SERVICES FOR KING SALMAN PARK PROJECT - PUBLIC COMMUNITY FACILITIES IN PHASES 2 AND 3. 2023 | SAUDI ARABIA

KING SALMAN PARK FOUNDATION

Management, Coordination and Carrying out the environmental mitigation measures for the project.

- "MITIGATION MEASURES REPORT", INCLUDING DRAWINGS AND SPECIFICATIONS IN SCHEMATIC DESIGN, DESIGN DEVELOPMENT AND CONSTRUCTION DOCUMENTATION, "ENVIRONMENTAL HANDBOOK" AND "FCEMP" (FRAMEWORK FOR CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN) IN CONSTRUCTION DOCUMENTATION FOR BID PACKAGE 7, 8, 9, 10 (ENTERTAINMENT DISTRICT +ATHLETICS DISTRICT) FROM THE PHASE 2B OF THE PROJECT "RIYADH SPORTS BOULEVARD". 2020-2024. | SAUDI ARABIA

SPORT BOULEVARD FOUNDATION (SBF)

Project Director. Management, Coordination and Carrying out the environmental mitigation measures and the FCEMP Report for the project. Answers to the questions of the bidders.

- "ENVIRONMENTAL CONSIDERATION REPORT", "SCOPING DOCUMENT" AND "ENVIRONMENTAL IMPACT ASSESSMENT REPORT" (INCLUDING NOISE STUDY) FOR BID PACKAGE 7, 8, 9, 10 (ENTERTAINMENT DISTRICT +ATHLETICS DISTRICT) FROM THE PHASE 2B OF THE PROJECT "RIYADH

SPORTS BOULEVARD". IN ADDITION OF OBTAINING THE ENVIRONMENTAL PERMIT TO CONSTRUCT. 2020-2022. | SAUDI ARABIA

SPORT BOULEVARD FOUNDATION (SBF)

Project Director. Management, Coordination and Carrying out environmental documents for environmental procedure.

- "ENVIRONMENTAL CONSIDERATION REPORT", "SCOPING DOCUMENT" AND "ENVIRONMENTAL IMPACT ASSESSMENT REPORT" (INCLUDING NOISE STUDY) FOR BID PACKAGE 6 (URBAN WADI) FROM THE PHASE 2A OF THE PROJECT "RIYADH SPORTS BOULEVARD". IN ADDITION OF OBTAINING THE ENVIRONMENTAL PERMIT TO CONSTRUCT. 2020-2021. | SAUDI ARABIA

SPORT BOULEVARD FOUNDATION (SBF)

Project Director. Management, Coordination and Carrying out environmental documents for environmental procedure.

- "MITIGATION MEASURES REPORT", INCLUDING DRAWINGS AND SPECIFICATIONS IN SCHEMATIC DESIGN, DESIGN DEVELOPMENT AND CONSTRUCTION DOCUMENTATION, "ENVIRONMENTAL HANDBOOK" AND "FCEMP" (FRAMEWORK FOR CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN) IN CONSTRUCTION DOCUMENTATION FOR BID PACKAGE 6 (URBAN WADI) FROM THE PHASE 2A OF THE PROJECT "RIYADH SPORTS BOULEVARD". 2020-2021. | SAUDI ARABIA

ROYAL COMMISSION FOR RIYADH CITY (RCRC)

Project Director. Management, Coordination and Carrying out the environmental mitigation measures and the FCEMP Report for the project. Answers to the questions of the bidders.

- FIVE "ENVIRONMENTAL CONSIDERATION REPORTS", FIVE "SCOPING DOCUMENTS" AND FIVE "ENVIRONMENTAL IMPACT ASSESSMENT REPORTS" (INCLUDING ECOLOGICAL SURVEYS AND NOISE STUDIES) FOR FIVE SEPARATE BID PACKAGES (BP1A WADI HANIFAH ZONE A, BP1B WADI HANIFAH ZONE B, PB2 PROMENADE, BP4 PRINCE TURKI INTERSECTION AND BP5 ARTS DISTRICT) FROM THE PHASE 1 OF THE PROJECT "RIYADH SPORTS BOULEVARD". IN ADDITION OF OBTAINING THE ENVIRONMENTAL PERMIT TO CONSTRUCT FOR EACH BP. 2019-2021| SAUDI ARABIA

SPORT BOULEVARD FOUNDATION (SBF)

Project Director. Management, Coordination and Carrying out environmental documents for environmental procedure.

- FIVE "MITIGATION MEASURES REPORTS", INCLUDING DRAWINGS AND SPECIFICATIONS IN SCHEMATIC DESIGN, DESIGN DEVELOPMENT AND CONSTRUCTION DOCUMENTATION, FIVE "ENVIRONMENTAL HANDBOOKS" AND FIVE "FCEMPS" (FRAMEWORK FOR CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN) IN CONSTRUCTION DOCUMENTATION AND ISSUED FOR CONSTRUCTION FOR FIVE SEPARATE BID PACKAGES (BP1A WADI HANIFAH ZONE A, BP1B WADI HANIFAH ZONE B, PB2 PROMENADE, BP4 PRINCE TURKI INTERSECTION AND BP5 ARTS DISTRICT) FROM THE PHASE 1 OF THE PROJECT "RIYADH SPORTS BOULEVARD". 2019-2021. | SAUDI ARABIA

SPORT BOULEVARD FOUNDATION (SBF)

Project Director. Management, Coordination and Carrying out the environmental mitigation measures and the FCEMP Report for the project. Answers to the questions of the bidders.

- ENVIRONMENTAL IMPACT ASSESSMENT OF FEASIBILITY STUDY WITH DETAIL DESIGN AND TENDER DOCUMENT PREPARATION FOR CONSTRUCTION OF RAIL LINE FROM BHANGA TO PAYRA, VIA BARISAL. 2018-2020. | BANGLADESH

MINISTRY OF RAILWAYS AND THE BANGLADESH RAILWAY AUTHORITY

Project Director

- BORROW AND DUMPING AREAS SURVEY. MANAGEMENT FRAMEWORK FOR EXCAVATED MATERIALS. FEASIBILITY STUDY AND PRELIMINARY DESIGN FOR CONSTRUCTION OF DHAKA SUBWAY. 2019-2020. | BANGLADESH

BANGLADESH BRIDGE AUTHORITY

Project Director

- MITIGATION MEASURES OF BATU (ZEWAY) - ARSI NEGELE ROAD PROJECT. 57,1 KM. 2018-2019. | ETHIOPIA

ETHIOPIAN ROAD AUTHORITY

Project Director. Management, Coordination and Carrying out environmental documents for the project. Collaboration in Public Participation Process.

- ENVIRONMENTAL INTEGRATION OF THE CONSTRUCTION PROJECT: MEDITERRANEAN CORRIDOR HIGH SPEED RAILWAYS. SECTION NÍJAR-ALMERÍA. 2017-2018. | SPAIN

ADIF

Project Director

- REVIEW OF THE ENVIRONMENTAL IMPACT ASSESSMENT STUDIES OF THREE ROADS IN CHILE: SANTIAGO SOUTH ORBITAL, AMÉRICO VESPUCIO NOR-PONIENTE SYSTEM, SECTION EL SALTO – 78 ROUTE AND 5 ROUTE CONCESSION, SECTION TALCA – CHILLAN". 2017-2018. | CHILE

MINISTRY OF PUBLIC WORKS. CHILE GOBERNMENT

Project Reviewer

- ENVIRONMENTAL MITIGATION MEASURES OF THE LIMA METRO DETAILED DESIGN LINES 2 AND 4. 2018. | PERU

PROINVERSIÓN/Construction Consortium

Project Director

- VISUAL IMPACT ASSESSMENT OF LAHORE METRO ON THE INTEGRITY OF THE WORLD HERITAGE SITE "SHALAMAR GARDENS". 2016-2017. | PAKISTAN

DIRECTORATE GENERAL OF ARCHEOLOGY, GOVERNMENT OF PUNJAB

Project Director

- ENVIRONMENTAL ASSESSMENT OF THE ROAD M-501. SECTION: M-40 - LIMIT OF THE COMMUNITY OF MADRID. 2015-2016. | SPAIN

COMMUNITY OF MADRID

Project Director

- LANDSCAPING OF THE CONSTRUCTION PROJECT: RIYADH METRO. LINE 4, 5 AND 6. 2014-2016. | SAUDI ARABIA

ARRIYADH DEVELOPMENT AUTHORITY. CONSORCIO CONSTRUCTOR (FCC, SAMSUNG, ALSTOM, STRUKTON, FREYSSINET).

Project Director

- ENVIRONMENTAL INTEGRATION OF THE CONSTRUCTION PROJECT: RIYADH METRO. LINE 4, 5 AND 6. 2013-2016. | SAUDI ARABIA

ARRIYADH DEVELOPMENT AUTHORITY. CONSORCIO CONSTRUCTOR (FCC, SAMSUNG, ALSTOM, STRUKTON, FREYSSINET).

Project Director

- ENVIRONMENTAL ASSESSMENT REPORT FOR AN INDUSTRIAL CITY RIYADH 3. 2014. | SAUDI ARABIA

MODON

Project Director

- ENVIRONMENTAL IMPACT ASSESSMENT AND SUSTAINABILITY STUDIES OF LIGHT RAIL TRANSIT/TRAM OF ABU DHABI PROJECT (UAE). 2013. | UNITED ARAB EMIRATES

DEPARTAMENT OF TRANSPORT OF ABU DHABI

Carrying out environmental documents

- ENVIRONMENTAL INTEGRATION OF THE CONSTRUCTION PROJECT: PANAMERICANA SUR, PERU. 2012-2013. | PERU

ODEBRECHT

Project Director

- ENVIRONMENTAL IMPACT OF THE CONSTRUCTION PROJECT: HIGHWAY CL-510. (SALAMANCA-ALBA DE TORMES, SPAIN). 2010-2012. | SPAIN

CONSEJERÍA DE FOMENTO DE LA JUNTA DE CASTILLA Y LEÓN

Project Director

- CORRECTIVE MEASURES AND ENVIRONMENTAL INTEGRATION PROJECT OF A-66 HIGHWAY. BENAVENTE-ZAMORA. 2011. | SPAIN

MINISTERIO DE FOMENTO

Project Director

- CORRECTIVE MEASURES AND ENVIRONMENTAL INTEGRATION FOR SECURITY UTILITIES AND COMMUNICATIONS PROJECT IN THE MADRID – GALICIA HIGH SPEED RAILWAY. SECTION: OLMEDO – ZAMORA. (2011). | SPAIN

ADIF

Project Director

- ENVIRONMENT INTEGRATION OF THE CONSTRUCTION PROJECT TO THE TRACTION POWER SUBSTATION OF SAX. MONTESA – CAMPANARIO. (ALBACETE – ALICANTE. SPAIN). 2009. | SPAIN

ADIF

Project Director

- ENVIRONMENTAL INTEGRATION OF THE CONSTRUCTION PROJECT: TRANSPORTS CONNECTION STATION OF AVENIDA DE AMÉRICA. 2009. | SPAIN

REGIONAL CONSORTIUM OF TRANSPORT IN MADRID. COMMUNITY OF MADRID

Project Director

Solar PV Plants and Wind Farms. Environmental Impact Assessment Studies

- DIRECTION OF FIVE ENVIRONMENTAL IMPACT ASSESSMENT STUDIES OF FIVE SOLAR POWER PLANTS IN SAUDI ARABIA; BISHA, NAJRAN, AFIF 1, AFIF 2 AND HARADH I SOLAR POWER PLANTS. 2024. | SAUDI ARABIA

MINISTRY OF ENERGY (MOE)

Project Director

- DIRECTION OF ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF ONE SOLAR POWER PLANT IN SAUDI ARABIA; AS SADAWI SOLAR POWER PLANT. IN ADDITION OF OBTAINING THE ENVIRONMENTAL PERMIT TO CONSTRUCT. 2022-2023. | SAUDI ARABIA

MINISTRY OF ENERGY (MOE)

Project Director

- ENVIRONMENTAL STUDIES, BIRDS STUDIES, AND ARCHAEOLOGICAL STUDIES OF 2 HYBRID PROJECTS (WIND FARMS AND SOLAR POWER PLANTS) IN SPAIN: REMEDIOS AND SERVITAS. 2022-2024. | SPAIN

RIC ENERGY

Project Director

- ENVIRONMENTAL STUDIES, BIRDS STUDIES, AND ARCHAEOLOGICAL STUDIES OF 8 SOLAR POWER PLANTS IN SPAIN: ATASCABURRAS, SARRACENO, BUENDÍA, PTOLOMEO, AZORÍN, RIAZOR, SERVITAS AND LIBRICOS. 2022-2023. | SPAIN

RIC ENERGY

Project Director

- DIRECTION OF ENVIRONMENTAL 3 IMPACT ASSESSMENT STUDIES AND 3 SCOPING REPORTS OF 3 SOLAR POWER PLANTS IN SAUDI ARABIA; HASMA, SHARIFA, AND AIRPORT WEST SOLAR POWER PLANTS. IN ADDITION OF OBTAINING THE ENVIRONMENTAL PERMIT TO CONSTRUCT. 2022. | SAUDI ARABIA

NEOM

Project Director

- ENVIRONMENTAL ASSESSMENT OF PROJECT PROSPERITY OHL ROUTING AND FEASIBILITY STUDIES IN JORDAN. 2022.. | JORDAN

MASDAR

Project Director

- INITIAL ENVIRONMENTAL DOCUMENT OF 12 SOLAR POWER PLANTS IN SPAIN: ATASCABURRAS, SARRACENO, ZALAMANDROÑA, BUENDÍA, PTOLOMEO, AZORÍN, LORENZO, CRUZ, FUENTES, RIAZOR, SERVITAS AND LIBRICOS. 2022.. | SPAIN

RIC ENERGY

Project Director

- REVISION OF ENVIRONMENTAL IMPACT ASSESSMENT STUDIES OF AL MOWAYH AND HADEN SOLAR POWER PLANTS. IN ADDITION OF OBTAINING THE ENVIRONMENTAL PERMIT TO CONSTRUCT. 2022.. | SAUDI ARABIA

MINISTRY OF ENERGY (MOE)

Project Reviewer

- ENVIRONMENTAL IMPACT STUDY OF LAYLA PV PLANT. 2016. | SAUDI ARABIA

TAQNIA ENERGY

Project Director

Ports. Environmental Impact Assessment Studies and Projects of Mitigation Measures

- ENVIRONMENTAL INTEGRATION OF THE CONSTRUCTION PROJECT: “MODERNIZATION OF SOLID IN BULK TERMINAL CORTÉS PORT”, HONDURAS. 2012. | HONDURAS

MARITIME PORTS IN HONDURAS (PMH)

Project Director

- ENVIRONMENTAL INTEGRATION OF THE CONSTRUCTION PROJECT "DEVELOPING A PLAN CABOTAGE TO SÃO TOMÉ E PRÍNCIPE ". 2012. | SANTO TOMÉ E PRINCIPE

DELEGATION OF EUROPEAN COMMISSION IN GABÓN

Project Director

- ENVIRONMENTAL IMPACT STUDY OF THE CONSTRUCTION PROJECT OF THE PLEASURE BOATS DOCK SOUTH OF DAM CURRA (CARTAGENA. MURCIA). 2006. | SPAIN

MINISTRY OF FOMENTO

Project Director

Hydraulic. Environmental Impact Assessment Studies and Projects of Mitigation Measures

- REVIEW OF THE ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF CASUPÁ DAM IN URUGUAY. 2017-2018. | URUGUAY

OSE URUGUAY

Project Director

- REVIEW OF THE ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF THE CARRIZAL HYDROELECTRIC POWER PLANT IN BOLIVIA. 2017-2018. | BOLIVIA

ENDE BOLIVIA

Project Director

- ENVIRONMENTAL IMPACT ASSESSMENT OF SEVERAL CANAL DE ISABEL II PROJECTS, INCLUDING WATER SUPPLY, SEWERAGE NETWORKS, WATER TREATMENT AND DRAINAGE. MORE THAN 93 IMPACT STUDIES. 2006-2016 | SPAIN

CANAL DE ISABEL II

Project Director

- ENVIRONMENTAL IMPACT ASSESSMENT OF LAKE EXPANSION PROJECT IN SANTANDER GROUP CITY IN BOADILLA DEL MONTE, MADRID. 2012. | SPAIN

SANTANDER GROUP CITY

Project Director

- ENVIRONMENTAL IMPACT STUDY OF THE CONSTRUCTION PROJECT FOR THE COLLECTION OF WASTEWATERS IN THE LEFT BANK OF MANZANARES RIVER IN MADRID. 2008. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF THE CONSTRUCTION PROJECT FOR THE STORM TANK IN ARROYOFRESNO IN MADRID. 2007. | SPAIN

CANAL DE ISABEL II

Project Director

- ENVIRONMENT INTEGRATION OF THE ALCOLLARÍN AND BÚRDALO DAM CONSTRUCTION PROJECT (CÁCERES). 2007. | SPAIN

MINISTRY OF AGRICULTURE, FEEDING AND ENVIRONMENT

Project Director

- ENVIRONMENT INTEGRATION OF THE CONSTRUCTION PROJECT OF SANITATION AND WASTEWATER IN LA VERA (CÁCERES). 2006. | SPAIN

CONFEDERACIÓN HIDROGRÁFICA DEL TAJO

Project Director

Mining. Environmental Impact Assessment Studies

- CONSOLIDATED ENVIRONMENTAL IMPACT STUDY OF THE MUGA MINING PROJECT. NAVARRA AND ARAGÓN. 2017. | SPAIN

GEOALCALI

Project Director

Airports. Environmental Impact Assessment Studies

- ENVIRONMENTAL IMPACT AND MITIGATION MEASURES OF THE PROJECT "PREPARATION OF FOUR ALTERNATIVE CONCEPTUAL DESIGNS FOR THE KING KHALID INTERNATIONAL AIRPORT T5 SOUTH TERMINAL IN RIYADH". SAUDI ARABIA. 2022. | SAUDI ARABIA

RIYADH AIRPORTS COMPANY (RAC)

Project Director.

- "MITIGATION MEASURES REPORT", INCLUDING DRAWINGS AND SPECIFICATIONS AND "FCEMP" (FRAMEWORK FOR CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN) OF THE PROJECT "REHABILITATION OF RUNWAYS AND TAXIWAYS AT KING KHALID INTERNATIONAL AIRPORT IN RIYADH" BELONGING TO THE RIYADH AIRPORTS COMPANY (RAC). SAUDI ARABIA. 2020-2022. | SAUDI ARABIA

RIYADH AIRPORTS COMPANY (RAC)

Project Director. Management, coordination and carrying out the environmental mitigation measures of the project.

- VERIFICATION OF THE ADEQUACY TO THE ENVIRONMENTAL IMPACT STATEMENT OF THE CONSTRUCTION PROJECTS OF EXPANSION WORKS TO GRAN CANARIA AND REUS AIRPORTS 2006. | SPAIN

GRAN CANARIA AND REUS AIRPORTS

Project Director

Shopping. *Environmental Impact Assessment Studies*

- SINCE 1997 UNTIL 2007 SHE HAS DONE MORE THAN 20 STUDIES OF ENVIRONMENTAL IMPACT OF CARREFOUR SHOPPING THROUGHOUT THE SPANISH GEOGRAPHY: PORRIÑO, CHICLANA, MAIRENA DEL ALCOR, LEGANÉS, MEJORADA DEL CAMPO, TORREJÓN DE ARDOZ, VALDESPARTERA, BAENA, NAVALCARNERO, CIEMPOZUELOS, ALMENDRALEJO, TALAVERA DE LA REINA, VIGO, CORISTANCO, CASTELLÓN, HUELVA, VALLECAS, PONFERRADA AND SANTANDER. | SPAIN

CARREFOUR

Project Director

Golf. Environmental Impact Assessment Studies

- ENVIRONMENTAL IMPACT STUDY OF THE IMPROVEMENT OF THE GOLF COURSE RACE (SAN SEBASTIÁN DE LOS REYES, MADRID). 2008-2010. | SPAIN

RACE

Project Director

- ENVIRONMENTAL IMPACT STUDY OF THE IMPROVEMENT OF THE GOLF COURSE SOTO OF REAL (ARANJUEZ, MADRID). 2008-2010. | SPAIN

CLUB DE GOLF DE ARANJUEZ

Project Director

Hospitals. Environmental Impact Assessment Studies

- ENVIRONMENTAL IMPACT STUDY OF THE MODIFICATION OF THE UNIVERSITY CLINIC OF NAVARRA IN MADRID. 2017. | SPAIN

UNIVERSITY CLINIC OF NAVARRA

Project Director

- ENVIRONMENTAL IMPACT STUDY OF THE UNIVERSITY CLINIC OF NAVARRA IN MADRID. 2014-2015. | SPAIN

UNIVERSITY CLINIC OF NAVARRA

Project Director

- ENVIRONMENTAL STUDY OF THE MEDICAL CENTER IN GROUP SANTANDER CITY. BOADILLA DEL MONTE. MADRID. 2013. | SPAIN

GROUP SANTANDER CITY

Project Director

Strategic Environmental Assessment. Strategic Environmental Studies

Since 1998 until today she has done for Madrid City Hall more than 20 studies of environmental impact of planning changes. The most relevant in the last years are:

- STRATEGIC INITIAL DOCUMENT OF THE SPECIFIC MODIFICATION OF THE PGOU IN THE RAILWAY SPACE OF IRÚN. 2018. | SPAIN

IRÚN TOWN COUNCIL

Project Director

- STRATEGIC ENVIRONMENTAL DOCUMENT FOR THE FRAMEWORK PLAN OF PREVENTION AND MANAGEMENT OF WASTE IN MADRID MUNICIPALITY 2017-2022. 2017| SPAIN

MADRID TOWN COUNCIL

Project Director

- STRATEGIC ENVIRONMENTAL DOCUMENT FOR THE SPECIAL PLAN OF ONCE´S PLOT IN "PASEO DE LA HABANA". NOISE STUDY. 2017-2018. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF THE SECTORAL PLAN OF THE "NUEVA CENTRALIDAD DEL ESTE", MADRID. 2008-2009. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF THE SPECIFIC MODIFICATION OF THE PLAN IN THE PARCEL OF MAHOU-VICENTE CALDERÓN (MADRID). 2008-2009. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF SPOT MODIFICATION OF PGOUM IN THE APR 01.02 SCOPE. MADRID CITY HALL. 2008. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF THE SPECIFIC MODIFICATION OF THE PLAN IN THE PARCEL OF CORNISA- SAN FRANCISCO- SEMINARIO. (MADRID). 2008. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF SPOT MODIFICATION OF PGOUM IN THE FRUIT AND VEGETABLES MARKET SCOPE. 2006. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF SPOT MODIFICATION OF PGOUM IN ONCE GROUNDS IN MADRID CITY HALL. 2006. 2008. 2010. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF ROBOTIC PARKING IN CUESTA DE LOS SAGRADOS CORAZONES AND ROSA JARDÓN STREETS. MADRID CITY HALL. 2006. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF REVITALIZATION AND DEVELOPMENT OF THE CORNISA DE SAN FRANCISCO EL GRANDE AND SEMINARIO CONCILIAR (APR 01.06/07-M). MADRID CITY HALL. 2006. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF A BUILDING IN COSTANILLA DE LOS DESAMPARADOS AND FÚCAR (APE 01.05/M) IN CENTER DISTRICT. MADRID CITY HALL. 2005. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF THE PARCEL LOCATED IN ARGANZUELA DISTRICT, MADRID CITY HALL. 2005. | SPAIN

MADRID TOWN COUNCIL

Project Director

- ENVIRONMENTAL IMPACT STUDY OF SPOT MODIFICATION OF PGOUM IN THE 01.09 "SANTO DOMINGO-CALLAO SCOPE. MADRID CITY HALL. 2005. | SPAIN

MADRID TOWN COUNCIL

Project Director

Costal Restoration Projects

- ECOSYSTEM RESTORATION PROJECT IN THE WATERFRONT OF SAN JAUME D'ENVEJA. (TARRAGONA). 2002. | SPAIN

GENERAL DIRECTION OF COASTLINES

Project Director

- ECOSYSTEM RESTORATION PROJECT OF GUARDAMAR-ELCHE DUNES. SECTION: RÍO SEGURA – PLAYA DE LA MARINA. (ALICANTE). 2001-2002. | SPAIN

GENERAL DIRECTION OF COASTLINES

Project Director

- ECOSYSTEM RESTORATION PROJECT OF SA CANOVA DUNES IN ARTÁ (BALEARES). 2000-2001. | SPAIN

GENERAL DIRECTION OF COASTLINES

Project Director

Environmental monitoring

- ENVIRONMENTAL MONITORING OF THE PROJECT OF STORAGE PONDS OF REGENERATED WATER IN BOADILLA DEL MONTE, MADRID. 2012. | SPAIN

GROUP SANTANDER CITY

Project Director

- ENVIRONMENTAL MONITORING OF THE LAKE EXPANSION PROJECT IN SANTANDER GROUP CITY IN BOADILLA DEL MONTE. MADRID. 2012. | SPAIN

GROUP SANTANDER CITY

Project Director

- ENVIRONMENTAL MONITORING OF THE MASTER PLAN OF SANITATION AND WASTEWATER IN THE 100% OF THE MUNICIPALITIES IN THE WESTERN PART OF THE COMMUNITY OF MADRID. 2002-2004. | SPAIN

CANAL DE ISABEL II

Project Director

- ENVIRONMENTAL MONITORING OF THE PROJECT OF NATIONAL ROADS IN DOMINICAN REPUBLIC. 1999. | DOMINICAN REPUBLIC

MINISTRY OF TRANSPORT IN DOMINICAN REPUBLIC

Project Director

Waste

- WASTE MANAGEMENT SYSTEM OF FINANCIAL CAMPUS SCH BANK IN BOADILLA (MADRID). 2002-2003. | SPAIN

GROUP SANTANDER CITY

Project Director

Discharges and Water Quality

- ENVIRONMENTAL ACTION PLAN DISCHARGES IN SPANISH AIRPORTS. 2004-2005. | SPAIN

AENA

Project Director

Due Diligence and Environmental Management

- ENVIRONMENTAL DUE DILIGENCE OF A ROAD PROJECT IN CATALUÑA. ROAD C-15. 2019. | SPAIN

EIX DIAGONAL CONCESSIONARIA DE LA GENERALITAT DE CATALUNYA S.A.

Project Director

- ENVIRONMENTAL DUE DILIGENCE OF AN URBANIZATION PROJECT IN SESEÑA (TOLEDO). 2019. | SPAIN

ARCANO PARTNERS

Project Director

- ENVIRONMENTAL DUE DILIGENCE OF THE HOTEL EXE MONCLOA. MADRID. 2018. | SPAIN

INVESCO

Project Director

- ENVIRONMENTAL DUE DILIGENCE OF THE NAVIOS IRON ORE-TERMINAL NUEVA PALMIRA IN URUGUAY. 2018 | URUGUAY

CORPORACIÓN NAVIOS S.A

Project Director

- ENVIRONMENTAL DUE DILIGENCE OF THE CONGRESS PALACE IN TORREMOLINOS (MÁLAGA). 2017. | SPAIN

INTU

Project Director

- ENVIRONMENTAL DUE DILIGENCE OF AN INDUSTRIAL UNIT IN PAMPLONA. 2016 | SPAIN

COLVER LOGISTIC BETA, S.L.

Project Director

- REVIEW REPORT OF ENVIRONMENTAL IMPACT STUDY AND MITIGATION MEASURES OF RAILWAY PROJECTS. PACKAGES CTW120, CTW130 AND NBL. 2015-2016. | SAUDI ARABIA

SAUDI RAILWAY COMPANY

Project Director

- DUE DILIGENCE OF THE SHOPPING CENTER PLAZA RIO-2. 2015. | SPAIN

BANCO SABADELL

Project Director

- HEALTH, SAFETY AND ENVIRONMENTAL PLAN CONSTRUCTION SUPERVISION CONSULTANCY PACKAGES CTW120, CTW130 AND NBL RAILWAYS PROJECTS. 2014. | SAUDI ARABIA

SAUDI RAILWAY COMPANY

Project Director

- ENVIRONMENTAL TECHNICAL REVIEW OF THE NER 300 ENERGY PROJECT. 2013 FOR THE EIB-COWI CONSORTIUM. 2013. | SPAIN

COWI CONSORTIUM

Project Director

- DUE DILIGENCE OF THE BUILDING OF THE GRANADA UNIVERSITY. ENVIRONMENT AND WASTE MANAGEMENT. 2012. | SPAIN

JICAR-GRANADA

Project Director

- PREPARATION OF HYDROGEOLOGICAL REPORT CONCERNING THE CANTABRIA TECHNOLOGY CENTER FOR SANTANDER GROUP. 2010. | SPAIN

GROUP SANTANDER CITY

Project Director

- REVIEW OF THE TERRITORIAL ACTION PLAN OF THE COAST OF VALENCIA COMMUNITY. 2006. | SPAIN

COMUNITY OF VALENCIA

Project Director

- ENVIRONMENTAL TECHNICAL REVIEW OF THE WATER TREATMENT PROJECT IN THE CABRERA, TORRELAGUNA AND SAN AGUSTÍN DE GUADALIX FOR THE CANAL DE ISABEL II 2006. | SPAIN

CANAL DE ISABEL II

Project Director

- ENVIRONMENTAL TECHNICAL REVIEW OF THE MADRID SUBWAY LINE 9 PROJECT 2005. | SPAIN

METRO DE MADRID

Project Director

- PREPARATION OF ENVIRONMENTAL REPORT CONCERNING THE AFFECTED VEGETATION DUE TO INFRASTRUCTURE WORKS OF MADRID SUBWAY. 2004-2005. |SPAIN

METRO DE MADRID

Project Director

- ENVIRONMENTAL TECHNICAL REVIEW OF THE HYDRAULIC INFRASTRUCTURES PROJECTS IN THE NATIONAL HYDROLOGICAL PLAN FOR ACUAMED. 2004. | SPAIN

ACUAMED

Project Director

- ENVIRONMENTAL TECHNICAL REVIEW OF THE HYDRAULIC PROJECTS IN THE MASTER PLAN OF SANITATION AND WASTEWATER IN THE 100% OF THE MUNICIPALITIES IN THE WESTERN PART OF THE COMMUNITY OF MADRID. 2001. | SPAIN

CANAL DE ISABEL II

Project Director

- PROCESSING OF AID APPLICATIONS TO THE COHESION FUND OF THE EUROPEAN COMMISSION FOR THE CASTILLA-LA MANCHA COMMUNITY. 1999-2000. | SPAIN

COMUNITY OF CASTILLA-LA MANCHA

Project Director

- REPORT ON THE ANALYSIS OF THE ENVIRONMENTAL IMPACTS RESULTING FROM ACCIDENTAL SPILLAGE OF GASOLINE IN THE FIELD OF FRONDA S.A. (MADRID). | SPAIN

FRONDA S.A.

Project Director

- DEVELOPMENT OF AN ENVIRONMENTAL MANAGEMENT GUIDE FOR GOLF COURSES. 1997. | SPAIN

JUNTA DE ANDALUCÍA

Project Director

María Luisa Villalmanzo Sánchez

12.1989
11.1992

Free professional partner for the following companies: Estudios y Proyectos Mineros, Polytechnic University of Madrid, Environment Agency, AMBIOTEC, EPTISA y PICSA.

Most relevant works:

- ENVIRONMENTAL IMPACT STUDIES OF FOUR DAMS IN SPAIN. 1989. | SPAIN

PICSA

Free professional partner. Environmental Expert

- CORRECTIVE MEASURES STUDY APPLICABLE TO IMPACTS CAUSED BY LINEAL INFRASTRUCTURES.1992. | SPAIN

POLITECHNIC UNIVERSITY OF MADRID

Free professional partner. Environmental Expert

- ENVIRONMENTAL IMPACT STUDIES OF 13 ROADS AND HIGHWAYS IN SPAIN. 1989-1992. | SPAIN

AMBIOTEC S.L.

Free professional partner. Environmental Expert

- ENVIRONMENTAL IMPACT STUDIES OF 8 QUARRIES AND RESTORATION PLAN IN CANTABRIA AND GALICIA.1990-1992. | SPAIN

AMBIOTEC S.L.

Free professional partner. Environmental Expert

- ECOSYSTEM RESTORATION. LA MADRE STREAM IN VILLAVICIOSA DE ODÓN, MADRID. 1990. | SPAIN

COMUNITY OF MADRID

Free professional partner. Environmental Expert

- ENVIRONMENT INTEGRATION OF THE CONSTRUCTION PROJECT OF ELCHE SEWAGE. ALICANTE. 1990.. | SPAIN

AMBIOTEC S.L.

Free professional partner. Environmental Expert

- ENVIRONMENTAL AUDIT OF SAN ANTONIO AND Mª ISABEL MINES. CIUDAD REAL. 1992. | SPAIN

ESTUDIOS Y PROYECTOS MINEROS S.A.

Free professional partner. Environmental Expert

María Luisa Villalmanzo Sánchez

PUBLICATIONS AND GIVEN COURSES

"Course on environmental monitoring in the works". Madrid, Spain, December 2005. TYPSA.

"Course on environmental consideration in work specifications". Madrid, Spain, March 2004. TYPSA.

"Course on environmental monitoring in the works". Valencia, Spain 2003.

"Methodology for the formulation and implementation of environmental studies in fragile ecosystems". Tecnoambiente magazine. February 2000.

"Case study in the La Madre stream restoration in Villaviciosa de Odón". Madrid, Spain.

"Case study in environmental impact assessment. Yegüas Dam". Madrid, Spain 1988.

EXPERT ON ENVIRONMENTAL ASSESSMENT & RURAL PLANNING

Marta Muriel Enríquez

PROFILE

Over her 25 years of working experience Mrs. Muriel has developed her professional career in the Environmental Departments of Engineering and Consultancy Firms, working both as project manager and senior consultant in environmental and social assessment procedures, natural resources management and rural and urban planning.

Her main areas of expertise include the development of Environmental Impact Assessment and Mitigation Measures identification and design for projects related to linear infrastructures and energy sector (wind turbines and solar energy plants), both for public and private clients. She has also participated in other diverse environmental projects along its professional experience, as the management of European Funds to develop environmental actions for public administration or the establishment of sewage treatment systems in several villages of the Pyrenees.

UNIVERSITY DEGREE

BACHELOR OF ENVIRONMENTAL SCIENCES (1994-1998)
Autónoma University of Madrid, Spain.
Final Degree project: "Spatial implications of conservations versus development conflict: the case of Special Birds Protection Areas in Madrid":

SPECIALIZED POST-GRADUATE STUDIES ON "RURAL PLANNIG IN RELATION TO THE ENVIRONMENT" (1998-1999).
International Center for Advanced Mediterranean Agronomic Studies (CIHEAM) - Mediterranean Agronomic Institute of Zaragoza (IAMZ). Zaragoza.
Development of Integral Ecoplanning project in a multidisciplinary and international group of students: "Rural Planning and Development of Sierra de Cucalón (Teruel)".

COMPLEMENTARY EDUCATION

Courses

- Seminar on "Rural Innovation and Sustainable Development" held by Group of Geographic and Territorial Studies from Universidad Autónoma de Madrid 1999.
- Course on "Environmental Assessment and Integrated Pollution Prevention and Control Processes". Environmental, Industry, Trade and Development of Gobierno de Aragón, Biologist Official Association, etc. Zaragoza. 2003.
- Seminar on "Touristic marketing Strategies". Cinco Villas Business Association, Ejea de los Caballeros (Zaragoza). 2006.
- Course on "Health and Safety at Construction Site" and "Environmental Management at the Construction Site", IDOM's training, Zaragoza. 2007.
- Seminar week "Land and Water: Regional Planning and Afforestation". Expo Zaragoza. 2008.
- Advanced ArcGIS Course "Analyse tools -3D, Spatial, Network analysis". Zaragoza 2009.
- Advanced course on "Decision support systems for the development and environmental management of rural areas". International Center for Advanced Mediterranean Agronomic Studies (CIHEAM) - Mediterranean Agronomic Institute of Zaragoza (IAMZ). Zaragoza. 2012
- Autocad for Environmental Technicians Course. Instituto Superior del Medio Ambiente. Madrid. 2019.

OTHER KNOWLEDGE

- Microsoft Office: Word, Excel, Access, PowerPoint, Outlook
- Geographic Information Systems (GIS) and drawing: Arcview, ArcGIS, ArcMap, QGis, Grass, Autocad

Marta Muriel Enríquez

LANGUAGES

	Spanish	English	French
Auditive comprehension	Mother tongue	C1	B1
Reading comprehension	Mother tongue	C1	B1
Oral interaction	Mother tongue	C1	A2
Oral expresión	Mother tongue	C1	A2
Written expresión	Mother tongue	C1	B1

PROFESSIONAL CAREER

10.2020
Current

SENIOR CONSULTANT

TYPSA. Spain

Technical collaboration and development of environmental impact assessment reports as well as mitigation measures documents, management of environmental issues, GIS analysis and development of cartographic information and drawings.

01.2015
06.2020

SENIOR CONSULTANT FREELANCE

Peregrin MS & Barbatula Consultoría. Spain

Environmental impact assessment reports, development and analysis of cartographic contents, development of technical documents, environmental tenders on climate change and other related sectors.

08.2007
04.2010

PROJECT MANAGER AND SENIOR CONSULTANT

IDOM, Zaragoza

Technical collaboration and development of environmental impact assessment reports, environmental appendices of different projects, GIS analysis and development of cartographic information and drawings, conducting tenders, attending meetings, commercial activities, and management and control on personnel and budget as project manager.

MAIN PROJECTS

10.2020
Current

Company: TYPSA.

Roads, Linear infrastructures and Development Projects. Environmental Impact Assessment Studies and Projects of Mitigation Measures

- SINGLE AWARD TASK ORDER CONTRACT (SATOC) FOR THE OVERALL INTEGRATION OF THE P-563 PROGRAM. IT INCLUDES FACILITIES AND INFRASTRUCTURE TO SUPPORT THE OVERALL MINISTRY OF DEFENSE TRANSFORMATION INITIATIVES BEING DEVELOPED AS PART OF VISION 2030 IN SAUDI ARABIA. ITS MAJOR ELEMENTS ARE A NEW MILITARY CITY, A NATIONAL DEFENSE UNIVERSITY, AND A NEW JOINT FORCES COMMAND. 2023 | SAUDI ARABIA

US ARMY CORPS OF ENGINEERS (USACE).

Environmental technician. Development of environmental documents for environmental procedure (Scoping Report and EIA Report), as well as carrying out the environmental mitigation measures and the FCEMP Report for the project

- ENVIRONMENTAL IMPACT ASSESSMENT REPORT OF THE POWER TRANSPORT LINE 400 Kv XÁ MUTEBA – SAURIMO AND ASSOCIATED SUBSTATIONS. 2023 | ANGOLA

ELECNOR

Environmental technician. Development of environmental documents for environmental procedure,

- ARCHITECTURAL AND ENGINEERING DESIGN CONSULTANCY SERVICES FOR KING SALMAN PARK PROJECT - PUBLIC COMMUNITY FACILITIES IN PHASES 2 AND 3. 2023 | SAUDI ARABIA

KING SALMAN PARK FOUNDATION

Environmental technician. Carrying out the environmental mitigation measures for the project.

- ENVIRONMENTAL ANALYSIS OF ALTERNATIVES FOR "NEOM-20 THE CUBE ROAD". 2023 | SAUDI ARABIA

NEOM

Environmental technician. Analysis, under environmental criterium, of different alternatives for temporary road to access the Cube and the Staircase Temple.

- "MITIGATION MEASURES REPORT", INCLUDING DRAWINGS AND SPECIFICATIONS IN SCHEMATIC DESIGN, DESIGN DEVELOPMENT AND CONSTRUCTION DOCUMENTATION, "ENVIRONMENTAL HANDBOOK" AND "FCEMP" (FRAMEWORK FOR CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN) IN CONSTRUCTION DOCUMENTATION FOR BID PACKAGE 7, 8, 9, 10 (ENTERTAINMENT DISTRICT +ATHLETICS DISTRICT) FROM THE PHASE 2B OF THE PROJECT "RIYADH SPORTS BOULEVARD". 2020-2023. | SAUDI ARABIA

SPORT BOULEVARD FOUNDATION (SBF)

Environmental technician. Development the environmental mitigation measures document and the FCEMP Report for the project.

- "ENVIRONMENTAL CONSIDERATION REPORT", "SCOPING DOCUMENT" AND "ENVIRONMENTAL IMPACT ASSESSMENT REPORT" (INCLUDING NOISE STUDY) FOR BID PACKAGE 7, 8, 9, 10 (ENTERTAINMENT DISTRICT +ATHLETICS DISTRICT) FROM THE PHASE 2B OF THE PROJECT "RIYADH SPORTS BOULEVARD". IN ADDITION OF OBTAINING THE ENVIRONMENTAL PERMIT TO CONSTRUCT. 2020-2022. | SAUDI ARABIA

SPORT BOULEVARD FOUNDATION (SBF)

Environmental technician. Carrying out environmental documents for environmental procedure.

- "ENVIRONMENTAL CONSIDERATION REPORT", "SCOPING DOCUMENT" AND "ENVIRONMENTAL IMPACT ASSESSMENT REPORT" (INCLUDING NOISE STUDY) FOR BID PACKAGE 6 (URBAN WADI) FROM THE PHASE 2A OF THE PROJECT "RIYADH SPORTS BOULEVARD". IN ADDITION OF OBTAINING THE ENVIRONMENTAL PERMIT TO CONSTRUCT. 2020-2021. | SAUDI ARABIA

SPORT BOULEVARD FOUNDATION (SBF)

Environmental technician. Development of environmental documents for environmental procedure.

- "MITIGATION MEASURES REPORT", INCLUDING DRAWINGS AND SPECIFICATIONS IN SCHEMATIC DESIGN, DESIGN DEVELOPMENT AND CONSTRUCTION DOCUMENTATION, "ENVIRONMENTAL HANDBOOK" AND "FCEMP" (FRAMEWORK FOR CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN) IN CONSTRUCTION DOCUMENTATION FOR BID PACKAGE 6 (URBAN WADI) FROM THE PHASE 2A OF THE PROJECT "RIYADH SPORTS BOULEVARD". 2020-2021. | SAUDI ARABIA

ROYAL COMMISSION FOR RIYADH CITY (RCRC)

Environmental technician. Development the environmental mitigation measures document and the FCEMP Report for the project.

Solar PV Plants and Wind Farms. Environmental Impact Assessment Studies

- ENVIRONMENTAL IMPACT ASSESSMENT REPORT AND SCOPING DOCUMENTS FOR 6 SOLAR POWER PLANTS IN SAUDI ARABIA. 2023-2024. | SAUDI ARABIA

SAUDI POWER PROCUREMENT COMPANY

Environmental technician. Development of environmental documents for environmental procedure.

- ENVIRONMENTAL STUDIES, BIRDS STUDIES, AND ARCHAEOLOGICAL STUDIES OF 2 HYBRID PROJECTS (WIND FARMS AND SOLAR POWER PLANTS) IN SPAIN: REMEDIOS AND SERVITAS. 2022-2023. | SPAIN

RIC ENERGY

Environmental technician. Development of environmental documents for environmental procedure.

- ENVIRONMENTAL STUDIES, BIRDS STUDIES, AND ARCHAEOLOGICAL STUDIES OF 8 SOLAR POWER PLANTS IN SPAIN: ATASCABURRAS, SARRACENO, BUENDÍA, PTOLOMEO, AZORÍN, RIAZOR, SERVITAS AND LIBRICOS. 2022-2023. | SPAIN

RIC ENERGY

Environmental technician. Development of environmental documents for environmental procedure.

- IMPACT ASSESSMENT STUDIES AND SCOPING REPORTS OF 3 SOLAR POWER PLANTS IN SAUDI ARABIA; HASMA, SHARIFA, AND AIRPORT WEST SOLAR POWER PLANTS. IN ADDITION OF OBTAINING THE ENVIRONMENTAL PERMIT TO CONSTRUCT. 2022. | SAUDI ARABIA

NEOM

Environmental technician. Corrections of the environmental documents for environmental procedure.

- INITIAL ENVIRONMENTAL DOCUMENT OF 12 SOLAR POWER PLANTS IN SPAIN: ATASCABURRAS, SARRACENO, ZALAMANDROÑA, BUENDÍA, PTOLOMEO, AZORÍN, LORENZO, CRUZ, FUENTES, RIAZOR, SERVITAS AND LIBRICOS. 2022.. | SPAIN

RIC ENERGY

Environmental technician. Development of environmental documents for environmental procedure.

Ports. Environmental Impact Assessment Studies and Projects of Mitigation Measures

- ENVIRONMENTAL IMPACT ASSESSMENT REPORT OF THE DEVELOPMENT OF UNICARGAS PORT IN LUANDA, ANGOLA. 2023-2004 | ANGOLA

ABU DHABI PORTS GROUP (ADP)

Environmental technician. Development of environmental documents for environmental procedure.

Airports. Environmental Impact Assessment Studies

- ENVIRONMENTAL IMPACT AND MITIGATION MEASURES OF THE PROJECT "PREPARATION OF FOUR ALTERNATIVE CONCEPTUAL DESIGNS FOR THE KING KHALID INTERNATIONAL AIRPORT T5 SOUTH TERMINAL IN RIYADH". SAUDI ARABIA. 2022. | SAUDI ARABIA

RIYADH AIRPORTS COMPANY (RAC)

Environmental technician. Analysis, under environmental criterium, of different alternatives for design of terminal T5 at KKIA.

- "MITIGATION MEASURES REPORT", INCLUDING DRAWINGS AND SPECIFICATIONS AND "FCEMP" (FRAMEWORK FOR CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN) OF THE PROJECT "REHABILITATION OF RUNWAYS AND TAXIWAYS AT KING KHALID INTERNATIONAL AIRPORT IN RIYADH" BELONGING TO THE RIYADH AIRPORTS COMPANY (RAC). SAUDI ARABIA. 2020-2022. | SAUDI ARABIA

RIYADH AIRPORTS COMPANY (RAC)

Environmental technician. Mitigation measures document and FCEMP Report.

PUBLICATIONS

Communication at the Seminar on Rural Innovation and Sustainable Development held by Group of Geographic and Territorial Studies from Autónoma University of Madrid. Poster entitled: "Conflicts in Natural Protected Areas". May 1999.

ENVIRONMENTAL MANAGER

Patricia Rullan de la Mata

PROFILE

More than 18 years of professional experience in technical assessment, project management and business development.

Expert knowledge in

-Environmental Due diligence
-Strategic Environmental Assessment; Environmental Impact Assessment and design of mitigation measures, environmental monitoring of construction sites
-Sustainable land use and planning
-Natural resources management
-Environmental consulting
-Sustainability: Equator Principles, Environmental and Social Safeguards of Multilateral Organizations, Sustainable Development Goals, climate change, , circular economy, etc.

7 years based in Mexico managing the Environmental and Social División for TYPSA in Central America and the Caribbean. Since June 2022, she is head of the environmental and sustainability consultancy and assessment division for TYPSA GROUP.

UNIVERSITY QUALIFICATIONS

BACHELOR OF ENVIRONMENTAL SCIENCES | 2002

Autónoma University of Madrid (Spain)

MASTER´S DEGREE IN PRIVATE ENTERPRISE ENVIRONMENTAL MANAGEMENT | 2002

Superior Studies Institute (ISED), Vic University of Barcelona (Spain)

COMPLEMENTARY TRAINING

- "Solid and groundwater waste treatment". UAM. 1999
- "Environmental follow-up of civil works". TYPSA. 2003
- "Quality and Environmental Assurance Systems". TYPSA. 2003
- "Introduction to Geographical Information Systems (GIS)". TYPSA. 2003"
- "English for International Meetings". Blue Language Consultants. FORCEM. 2004
- "Soil contamination assessment" CIEMAT. 2004
- "Measurement, prediction and control of environmental noise and vibrations. Software and measure equipment novelties." Alava Engineers. 2004
- "Project management". Escuela Superior de Gestión Comercial de Marketing (ESIC). 2005
- "Environmental noise control and assessment". Alava Engineers. 2005
- "First aims in the assessment and evaluation of environmental noise. Development of strategy noise maps". Intevia. 2005

OTHER KNOWLEDGE

- Image treatment: Photoshop, Scanner
- Others: Mapviewer, SPSS, Adobe Acrobat
- Geographical Information Systems (SIG): Arcview

LANGUAGE SKILLS

	Spanish	English	German
Auditive comprehension	Mother tongue	C2	B1
Reading comprehension	Mother tongue	C2	B1
Oral interaction	Mother tongue	C2	A1
Oral expression	Mother tongue	C2	A1
Written expression	Mother tongue	C2	A1

ENVIRONMENTAL MANAGER

Patricia Rullan de la Mata

CAREER DETAILS

JUNE 2022 – June 2023

TYPSA GROUP

- **HEAD OF ENVIRONMENT CONSULTANCY AND ASSESSMENT**

Functions: (i) Team Lead and coordination of experts for consultancy and E&S assessment to infrastructure projects (ii) Contract management and technical advice. (iii) Business development worldwide (iv) Management of sustainability team.

JUNE 2015 – June 2022

TYPSA. MEXICO

- **MANAGER OF ENVIRONMENT AND SOCIAL DIVISION OF MEXTYPSA.**

Functions: Team management for Technical Assistance and Supervision of environmental and social projects. Business opportunity development in the Mexican market.

- **BUSINESS DEVELOPMENT MANAGER E&S CONSULTANCY FOR TYPSA IN CENTRAL AMERICA AND THE CARIBBEAN**

Functions: (i) Business opportunities identification, profitability analysis, financing alternatives, national and international partners search, negotiation and draft of collaboration agreements; (ii) commercial strategy: market analysis, strategic planning, commercial intelligence, commercial prospecting, national and international exhibitions and events; (iii) national and international tendering: tenders identification, technical and economic proposals drafting and coordination, bid strategy; (iv) design and execution of projects funded by multilateral funds for the public and private sector (WB, IADB, AFD, BCIE, EU, ..)

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OCT. 2002 – MAY. 2012

TECNOMA, S.A. (TYPSA GROUP). SPAIN

- **PROJECT MANAGER IN THE ENVIRONMENTAL CONSULTANCY DIVISION.**

Management of different projects in the fields of environmental impact assessment, environmental assets integration, waste management, feasibility studies, soil contamination, climate change as well as development of bidding and commercial work.

MAIN PROJECTS

2002 –2012

- Environmental impact study of the Ebro water transfer infrastructure (Spanish Hydrological Plan, Section 5 – Almería Province).
- Development of the Environmental Conceptual Model of the "Albufera de Valencia" Wetland and Ramsar
- Study on the alternatives for pig manure treatment.
- Due diligence of a plot located at the industrial state of Coslada
- Project manager of soil contamination assessment at plot number 7, in Vigo´s Technological Park.
- Environmental assessment for the construction project of Section 4 (Olérdola-Calafell) of the Ebro water transfer (Spanish Hydrological Plan)
- Environmental assessment for Madrid´s General Urbanistic Plan (1997) in the Cabestreros Plaza (Lavapiés)

- Study of the environmental solutions for the hydrological plan of Pozas´ Ravine (Calatayud, Zaragoza)
- Environmental mitigation measures for the rural road "Vereda del Pujal" construction project (Huesca).
- Environmental assessment of the new railway access of Levante construction project, from Novelda to Monforte del Cid.
- Environmental report for the construction of several Carrefour shopping centers in the spanish territory (Galice, Madrid, Extremadura, Ciudad Real..)
- Project manager of the environmental report on the Loeches special urbanistic plan (including an individual study of plots number 5, 7 and 10)
- Assessment report on groundwater and wastewater sampling and analysis performed at Degussa factory (Sant Celoni, Barcelona)
- Environmental Impact Study and mitigating measures for the Madrid underground line number 3, Madrid – Villaverde section, enlargement project
- Master Plan of the noise protection study of the residential state "Nuevo Zuasti"(Basque country)
- Noise assessment of the railway line between Valencia and Tarragona (Oropesa-Alcanar) project
- Environmental integration project of the Ezkio Itxaso- Beasain railway platform (Basque country)
- Study of the acoustic protection measures in the Puerta de Atocha railway station (Madrid)
- Contamination assessment (Phase I) of a plot located at Madrid Avenue number 25, in Arganda (Madrid)
- Environmental report on the Tres Cantos special urbanistic plan.
- Technical Assistance for the environmental impact study of the highway planned to be constructed between Badajoz and Espiel (Cordoba).
- Development of the Strategic noise maps for Castellon Province Highways and Roads managed by the State Government (110 km.) The project includes the assessment for the development of strategy plans, in order to prevent noise in residential areas.
- Plovdiv – Svilengrad Railway Electrification & Upgrading of Corridors IV & IX, Technical Assistance for the Supervision of the Works for the Whole Line, at the Republic of Bulgaria (EuropeAid/117011/D/SV/BG)
- Technical Assistance for the environmental impact study of the M-61 highway (Madrid).

2015 – 2022

Project and team management. Some projects developed under this management:

- Environmental feasibility studies of solar plants in Sonora, Guanajuato, San Luis Potosi, Aguascalientes, Baja California, Chihuahua and Zacatecas
- Environmental Impact study for the Solar Plant "Kanasin 90" (30MW) in Yucatan
- Development and implementation of the Restoration Plan for the Coahuila AICA
- Environmental Impact Study for the Wind Farm Ingenio, Oaxaca
- Development of the programs required for the compliance with Semarnat's Resolution for the Ventana Madin project (Atizapán de Zaragoza)
- Environmental Impact Studies for several roads in Mexico such as:
- Querétaro – San Luis Potosí
- Jala- Compostela
- Torreón – Saltillo – Monterrey
- Texcoco – Zacatepec
- Atizapán – Atlacomulco
- Development of Environmental Evaluation Studies for the project interconnection CA-09 Norte- CA-01 Oriente road in Guatemala
- Environmental Impact Study of a Solar Plant in Abasolo (Guanajuato)
- "Development of Design and Guidelines, and Capacity-Building for the Adoption of Ecosystem-Based Solutions to Protect Infrastructure Assets in Haiti"

2022 – 2023

Project and team management as well as business development. Projects developed under this management:

- Mitigation measures report, including drawings and specifications and "FCEMP" (Framework for Construction Environmental Management Plan) of the "Rehabilitation of runways and taxiways at King Khalid International Airport in Riyadh", Riyadh Airports Company (RAC). Saudi Arabia.
- Technical Assistance to the EU´s NDC (Nationally Determined Contributions) Facility. Global. EU. DG INTPA
- Technical Assistance to FONPLATA Regional Loan. 08/2019. Bolivia, Argentina, Brazil, Uruguay y Paraguay. EIB / FONPLATA
- Technical Assistance to the program to support the reform of public administration and finance and the mobilization of internal resources. Dominican Republic EU-Ministry of Finance
- Project appraisal support and capacity building for final beneficiaries for post-earthquake reconstruction framework loan (PER III). Ecuador EIB / Ecuador Government
- Environmental Impact and mitigation measures of the "Preparation of four alternative conceptual designs for the King Khalid International Airport T5 south terminal in Riyadh" project. Saudi Arabia.
- Initial environmental document of 12 solar power plants in Spain: Atascaburras, Sarraceno, Zalamandroña, Buendía, Ptolomeo, Azorín, Lorenzo, Cruz, Fuentes, Riazor, Servitas and Libricos. Spain
- Environmental impact assessment studies and scoping reports of 3 solar power plants in Saudi Arabia; Hasma, Sharifa, and Airport West solar power plants. in addition to obtaining the environmental permit to construct
- Environmental studies, bird studies, and archaeological studies of 2 hybrid projects (wind farms and solar power plants) in Spain: Remedios and Servitas.
- Scoping report and Environmental Impact Assessment study of the As Sadawi solar power plant in Saudi.
- Climate resilience assessment for the Costa Verde hospital (Panama) Bid Invest
- Xochi corridor climate resilience assessment (Guatemala). Bid Invest
- Oxagon village – midscale hotel/ NEOM brand. Concept design 3a, 3b interior design & tender documents (300-key midscale hotel). Saudi Arabia
- Technical assistance for the environmental management of construction works on lines subject to EIA, assigned to Adif.

CLIMATE CHANGE AND ENVIRONMENTAL SPECIALIST

NURIA MESONERO PICAZO

PROFILE

With more than 20 years of professional experience, Mrs. Mesonero is an environmental expert specialized in the environmental management projects of waste, environmental impact studies on issues of noise impact on landfill issues in soil contamination and consulting sustainability (climate change, sustainability reports strategic plans, environmental permits integrated strategic environmental assessments, etc.). For more than 8 years, Mrs. Mesonero has occupied the position of project manager and senior consultant for both national and international projects related to the environment management and climate change mitigation and adaptation, successfully achieving the technical and managerial tasks.

UNIVERSITY DEGREE

BACHELOR'S DEGREE IN ENVIRONMENTAL SCIENCES | 1997 - 2001

University Autonoma of Madrid

MASTER'S IN ENVIRONMENTAL ENGINEERING AND MANAGEMENT | 2002

EOI Escuela de Negocios

COMPLEMENTARY EDUCATION

- Qualification of Internal Auditors of the TYPSA Group's QHSE Management System (Quality ISO 9001:2015 and Environment ISO 14001:2015)
- Diploma in Regional Climate Finance, IEESFORD running (132h) (May to August 2014)
- Basics Module on Climate Change Institute Global Sustainability (5 hours) (October 2013)
- Module Methodologies and Mitigation Measures Gas Greenhouse (20 hours), Global Institute for Sustainability (October 2013)
- Module Development of State Program of Action on Climate (15 hours), Global Change Institute for Sustainability (October 2013)
- Course of Business and Climate Change. TECNIBERIA (March-April 2010)
- Tutored Workshop Environmental Responsibility, Chamber of Commerce of Madrid (October 2009-May 2010)
- Course of Business and Climate Change, Tecniberia (March-April 2010)
- II Workshop on Environmental Liability. Hall of CSIC (June 2009)
- Implementation of the Regulations on Environmental Responsibility in business, Chamber of Madrid (June 2009)
- Environmental Objectives PNIR Day 2008-2015, contribution of different management systems in compliance, AIM (May 2009)
- Conference between PNIR and the new directive "Keys to sustainable waste management", ISR (March 2009)
- Seminar on Heritage, Landscape Planning and Sustainability, University of Alcalá de Henares (November 2008).
- Course Management Skills and Leadership. Done in ESIC offices. (16 hours) (May 2008)
- Online Conference on the UNE 150008. Identification and Environmental Risk Assessment. (February 2008)
- Course on "Environmental Liability Law and Environmental Risk Management." On Line. CROEM. (4-26 December 2007)
- Course on "Projects." Offices held in CAS TRAINING (30 hours) (January 2006)
- Course on "Internal Auditing Environmental Management Systems." Offices held in Soluziona (40 hours) (April 2005).
- Course on Environmental Management Systems and Methodology and 5. Environmental Qualifiers mode. "Done in a on-line via the Virtual Classroom service of the Environment Foundation (April-June 2004).
- Course on Project Management. Win Project. " Done in point is (May 2004).
- Course "ARC-GIS Basic Level." Held in the General Foundation of the Universidad Complutense de Madrid (April 2004).
- Course "Environmental Criteria for Design of Cities." Made in TYPSA Group Headquarters (January 2004)
- Course Electronic Edition on CD-ROM and DVD projects. " Made in TYPSA Group Headquarters (October 2003)

OTHER KNOWLEDGE

- Microsoft Office: Word, Excel, Access, PowerPoint, Project
- Image processing: Photoshop, Scanner, Mapviewer, Surfer
- Geographic Information Systems (GIS): ArcView, ArcGIS.
- Models of atmospheric diffusion of pollutants: SCREEN
- Models of aqueous diffusion of pollutants: CORMIX
- Mathematical Software: Matlab

LANGUAGE SKILLS

	Spanish	English
Auditive comprehension	Native	B2
Reading comprehension	Native	B2
Oral interaction	Native	B2
Oral expresion	Native	B2
Written expresion	Native	B2

NURIA MESONERO PICAZO

PROFESIONAL CAREER

2014 – TO DATE

- **Section Coordinator of Climate Change and Sustainability Division within the Environmental Consulting DG Environment and Energy.**

TYPSA. Spain

Manage projects such as project manager, project collaboration and environmental impact assessment, climate change, waste management, contaminated soil and sustainability consulting, conducting tenders, commercial work, etc

APRIL 2003 – DECEMBER 2013

- **Project Manager Environmental Consulting. Coordinator of trade issues in the private sector. Dealing with matters of the company training.**

TECNOMA S.A. SPAIN

Managing several projects as project manager and project collaboration in environmental impact assessment, waste management, landfill, contaminated soil and sustainability consulting, conducting tenders, commercial activities, etc.

FEBRUARY 2003 – APRIL 2003

- **Environmental Technician**

ADEAC (Association of Environmental and Consumer Education). Spain

Conducting the National Blue Flag Campaign 2003.

MAIN PROJECTS

2014 – TO DATE

- Technical Coordinator of the Technical Assistance to the Commission European for the implementation of the International Programme EUROCLIMA (European Commission, EuropeAid, 36 months). November 2010-April 2014.
- Technical Coordinator of the Technical Assistance to the Commission European for the implementation of the International Programme EUROCLIMA (European Commission, EuropeAid, 36 months). initiation in March 2014- June 2017.
- HUECO Project, Tecniberia (Foundation funds Biodiversity) (12 months). 2014
- Preparation of the Information and Awareness Program within the Framework Plan for Prevention and Waste Management of the Municipality of Madrid for the period 2017-2022. 2017
- Feasibility study for the creation of the "City of Recycling" in the vicinity of the Valdemingómez Technology Park. Customer City Council of Madrid. 2016
- ROADBIM project (CDTI funds). (24 months). 2016 – 2019
- Mitigation and adaptation to climate change of the extension project of line 1 of the metro from Sevilla to Alcalá de Guadaíra. Junta de Andalucía. February 2019
- Carbon footprint calculation of Feasibility study for the renewal of the Belabo railway line and Ngaoundéré in Cameroon. March 2019
- Integration of climate change in the Environmental Impact Assessment of Feasibility Study with Detail Design and Tender Document Preparation for Construction of Rail Line from Bhanga to Payra, via Barisal, Bangladesh Railway. 2018-2019.
- Technical Due Diligence – Sao Rafael Suites Hotel in Albufeira, Portugal (2020)
- Technical Due Diligence – Sao Rafael Atlantico Hotel in Albufeira, Portugal (2020)
- Sustainability_Framework Riyadh Sport Boulevard. Riyadh. Saudi Arabia (CR/MLR) 2020

APRIL 2003 – DECEMBER 2013

- Technical Assistance for the implementation of the Environmental Impact Assessment study of a project for a photovoltaic solar plant in Lorca (Murcia): "Lorca Solar PV". Spain 2020
- Technical Assistance for the implementation of the Environmental Impact Assessment study of a project for a photovoltaic solar plant in Guadalajara and Madrid: "Aura Solar". Spain 2020
- Intra ACP Climate Change Services. Multicountry, 2021- on going.
- Environmental Due Diligence and Sustainability Master Plan of 4 shoping centres Carrefour in Madrid (Spain) 2022- 2023
- Mitigation and adaptation to climate change of the Line 3 Sevilla Metro. Junta de Andalucía. 2020 - On going
- Technical support for the identification of climate risks, vulnerability to climate change and adaptation and resilience measures for the Hospital Costa Verde. 2023. Panamá. BID
- Technical support for the identification of climate risks, vulnerability to climate change and adaptation and resilience measures for the Xochi. 2023. Guatemala. BID
- Climate vulnerability and risk study for the master plan project for the Panama Canal Authority (ACP). 2023. Panamá
- Climate vulnerability and risk assessment with adaptation measures and cost-benefit analysis of the thuan bac solar plant. 2023. EDPR Vietnam

Identification of climate risks, vulnerability to climate change and development of a catalogue of adaptation measures for the ABERTIS group. 2023-2024 | Spain

- Acoustic Study of the proposed construction of the motorway A-66 Plate. N-630 from Gijón to Seville. Section: Sorihuela - Béjar. Client: TYPSA. 2003
- Study of the Impact of Sustainable Development Policy for the Training and Employment. Client: EOI (Escuela de Organización Industrial). 2003
- Sustainable Development Analysis of the Albufera of Valencia. Client: TYPSA Valencia. 2003-2004
- Technical Assistance for the Treatment of Environmental Impact Studies and Integrated Environmental Authorizations of livestock farms. Client: INAG 2004
- Technical Assistance for the Preparation of an Environmental Action Plan Release into Spanish airports. Client: AENA 2004-2005
- Study to assess the potential soil contamination in the parcel of DEMAG (Polígono Industrial de Coslada). Client: LAR 2004 GROSVENOR Minimizing Implementation Plan in plants of the Directorate General Chemistry 2004 Repsol YPF
- Study to assess the potential soil contamination in the parcel of SAARGUMMI (Arganda). Client: LAR 2005 GROSVENOR
- Integrated Environmental Clearance, Environmental Impact Study, Progress Report Soil and Phases I and II (analytical information) Decommissioning Plan, Study Plan Noise and Hazardous Waste Minimization. Customer: (CEBIS) 2006-2007
- Study of compatibility of industrial uses in urban planning in the area of Lutxana. Client: Ayuntamiento de Barakaldo. 2005.
- Audit of Implementation of Projects on Waste Management in Madrid 2001 Group 2 Approved by the Decision of the European Commission and financed by the Cohesion Fund. 2005 Client: City of Madrid.2005
- Development of Environmental Management Plans for the maintenance and operation of urban roads M-30.Cliente: SACYR. 2005
- Determination of PCI MSW and RDF samples of plants of "Las Lomas" and "La Paloma" in the Technology Park Valdemingómez. City Hall of Madrid. 2005
- Development of Strategic Environmental Assessment Strategic Development Plan of the Region of Murcia 2007-2013. Client: Red2Red. 2005-2006
- Develop Traceability Audits Agents Involved in the Activities of Recovery and Recovery of Packaging and Packaging Waste. Client: ECOEMBES. 2006-2010
- Developing a Guide for Municipal Waste Management and street cleaning. FEMP client. 2006
- Start-up, processing and tracking of two procedures of Integrated Environmental Authorisation Application (Torrelavega and Zaragoza). Client: AIR LIQUIDE 2006
- Development of 20 Reports Preliminary Status of Soil throughout Spain. AIR LIQUIDE. 2006- 2007

- Preparation of Preliminary Report for Soil and land Analytical Characterization of Complex Industrial de Alcobendas. Client: LILLY. LABORATORIES, SA 2007
- Development of Strategic Environmental Assessment of the Operational Programmes and Asturias Murcia EAFRD. Client: Red2Red. 2006-2007
- Development of Strategic Environmental Assessment of the ERDF in Murcia, Asturias and Navarra. Client: Red2Red. 2006-2007.
- Preparation of Environmental Reports ERDF OPs Castilla y León, Galicia, La Rioja, Catalonia and Ceuta. Client: Ministry of Economy and Finance. 2007
- Preparation of Environmental Sustainability Analysis, Planning and Landscape Impact of a Partial Plan Cambre. Client: Echevarria Promotions, Inc. 2007
- Preliminary Assessment Report of Soils for the Provinces of Avila, Salamanca and Zamora. Cliente: JUNTA DE CASTILLA Y LEON. 2007-2008
- Analysis Report and Explosive Oxidizing properties of a solid waste. Client: CALLE 30. 2008
- Development of a Sound Level Study of the External Environment Factory Air Liquide in Guadalajara. Client: Air Liquide. 2008

- Development of a comparative study of Act 11/97 on packaging and packaging waste and the draft bill to amend it. Client: ECOEMBES. 2008-2009
- Development of a Guide to Environmental Projects likely to be subject to grant the City of Madrid. Client: Ayuntamiento de Madrid. 2008-2009.
- Technical assistance for the development of the Observatory of Sustainability of the City of Madrid. Client: Ayuntamiento de Madrid, 2008.
- Report supra The Local Government and Climate Change. Client: FEMP, 2008-2009
- Technical assistance for the promotion and attraction of foreign investments in environmental issues. Client: Invest in Spain (Ministry of Industry, Tourism and Trade), from 2009 to 2011
- Developing a summary report on a plot of Paracuellos de Jarama. Client: COASTAL, Inc. 2009
- Study of Life Cycle Assessment for equipment and providers of AENA. Carbon Footprint calculation. 2009-2010
- Developing an Action Plan for Sustainable Energy in Local Government. FEMP. Underway
- Technical Assistance to the European Commission for the implementation of the International EUrocLIMA (European Commission, EuropeAid, 30 months). Running

OTHER MERITS

- Member of the Working Group of Databases of Carbon Footprint of the Institute with Presidency of the Spanish Office of Climate Change and Secretariat of the Institute of Construction Sciences Eduardo Torroja. (2014 to present
- Member Working Group on Climate Change Tecniberia
- Member of the Working Group on Sustainable Consumption Spanish Technological Platform on Environmental Technologies (March 2009-present)

Juan Carlos I, Rey de España

y en su nombre el

Rector de la Universidad Autónoma de Madrid

UAM
UNIVERSIDAD AUTONOMA DE MADRID

Considerando que, conforme a las disposiciones y circunstancias prevenidas por la legislación vigente,

Doña Nuria Mesonero Picazo

nacida el día 3 de septiembre de 1979 en Madrid, de nacionalidad española,

ha superado los estudios universitarios correspondientes organizados por la Facultad de Ciencias, conforme a un plan de estudios homologado por el Consejo de Universidades, expide el presente título universitario oficial de

Licenciada en Ciencias Ambientales

con validez en todo el territorio nacional, que faculta a la interesada para disfrutar los derechos que a este título otorgan las disposiciones vigentes.

Dado en Madrid, a 13 de septiembre de 2001

La interesada, | *El Rector,* | *La Jefa del Área de Títulos,*

RAÚL VILLAR LÁZARO | Mª ÁNGELES ÁLVAREZ OCHANDO

Registro Nacional de Títulos	Código de CENTRO	Registro Universitario de Títulos
2002/108396	28027060	000065153

I-BB-680846

CERTIFICADO DE CORRESPONDENCIA

De acuerdo con el artículo 27.2 del *Real Decreto 967/2014, de 21 de noviembre*, y de conformidad con el Acuerdo de Consejo de Ministros de 04-09-2015, publicado por Resolución de 14-09-2015 de la Dirección General de Política Universitaria (BOE 02-10-2015), la Subdirectora General de Títulos

CERTIFICA:

Que al título de **Licenciado en Ciencias Ambientales** obtenido por NURIA MESONERO PICAZO con NIF 03251988H e inscrito en el Registro Nacional de Titulados Universitarios Oficiales con número 2002108396, le corresponde el nivel **3 (Máster)** del Marco Español de Cualificaciones para la Educación Superior (**MECES**) y el nivel **7**, del Marco Europeo de Cualificaciones (**EQF**).

Lo que se certifica en Madrid, a 6 de junio de 2017

La autenticidad de este documento se puede comprobar en https://sede.educacion.gob.es/cid/ mediante el código seguro de verificación (csv).

Unofficial translation

CERTIFICATE OF CORRESPONDENCE

According to Article 27.2 of Royal Decree 967/2014, of 21 November, and in accordance with the Cabinet Agreement of 04-09-2015 published by Resolution of 14-09-2015 of the Directorate-General of University Policy (BOE 02-10-2015), the Deputy Directorate-General

CERTIFIES:

*That the degree of **Licenciado en Ciencias Ambientales** obtained by NURIA MESONERO PICAZO with ID 03251988H and listed in the National Register of Official University Graduates with number 2002108396, has been placed within level **3 (Máster)** of the Spanish Higher Education Qualifications Framework (**MECES**) and level **7**, of the European Qualifications Framework (**EQF**).*

csv: 258755928378845633843575

SUSTAINABILITY STRATEGY

Divyangi Singh

PROFILE

The nature of Divyangi's academic and work experiences, which have complemented engineering with business, have allowed for the development of multi-faceted analytical, quantitative, problem-solving, and decision-making capabilities. One of the aspects in which she has particularly developed her capability is in concepts related to sustainability, climate change, resilience, costs, and environmental justice issues. Divyangi gained her dual Master's degree at the Stockholm School of Economics and Sciences Po, Paris, with a thesis on the green-technology innovation ecosystem in Sweden, assessing roles in creating value in the ecosystem by transforming and supporting new technologies and ventures into reality through access and financial investment.

UNIVERSITY QUALIFICATIONS

Bachelor of Technology, Mechanical Engineering (2019).
Shiv Nadar University, Greater Noida (India)

MSc. in Business and Management (dual-degree, 2022)
Stockholm School of Economics (Handelshögskolan i Stockholm) (Sweden)
Master in International Management and Sustainability (dual-degree, 2022)
Sciences Po, Paris (France)

ADDITIONAL QUALIFICATIONS AND COURSES

Courses:

- Python Foundation Nanodegree, Udacity (2018)

Conferences and workshops

- Attendance and presentation at the International Conference on Mechanical Engineering Design (ICMechD). Chennai, India (2019).

OTHER SKILLS

- Microsoft Office
- Computer-aided design software: AutoCAD
- Programming languages: Python, R, MATLAB
- Power BI (basic)

LANGUAGES

	Hindi	English	French
Listening	Mother tongue	C2	A2
Reading	Mother tongue	C2	B1
Spoken interaction	Mother tongue	C2	A2
Spoken production	Mother tongue	C2	A2
Writing	Mother tongue	C2	B1

Divyangi Singh

CAREER DETAILS

04.2022
Current

PROJECT ENGINEER

TYPSA AB. Sweden

Support the formulation of strategy and planning for infrastructure projects' sustainability, decarbonization, ESG, resource conservation aspects.
Conduct research into a variety of sustainability, decarbonization, resilience topics (e.g., materials and technology, communities).
Contribute to project deliverables including presentations and reports.

07.2021
08.2021

BUSINESS DEVELOPMENT INTERN

RAIL.ONE. Germany

Developed sales presentations for the urban transit business segment.
Formulated templates and informative material for the company-wide sales application.

06.2020
08.2020

BUSINESS INTELLIGENCE AND PRODUCT MARKETING INTERN

PANDROL. France

Analyzed and consolidated internal data for development of a new Customer Relationship Management (CRM) software.
Supported preparation of several product launches.
Designed product marketing presentations.
Collected and evaluated data on key markets.
Developed market-size estimation frameworks for key product lines, assembling territory-wise data on usage patterns.

09.2019
04.2020

SUSTAINABILITY CONSULTANT

CMA-CGM. France

Analysis and proposition for integration of CMA-CGM's CSR strategy with objectives of recently acquired firm CEVA Logistics.
Analyzed CEVA Logistics CSR efforts, identifying opportunities and areas for improvement.
Benchmarked CEVA CSR operations with those of direct competitors.
Formulated action plans for integration of CSR efforts, with a focus on KPIs, legal requirements and certifications for sustainability efforts.

06.2018
08.2018

TECHNOLOGY INTERN

GREYORANGE. India

Carried out an appraisal of company's processes and systems.
Devised a plan for implementing augmented reality-based platforms within different areas - service and support, research & development, sales & marketing.

Divyangi Singh

MAIN PROJECTS

10.2019
05.2020

PROJECTS AT SCIENCES PO, PARIS | France

HUMAN DEVELOPMENT RESEARCH INITIATIVE

Human Development Research Initiative is a think tank run by Sciences Po students. As a member of the Environment, Climate Change & Energy Research Team, contributed to research papers and advocacy initiatives, spanning subjects from energy infrastructure to agri-food industry.

03.2017
01.2018

PROJECTS DEVELOPED AT SHIV NADAR UNIVERSITY | India

ENDURO STUDENT INDIA 2018. All-Terrain Vehicle Manufacturing Team

Main activities and responsibilities:

- Formulated and fashioned sponsorship proposal.
- Executed cost analyses and composed cost and budget reports.
- Procured financing from corporate sponsors; doubled financing amount as compared to previous editions.
- Administered Failure Modes and Effects Analysis (FMEA) for all vehicle subsystems.
- Design, manufacture and assembly of suspension and steering assembly, in collaboration with sub-team.

PUBLICATIONS

Articles

Santhakumar, N., Singh, D., &; Jagadish, V. (2020). Investigating the route to flutter in a pitch–plunge airfoil subjected to combined flow fluctuations. Lecture Notes in Mechanical Engineering, 369–378, 2020, Elsevier.

Singh, D. (2019). The New Energy Paradigms: Advancing Distributed Energy Solutions. Paris; Human Development Research Initiative, Sciences Po.

Presentations at Conferences

Santalum N; Singh D; Venkatramani J. Investigating the Route to Flutter in a Pitch–Plunge Airfoil Subjected to Combined Flow Fluctuations, International Conference on Mechanical Engineering Design (ICMechD 2019), Chennai (India).

EXPERT IN ENVIRONMENTAL ASSESSMENT AND NATURAL ENVIRONMENT. TECHNICIAN RESPONSIBLE FOR ACTIVITY

Raúl Moral Fernández

PROFILE

Throughout his professional career, Mr. Moral has been involved in numerous environmental projects.

These projects have provided him with experience in the field of Environmental Impact Assessment, definition of preventive, corrective and compensatory measures, management of natural resources, ecological restoration, studies and management plans for the Natura 2000 Network, environmental monitoring in construction works and environmental certification.

He has experience in handling GIS and design tools for their application in environmental management.

UNIVERSITY QUALIFICATION

Degree in Environmental Engineering (2021)

Polytechnic University of Madrid. Spain

COMPLEMENTARY TRAINING

Courses

- Envision Sustainability Professional (2022). Institute for Sustainable Infrastructure (30 hours)
- Athens Course: Non-contact techinques for material testing (2019). Technical University of Munich (30 hours)
- Sustainable Development Goals (SDGs) (2023). PHAROS Structuralia (40 hours)

Conferences and workshops

- Cycle of conferences Urban Forest Management (12 hours). Polytechnic University of Madrid (2018)
- Environmental assessment of irrigation works (5 hours). MAPA (2021)
- Workshop. Implementing Nature-based Solutions: Disaster and Climate Resilience for Business (5 hours) (2021)

OTHER EXPERTISE

Professional level user of:

- Microsoft Office: Word, Excel y Power Point
- Geographic Information Systems (GIS): ArcMap and QGIS
- Official map viewers

User level of:

- CAD Tools: AutoCAD and BricsCAD
- Development environments: RStudio
- Hydrology Softwares: HEC-RAS
- Measurement and Budgeting Programmes: PRESTO

LANGUAGES

	Spanish	English
Auditive comprehension	Mother tongue	C1+
Reading comprehension	Mother tongue	C1+
Oral interaction	Mother tongue	C1+
Oral expression	Mother tongue	C1+
Written expression	Mother tongue	C1+

EXPERT IN ENVIRONMENTAL ASSESSMENT AND NATURAL ENVIRONMENT. TECHNICIAN RESPONSIBLE FOR ACTIVITY

Raúl Moral Fernández

PROFESSIONAL CAREER

12.2020
Current

- **TECHNICIAN RESPONSIBLE FOR ACTIVITY IN THE DIVISION OF SUSTAINABILITY AND ENVIRONMENTAL ASSESSMENT**

TYPSA. Spain

Environmental Impact Assessments, Natura 2000 Network studies, projects for preventive, corrective and compensatory measures, natural resource conservation projects, Environmental Due Diligence and Environmental Integration Annexes for Construction Projects. Environmental projects at national and international level. Environmental certification of projects (ENVISION), responsible for the environmental coordination of projects and processing of GIS cartography.

12.2019
12.2020

- **INTERNSHIP IN THE ENVIRONMENTAL ASSESSMENT DIVISION**

TYPSA. Spain

Collaboration in environmental projects: Environmental Impact Assessments, studies of the Natura 2000 Network, projects for preventive, corrective and compensatory measures, natural resource conservation projects, Environmental Due Diligence and Environmental Integration Annexes for Construction Projects. Environmental projects at national and international level.

Raúl Moral Fernández

MAIN PROJECTS

12.2019
Current

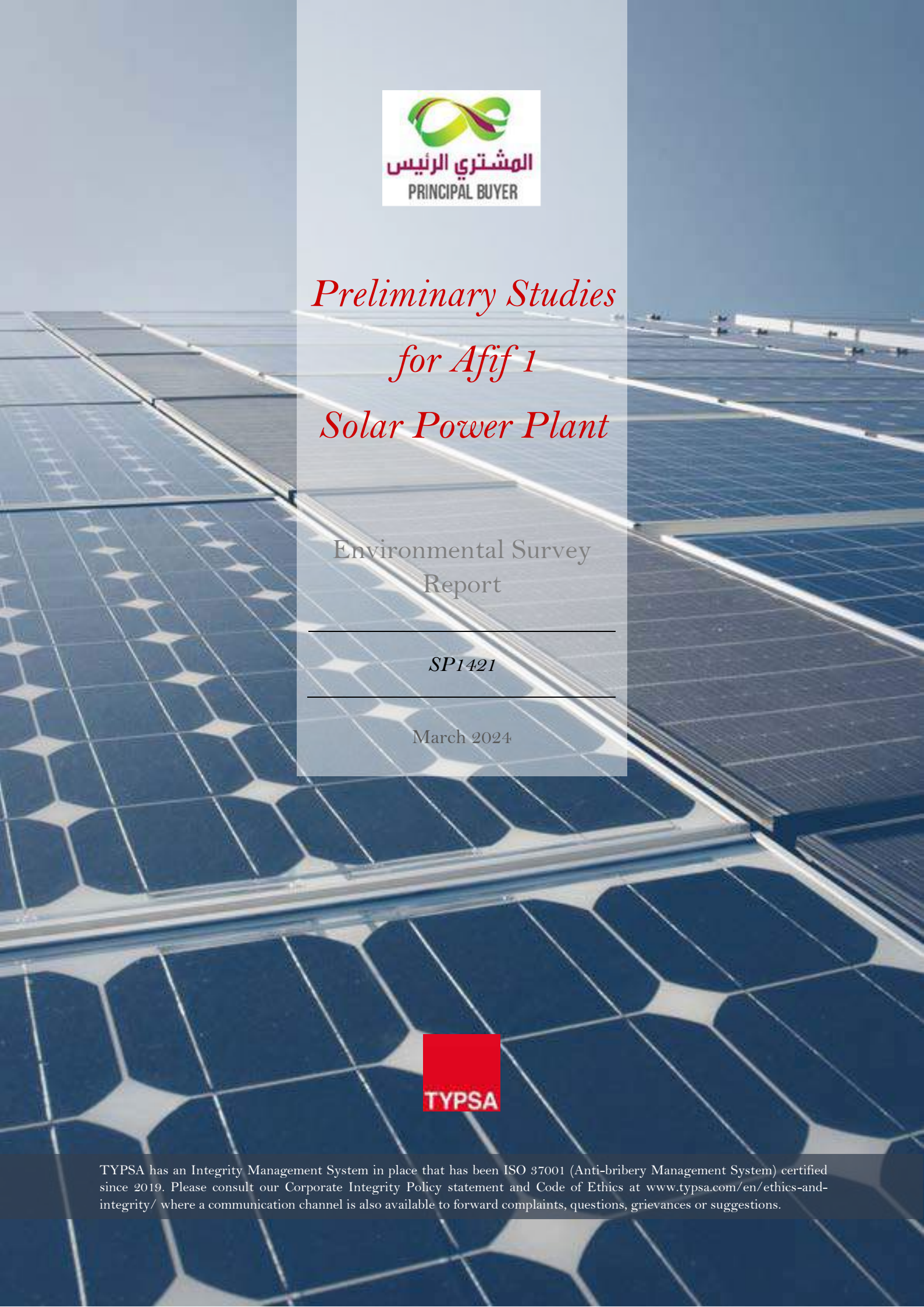
Company: TYPSA Group.
The main projects in which he has carried out his duties are:

- Preparation of the Environmental Document for the A-5 underground project in Madrid. Field work (forest inventory) and office work. 2019
- Preparation of the Preliminary Audit Due Diligence reports for the Sao Rafael Suites Hotel and Sao Rafael Atlantico Hotel in Albufeira, Portugal. 2019
- Collaboration in the Environmental Impact Assessment of the construction project of a house on the island of Ibiza, Balearic Islands, Spain. Analysis and assessment of the habitats of the Natura 2000 network. 2019
- Collaboration in the CEMP (Construction Environmental Management Plan) of three Bid Packages (BP1A Wadi Hanifah zone A, BP1B Wadi Hanifah zone B and PB2 Promenade) of Phase 1 of the project "Riyadh Sports Boulevard" belonging to the Royal Commission for Riyadh City (Saudi Arabia). 2019-2021
- Collaboration in the "Environmental Impact Assessment Report" (including noise study) of Bid Package 6 (Urban Wadi) of Phase 2A of the project "Riyadh Sports Boulevard" belonging to the Royal Commission for Riyadh City (Saudi Arabia). 2020-2022
- Collaboration in the "Environmental Consideration Report" and "Scoping Document" (including noise study) of Bid Packages 7, 8, 9, 10 (Entertainment District +Athletics District) of Phase 2B of the project "Riyadh Sports Boulevard" belonging to the Royal Commission for Riyadh City (Saudi Arabia). 2020-2022
- Expansion of T4 and T4S Madrid-Barajas. Preparation of environmental procedure documents, preparation of the project's Environmental Integration Annex and field work to determine surface soil contamination. 2019-2022
- Somport railway tunnel. Preparation of inventory and environmental project document. 2020
- Analysis of environmental conditioning factors for the implementation of 8 PV Plants hybridising 6 WP in Portuguese territory. Technician responsible for the activity. Developer: Finerge. 2022
- Participation in preliminary studies for 6 PV Plants in Saudi Arabia. Client: Saudi Power Procurement Company (Principal Buyer) SPPC. 2023-2024
- Forest inventory for the A-11 highway project. Alcañices-F. Portugal. 2022
- Forest inventory for the "Vías de apartado en tramo León-Monforte" Project. 2022
- ENVISION certification design and post-construction for Xochi Road Project, Corredor de las Flores, Guatemala. Client: BID INVEST. 2023-2024
- Documental and technical environmental supervision of a preliminary project of the General Directorate of Roads (DGC). 2022
- Noise measurements to assess Public Transport Accessibility on the A-4. Madrid. Client: DGC. 2021
- Participation in the Initial Document and Environmental Impact Study of the Ferry Berths in the West Dock of the Port of Palma. Client: Autoridad Portuaria de Baleares. 2021-2024
- Drafting of environmental documents for environmental processing, environmental mitigation measures and FCEMP of the project "Work order to carry out the global integration of the P-563 Programme". New facilities and infrastructure as part of the "Vision 2030" plan in Saudi Arabia. A new military city, a national defence university and a new joint forces command. 2023-2024

- Participation in the environmental analysis of alternatives for "NEOM-20 The Cube Road". Saudi Arabia. Client: NEOM. 2023

8.3. Annex nº 3. Project Technical Documents

8.3.1. Annex Nº 3.1 Baseline Survey



المشتري الرئيس
PRINCIPAL BUYER

Preliminary Studies for Afif 1 Solar Power Plant

Environmental Survey Report

SP1421

March 2024

TYPSA

TYPSA has an Integrity Management System in place that has been ISO 37001 (Anti-bribery Management System) certified since 2019. Please consult our Corporate Integrity Policy statement and Code of Ethics at www.typsa.com/en/ethics-and-integrity/ where a communication channel is also available to forward complaints, questions, grievances or suggestions.

Quality control sheet

Document	Environmental Survey Report	
Project	**Preliminary Studies for Afif 1 Solar Power Plant**	
Code	SP1421-AF1-REP-003-Enviro_Survey-D01	
Authors:	Signed:	MVS, RMF, MME
	Date:	March 2024
Revised:	Signed:	ATO
	Date:	March 2024
Verified	Signed:	LRT
	Date:	March 2024
Recipient	TYPSA	
Submission to	PRINCIPAL BUYER	
Notes		

Environmental Survey Report

As part of the "Work Group 3 - Social and Environmental Impact Assessment", TYPSA must carry out a field campaign. For this purpose, TYPSA has hired AH Environmental as local consultant.

Environmental and cultural field surveys are necessary to recognize and characterize the most important environmental, social and cultural issues in the proposed sites.,

The environmental site survey evaluates factors such as soil and air quality, vegetation, wildlife habitats, key social and landscape features, archeological features. and any potential ecological sensitivity within the site.

This assessment aids in understanding the surroundings and the elaboration of the environmental and Social Impact Assessment to propose the implementation of appropriate mitigation measures.

The scope of work for the site survey includes the following:

- Flora
  - Flora species recorded across the site to establish a species list.
  - List of species that may be present but not recorded during survey.
  - Relative flora abundance within quadrats.
  - Rare and notable flora. Threatened species or High Conservation Priority (HCP) species. Ecologically important trees.
  - Identification of invasive species
- Fauna
  - Fauna species as observed on site, including signs of presence.
  - List of species that may be present but not recorded during survey.
  - Identification of species which are Threatened or HCP species. Period of breeding and feeding.
  - Significant constraints for fauna: habitats which may support breeding and feeding of protected species, important fauna corridors, etc.
- Habitats
- Key landscape features and fauna corridors.
- Noise. 24 h measurement and 1 h period measurement to establish the current noise baseline.
- Air quality to establish the current baseline air quality levels, focusing on key pollutants such as Ozone (O3), nitrogen dioxide (NO2), sulfur dioxide (SO2), carbon monoxide (CO) and particulate matter (PM2.5 and PM10).
- Archeological and heritage features.
- Land use features.
- Environmental degradation.

As a result of the survey, AH has presented its findings and, after some revisions made by the TYPSA team, the following document is presented.

The next step includes preparing the ESIA Class 2 report and obtaining the final permit. The following report will be included in an Annex to the ESIA and its conclusions will be incorporated in section 4 of the ESIA (Description of the surrounding environment).

ENVIRONMENTAL BASELINE SURVEY REPORT FOR

Afif 1 Photovoltaic Plant

Rev 04, March 2024

Prepared by:

ENVIRONMENTAL CONSULTING OFFICE
مكتب علي خضير الحربي للإستشارات البيئية

Document History

Revision code	Description of changes	Purpose of issue	Date
Rev00	First issue	Issued to TYPSA	February 2024
Rev01	Second issue	Issued to TYPSA	February 2024
Rev02	Third issue	Issued to TYPSA	February 2024
Rev03	Fourth issue	Issued to TYPSA	March 2024
Rev04	Fifth issue	Issued to TYPSA	March 2024

Document Approval

	Prepared by	Reviewed by	Approved by
Name	Bechir Fradj	Abderrazak Zemzmi	Ennacer Besghaeir
Job Title	Ecologist Specialist	Environmental Consultant	Environmental Consultant

Table of contents

TABLE OF CONTENTS 3
LIST OF TABLES 5
LIST OF FIGURES 5
ABBREVIATIONS LIST 7
1 INTRODUCTION 8
1.1 Overview 8
1.2 Scope of Report 8
1.3 Project site location 9
2 LEGAL FRAMEWORK AND STANDARDS 10
2.1 National Legislation 10
2.1.1 Implementing Regulation for Protected Areas 10
2.1.2 Implementing Regulation for Trade in Wild Organisms, their Products, and Derivatives 11
2.1.3 Implementing Regulation for Hunting Terrestrial Wildlife Species 11
2.1.4 Implementing Regulation for Logging Violations 12
2.1.5 Implementing Regulation for the Development of Vegetation Cover and Combating Desertification 12
2.1.6 Implementing Regulation for Controlling Violations and Imposing Penalties 12
2.2 Regional Conventions and Protocols 12
2.3 International Conventions and Protocols 13
2.4 Significance Of Survey Findings 15
3 SURVEY METHODOLOGY 18
3.1 Survey Team 18
3.2 Terrestrial Ecology survey 18
3.2.1 Desk Study and Pre-survey Preparations 18
3.2.2 Field Study 19
3.3 Air quality and Noise monitoring 26
3.3.1 Air quality measurement 26
3.3.2 Noise measurement 29
4 SURVEY RESULTS 33
4.1 Site conditions 33
4.2 Habitats 33

4.2.1 Flora....39
4.3 Terrestrial Fauna....42
4.3.1 Mammals....42
4.3.2 Reptiles....44
4.3.3 Invertebrates....44
4.3.4 Avifauna....45
4.4 Air quality and Noise....50
4.4.1 Air quality....50
4.4.2 Noise....54
4.5 Key Landscape features....55
4.6 Archaeological features....55
4.7 Land use features....55
4.8 Environmental degradation....58
5 SUMMARY AND CONCLUSIONS....60
6 RECOMMENDATIONS....61
7. REFERENCES....62
APPENDIX 1: DATA SHEET FOR VEGETATION SAMPLING....64
APPENDIX 2: FLORA QUADRAT RECORDS....66
APPENDIX 3: RECORDED BIRDS GEOGRAPHIC RANGE....68
APPENDIX 4: NOISE MONITORING REPORT....70
APPENDIX 5: AMBIENT AIR QUALITY MONITORING REPORT....96

List of Tables

Table 2-1: Summary of International Agreements Relevant to the Project 13
Table 2-2: IUCN Extinction Risk Categories 17
Table 3-1: Survey Team 18
Table 3-2: Globally Threatened species of Migratory Soaring Birds in Arabic Peninsula 23
Table 4-1: Identified habitats in the surveyed section. 34
Table 4-2: Recorded Flora during the survey 39
Table 4-3: Example of the recorded Flora 39
Table 4-4: Mammals species recorded in the surveyed sections. 43
Table 4-5: Avifauna species recorded within the site. 47
Table 4-6: Example of the recorded Avifauna 48
Table 4-7: Summary of SO2 Results 50
Table 4-8: Summary of NO_2, NO and NO_x Results 51
Table 4-9: Summary of CO Results 52
Table 4-10: Summary of O_3 Results 52
Table 4-11: Summary of PM_{10} Results 53
Table 4-12: Summary of $PM_{2.5}$ Results 53
Table 4-13: Monitored Meteorological Parameters 54
Table 4-14: Noise Monitoring Result Test 55
Table 4-15: Examples of Land Use Features within the Project Site 57

List of Figures

Figure 1-1: Project site location 9
Figure 2-1: IUCN System of Classification for Species Threat of Extinction (IUCN, 2020). 16
Figure 3-1: Grid System Layout for Afif 1 Survey 19
Figure 3-2: Quadrats location 20
Figure 3-3: Example of Vegetation Quadrat 20
Figure 3-4: Vantage points for bird survey in PV Afif 1 site 21
Figure 3-5: Project Site Relative to the Rift Valley/Red Sea Flyway 22
Figure 3-6 : Results from at BirdLife International Sensitivity Mapping Tool for Migratory Soaring Birds, showing a point in the middle of the Project Site delineation with a buffer zone of 20km. 23
Figure 3-7: Pitfall Traps locations 24
Figure 3-8: Locations of the camera traps 25
Figure 3-9: A camera trap near an active burrow 25
Figure 3-10: Drive through /Walkover transect. 26
Figure 3-11: Location of the Ambient Air quality monitoring station 27
Figure 3-12: Location of the Ambient Air quality monitoring station in the site at point 1 28
Figure 3-13: Location of the Ambient Air quality monitoring station in the site at point 2 29
Figure 3-14: Location of Monitoring points 30
Figure 3-15: The noise monitoring location at the point 1 31
Figure 3-16: The noise monitoring location at the point 2 32
Figure 4-1: STL Abandoned Burrow 44

Figure 4-2: Recorded invertebrates' examples.....45
Figure 4-3 : Camp location 56
Figure 4-4: Wheel waste 58
Figure 4-5 : Environmental degradation locations 59

Abbreviations list

Abbreviation	Description
AHEC	Ali Harbi Environmental Consulting Office
BS	British Standards
BSA	Bander Said Allehiany
DAFOR	Dominant, Abundant, Frequent, Occasional, Rare
EN	Endangered
GCC	Gulf Cooperation Council
GIS	Geographical Information System
GPS	Global Positioning System
HCP	High Conservation Priority
IBA	Important Bird Area
IFC	International Finance Corporation
IUCN	International Union for the Conservation of Nature
KSA	Kingdom of Saudi Arabia
LC	Least Concern
MEWA	Ministry of Environment, Water and Agriculture
NBSAP	National Biodiversity Strategy and Action Plan
NCEC	National Centre for Environmental Compliance
NCW	National Centre for Wildlife
NCWCD	National Commission for Wildlife Conservation and Development
NE	Not Evaluated
NL	Not listed
NPAS	National Protected Area System Plan
NREP	National Renewable Energy Program
PS	Performance Standards
PV	Photovoltaic
SGS	Saudi Geological Survey
STL	Spiny-tailed Lizard
SWA	Saudi Wildlife Authority
UNCBD	United Nations Convention on Biological Diversity
UNFCCC	United Nations Framework Convention on Climate Change
VU	Vulnerable
WHO	World Health Organization
WP	Waypoint/s

1 Introduction

1.1 Overview

The National Renewable Energy Program (NREP) is a strategic initiative under Vision 2030 and the Kingdom Renewable Energy Initiative. The program aims to maximize the potential of renewable energy in Saudi Arabia.

The program sets out an organized and specific road map to diversify local energy sources, stimulate economic development and provide sustainable economic stability to the Kingdom in light of the goals set for Vision 2030, which include establishing the renewable energy industry and supporting the advancement of this promising sector while working to fulfill the Kingdom's commitments to reducing carbon dioxide emissions.

The Ministry of Energy works to execute the NREP through its development branch Saudi Power Procurement Company (SPPC), as it is responsible for the Pre-Development phase and Tendering phase for renewable energy projects across the kingdom. This contract aims to appoint TYPSA to provide expertise and assistance in the engineering services to complete the preliminary studies for solar power projects in the Kingdom of Saudi Arabia.

Afif 1 Solar Power Plant is a project which includes a site with 39.87 square kilometers for solar power technology.

TYPSA has contracted AH Environmental Consulting Office to undertake the Environmental Baseline Survey (EBS) of Afif 1 PV plant project site. The aim of the EBS was to record and describe environmental characteristics and record features of importance.

1.2 Scope of Report

The EBS report will present the findings from the survey which will be conducted at the Project site. The survey campaign will aim to determine in detail:

- The current ambient noise and air quality in the site
- The identification of flora and fauna and ecosystems occupying the site
- Any environmental degradation
- Any archaeology and heritage features.
- Any landscape features.
- The current land use of the whole site, and;
- Identification of any sensitive receptor to the project
- And any sensitive receptor

1.3 Project site location

Afif 1 Solar Energy Park is located about 23 km southeast of the city of Afif, in the Riyadh Province. From the plant, we can also locate the following urban centers:

- Almardamah (about 8 south)
- Riyadh (about 370 west)

The site is located at 978 meter above sea level.

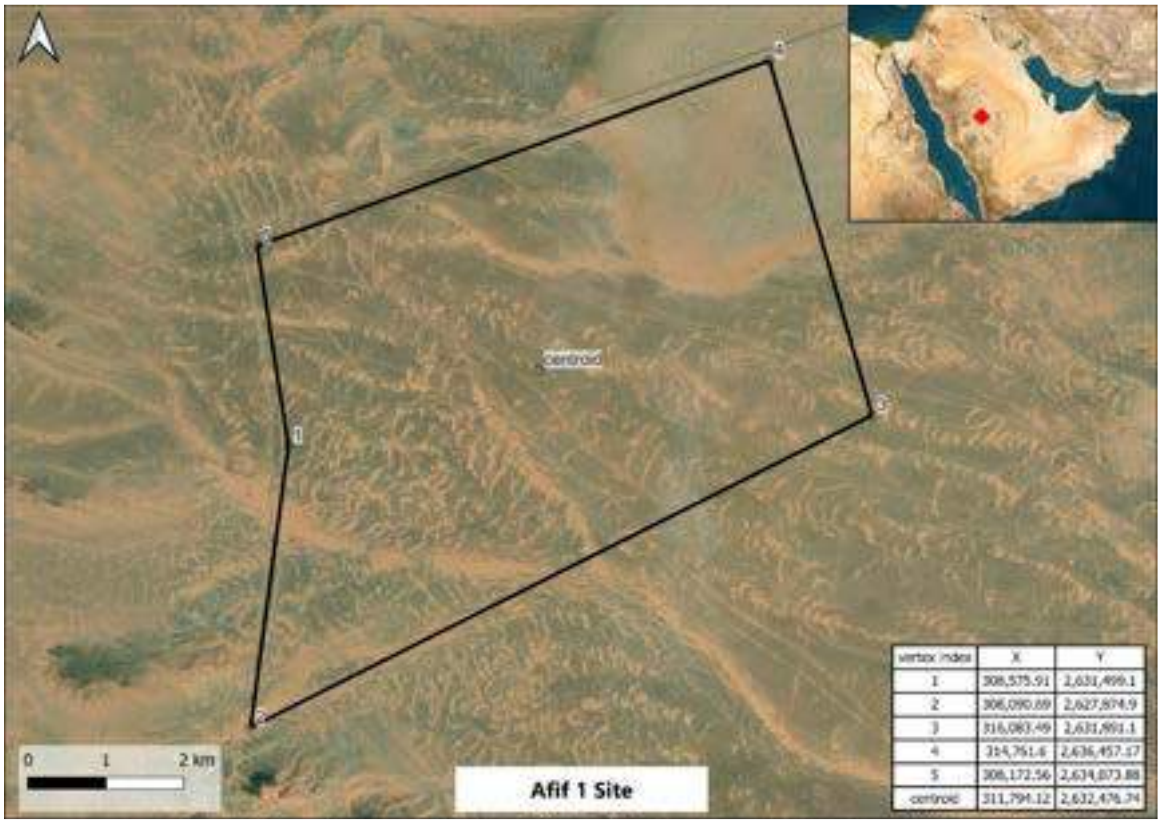


Figure 1-1: Project site location

2 Legal Framework and Standards

This section provides KSA's regulatory and legislative contextual background for the Survey and intends to provide context for the findings of the survey presented in the Baseline Survey Report.

2.1 National Legislation

KSA has had environmental legislation in place since the late 1970's which has been related to the protection of wildlife on land and with designating special protected areas which afford some conservation value to certain habitats and species.

The stakeholders involved in the implementation of the environmental laws and regulations in KSA for the Project, the Ministry of Environment, Water and Agriculture's (MEWA) and the new National Centres of Excellence that fall under MEWA's remit, which include the following:

- National Centre for Environmental Compliance (NCEC).
- National Centre for Meteorology.
- National Centre for Wildlife (NCW).
- National Centre for the Development of Vegetation Cover and Combating Desertification, and;
- National Centre for Waste Management.

In 2020, the Council of Ministers approved the new National Environmental Law. The new National Environmental Law issued under Royal Decree No M/165 of 19 Dhul Qada 1441 Hijri (corresponding to 10 July 2020) became law on 13 January 2021. The law aims to protect, develop, and sustain the environment, adhere to environmental principles, and regulate the environmental sector and related activities and services through a series of Implementing Regulations which set out specific standards and guidelines.

Under this Environmental Law and the creation of the National Centres of Excellence, the NCW has been established as the responsible authority for the protection and development of wildlife and biodiversity and the planning and management of protected areas. The NCW supersedes the Saudi Wildlife Authority (SWA) and will work with NCEC to develop and implement the national policy for conservation and protection of species and reserve areas. NCEC and NCW has identified conservation areas that require protection and are working to protect and prevent damage to these areas. Under the Environmental Law, the following Implementing Regulations pertaining to flora and fauna have been released as summarised below:

2.1.1 Implementing Regulation for Protected Areas

- The regulation allows the Center to propose new protected areas in accordance with the provisions of the regulation and is responsible for planning, managing, facilitating, and supervising approved protected areas and work on re-establishing endangered species in protected areas and in their natural habitats to maintain a balance of biodiversity.
- The Center is responsible for conducting studies and research and collecting all

information and data related to biodiversity in protected areas.

- The Center is responsible for establishing investment projects in protected areas and coordination with relevant authorities regarding the protection of archaeological and historical monuments located in protected areas.
- Regulating the use of protected areas for tourism and environmental purposes, scientific, marine, and other aspects, and setting the necessary controls and conditions to protect them from destruction.

The Center can Issue licenses and permits - within its competences - for activities and works within the boundaries of protected areas and collecting the financial compensation for them.

2.1.2 Implementing Regulation for Trade in Wild Organisms, their Products, and Derivatives

- The National Center for Wildlife oversees regulating the trade in wild and marine animal and plant and it is considered the administrative and executive authority of the Convention in its field of competence.
- The National Center for Vegetation Development and Combating Desertification oversees regulating trade in wild and marine plant species and is considered the administrative and executive authority of the Convention in its field of competence.
- The Centers to Implement the provisions of this regulation regarding inspection and examination upon import, export, re-export, transit, unloading or re-shipment in coordination with the authorities concerned with controlling the air, sea, and seaports.
- The Centers will prepare and issue lists of the wild species, their derivatives and products for which trafficking is regulated in the Kingdom and it will determine and declare the annual quotas for wild species that can be exported or imported.

The Centres will communicate with the Convention Secretariat and other countries and international organizations through the national focal point (MEWA) to implement administrative, executive, technical and scientific issues.

2.1.3 Implementing Regulation for Hunting Terrestrial Wildlife Species

To prohibit hunting wild organisms, endangered species, and overfishing and to regulate hunting activities in the Kingdom and provide hunters outlets to enjoy the sport in a safe and secure environment without harming the balance of the natural ecosystem.

- Publishing data on hunting such as species allowed to be hunted, seasons and places of hunting, and the methods allowed to be used.
- Coordination with the Ministry of Interior, Ministry of Health and NCW regarding public safety conditions while hunting and regulation of hunting in cases of outbreak of epidemic diseases.

To organize environmental awareness activities related to hunting, including holding courses, symposia, specialized working sessions and information campaigns.

2.1.4 Implementing Regulation for Logging Violations

- Regulating the import of firewood and coal.
- Enacting the rules, conditions and controls related to licenses and permits for firewood and coal.
- Issuing and renewing licenses and permits for activities related to firewood and coal.
- Coordination with the security authorities regarding the enforcement of this regulation and the control of violations.

Inspection and control of violations of the provisions of this regulation, investigation and proof, and coordination with the security authorities in the event of a request for support in relation to the arrest of violators.

2.1.5 Implementing Regulation for the Development of Vegetation Cover and Combating Desertification

- To count and classify vegetation and desertified lands based on geographical, climatic, and environmental features. The classification encompasses the following categories:
  - ✓ Pastures.
  - ✓ National, wild, and geological parks.
  - ✓ Plain areas.
  - ✓ Mountainous areas.
  - ✓ Plateaus.
  - ✓ Islands.
  - ✓ Forests.
  - ✓ Wet areas.
  - ✓ Sandy areas.
  - ✓ Valleys.
  - ✓ Coastal areas.
- The regulation aims to develop and protect vegetation lands and their living and non-living contents, and work to improve them quantitatively and qualitatively and provides strategies towards rehabilitating the desertified sites and degraded vegetation lands.

The regulation specifies coordination between NCEC, NCW and other regulatory authorities to monitor and control the activities.

2.1.6 Implementing Regulation for Controlling Violations and Imposing Penalties

The regulation stipulates procedures to detect violations in environmental systems, specify penalties, rehabilitation and compensation and procedures to dispose seized goods. The regulations define the role of review committees to proceed with the fate of violators.

2.2 Regional Conventions and Protocols

The KSA is a member of the Cooperation Council for the Arab States of the Gulf (also

known as the Gulf Cooperation Council or GCC) and the Council has issued the following relevant environmental laws and legislation:

- The General Environment Protection Law: A comprehensive framework incorporating the basic rules for environment conservation and protection (Muscat, 1995).
- The Common Law for the Environmental Assessment of Projects: The Law aims at observing the environmental impact of the various projects to prevent their adverse effects on the environment, natural resources, and development (Muscat, 1995).
- The Common Law for Protection of Wildlife: The Law aims at developing legislation for the protection of wildlife, both plants and animals, their habitats and rehabilitation of the environmentally affected areas (Kuwait, 1997).
- Convention on the Conservation of Wildlife and Natural Habitats. Focuses on the conservation of ecosystems and wildlife, especially those species at risk from extinction, and aims to raise the standards of conservation of flora, fauna, and natural habitats (Muscat, 2003).

2.3 International Conventions and Protocols

KSA is signatory to several international agreements related to terrestrial ecology. Table 2-1 provides a summary of those that are considered relevant to the Project.

Table 2-1: Summary of International Agreements Relevant to the Project

No.	Agreement Name	Year of Agreement	Summary
1	Agreement for the Establishment for Arab Centre for the Studies of Dry and Barren Land	1968	The Centre was established to conduct regional studies on barren areas in Arab countries, including e.g. studies of soils, studies on the degree of soil erosion and studies on the geological and geomorphological aspects of the different areas.
2	Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Ramsar Convention)	1971	States Parties should focus on wetland conservation for land and water birds through the establishment of natural sanctuaries in wetlands and providing the necessary protection. Note that there are no Ramsar sites within the project boundary but there are sites within the region.
3	Convention for the Protection of the World Cultural and Natural Heritage	1972	Established to protect and enhance cultural and natural heritage, whilst there has been a focus on UNESCO designated sites the convention requires member states to protect all relevant resources and specifically states that because a resource is not listed it should not be implied that the resource has no value.
4	Convention on International Trade in Endangered Species of Wild Fauna and Flora and Subsequent Amendments	1973	Established to identify species at risk and control trade in endangered species
5	Convention on the Conservation of Migratory Species of Wild Animals and all amendments including MOU on Turtles	1979	Established to coordinate conservation measures for migratory species. This covers a wide range of species, including birds, marine mammals, sea turtles and bats. Requires member states to preserve and protect species and habitats which occur regularly in their area. Through linkage with the Convention on Biological Diversity, Saudi Arabia is also required to provide protection to range species of bats under the Eurobat protocol of the CMS.

No.	Agreement Name	Year of Agreement	Summary
6	International Plant Protection Convention (1979 Revised Text)	1979	A convention established to protect the genetic resources of native plant species for agricultural and biological conservation purposes
7	Protocol Concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency	1982	Contracting Parties undertake to cooperate in combatting pollution by oil and other harmful substances and maintain and promote contingency plans
8	Montreal Protocol on Substances that Deplete the Ozone Layer	1987	Established to reduce emissions of chemicals harmful to the upper ozone layer
9	Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	1989	The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes. Includes restrictions on exporting of wastes but also includes requirements on member states to minimize production of hazardous waste and manage appropriately regardless of disposal location
10	United Nations Framework Convention on Climate Change	1992	UNFCCC is the main convention addressing the impacts and causes of climate change and aimed at returning global temperatures to a level which will not cause irreversible significant harm to ecosystem functioning
11	Convention on Biological Diversity	1992	Established to protect wildlife and ecosystems
12	Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa	1994	Aims to conduct research and prevent/reverse desertification of natural habitats
13	Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)	1995	The Agreement on the Conservation of African- Eurasian Migratory Waterbirds (AEWA) is an intergovernmental treaty dedicated to the conservation of migratory waterbirds and their habitats across Africa, Europe, the Middle East, Central Asia, Greenland, and the Canadian Archipelago. Developed under the framework of the Convention on Migratory Species (CMS) and administered by the United Nations Environment Programme (UNEP), AEWA brings together countries and the wider international conservation community to establish coordinated conservation and management of migratory waterbirds throughout their entire migratory range.
14	Agreement on International Trade in Endangered Species of Animal and Plant Groups (CITES)	1996	This international agreement seeks to protect endangered animals from threats related to international trading in their body parts or as specimens.
15	Cartagena Protocol on Biosafety to the Convention on Biological Diversity	2000	Relates to the transfer and use of living modified organisms and may apply to any hybrid species which are imported for planting if genetically modified
16	Convention on Persistent Organic Pollutants	2001	Requires member states to eliminate use of Persistent Organic Pollutants, mainly focused on herbicides but now extended to other substances
17	Convention on the Conservation of Wildlife and their Natural Habitats in the Countries of The Gulf Cooperation Council	2003	The objective of this Convention is to conserve the ecosystems and wildlife in a sound and growing state, particularly the species threatened with extinction, and specifically when the distribution of such species exceeds the international border of two neighboring countries or more, or when such species migrate across these countries, including the territorial waters or the airspace under their sovereignty.

No.	Agreement Name	Year of Agreement	Summary
18	Paris Agreement within the UNFCCC	2015	The agreement aims to strengthen the global response to the threat of climate change by holding the increase in global average temperature well below 2 degrees Celsius above pre-industrial levels as well as increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development. Managing climate change risk is critical to maintaining biodiversity and the ecosystems that support biodiversity.

2.4 Significance Of Survey Findings

Three main reference criteria have been used to evaluate the significance of survey findings which are discussed further below:

- International Union for the Conservation of Nature (IUCN) Red List.
- KSA High Conservation Priority (HCP) species list; and
- International Finance Corporation (IFC) Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management.

In the absence of any national protected species list, approaches are proposed to classify species of conservation concern for the Report, IUCN Red List and the HCP species.

The categorisation of threatened flora and fauna species has followed the IUCN Red List categories. The IUCN Red List classifies species in accordance with their risk of extinction on a global basis is used. Species are classified into nine groups based on the following criteria: rate of decline, population size, area of geographic distribution and degree of population and distribution fragmentation. The IUCN Version 3.1 Categories are shown in (Figure 2-1) and further defined in (Table 2-2).

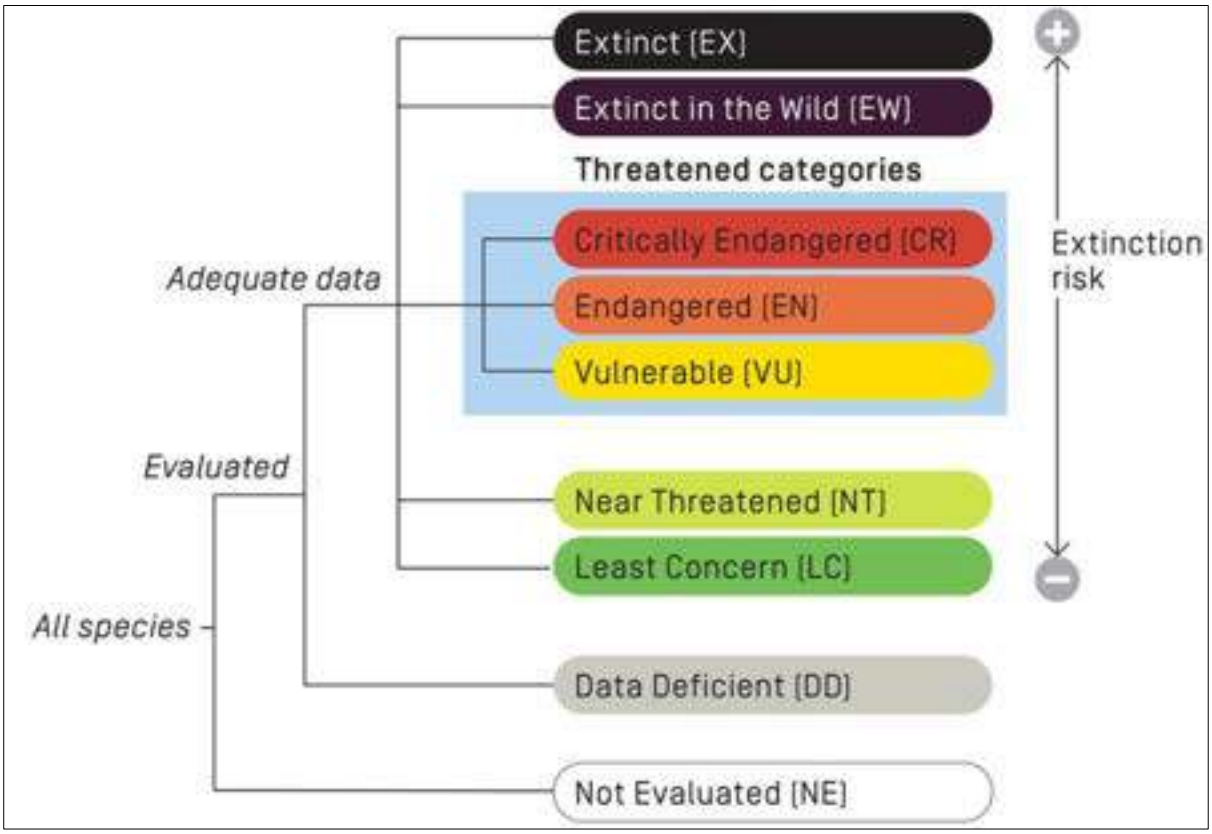


Figure 2-1: IUCN System of Classification for Species Threat of Extinction (IUCN, 2020).

Table 2-2: IUCN Extinction Risk Categories

IUCN Extinction Risk	Description
EXTINCT **(EX)**	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual) throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
EXTINCT IN THE WILD **(EW)**	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual) throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
CRITICALLY ENDANGERED **(CR)**	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered and it is therefore considered to be facing an extremely high risk of extinction in the wild.
ENDANGERED **(EN)**	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered and it is therefore considered to be facing a very high risk of extinction in the wild.
VULNERABLE **(VU)**	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable and it is therefore considered to be facing a high risk of extinction in the wild.
NEAR THREATENED **(NT)**	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category soon.
LEAST CONCERN **(LC)**	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
DATA DEFICIENT **(DD)**	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period has elapsed since the last record of the taxon, threatened status may well be justified.
NOT EVALUATED **(NE)**	A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

3 Survey Methodology

3.1 Survey Team

The Table 3-1 summarises the team members and their competencies involved in this survey.

Table 3-1: Survey Team

Terrestrial Ecology Survey Consultant	AHEC Consultants	
Consultant Team	**Name and Role**	**Expertise**
	Bechir Fradj - Ecology Specialist	Flora and vegetation, mammals, avifauna, invertebrates, reptiles, data compilation, reporting
	Ennacer Besghaeir - Project Director	Survey support, report review and approval
	Abderrazak Zemzmi – Environmental consultant	Data compilation, report review

3.2 Terrestrial Ecology survey

The Environmental survey was carried out from 1st to 11th of January 2024.

3.2.1 Desk Study and Pre-survey Preparations

The following tasks were undertaken as part of the desk study and pre-survey preparations:

3.2.1.1 Desk Study

The Desktop Review is based on previous studies, data, surveys, records available in published scientific papers, books, previous studies and journals on biodiversity recorded within the study region in general. It is important to note that since the available literature on the Project site and its vicinity is relatively limited, the literature reviewed will include a wide spectrum of references including international references that have a wider focus than the area of the Project.

3.2.1.2 Pre-survey Preparations

The following tasks were undertaken as part of the pre-survey preparations:

- Identification of the survey area. The main project site was subdivided into a grid system of zones: zone 1, zone 2 and zone 3 (see Figure 3-1). Deployment of a grid system supports in defining the survey activities, such as the placement of transects for vegetation and faunal studies respectively. The heterogeneity of the habitats within the Project site is thus isolated in each grid. This also allows the true ecological representation of the Project site to be established.
- Gathering of information of the Project site, including maps and geo-spatial imagery.
- Selection of the tentative location and placement of survey transects.
- Preparation of datasheets and survey pro-forma.

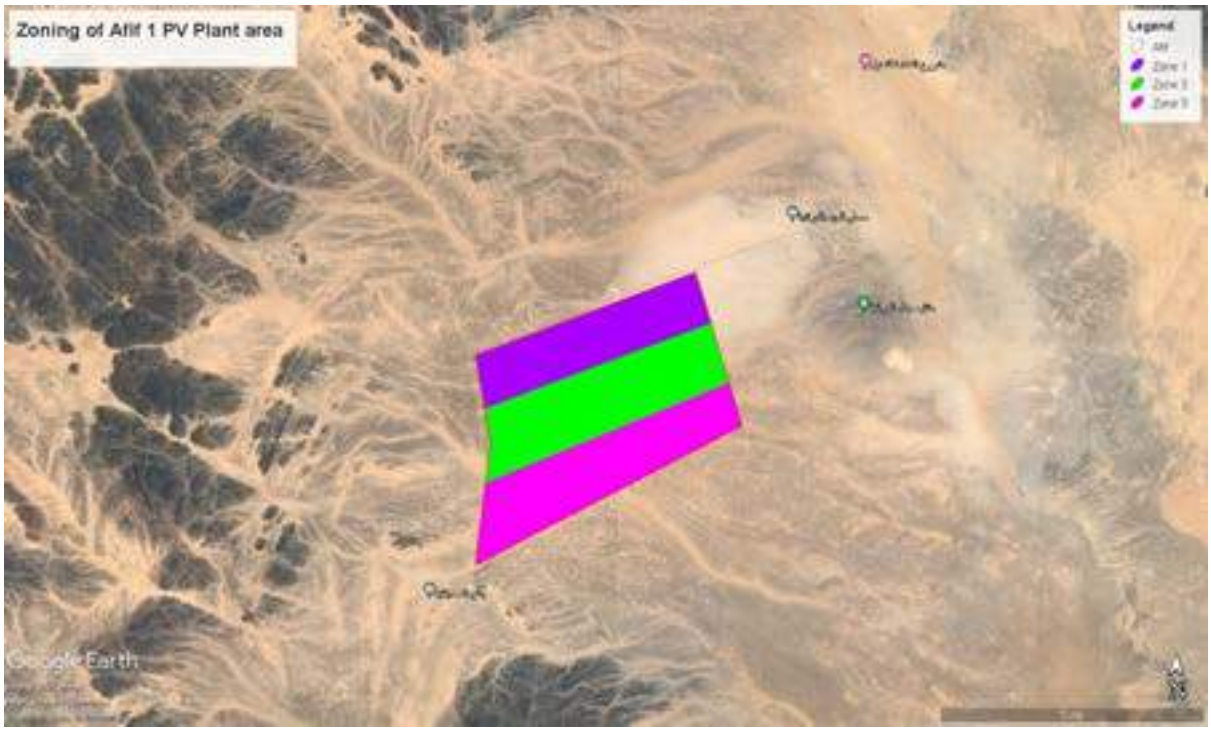


Figure 3-1: Grid System Layout for Afif 1 Survey

3.2.2 Field Study

3.2.2.1 Flora survey

The site was swept by driving through and walkover by the survey team along transects. The survey team drove through the site with great attention to the vegetation cover encountered during travelling. The team get out from the car and walk, once any change in vegetation cover or any point of interest of flora are noted.

While walking, the survey team will closely observe the flora features, analyze and identify the species of plants and photograph them using a camera (close up and landscape images), and a camera (zoom images). Locations will be recorded using a handheld Garmin GPSMAP 64sx global positioning system (GPS) device, and waypoint (WP) field notes will be taken. Flora species that could not be identified in the field, will be identified by their photos when back to office.

A total of nine quadrats were placed within homogenous biotypes in the site location. Once an area for a quadrat had been selected, the four corner points were determined using a tape measure. These were then staked out using tent pegs and a tape was placed around the boundary. The quadrat size was 10 m by 10 m.

Flora abundance was estimated for a given location and is therefore subject to observer judgement. Abundance was recorded making use of the DAFOR scale (Kent & Coker, 1992), where the relative abundance for each species, in the quadrat, is recorded as follows:

D - Species is "Dominant"

A - Species is "Abundant"

F - Species is "Frequent"

O - Species is "Occasional"

R - Species is "Rare"

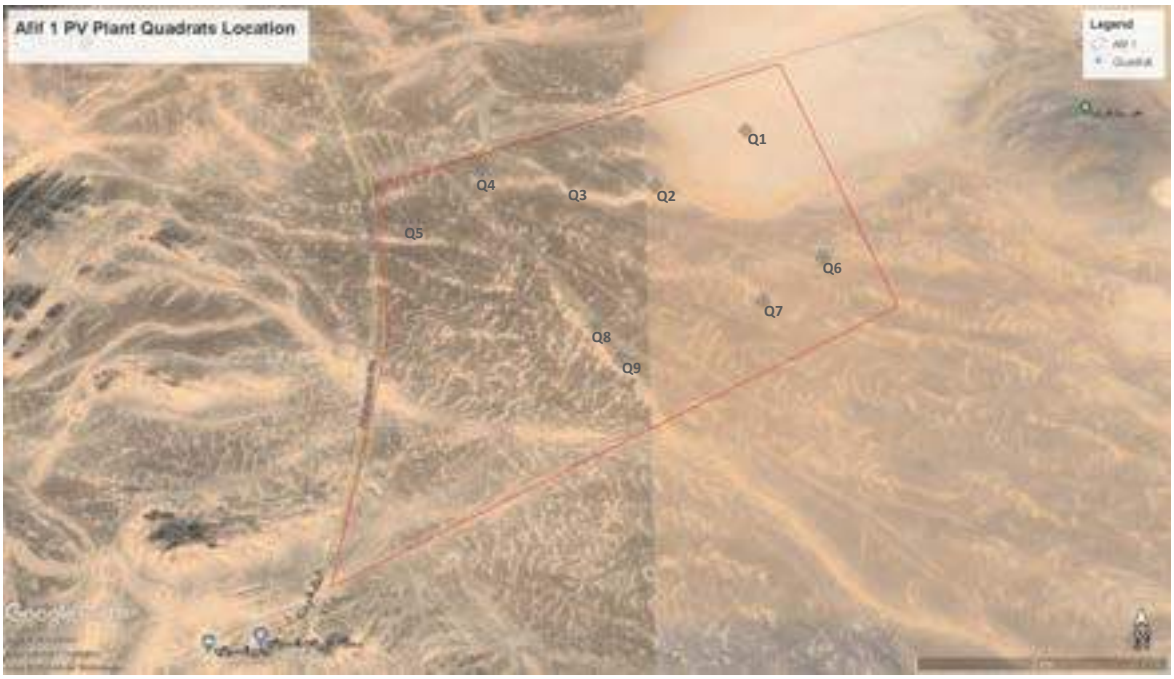


Figure 3-2: Quadrats location

Figure 3-3: Example of Vegetation Quadrat

3.2.2.2 Fauna Survey Methodology

Characterisation of the terrestrial fauna (mammals, birds, reptiles, and invertebrates) within the Project site was conducted via drive through and walkover transects and the deployment of camera traps. The location and routes of the drive through and walkover transects is presented in Figure 3-10.

The terrestrial fauna survey included the following methods:

3.2.2.2.1 Survey of Mammals

Drive through and walkover transects was conducted from at least 7h00am to 4h00 pm for indications of presence of mammals i.e., burrows, tracks showing gait characteristics, scat etc. During the survey any notable tracks, burrows or any sighting of live mammals was photographed.

3.2.2.2.2 Survey of Birds

Avifauna will be surveyed during the transects walks by naked-eye observation and by field binoculars (10×50) used to conduct bird counts at vantage points for a duration of 30 minutes in each point (see Figure 3-4). According to the Best Practices for bird survey the vantage point should cover a diameter between 2.5 to 3 km.

Bird species will be identified along with their migrant, breeding, and resident types based on "Avibase - Bird Checklists of the World" in the region of project.

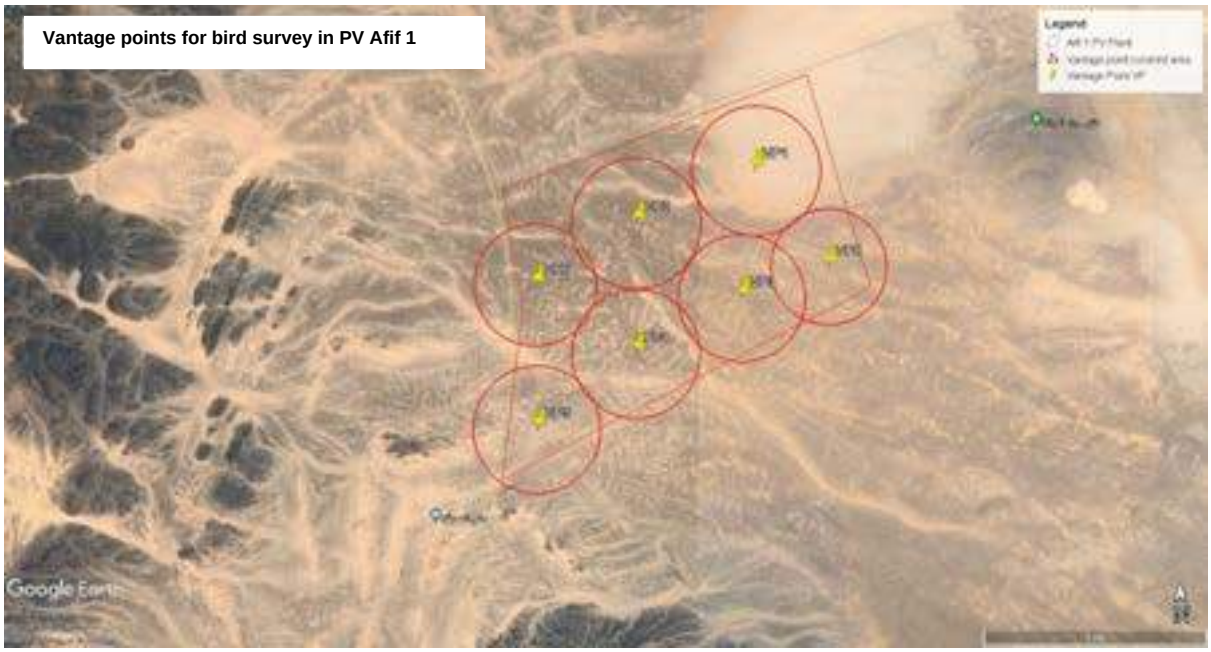


Figure 3-4: Vantage points for bird survey in PV Afif 1 site

- **Project Site Relative to the Rift Valley/Red Sea Flyway**

BirdLife is working to conserve soaring birds during their migration along the Rift Valley/Red Sea flyway[1]. According to BirdLife map the project site location is far from the entrance/exit routes of the migratory birds (See Figure 3-5).

Figure 3-5: Project Site Relative to the Rift Valley/Red Sea Flyway

- **Soaring Bird Sensitivity Mapping Tool**

According to the Sensitivity Mapping Tool, six (06) Species of Migratory Soaring Birds (MSBs) are considered to have their distribution range covering the Project Site (see Figure 3-6). These species are:

- Common Kestrel (*Falco tinnunculus*)
- Eastern Imperial Eagle (*Aquila heliacal*)
- Griffon Vulture (*Gyps fulvus)*
- Egyptian vulture (*Neophron percnopterus)*
- Lappet-faced Vulture (*Torgos tracheliotos*)
- Steppe Eagle (*Aquila nipalensis*)

[1] http://datazone.birdlife.org/birdlife-is-working-to-mainstream-soaring-bird-conservation-along-the-rift-valley/red-sea-flyway

Figure 3-6 : Results from at BirdLife International Sensitivity Mapping Tool for Migratory Soaring Birds, showing a point in the middle of the Project Site delineation with a buffer zone of 20km.

Taking a more comprehensive review of the distribution range of all globally threatened species shows that 19 species of Migratory Soaring Birds in Saudi Arabia Peninsula that could be found in the in the project site (see Table 3-2).

Table 3-2: Globally Threatened species of Migratory Soaring Birds in Arabic Peninsula

Family	English name	Scientific name	Global IUCN Red List Category
Anatidae (Ducks, Geese, Swans)	Common Pochard	*Aythya ferina*	VU
Columbidae (Pigeons, Doves)	European Turtledove	*Streptopelia turtur*	VU
Otididae (Bustards)	Asian Houbara	*Chlamydotis macqueenii*	VU
Threskiornithidae (Ibises, Spoonbills)	Northern Bald Ibis	*Geronticus eremita*	EN
Phalacrocoracidae (Cormorants)	Socotra Cormorant	*Phalacrocorax nigrogularis*	VU
Charadriidae (Plovers)	Sociable Lapwing	*Vanellus gregarius*	CR
Scolopacidae (Sandpipers, Snipes, Phalaropes)	Slender-billed Curlew	*Numenius tenuirostris*	CR
Scolopacidae (Sandpipers, Snipes, Phalaropes)	Great Knot	*Calidris tenuirostris*	EN
Accipitridae (Hawks, Eagles)	Egyptian Vulture	*Neophron percnopterus*	EN
Accipitridae (Hawks, Eagles)	Bateleur	*Terathopius ecaudatus*	EN
Accipitridae (Hawks, Eagles)	Lappet-faced Vulture	*Torgos tracheliotos*	EN
Accipitridae (Hawks, Eagles)	Greater Spotted Eagle	*Clanga clanga*	VU
Accipitridae (Hawks, Eagles)	Tawny Eagle	*Aquila rapax*	VU
Accipitridae (Hawks, Eagles)	Steppe Eagle	*Aquila nipalensis*	EN
Accipitridae (Hawks, Eagles)	Eastern Imperial	*Aquila heliaca*	VU

Family	English name	Scientific name	Global IUCN Red List Category
	Eagle		
Falconidae (Falcons, Caracaras)	Sooty Falcon	*Falco concolor*	VU
Falconidae (Falcons, Caracaras)	Saker Falcon	*Falco cherrug*	EN
Corvidae (Crows and jays)	Asir Magpie	*Pica asirensis*	EN
Acrocephalidae (Reed-warblers)	Basra Reed-warbler	*Acrocephalus griseldis*	EN

VU: Vulnerable, EN: Endangered, CR : Critically endangered, NT : Near Threatened

3.2.2.2.3 Survey of Reptiles and Invertebrates

During the same transects, a sweeping survey of the ground was conducted to detect the presence of any reptiles, such as lizards and for the presence of any borrow or larger reptile such as spiny tailed lizards. Surveys were focused on areas with as understory growth, herbaceous vegetation, rocks, and anthropogenic debris. During the survey attention was paid, also, to the presence of any invertebrates and Pit fall traps was deployed at chosen locations to identify invertebrates.

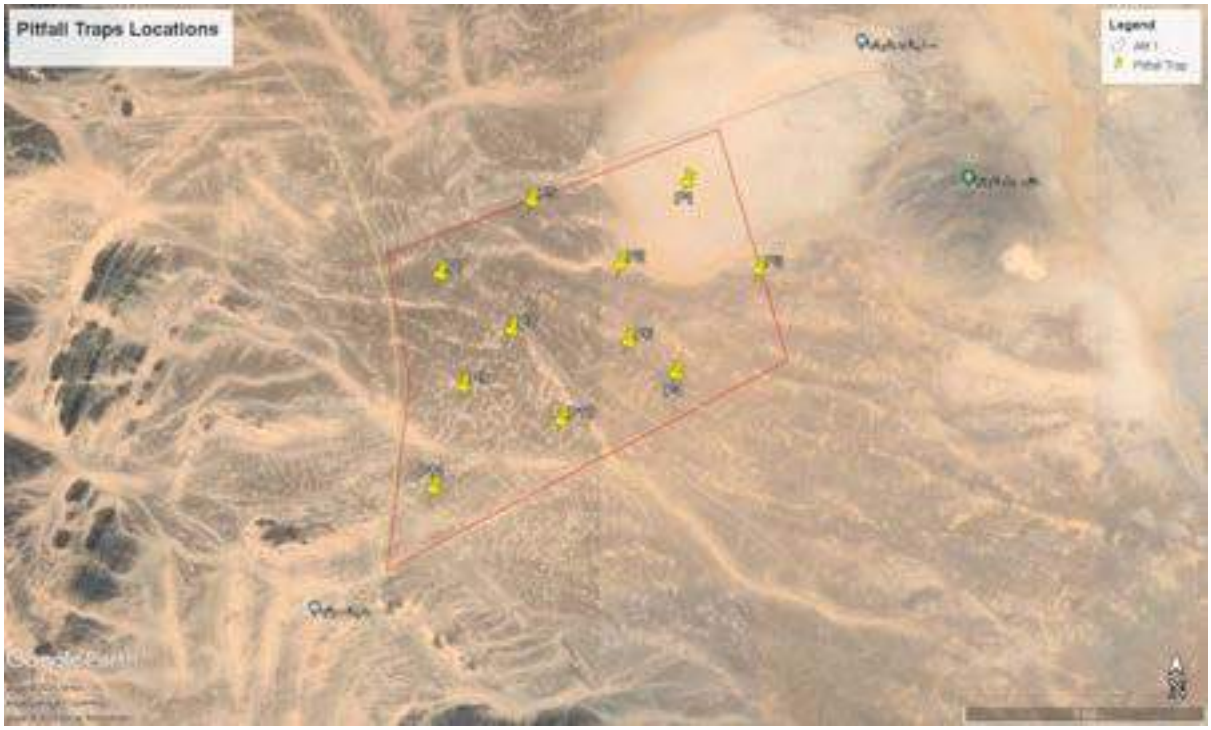


Figure 3-7: Pitfall Traps locations

3.2.2.2.4 Deployment of camera traps

The camera traps were deployed at three different locations within the project site, these locations were selected to be near active burrows and areas where recent faunal activities were indicated (see *Figure 3-8*).

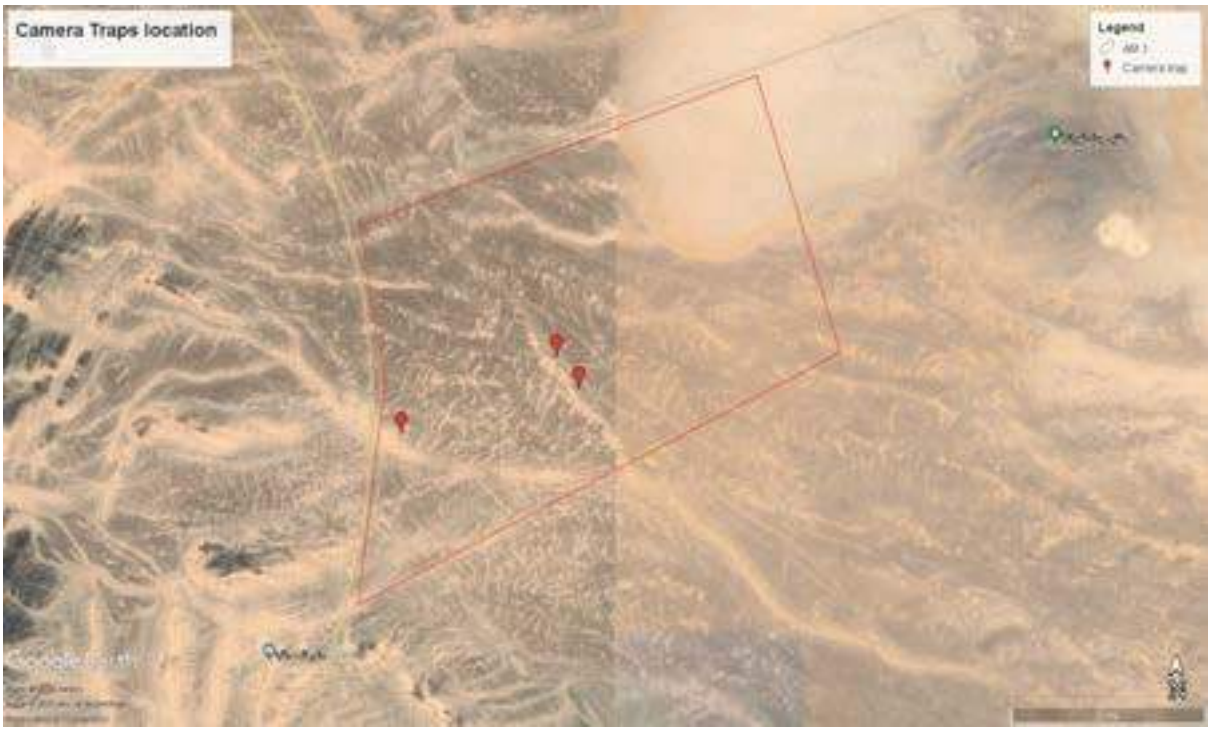


Figure 3-8: Locations of the camera traps

Figure 3-9: A camera trap near an active burrow

3.2.2.3 Survey Equipment and Materials

The following equipment and material were used for the survey:

- GPS device (01)

- Relevant Maps
- Digital Camera (01)
- Camera traps (03)
- Field Binocular (10×50) (01)
- Spotlight torches (1)
- Compass (01)
- Batteries for all electronic equipment
- 50m tape (or pre-measured 40m quadrat rope)
- Utility tool (pliers and hammer)
- Specimen collecting book (for identification)
- Data Sheets
- Reference guides (Mammals, birds, plants, and reptiles)
- Small Paper bags/envelops for seeds and fruits collection.
- Pencils, Pens, Eraser etc.

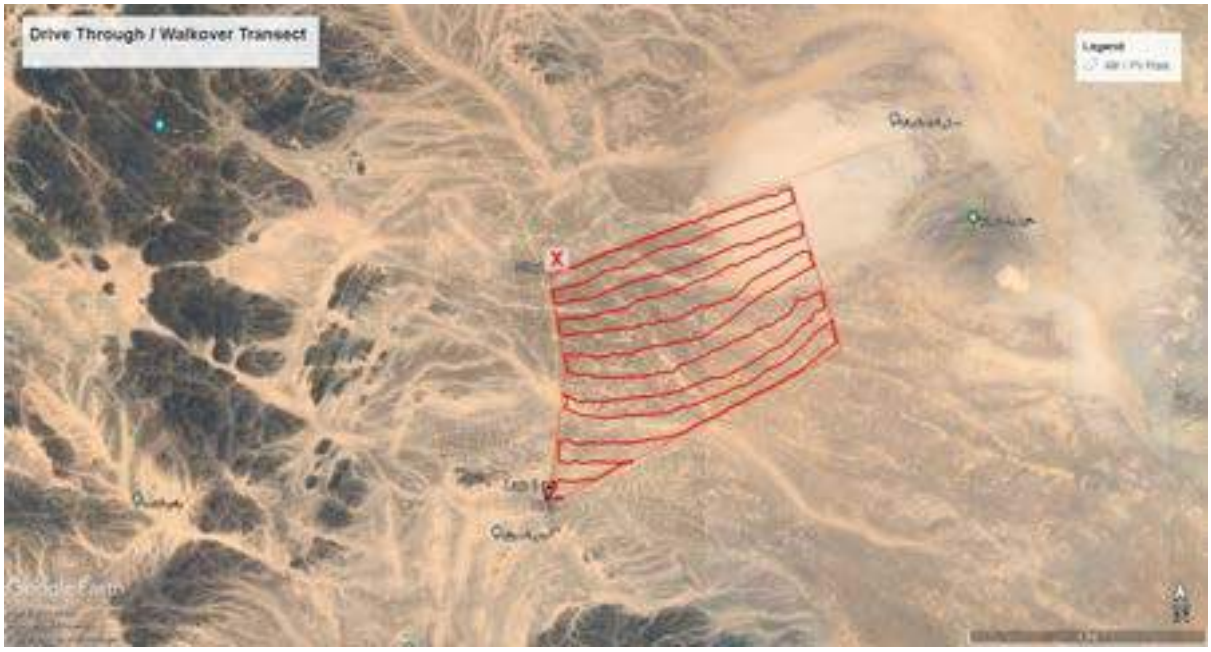


Figure 3-10: Drive through /Walkover transect.

3.3 Air quality and Noise monitoring

3.3.1 Air quality measurement

Bander Said Allehiany (BSA), a specialized organization involved in the Environmental Monitoring Services in the Kingdom of Saudi Arabia was invited by AHEC to conduct Ambient Air Quality Monitoring & reporting.

Accordingly, BSA conducted the Ambient Air Quality Monitoring for Afif 1 site, for 24 hours from 16th until 17th of January 2024, to determine the baseline ambient air quality at the project site according to NCEC.

A Mobile Air Quality Monitoring Station complying with BSA standards will be used to

measure ambient air pollutants concentration in real time, quickly and accurately (see Figure 3-12 and Figure 3-13).

Pollutants that will be measured are essentially, ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and particulate matter $PM_{2.5}$ and PM_{10}. Meteorological data including temperature, humidity, wind speed, wind direction, atmospheric pressure will be also measured. Measurement will be conducted in two (02) points fixed by AHEC.

Site Name		Geographical Coordinates	
AFIF 1 Project site	Location 1	N	23.769605
		E	43.135293
	Location 2	N	23.804565
		E	43.118066

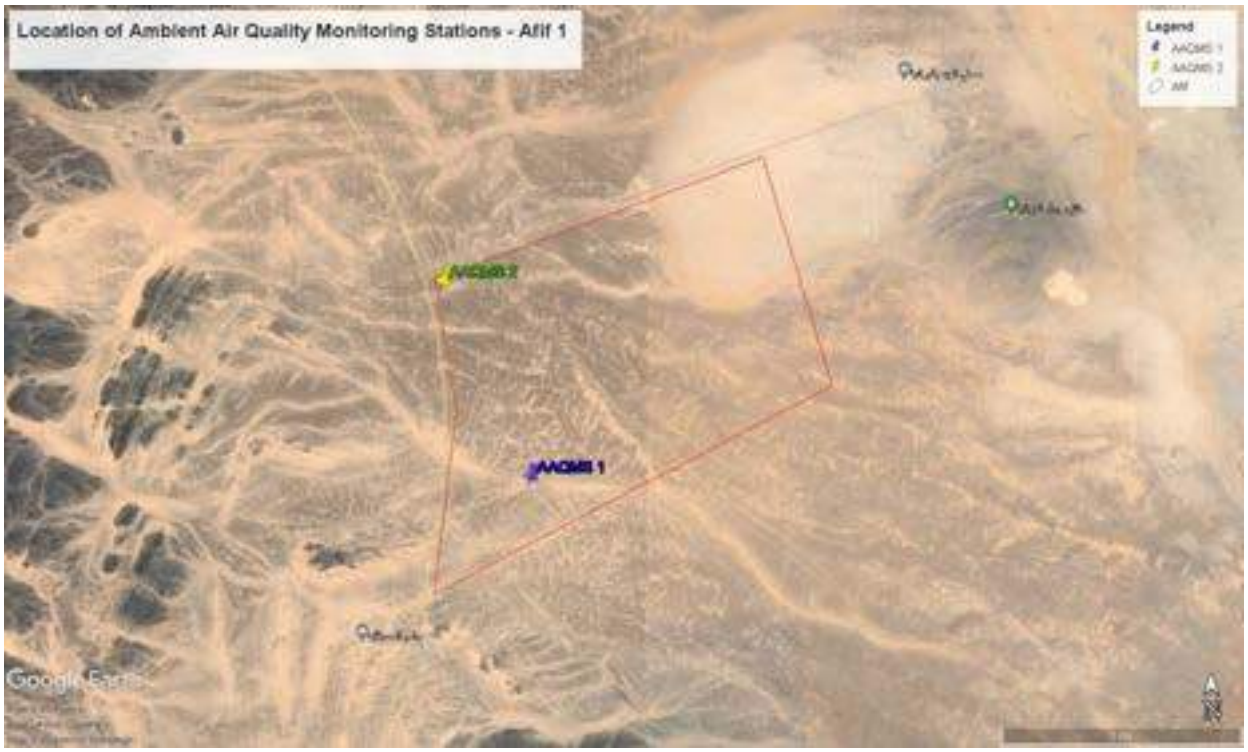


Figure 3-11: Location of the Ambient Air quality monitoring station

For each point, the station will be placed below the wind direction and run 24 hours.

Figure 3-12: Location of the Ambient Air quality monitoring station in the site at point 1

Figure 3-13: Location of the Ambient Air quality monitoring station in the site at point 2

3.3.2 Noise measurement

Bander Said Allehiany (BSA) carried out the noise survey from **16th January to 18th January 2024.**

This noise survey measurements were carried out using Type 1 Integrated sound level meter implementing continuous monitoring strategy recommended by NCEC. The Type 1 Integrated sound level meter was pre-set at fast response and calibrated before and after each location using Acoustic calibrator. The calibration field data was recorded accordingly.

The sound level meter was stationed and mounted over a tripod. The levels that were recorded at locations are L_{Aeq}, L_{A10}, L_{A50} and L_{A90}, L_{Day}, L_{night}. These parameters were reported as dB(A) (A-weighted decibels) at two sections of the day i.e., Morning time and Nighttime respectively. Furthermore, GPS coordinates were taken representing each location as shown in Figure 3-14. Also, meteorological data such as wind speed, wind direction, temperature and relative humidity were measured and recorded as these factors have a significant effect on the test results.

Site ID	Latitude	Longitude	Explanation for Selection
P1	23.769816	43.134910	Considered representative of roadside zone
P2	23.804222	43.118388	

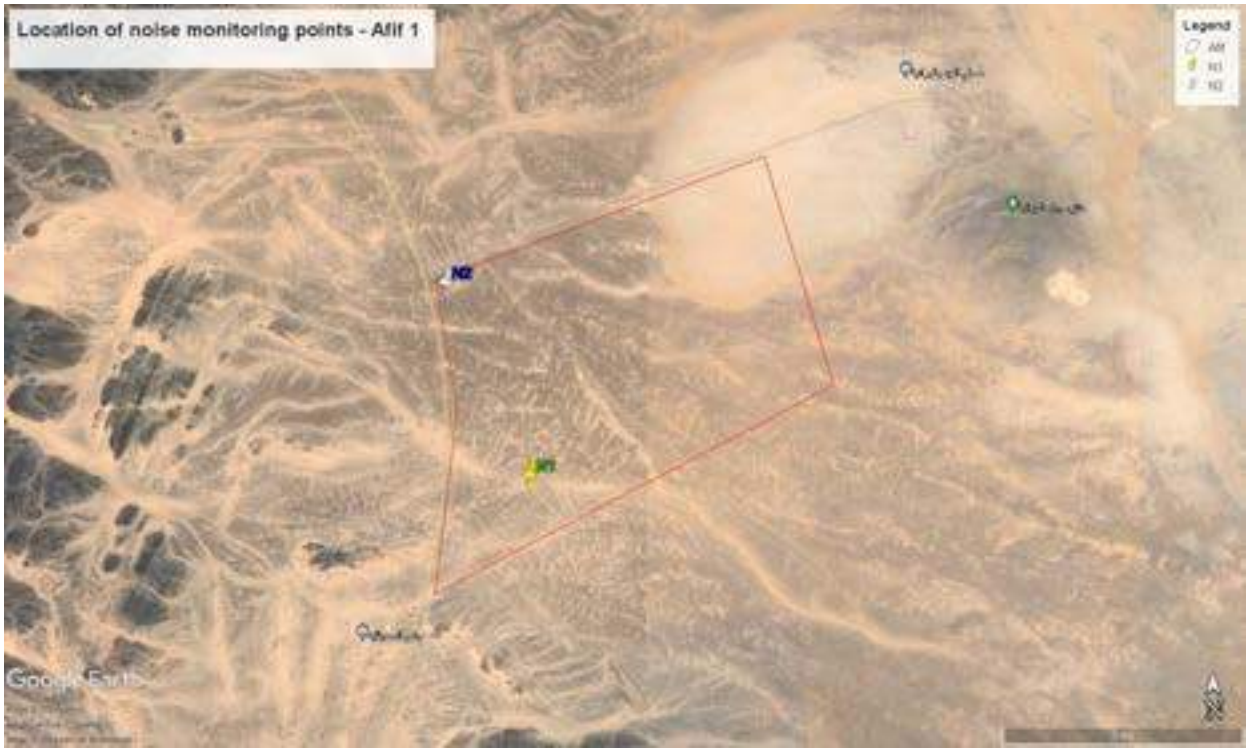


Figure 3-14: Location of Monitoring points

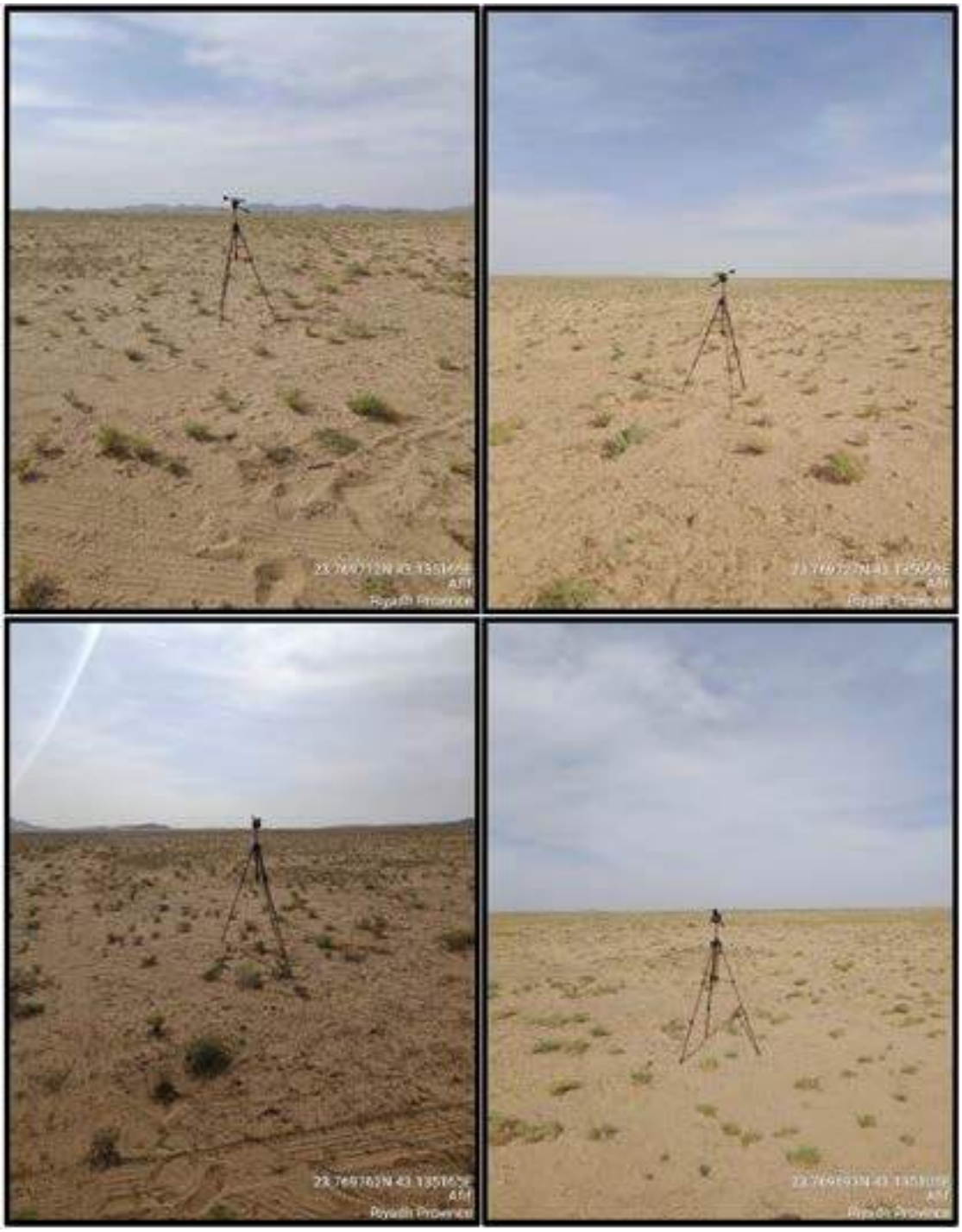


Figure 3-15: The noise monitoring location at the point 1

Figure 3-16: The noise monitoring location at the point 2

4 Survey Results

4.1 Site conditions

The proposed PV plant site is characterized by a barren and arid landscape, typical of Saudi Arabia, with patches of sparse vegetation. Vegetation coverage is more plentiful in the eastern area, which historically has been suitable for grazing camels and sheep. The terrain was observed to be predominantly flat during the field survey, with isolated outcrop formations located in the upper northern corner of the site and on its eastern boundary. During the survey many structures were identified:

- Roads: The road that connects routes 50 and 80 through Almardamah runs through the west limit of the Project site.
- Few settlements: Nomadic camps
- Livestock enclosures and mobile homes

4.2 Habitats

The Project site comprises of five key habitat types (Table 4-1).

Mapping Project Report namely:

- Sandy plains
- Sandy sheet with dwarf shrub cover.
- Gravel plains
- Gravel plains with dwarf shrubs cover.

Table 4-1: Identified habitats in the surveyed section.

Biotopes	Waypoint (lat./log.)	Descriptive photo
Sandy plains	23°49'16''N, 43°9'41''E	

Biotopes	Waypoint (lat./log.)	Descriptive photo
Sandy sheet with dwarf shrub cover.	23°48'32''N, 43°7'32''E	

Biotopes	Waypoint (lat./log.)	Descriptive photo
Gravel plains	23°48'50''N, 43°10'8''E	

Biotopes	Waypoint (lat./log.)	Descriptive photo
Gravel plains with dwarf shrubs cover	23°48'23''N 43°7'4''E	

Biotopes	Waypoint (lat./log.)	Descriptive photo
Isolated outcrops formations	23°49'27''N 43°10'15''E	

4.2.1 Flora

During the field survey, it was observed that only five (05) species of plants were present, primarily desert species, indicating a lack of vegetation cover in the project area.

The conservation status of the species identified were checked against the IUCN Red List, KSA HCP listings (2004) and GCC convention (2003). There is no HCP species recorded during this survey, all species are categorised as Not Listed (NL) under IUCN, only the *Acacia tortilis* which is characterised as Least Concerned (LC). (see Table 4-2 and Table 4-3).

Some examples of the recorded flora species are shown in Table 4-3.

Table 4-2: Recorded Flora during the survey

No.	Family	Scientific Name	IUCN classification	KSA HCP Species Criteria (NCWCD, 2004)	GCC Convention (GCC, 2003)
1	Apocynaceae	*Calotropis procera*	NE	NL	NL
2	Fabaceae	*Acacia tortilis*	LC	NL	NL
3	Zygophyllaceae	*Fagonia tenuifolia*	NE	NL	NL
4	Fabaceae	*Astragalus malacus*	NE	NL	NL
5	Cucurbitaceae	*Citrullus colocynthis*	NE	NL	NL

Table 4-3: Example of the recorded Flora

Flora	Descriptive photo
Calotropis procera	

Flora	Descriptive photo
Acacia tortilis	
Fagonia tenuifolia	

Flora	Descriptive photo
Citrullus colocynthis	
Astragalus malacus	

Flora	Descriptive photo
Desert truffles	

4.3 Terrestrial Fauna

4.3.1 Mammals

Four (04) mammals were sighted during the walkover including herds of Camels (*Camelus dromedarius*), goats (*Capra hircus) and sheep (Ovis aries*). The eastern area has been used for grazing of these animals. Also, one cat (*Arabian mau*) was observed within the project site. (See Table 4-4).

Table 4-4: Mammals species recorded in the surveyed sections.

Type	IUCN Status (2021, ver3.1)	KSA HCP Species Criteria (NCWCD, 2004)	GCC convention (2003)	Descriptive Photo
(Domestic Sheep and goats)	NL	NL	NL	
Camels (Camelus dromedarius)	NL	NL	NL	
(Cat) Arabian Mau	NL	NL	NL	

4.3.2 Reptiles

No live reptiles were recorded within the project area during the survey period. However, an abandoned Spiny Tailed Lizard (STL) burrow was recorded without any clear signs of activity (tracks, fresh faeces etc.) (see Figure 4-1).

Figure 4-1: STL Abandoned Burrow

4.3.3 Invertebrates

The overall abundance and diversity of invertebrates in the project area was low, a large variety of beetles, including several species of Tenebrionidae (darkling beetles) and Scarabaeidae (scarab beetles). The Ground mantis (*Eremiaphila baueri*) was also recorded in different places. The abundance and diversity will be influenced by vegetation cover, seasonality, and weather conditions.

Tenebrionidae (darkling beetles)

Ants (Technomyrmex sp)

The Ground mantis (Eremiaphila baueri)

Figure 4-2: Recorded invertebrates' examples

4.3.4 Avifauna

Only ten species of birds were recorded during the survey. One species Steppe Eagle (*Aquila nipalensis*) is currently listed as endangered according to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (international and/or regional assessment list). However, this species, Steppe Eagle, is nonbreeding in the study area. The presence of a dumping site near Afif could attract Steppe Eagles due to the availability of food resources. Dumping sites often contain organic waste, which can attract rodents and other small animals that eagles prey upon. Additionally, eagles are known to scavenge for food, so they may be drawn to the site to feed on discarded food scraps. The proximity of the dumping site to

Afif could provide a reliable and easily accessible food source for Steppe Eagles, explaining their presence in the area.

All other recorded bird species are listed as Least Concern (LC) according to the (IUCN) Red List of Threatened Species (See Table 4-5).

Table 4-5: Avifauna species recorded within the site.

Order	Common name	Scientific name	IUCN Status (2021, ver3.1)	KSA HCP Species Criteria (NCWCD, 2004)	GCC convention (2003)	Local Status
Accipitriformes	Steppe Eagle	*Aquila nipalensis*	EN	7,5	NL	Extant nonbreeding
Falconiformes	Common Kestrel	*Falco tinnunculus*	LC	NL	NL	Extant resident
Columbiformes	Eurasian Collared Dove	Streptopelia decaocto	LC	NL	NL	Extant resident
Passeriformes	The greater hoopoe-lark	*Alaemon alaudipes*	LC	NL	NL	Extant resident
Passeriformes	The crested lark	*Galerida cristata*	LC	NL	NL	Extant resident
Passeriformes	Isabelline Wheatear	*Oenanthe isabellina*	LC	NL	NL	Extant resident
Passeriformes	Temminck's lark	*Eremophila bilopha*	LC	NL	NL	Extant resident
Passeriformes	Tawny pipit	*Anthus campestris*	LC	NL	NL	Extant nonbreeding
Passeriformes	The brown-necked raven	*Corvus ruficollis*	LC	NL	NL	Extant resident
Bucerotiformes	Common Hoopoe	*Upupa epops*	LC	NL	NL	Extant passage

Table 4-6: Example of the recorded Avifauna

Type	Descriptive Photo
Steppe Eagle *(Aquila nipalensis)*	
Common Kestrel *(Falco tinnunculus)*	

Type	Descriptive Photo
The greater hoopoe-lark *(Alaemon alaudipes)*	
The crested lark (*Galerida cristata)*	
Isabelline Wheatear *(Oenanthe isabellina)*	

Type	Descriptive Photo
Common Hoopoe (*Upupa epops*)	

4.4 Air quality and Noise

4.4.1 Air quality

The summary of test results and meteorological data are mentioned in Table 4-7, Table 4-8, Table 4-9, Table 4-10, Table 4-11, Table 4-12, Table 4-13.

Table 4-7: Summary of SO2 Results

SO_2	Concentration at sampling point		NCEC Exceedance Level µg/m³	
	Point 1	Point 2	1 Hour	24 Hour
Percentage data capture (Hourly Values)	100	100	441	217
Hourly Maximum (µg/m3)	5.1	5.3		
Hourly Minimum (µg/m3)	2.1	1.9		
Daily Average (µg/m3)	2.5	2.7		
Hourly value > 441 (ug/M³)	0	0		

*There were no exceedances of NCEC standards.

Table 4-8: Summary of NO_2, NO and NO_x Results

NO_2	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	1 Hour
Percentage data capture (Hourly Values)	100	100	200
Hourly Maximum (ug/M³)	17.5	27.6	
Hourly Minimum (ug/M³)	0.03	1.8	
Hourly value > 200 (ug/M³)	0	0	
Daily average (ug/M³)	6.2	7.5	
NO			1 Hour
Percentage data capture (Hourly Values)	100	100	NA
Hourly Maximum (µg/m3)	7.8	6.1	
Hourly Minimum (µg/m3)	1.0	1.5	
Daily Average (µg/m3)	4.6	3.2	
NOX			1 Hour
Percentage data capture (Hourly Values)	100	100	NA
Hourly Maximum (µg/m3)	29.7	35.8	
Hourly Minimum (µg/m3)	1.7	4.5	
Daily Average (µg/m3)	13.4	12.5	

*There were no exceedances of NCEC standards.

Table 4-9: Summary of CO Results

CO	Concentration at sampling point		NCEC Exceedance Level µg/m³	
	point 1	point 2	1 Hour	8 Hour
Percentage data capture (Hourly Values)	100	100	40,000	10,000
Hourly Maximum (ug/M³)	160.0	340.1		
Hourly Minimum (ug/M³)	30.0	60.0		
8 Hour Maximum (ug/M³)	126.3	242.5		
8 Hour Minimum (ug/M³)	79.8	102.5		
Hourly value > 40000 (ug/M³)	0	0		
8-Hourly rolling average value > 10000 (ug/M³)	0	0		
Daily average (ug/M³)	106	115		

*There were no exceedances of NCEC standards.

Table 4-10: Summary of O_3 Results

Ozone	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	8 Hour
Percentage data capture (Hourly Values)	100	100	157
Hourly Maximum (ug/M³)	81.8	82.0	
8 Hour Maximum (ug/M³)	68.2	76.5	
8 Hour value > 157 (ug/M³)	0	0	
Daily average (ug/M³)	55.3	56.9	

*There were no exceedances of NCEC standards.

Table 4-11: Summary of PM_{10} Results

PM_{10}	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	24 Hour
Percentage data capture (Hourly Values)	100	100	340
Hourly Maximum (ug/M³)	114.0	147.6	
Hourly Minimum (ug/M³)	37.1	38.6	
Daily Values >340 (ug/M³)	0	0	
Daily average (ug/M³)	48.0	68.9	

*There were no exceedances of NCEC standards.

Table 4-12: Summary of $PM_{2.5}$ Results

$PM_{2.5}$	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	24 Hour
Percentage data capture (Hourly Values)	100	100	35
Hourly Maximum (ug/M³)	30.3	31.6	
Hourly Minimum (ug/M³)	11.3	13.8	
Daily Values >35 (ug/M3)	0	0	
Daily average (ug/M³)	14.5	18.7	

*There were no exceedances of NCEC standards.

Table 4-13: Monitored Meteorological Parameters

Ambient Temperature	Point 1	Point 2
Percentage data capture (Hourly Values)	100.0	100.0
Hourly Maximum (°C)	24.8	26.2
Hourly Minimum (°C)	11.2	10.1
Relative Humidity	**Point 1**	**Point 2**
Percentage data capture (Hourly Values)	100.0	100.0
Hourly Maximum (%)	83.3	49.7
Hourly Minimum (%)	19.5	21.4
Barometric Pressure	**Point 1**	**Point 2**
Percentage data capture (Hourly Values)	100.0	100.0
Hourly Max (hPa)	928.0	931.0
Hourly Minimum (hPa)	923.0	927.0
Wind Parameters	**Point 1**	**Point 2**
Percentage data capture (Hourly Values)	100.0	100.0
Wind Speed Hourly Maximum (m/s)	6.0	6.1
Wind Speed Hourly Minimum (m/s)	1.4	1.2
Mean Wind Speed(m/s)	3.7	3.2
Prevailing Wind Direction	NW/SW	

The results of Ambient Air monitoring for all parameters **are in compliance with NCEC** Ambient Air Quality Standards.

4.4.2 Noise

The Summary of Noise Monitoring results is shown in Table 4-14 during daytime and night time.

Table 4-14: Noise Monitoring Result Test

Site ID	$L_{Aeq,T}$	L_{DAY}	L_{NIGHT}	L_{A10}	L_{A50}	L_{A90}	Lmax	Lmin	Day limit 7.00 am- 8.00 pm	Night limit 8.00pm-7.00 am
N1	48.7	52.6 42.1	45.5	48.2	37.5	32.5	83.6	26.2	70	65
N2	48.7	53.0 42.4	45.8	48.2	37.5	32.5	82.5	27.0	70	65

The overall conclusion, the noise levels are in full compliance with NCEC standards for. Since Afif 1 is adjacent to a road, the standards that must be applied are the sides of roads and highways ones (see Appendix 4-article5).

4.5 Key Landscape features

No key landscape features can be considered as ecologically important for flora or fauna.

4.6 Archaeological features

No archaeological or historical features have been recorded at the project site. A review of the database revealed no other nationally registered sites or previously identified sites of endemic importance in the proposed PV plant area.

4.7 Land use features

A camp was recorded across the Project Site. The camp appears to be nomadic in nature and unlikely to become a permanent feature of the site and a drill rig doing the geotechnical sampling were recorded in the site location.

Figure 4-3 : Camp location

Table 4-15: Examples of Land Use Features within the Project Site

Nomad Camp	
Drill rig	

4.8 Environmental degradation

During the survey some wheels waste and plastic wastes were recorded in the site location. All these features can be considered as an environmental degradation of the project site. (see Figure 4-4).

Figure 4-4: Wheel waste

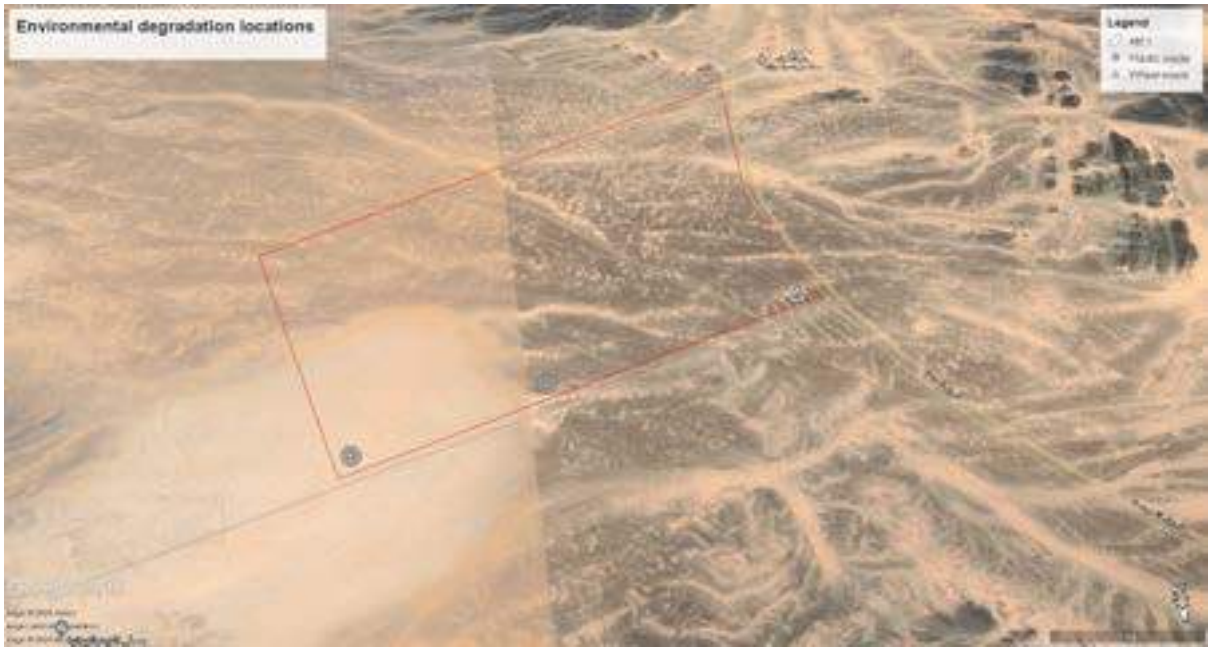


Figure 4-5 : Environmental degradation locations

5 Summary and Conclusions

- Afif 1 Solar Energy Park is located about 23 km southeast of the city of Afif, in the Riyadh Province.
- The survey of the Project site included floristic, faunal, archeological, land use, degradation surveys. In addition, nocturnal and diurnal, noise and air quality (dust) monitoring was also conducted. The survey data reflects the environmental features and other features as observed at the time of the survey.
- The site was predominantly flat ranging between gravel plains and sandy plains.
- A total of five (05) flora species were identified to species level and recorded for the Project Site. No species recorded are listed as IUCN threatened species or as KSA HCP species, except for *Acacia tortillis* which is included as Least Concern (LC) IUCN categories.
- Four (04) mammals were recorded during the survey. None of them is classified as threatened or HCP species.
- The project site is far from the entrance/exit route of the migratory birds. Ten (10) bird species were recorded in the study area. According to the IUCN Red List of Threatened Species only the Steppe eagle (*Aquila nipalensis*) is classified as Endangered (EN), non-breeding in the area.
- No live reptiles were recorded within the project area during the survey period. However, an abandoned *Spiny Tailed Lizard* (STL) burrow was recorded without any clear signs of activity (tracks, fresh faeces etc.)
- The results of Ambient Air monitoring for all parameters are in compliance with NCEC Ambient Air Quality Standards.
- The noise levels are in full compliance with NCEC Standards.
- There were no archaeology and heritage features located within the Project Site.
- For the environmental degradation, some wheels and plastic wastes were observed in the project site.
- No other ecological sensitive receptor species was observed at the site during the survey.

6 Recommendations

Flora: Translocation of all trees in the construction phase.

Mammals and Reptiles: No significant constraints are considered likely. According to reptiles, in case any active Spiny Tailed Lizard (STL) burrow is detected and cannot be avoid, relocations under the guidance of experts will be considered.

Avifauna: Since steppe eagle individuals have been observed within the Solar Plant plot, preventive mitigation measures will be designed in order to avoid/reduce impacts on the species, classified as Endangered by IUCN.

Key Landscape Features: No significant constraints are considered likely.

Archaeological and Heritage Features: No significant constraints are considered likely.

Environmental Degradation:

- Remove all wastes within the site location.
- Removal of abandoned camp litter.

7. References

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Appendix 1: Data sheet for vegetation sampling

Datasheet for Vegetation Sampling

Site		Afif 1 PV plant						Doc ID				
Quadrat size		10*10						Data Collected By				
Vegetation Type		Arid Zone										
S.No	Common name	Scientific Name	Family	Quadrat counts								
				Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9

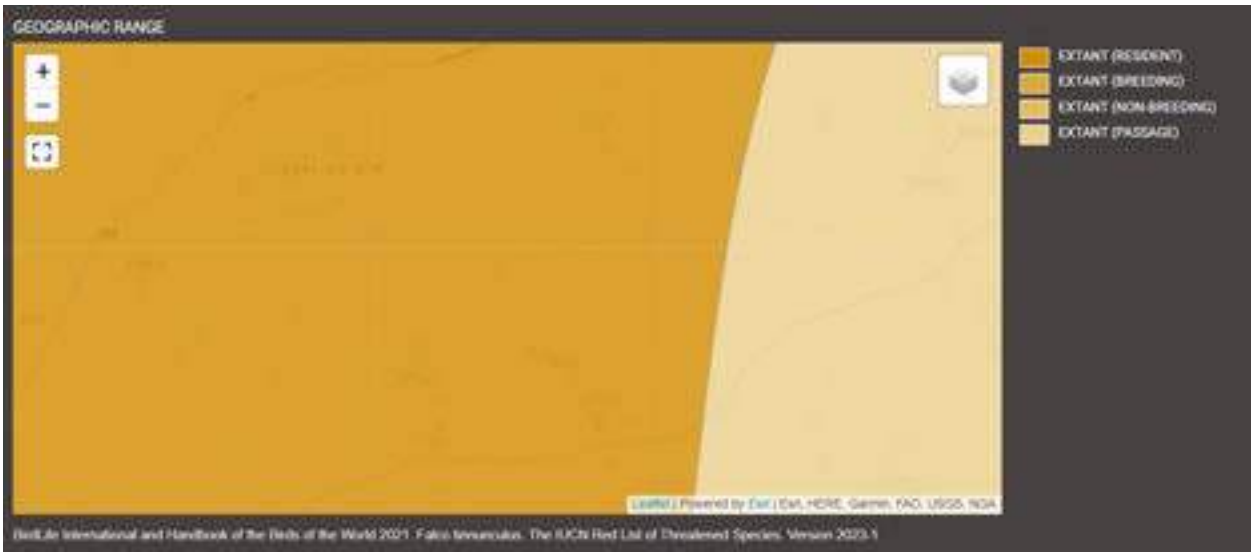
Appendix 2: Flora quadrat records

Site		Afif 1 PV plant												
Vegetation Type		Arid Zone												
S.No	Family	Scientific name	IUCN classification	KSA HCP Species Criteria (NCWCD, 2004)	Quadrat counts								
					Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
1	Apocynaceae	*Calotropis procera*	NE	NL	F								
2	Fabaceae	*Acacia tortilis*	LC	NL		F							
3	Zygophyllaceae	*Fagonia tenuifolia*	NE	NL	A	A	A	F	A	A	A	A	A
4	Fabaceae	*Astragalus malacus*	NE	NL			F	A	F		F	F	
5	Cucurbitaceae	*Citrullus colocynthis*	NE	NL					R	R		F	F

Appendix 3: Recorded birds Geographic range

- Steppe Eagle (*Aquila nipalensis*)

- Common Kestrel (*Falco tinnunculus*)



- Isabelline Wheatear (*Oenanthe isabellina*)

- Common Hoopoe (*Upupa epops*)

Appendix 4: Noise monitoring report

BSA Lab

NOISE MONITORING REPORT

For

AFIF 1 Project

Prepared by

Bander Said Allehiany (BSA)

Summited to

Ali khudhair Al Harbi for Environmental Consultancy Office

NOISE MONITORING REPORT

For

AFIF 1 Project

Prepared by

Bander Said Allehiany

Project Name:		AFIF 1 Project		
Document Title:		Noise Survey Report		
Client:		Ali khudhair Al Harbi for Environmental Consultancy Office		
Report Number:		P.NO. BSA LABS (22412024)		
Rev	Date	Prepared by	Project supervision	Approved by
00	24 January	Eng. Ahmed Rady	Eng. Ahmed Hassan	Dr. S. Ghandy

BSA Lab

Table of Contents

1 EXECUTIVE SUMMARY 4
2 INTRODUCTION 6
3 SCOPE OF WORK 6
3.1 Noise baseline survey 6
3.2 Monitoring Location 6
4 NOISE MONITORING METHODOLOGY 10
4.1 Monitoring Records 10
4.1.1 Site Selection Criteria 10
4.1.2 Site Conditions 10
4.2 Equipment Used for Measurements 10
4.3 Equipment Measuring Procedures 10
4.4 Calibration procedure 11
4.5 Measurement procedures 11
4.6 Meteorological Conditions 11
5 ENVIRONMENTAL NOISE STANDARDS 13
5.1 Implementing Regulations for Noise of the Environmental Law 13
5.2 Noise Standards for Residential and Commercial Areas 13
5.3 Noise Standards for Roadsides 14
5.4 Standards for Industrial Zones 14
5.5 Allowed Noise Level Limits in Construction Work Sites 14
6 RESULTS 15
7 DISCUSSIONS AND COMPLIANCE 19
8 CONCLUSION 19
9 REFERENCES 19
10 GLOSSRAY 20
APPENDIX (A) GRAPHICAL REPRESENTATION 21
APPENDIX (B) CALIBRATION CERTIFICATE 22

List of Figures

Fig. (1): L_{max}, L_{Min} and L_{eq} chart over 24-hour period for four locations 5
Fig. (2): Shows noise intensity levels 5
Fig. (3): show The Noise monitoring locations 7
Fig. (4): The Noise monitoring locations at the Point 1 8
Fig. (5): The Noise monitoring locations at the Point 2 9
Fig. (6): Wind Direction and wind speed at point 1 12
Fig. (7): Wind Direction and wind speed at point 2 12
Fig. (8): L_{day} and L_{night} chart over 24-hour period at location P 1 15
Fig. (9): L_{day} period at P. 1 16
Fig. (10): L_{night} period at P. 1 16
Fig. (11): L_{day} and L_{night} chart over 24-hour period at location P. 2 17
Fig. (12): L_{day} period at P. 2 17
Fig. (13): L_{night} period at P. 2 18
Fig. (14): LAeq noise parameters over 24-hour period at location P 1 21
Fig. (15): LAeq noise parameters over 24-hour period at location P 2 21

List of Tables

Table 1: time of monitoring 4
Table 2: Summary of Results 4
Table 3: Coordinates of noise monitoring locations 7
Table 4: Monitored Meteorological Parameters result 11
Table 5: Standards of Noise Level for Residential and Commercial Areas 13
Table 6: Standards of Noise Level for Roadsides 14
Table 7: Standard of Noise Level for Industrial Zones 14
Table 8: The Correction Values of Allowed Noise Levels in construction work sites 14
Table 9: Summarized statistical parameters and related graphs 15

1 EXECUTIVE SUMMARY

Noise monitoring survey was conducted at (AFIF 1 Project). Which located in (Afif), it was conducted at 2 locations where data was sampled continuously and stored every 2 second for a period of 24 hours at each location. Monitoring was conducted within 2 days as shown in the following table. The Two locations were chosen to obtain data that would be representative of background or baseline conditions at (AFIF 1 Project). each monitoring location was manned by a team of personnel working in shifts, key observations such as unusual sounds, wind speeds etc., was noted. The stored data was subsequently used to derive the key sound level parameters such as L_{Aeq}, L_{A10}, L_{A50} and L_{A90}, L_{Day}, L_{night} Data was compared with the national center for environmental compliance (NCEC).

Table 1: time of monitoring

Site ID	Start Time	End Time	Duration (hrs.)
N1	16/01/2024 1:00 pm	17/01/2024 12:59 pm	24
N2	17/01/2024 2:00 pm	18/01/2024 1:59 pm	24

Table 2: Summary of Results

Site ID	$L_{Aeq,T}$	L_{DAY}	L_{NIGHT}	L_{A10}	L_{A50}	L_{A90}	Lmax	Lmin	Day limit 7.00 am- 8.00 pm	Night limit 8.00pm-7.00 am
N1	48.7	52.6 42.1	45.5	48.2	37.5	32.5	83.6	26.2	70	65
N2	48.7	53.0 42.4	45.8	48.2	37.5	32.5	82.5	27.0	70	65

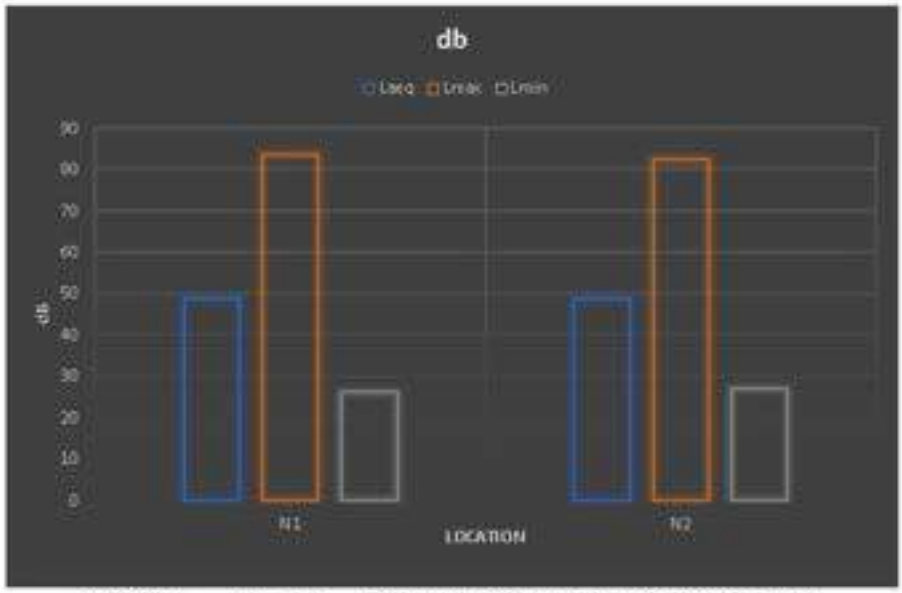


Fig. (1): L_{max}, L_{Min} and L_{eq} chart over 24-hour period for four locations

Fig. (2): Shows noise intensity levels

2 INTRODUCTION

A noise monitoring survey was conducted for two locations at (AFIF 1 Project) to develop baseline 24-hour noise levels for each location outside the project location. A summary of the data and the key findings are presented in this report. The summarized data was derived from the logged data to provide averages over daytime, and night-time. Graphical representation of all the parameters monitored are presented in Appendix A.

3 SCOPE OF WORK

3.1 Noise baseline survey

A noise monitoring survey using sound level meter class 1 for industrial, commercial, residential, and sensitive zones in the study area was conducted to characterize the baseline noise environment. The monitoring location was selected at (AFIF 1 Project) to represent various land uses as set out in the Implementing Regulation for Noise. Noise monitoring was conducted for 24 hours for each location to monitor instantaneous sound pressure level (SPL) at uniform intervals. The continuous equivalent sound pressure level (L Aeq) during day and night-time could then be determined to compare with the standards. Noise parameters (L Aeq, L Day, L Night LA10, LA50, LA90,) were monitored and compared to the relevant national standards to evaluate the ambient noise levels.

3.2 Monitoring Location

Monitoring location was selected to provide baseline noise levels outside the (AFIF 1 Project) Site. The coordinates and the justification for this location are shown below in Table 3 and Fig. (3) shows the location map of the Site. Fig (4,5) shows the noise monitoring at sites for AFIF 1 Project Monitoring was conducted within 2 days at Two locations, weather was dry throughout the monitoring period and hourly wind speeds were below the required.

Table 3: Coordinates of noise monitoring locations

Site ID	Latitude	Longitude	Explanation for Selection
P1	23.769816	43.134910	Considered representative of roadside zone
P2	23.804222	43.118388	

Fig (3): show The Noise monitoring locations

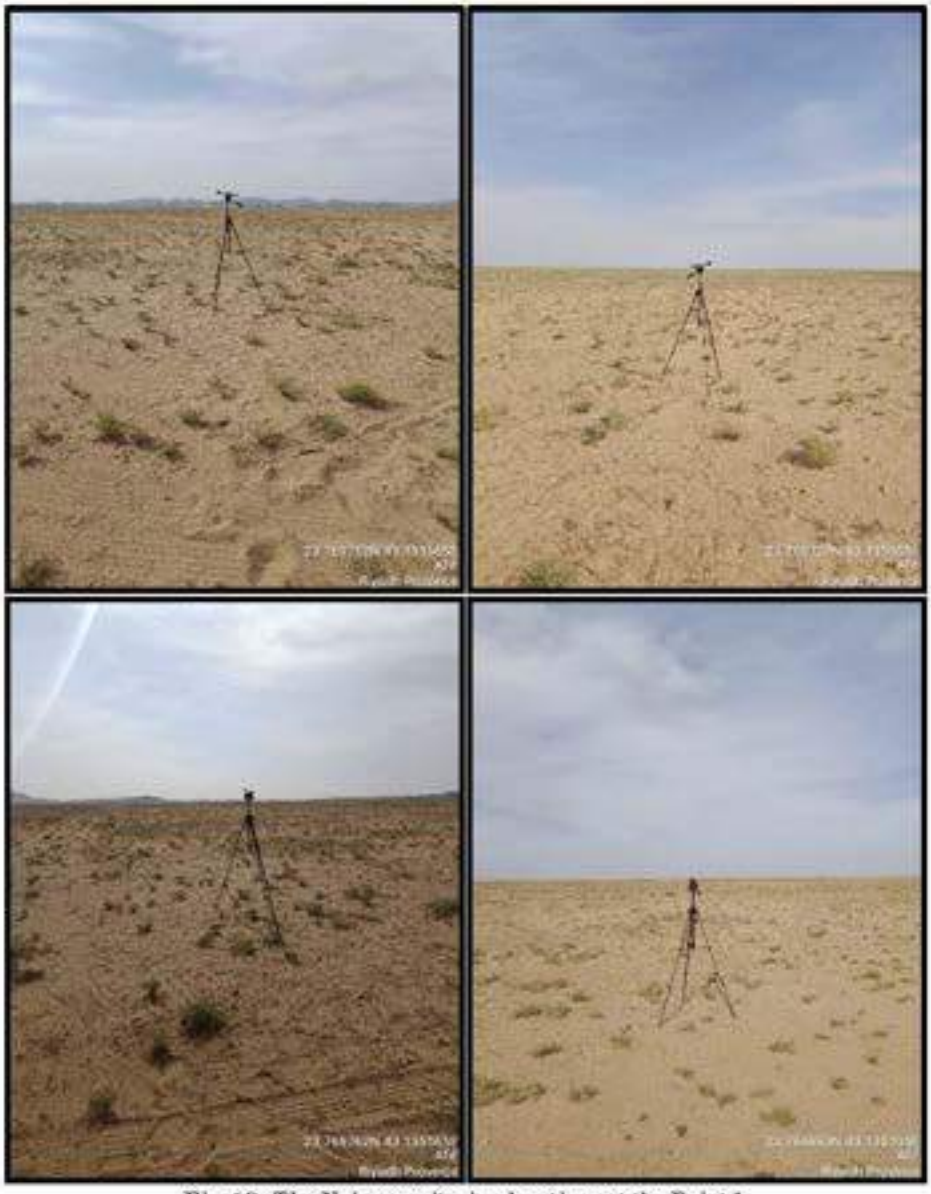


Fig. (4): The Noise monitoring locations at the Point 1

Fig. (5): The Noise monitoring locations at the Point 2

4 NOISE MONITORING METHODOLOGY

4.1 Monitoring Records

The date, time, location, and duration of the measurement as well as environmental conditions was recorded. The operator also recorded any unusual activities (relevant to sound level measurements) that occurred during the monitoring period. All relevant details were recorded, including the following:

- Operator observations.
- Serial no, and device detail

4.1.1 Site Selection Criteria

- 2 Noise monitoring location was selected such that it meets the land use pattern as prescribed in the standard e.g., industrial, commercial, and residential & silence zone.

4.1.2 Site Conditions

- Site conditions and noise sources recorded on a standard record sheet.
- Noise measurement paused during periods of high intrusive noise (e.g., dog barking, helicopter noise) if possible.
- Meteorological information used in the analysis of noise data.

4.2 Equipment Used for Measurements

- A Class-1 Cirrus Research pic was used, which is approved by EPA. Model: CR:1710 serial number: G300932.

4.3 Equipment Measuring Procedures

1. The sound meter was mounted 1.5m. above ground level.
2. Fixing equipment to prevent any vibration.
3. Calibrate the instrument with the calibrator at 94 db.
4. Start the reading.
5. After finishing the period of monitoring, Power off and recalibrate to ensure the accuracy of reading.
6. Connect the laptop and extract the data.

4.4 Calibration procedure

- The noise measurement instrument would be calibrated before and after each measurement to ensure that it is measuring accurately, and the measurement complies with the (IEC 60942:2003) Class Performance and 94dB sound pressure level output.

- Procedures used to calibrate:
  1- Select calibration mode.
  2- Fully insert microphone into designated calibrator and turn calibrator on.
  3- Press the (RUN key) to start measurement.
  4- Once the measurement stabilizes, press (RESET).
- Copies of the relevant calibration certificates can be provided.

4.5 Measurement procedures

The stored data was subsequently used to derive the key sound level parameters such as LAeq, LA10, LA50 and LA90 over specific time intervals such as daytime, and night-time. Data was compared with the national ambient noise standards. The measurement positions were chosen (and recorded on a map) bearing in mind for all noise measurements the axis of maximum sensitivity of the microphone would be directed towards the noise source.

4.6 Meteorological Conditions

The weather conditions during monitoring were dry throughout the monitoring period and hourly wind speeds were below the required according to the air quality report conducted on the same days

Table 4: Monitored Meteorological Parameters result

Ambient Temperature	Point 1	Point 2
Percentage data capture (Hourly Values)	100.0	100.0
Hourly Maximum (°C)	24.8	26.2
Hourly Minimum (°C)	11.2	10.1
Wind Parameters	**Point 1**	**Point 2**
Percentage data capture (Hourly Values)	100.0	100.0
Wind Speed Hourly Maximum (m/s)	6.0	6.1
Wind Speed Hourly Minimum (m/s)	1.4	1.2
Mean Wind Speed(m/s)	3.7	3.2
Prevailing Wind Direction	NW/SW	

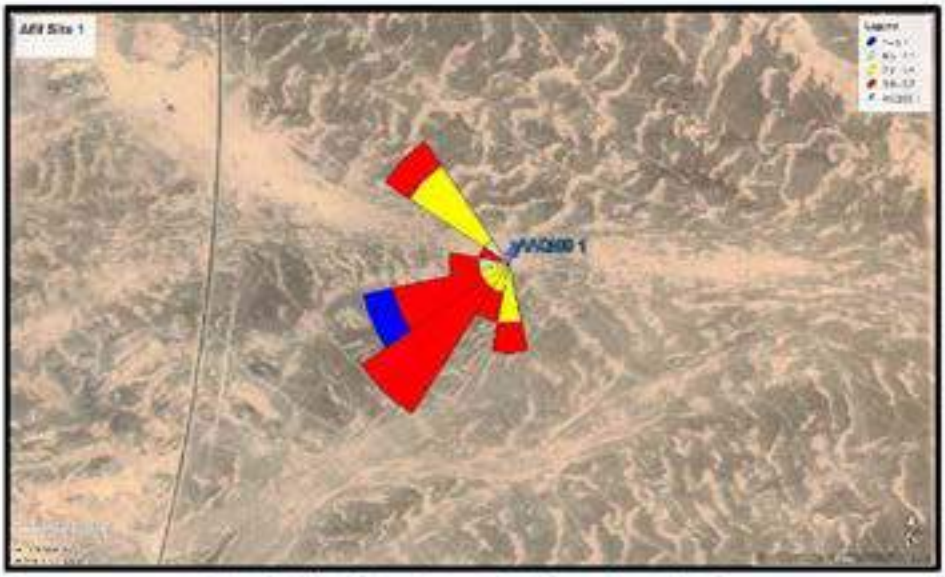


Fig. (6): Wind Direction and wind speed at point 1

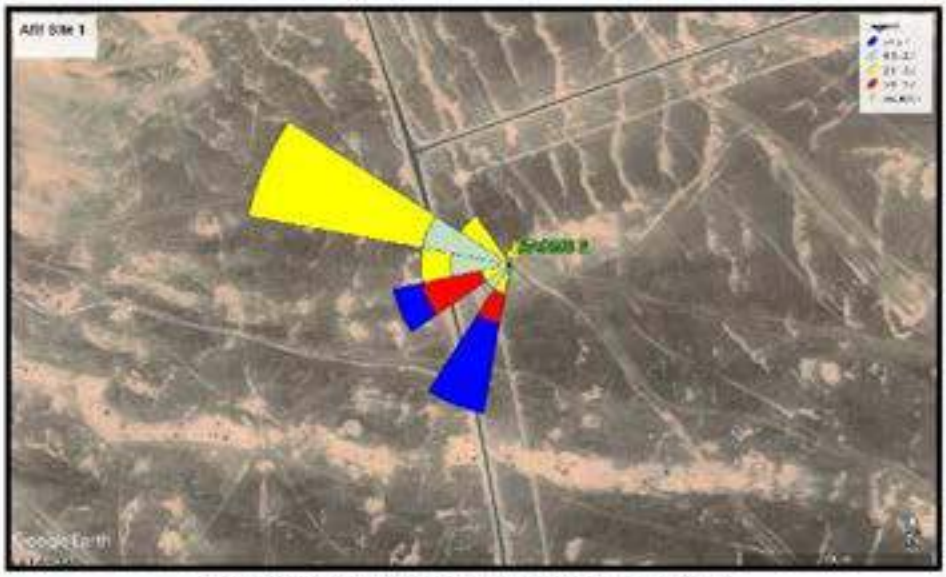


Fig. (7): Wind Direction and wind speed at point 2

5 ENVIRONMENTAL NOISE STANDARDS

5.1 Implementing Regulations for Noise of the Environmental Law

The KSA standards in the tables below have been referenced from the Implementing Regulation for Noise the Environment Law issued by Royal Decree No. (M/165) as of 19/11/1441 AH, these standards relate to the following:

- Residential and commercial areas (Ambient Noise Standards).
- Industrial zone.
- Industrial areas.
- Construction sites.

5.2 Noise Standards for Residential and Commercial Areas

(1) Standards of noise level for residential and commercial areas shall apply as per the following categories:

a. **Category (A):** Low-density residential areas in addition to tourist attractions, recreationalparks, surroundings of hospitals, schools, elder care centers, nurseries, and environmentally sensitive areas.
b. **Category (B):** Medium-density residential areas.
c. **Category (C):** High-density residential areas in addition to areas of both residential andcommercial activities.
d. **Category (D):** Commercial areas, including warehouses and financial centers.

(2) It is prohibited to exceed the standards of noise level for residential and commercial areas set out in Table 3 with no prior permit from NCEC.

Table 5: Standards of Noise Level for Residential and Commercial Areas

Category	Daytime $L_{Aeq,T}$ (dB)	Night-time $L_{Aeq,T}$ (dB)
A	50	40
B	55	45
C	60	50
D	65	55

5.3 Noise Standards for Roadsides

(1) These standards apply to the main Roadside zone and highways.

(2) It is prohibited to exceed the standards of noise level for Roadside zone set forth in table with no prior permit from the Center.

Table 6: Standards of Noise Level for Roadsides

Daytime $L_{Aeq,T}$ (dB)	Night-time $L_{Aeq,T}$ (dB)
70	65

5.4 Standards for Industrial Zones

(1) These standards apply in industrial zones.

(2) It is prohibited to exceed the standards of noise level for industrial zones set forth in table (5),with no prior permit from the Center.

Table 7: Standard of Noise Level for Industrial Zones

Daytime $L_{Aeq,T}$ (dB)	Night-time $L_{Aeq,T}$ (dB)
70	65

5.5 Allowed Noise Level Limits in Construction Work Sites

(1) It is permitted to exceed the standards of noise level set forth in articles (4), (5) and (6) of these Executive Regulations in construction work sites from 7.00 am to 6.00 pm.

(2) The excess referred to in clause (1) of this article shall be in accordance with the correction values set forth in table (5) as a maximum limit.

(3) It is prohibited to exceed the "corrected" limits of permitted noise levels in construction worksites during the specified periods unless a prior permit is issued from the Center.

Table 8: The Correction Values of Allowed Noise Levels in construction work sites.

Period of Construction Activities	Corrections Applied to the Allowed Noise Levels $L_{Aeq,T}$ (dB)
Up to 2.5 hours	10
From 2.5 to 8 hours	5

6 RESULTS

The most appropriate national standards for ambient noise for all locations based on **Table 6** would be: Standard of Noise Level for roadside zone, the monitored noise data summarized in Table 9 shows the noise parameters derived for the day, and night periods based on the results obtained and summarized below in Table 9.

Table 9: Summarized statistical parameters and related graphs.

Site ID	$L_{Aeq,T}$	L_{DAY}	L_{NIGHT}	L_{A10}	L_{A50}	L_{A90}	Lmax	Lmin	Day limit 7.00 am- 8.00 pm	Night limit 8.00pm-7.00 am
N1	48.7	52.6 42.1	45.5	48.2	37.5	32.5	83.6	26.2	70	65
N2	48.7	53.0 42.4	45.8	48.2	37.5	32.5	82.5	27.0	70	65

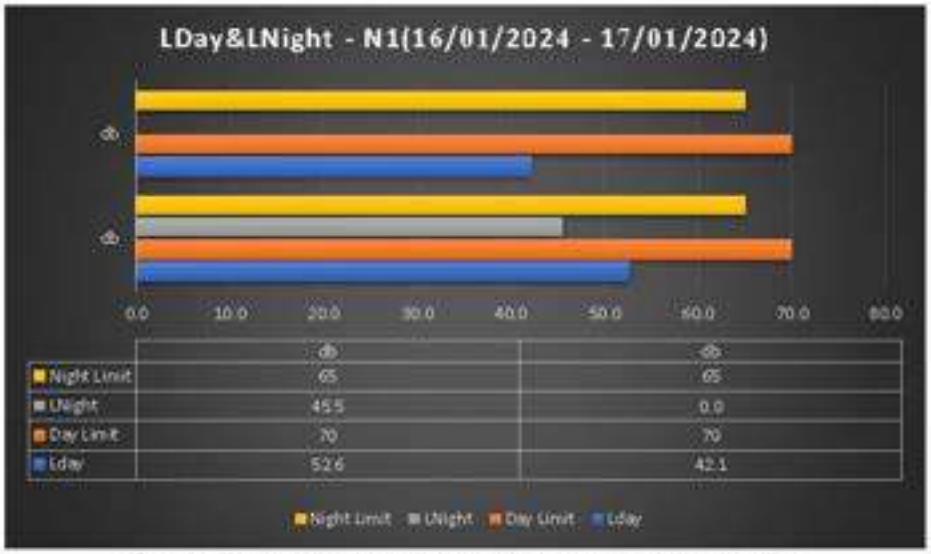


Fig. (8): L_{day} and L_{night} chart over 24-hour period at location P 1

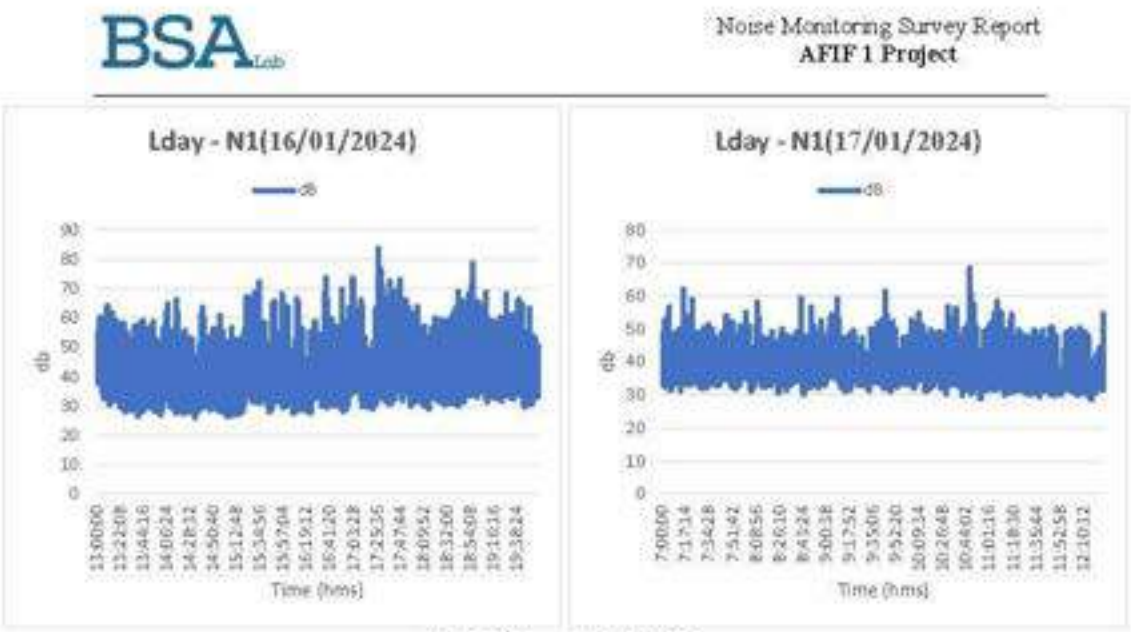


Fig. (9): L_{day} period at P. 1

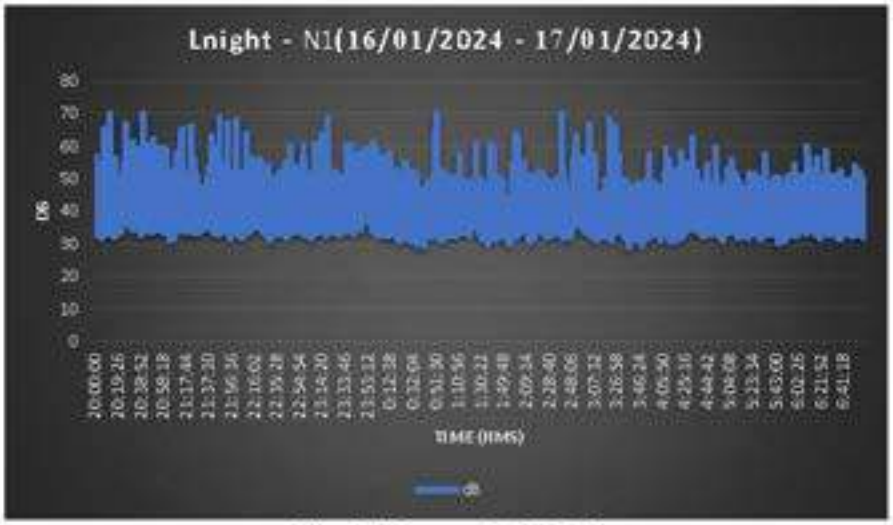
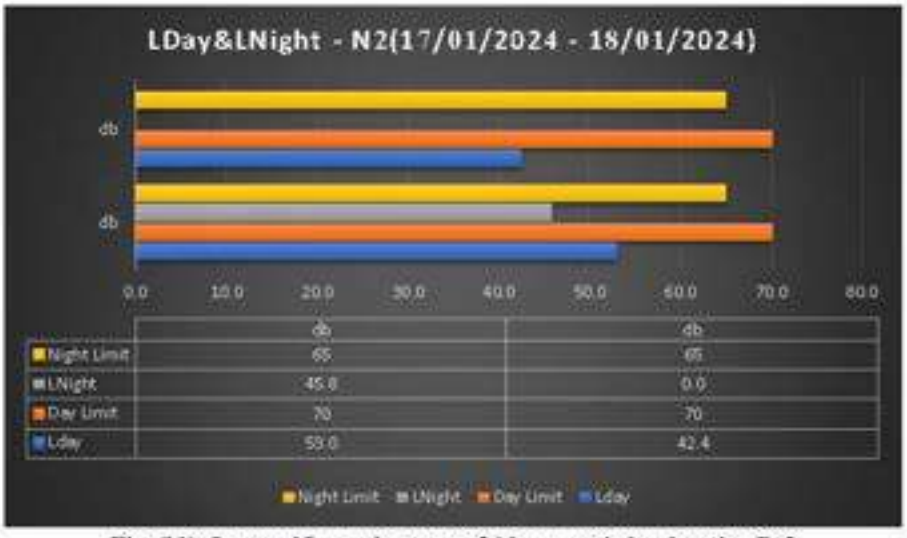


Fig. (10): L_{night} period at P. 1



	db	db
Night Limit	65	65
LNight	45.8	0.0
Day Limit	70	70
Lday	59.0	42.4

Fig. (11): L_{day} and L_{night} chart over 24-hour period at location P. 2

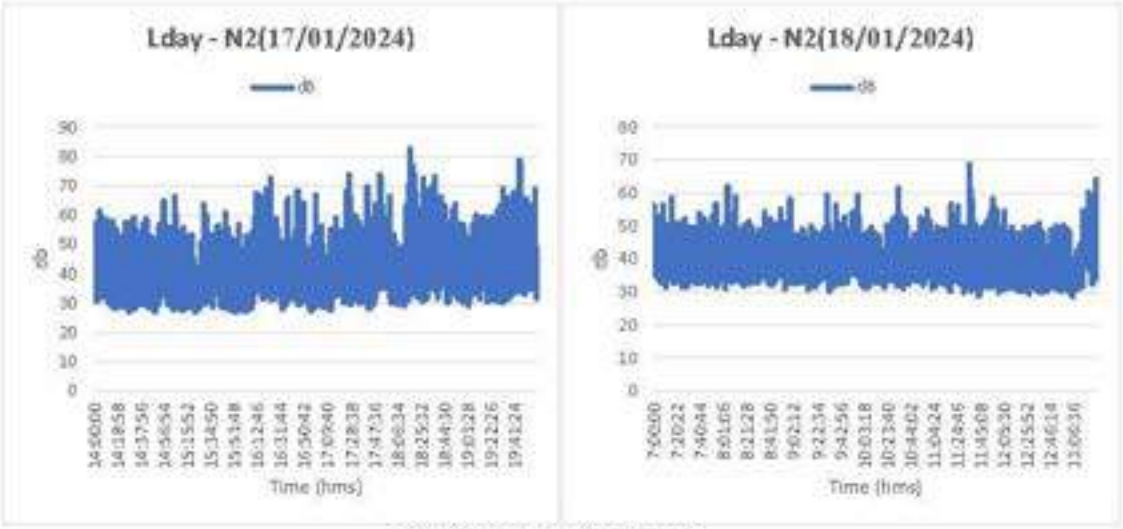


Fig. (12): L_{day} period at P. 2

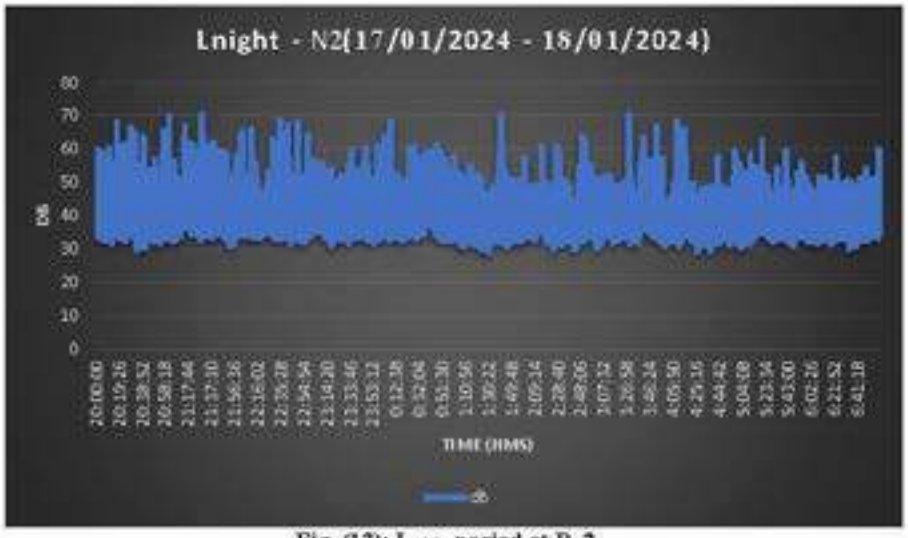


Fig. (13): L_{night} period at P. 2

7 DISCUSSIONS AND COMPLIANCE

Monitoring location was in (AFIF 1 Project)-Site which located in (Afif), therefore the most appropriate category for noise assessment for all locations based on **Table 6** (taken form the NCEC standards), would be: Standard of Noise Level for roadside zone, the L_{Aeq}, L_{Day}, L_{night} for all monitoring locations have not exceeded the (NCEC) compliance limit during the day and night-time.

8 CONCLUSION

Noise monitoring was conducted at Two locations, for a 24- hour period. For each monitoring location in the period of (16 - 18 January). Nosie levels during day and night time, and it were found to be under the limits within the relevant (NCEC) noise executive regulation.

9 REFERENCES

[1] Environmental noise executive regulation of national center for environmental compliance (NCEC), Saudi Arabia, 2020.

[2] Royal commission environmental regulations, "volume I - regulations and standards," Saudi Arabia, 2015.

10GLOSSRAY

(SPL)	Sound pressure A-weighting dB (A) or sound pressure level, is the result of the pressure variations in the air achieved by the sound waves. The lowest sound pressure which can be heard by humans is called the hearing threshold, the highest which can be endured is known as the pain threshold. Sound pressure level (SPL) is the pressure level of a sound, measured in decibels (dB). It is equal to 20 x the Log^{10} of the ratio of the Root Mean Square (RMS) of sound pressure to the reference of sound pressure (the reference sound pressure in air is 2 x 10-5 N/m2, or 0,00002 Pa).
Decibel (dB)	DB is a logarithmic unit of measurement that expresses the magnitude of a physical quantity (usually power or intensity) relative to a specified or implied reference level. Since it expresses a ratio of two quantities with the same unit, it is a dimensionless unit.
A weighting dB(A)	A-weighted sound level means the sound pressure level in decibels as measured on a sound level meter using the A-weighting network. The level so read is designated dB (A) or dBA.
EIA	Environmental Impact Assessment.
EPA	Environmental Protection Agency.
KSA	Kingdom of Saudi Arabia.
L_{Aeq}	It is the equivalent continuous sound pressure level and is a form of "average" level – an average energy level of all the sampled levels.
L_{AFmax}	The maximum level with A-weighted frequency response and fast time constant.
L_{Cpeak}	The C-weighted Peak measurement is usually expressed as Lcpeak and used for occupational noise measurement.
L_{A10}	It is the 10th percentile, or the level exceeded for 10 percent of the time.
L_{A90}	The most commonly used percentile level L_{A90} which is the 90th percentile level and is the level exceeded for 90 percent of the time and good indicator of "background" noise level.
LDay	day noise level, the A-weighted, Leq (equivalent noise level), over the 12-hour day period
LNight	Night noise level, the A-weighted, Leq (equivalent noise level), over the 12-hour Night period

APPENDIX (A) GRAPHICAL REPRESENTATION

GRAPHICAL REPRESENTATION OF 24 HOURS AVERAGES

Fig. (14): LAeq noise parameters over 24-hour period at location P 1

Fig. (15): LAeq noise parameters over 24-hour period at location P 2

APPENDIX (B) CALIBRATION CERTIFICATE

RICI

Certificate of Calibration

شهادة المعايرة

Certificate No.	23-5595	Page	1 of 2
Environmental Conditions During Test:			
Temperature	23 to 25 °C		
Humidity	40 to 60 % RH		

Customer Details:

Name: Bandar Saeed Laboratory for Environmental Consultancies Est.

Address: Jeddah, Kingdom of Saudi Arabia

This calibration certificate has been issued after the completion of all the tests & calibrations of the equipment listed below. The standards used for testing &/or calibration are traceable to national & International standards having uncertainties derived from the accepted values of natural physical constant or by ratio type of self-calibration techniques. The test results of the equipment are valid only at the environmental condition(s) of this certificate. This certificate remains the property of RICI and shall be returned immediately upon request.

Validity of this certificate is considered null & void without the signature of the respective authorized personnel.

This calibration certificate applies only to the following item listed below.

Unit Under Calibration (UUC) Details			
Description	Sound Level Meter	Capacity/Range	30 to 130 dB
Manufacturer	Cirrus	Resolution	0.1 dB
Serial No.	G091017	Calibration Date	August 30, 2023
Model No.	CR:171B	Suggested Due Date	August 29, 2024
Identification No.	3CA	Calibration Site	Off-site

Measurement Uncertainty:

The reported Expanded Uncertainty of Measurement is stated as the Standard Uncertainty of Measurement multiplied by the Coverage Factor k=2 providing a Level of Confidence of approximately 95%.

Calibration Method:

Unit Under Calibration (UUC) is calibrated by measuring and comparing its indications with RICI Co. Ltd. Reference Equipment.

Calibrated By: (Calibration Engineer)

Approved By: (Technical Manager)

RICI COMPANY LTD.

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شركة آر آي سي آي المحدودة
وحدة رقم ١٥، السمراء ٢٣٢٣٥ - ٣٦٠٢، المملكة العربية السعودية
سجل تجاري رقم ٢٤٠٢٠١٢٣٤٣ | هاتف: ١٢٦٥٢٠٤٨ | فاكس: ١٢٦٥٢٠٤٨
البريد الإلكتروني: info@ricionline.com | الموقع الإلكتروني: www.ricionline.com

RICI

Certificate No.	25-5597z	Page	2 of 2

Calibration Results :

Reference Nominal Value	UUC Reading	Error
(dB)	(dB)	(dB)
94.00	93.9	0.1
114.00	113.8	0.2

Expanded Uncertainty, Uy : ± 0.21 dB (k = 2, CL = 95%)

Standard Equipments Used:

Description	Model/ Serial No.	Asset No.	Cal. Due Date	Cal. Agency/ Traceability
Sound Level Calibrator	8003 / 1909064	JLMS-106	November 8, 2025	RICI/CL/181

Traceability of Standard Equipments Used:
The above measurements have been made using RICI Co. Ltd. Standards which are traceable to international Standards in line with ISO 17025:2017.

Reference Standards:
1. Calibration Procedure Ln.RC-076

Calibrated By:
(Calibration Engineer)

Approved By:
(Technical Manager)

RICI COMPANY LTD.

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Appendix 5: Ambient Air quality monitoring report

BSA Lab

Air Quality Monitoring Report

for

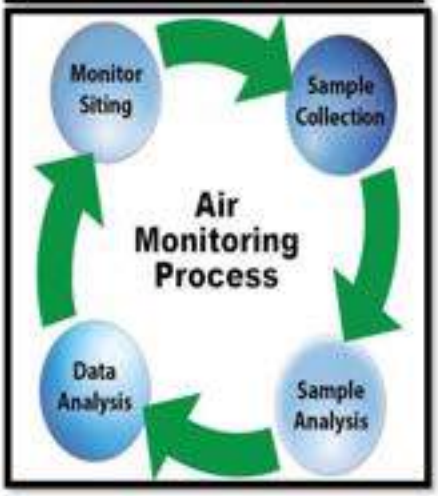
AFIF 1 Project

Prepared by

Bander Said Allehiany (BSA)

Summited to

Ali khudhair Al Harbi for Environmental Consultancy Office



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Air quality Monitoring Report For

AFIF 1 Project

Prepared by

Bander Said Allehiany (BSA)

Project:	AFIF 1 Project
Document Title:	Ambient Air Quality Monitoring Report
Client:	Ali khudhair Al Harbi for Environmental Consultancy Office
Report Number:	P.NO. BSA LABS 12412024

Rev	Reporting Date	Project supervision	Prepared by	Approved By
00	24 January	Eng. Ahmed Hassan	Eng. Ahmed Rady	Dr. S. Ghandy

Definitions & Abbreviations

°C	Degrees Celsius
µg/m³	Micrograms per cubic meter at standard temperature and pressure (25°C and 101.3 kPa)
W/m²	Watt per square meter
AAQMS	Ambient Air Quality Monitoring Station
CO	Carbon Monoxide
Deg.	Degrees (True North)
m/s	Meters per second
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Oxides of nitrogen
O_3	Ozone
hPa	Hecto Pascal
PM_{10}	Particulate less than 10 microns in equivalent aerodynamic diameter
$PM_{2.5}$	Particulate less than 2.5 microns in equivalent aerodynamic diameter
ppb	Parts per billion
ppm	Parts per million
RH	Relative Humidity
SO_2	Sulfur dioxide
WD	Wind Direction
WS	Wind Speed

Contents

Executive Summary 6
1) Introduction 8
2) Monitoring and Data Collection 9
2.1. Siting Details 9
2.1 Monitoring Methodology 12
2.2. Monitored Parameters 13
2.3. Data Collection Methods 14
2.3.1 Compliance with Standards 14
2.3.2. Data Acquisition 14
2.4. Data Validation and Reporting 14
2.4.1. Validation 14
2.4.2 Data Validation Levels 14
2.4.3 Considerations in Evaluating AAQ Data 15
2.4.4 Reporting 16
3) Ambient Air Quality Standards 17
4) Calibrations and Maintenance 18
4.1. Maintenance 18
4.2. Calibration 18
5) Results and discussion 19
5.1. Air Quality Summary 19
6) Conclusions 46
Appendix 1 Valid Data Exception 47
Appendix 2 Valid Data Terms 47
Appendix 3 Calibration certificates 48

List of Figures

Figure 1: Location of the Ambient Air quality monitoring station 9
Figure 2: Location of the Ambient Air quality monitoring stations in the site at point 1 10
Figure 3: Location of the Ambient Air quality monitoring stations in the site at point 2 11
Figure 4: SO_2 hourly concentration at point 1 20
Figure 5: SO_2 Hourly Concentration at point 2 20
Figure 6: NO Hourly Concentration at point 1 22
Figure 7: NO Hourly Concentration at point 2 23
Figure 8: NO_2 Hourly Concentration at point 1 23
Figure 9: NO_2 Hourly Concentration at point 2 24
Figure 10: NO_X Hourly Concentration at point 1 24
Figure 11: NOx Hourly Concentration at point 2 25
Figure 12: CO Hourly Concentration at point 1 26
Figure 13: CO Hourly Concentration at point 2 26
Figure 14: CO 8 Hour Rolling Average Concentrations at point 1 27
Figure 15: CO 8 Hour Rolling Average Concentrations at point 2 27
Figure 16: O_3 Hourly Concentration at point 1 29
Figure 17: O_3 Hourly Concentration at point 2 29
Figure 18: O_3 8 Hour Rolling Average Concentrations at point 1 30
Figure 19: O_3 8 Hour Rolling Average Concentrations at point 2 30
Figure 20: NO_2 vs. O_3 Hourly Concentrations at point 1 31
Figure 21: NO_2 vs. O_3 Hourly Concentrations at point 2 31
Figure 22: PM_{10} Hourly Concentrations at point 1 33
Figure 23: PM_{10} Hourly Concentrations at point 2 33
Figure 24: $PM_{2.5}$ Hourly Concentrations at point 1 34
Figure 25: $PM_{2.5}$ Hourly Concentrations at point 2 34
Figure 26: Hourly Temperature at point 1 37
Figure 27: Hourly Temperature at point 2 37
Figure 28: Hourly Relative Humidity at point 1 38
Figure 29: Hourly Relative Humidity at point 2 38
Figure 30: Hourly Pressure at point 1 39
Figure 31: Hourly Pressure at point 2 39
Figure 32: Hourly Wind Speed at point 1 40
Figure 33: Hourly Wind Speed at point 2 40
Figure 34: Wind Rose at point 1 41
Figure 35: Wind Rose at point 2 42
Figure 36: wind class frequency distribution graph at point 1 43
Figure 37: wind class frequency distribution graph at point 2 43

List of Tables

Table 1: Percent of Data Captured for all Parameters 7
Table 2: Location of Ambient Air Quality Monitoring Stations 9
Table 3: Reference Measurement Principle and equivalent reference method 12
Table 4: Parameters Measured at Air Quality Monitoring Stations 13
Table 5: KSA NCEC Ambient Air Quality Standards 17
Table 6: Summary of SO_2 Results 19
Table 7: Summary of (NO, NO_2, NOx) Results 22
Table 8: Summary of CO Results 26
Table 9: Summary of O3 Result 28
Table 10: Summary of PM_{10} Results 32
Table 11: Summary of $PM_{2.5}$ Results 32
Table 12: Monitored Meteorological Parameters result 36
Table 13: wind class frequency distribution at point 1 44
Table 14: wind class frequency distribution at point 2 44
Table 15: wind class count at point 1 45
Table 16: wind class count at point 2 45

Executive Summary

Bander Said Allehiany (BSA) was commissioned by ALI KHUDHAIR AL HARBI FOR ENVIRONMENTAL CONSULTANCY OFFICE to conduct ambient air quality monitoring as a part of the environmental impact assessment (EIA) at AFIF 1 Project. Continuous ambient air monitoring was conducted at two locations for a period of two days at the air quality monitoring station (AQMS). The Air Quality Monitoring started on January 16, 2024, for point 1 and January 17, 2024, for point 2. This report presents a summary of the validated data that was obtained of.

- **Point 1**: January 16-17, 2024 at 1:00 pm to 12:00 pm
- **Point 2**: January 17-18 ,2024 at 2:00 pm to 1:00 pm

The ambient air quality monitoring station (AAQMS) was equipped to measure standard air pollutants and meteorological parameters as listed below.

Air Pollutants Monitored	Meteorological Parameters Monitored
Oxides of Nitrogen (NO_2)	Wind Speed
Sulphur Dioxide (SO_2)	Wind Direction
Carbon Monoxide (CO)	Air Temperature
Ozone (O_3)	Relative Humidity
Particulates Matter - PM_{10}	Barometric Pressure
Particulates Matter - $PM_{2.5}$	

Hourly data capture rates are 100% for all the parameters at the location. For QA/QC checks, in accordance with the relevant United States Environmental Protection Agency (EPA) methods for each parameter, were carried out within the required schedule. USEPA data handling guidelines were followed in collecting, verifying, and validating continuous ambient air quality and meteorological monitoring data in this report.

BSA Lab

Ambient Air Quality Monitoring Report For
AFIF 1 Project

Table 1: Percent of Data Captured for all Parameters.

Parameters	Total hours in monitoring period	Total available hours in monitoring period	Exception hours	AAQMS-Hour's data capture %
Temp. (°C)	24	24	0	100
Humidity (%)	24	24	0	100
Pressure(hPa)	24	24	0	100
Wind Direction (φ)	24	24	0	100
Wind Speed (m/s)	24	24	0	100
NO (ug/M³)	24	24	0	100
NO_2 (ug/M³)	24	24	0	100
NOx (ug/M³)	24	24	0	100
O_3 (ug/M³)	24	24	0	100
CO (ug/M³)	24	24	0	100
SO_2 (ug/M³)	24	24	0	100
PM10 (µg/m³)	24	24	0	100
PM2.5 (µg/m³)	24	24	0	100

1) Introduction

An ambient air quality monitoring survey was conducted as a part of the baseline monitoring program to support the environmental impact assessment (EIA) for the AFIF 1 Project. Bander Said Allehiany -BSA (is an environmental laboratory in field of air quality monitoring approved by NCEC) installed the AQMS at two locations in the proposed project site as per client request and environmental judgment. BSA stations Lab was retained by ALI KHUDHAIR AL HARBI FOR ENVIRONMENTAL CONSULTANCY OFFICE and BSA was responsible for the operation and maintenance of the AAQMS as well as the validation of the data recorded. This report presents the data collected at the project site for the period:

- **Point 1**: January 16-17, 2024 at 1:00 pm to 12:00 pm
- **Point 2**: January 17-18, 2024 at 2:00 pm to 1:00 pm

This report summarizes the results obtained from the ambient air quality survey and field observations for any exceedances of the NCEC air quality standard. The ambient air quality standards used to identify pollution include the national standards set out in the Implementing Regulations for Air Quality of the Environmental Law issued by Royal Decree No. (M/165) as of 19/11/1441 AH. Graphical representations of the monitoring results within the context of the relevant limit values are also provided.

The following air pollutants were measured at each point:

- Particulate matter with aerodynamic diameters less than 10 microns (PM_{10})
- Particulate matter with aerodynamic diameters less than 2.5 microns ($PM_{2.5}$)
- Sulfur dioxide (SO_2)
- Oxides of Nitrogen (NO_2)
- Ozone (O_3)
- Carbon Monoxide (CO)

In addition, meteorological data for wind speed, wind direction, ambient temperature, relative humidity, barometric pressure were also measured.

2) Monitoring and Data Collection

2.1. Siting Details

The location of the ambient air quality monitoring station as shown in Table 2 and Figure 1. The Monitoring location was chosen by (ALI KHUDHAIR AL HARBI FOR ENVIRONMENTAL CONSULTANCY OFFICE) and was intended to provide background or baseline data for the site. Inlet manifold length 5 meters from ground level, and the power source of diesel generator was located 100 meters far from the station in down wind direction.

Table 2: Location of Ambient Air Quality Monitoring Stations

Site Name		Geographical Coordinates	
AFIF 1 Project site	Location 1	N	23.769605
		E	43.135293
	Location 2	N	23.804565
		E	43.118066

Figure 1: Location of the Ambient Air quality monitoring station

Figure 2: Location of the Ambient Air quality monitoring stations in the site at point 1.

Figure 3: Location of the Ambient Air quality monitoring stations in the site at point 2.

2.1 Monitoring Methodology

- Monitoring Methodology for AAQMS

Monitoring methodology and Reference Measurement Principle and Calibration Procedures for the Measurement of Ambient Air Quality Pollutants are summarized in Table 3.

Table 3: Reference Measurement Principle and equivalent reference method

Measured Parameter	Data Collection Methods Used	Description of the Method	Method Type	Automated Equivalent Reference Method ID
Sulfur Dioxide (SO_2)	40 CFR Appendix A-1 to Part 50	Reference Measurement Principle and Calibration Procedure for the Measurement of Sulfur Dioxide in the Atmosphere (Ultraviolet Fluorescence Method)	FRM	EQSA-0486-060
Nitrogen Oxides (NO - NO_2 - NO_x)	Code of Federal Regulations, Title 40, Part 50, Appendix F	Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence)	FRM	RFNA-1289-074
Ozone (O_3)	USEPA Code of Federal Regulations (Title 40, Part 50, Appendix D)	Reference Measurement Principle and Calibration Procedure for the Measurement of Ozone in the Atmosphere (UV light absorption Method)	FRM	EQOA-0880-047
Carbon Monoxide (CO)	40 CFR Appendix C to Part 50	Measurement Principle and Calibration Procedure for the Measurement of Carbon Monoxide in the Atmosphere (Non-Dispersive Infrared Photometry)	FRM	RFCA-0981-054
Particulate Matter (PM_{10} &$PM_{2.5}$)	40 CFR 50 Appendix L	Reference Method for the Determination of Fine Particulate Matter	FRM	EQPM-0609-183

* FRM: Federal Reference Method

2.2. Monitored Parameters

Table 4 below shows the details of parameters monitored and the instruments used at both monitoring stations. Note that the meteorological instruments (wind Speed, wind direction, Temp, and RH) sensors installed at 10m above ground level Barometric pressure installed at 3m above ground level.

Table 4: Parameters Measured at Air Quality Monitoring Stations

PARAMETERS	SN	INSTRUMENT AND MEASUREMENTS
O_3	0515011470	THERMO ENVIRONMENTAL INSTRUMENTS,49C EQOA-0880-047
NO, NO_2, NOx	1324258454	THERMO ENVIRONMENTAL INSTRUMENTS,42I RFNA-1289-074
CO	78485389	THERMO ENVIRONMENTAL INSTRUMENTS 48 C RFCA-0981-054
SO_2,	1153170025	THERMO ENVIRONMENTAL INSTRUMENTS 43I EQSA-0486-060
DILUTION CALIBRATOR	4619	NA
ZERO AIR GENERATOR	4630	NA
AMBIENT TEMPERATURE	031194	41382 VF-METTONE-USA
BAROMETRIC PRESSURE	Y16801	092-METTONE-USA
RELATIVE HUMIDITY	031194	41382 VF-METTONE-USA
WIND SPEED, WIND DIRECTION	168369	RM YOUNG-USA
PM_{10}	250	SCATTERED LIGHT SPECTROMETRY
$PM_{2.5}$	250	SCATTERED LIGHT SPECTROMETRY
RAIN GAUGE	Y17122	TIPPING BUCKET

SN: serial number

2.3. Data Collection Methods

2.3.1 Compliance with Standards

The instruments used in the stations were approved by the US EPA and all procedures for ambient air monitoring are in accordance with US EPA procedures.

2.3.2. Data Acquisition

Data acquisition was performed by using a PC based situated at each of the monitoring sites. Data was logged every 15 seconds and stored every 15 seconds. The data was backed up and downloaded every day and subjected to a rigorous program of quality checking.

2.4. Data Validation and Reporting

2.4.1. Validation

The purpose of the data validation section is to specify the guidelines that have been taken into consideration whenever possible in collecting, verifying, and validating continuous ambient air quality and meteorological monitoring data in this project.

BSA maintains one distinct database containing non-validated and validated data respectively. The validated database is created by duplicating the non-validated database and then flagging data affected by instrument faults, calibrations, and other maintenance activities. Invalid data is removed with the support of valid reason e.g., supported by maintenance notes, calibration sheets etc. as documented in exception tables).

Validation is performed by a trained data analyst. All data is checked and reviewed by the BSA section head. Graphs and reports are generated based on the validated hourly data and daily data.

2.4.2 Data Validation Levels

Level 0

Routine checks – Field and laboratory operations, data processing, reporting conducted in accordance with Standard Operating Procedures (SOPs) – Proper data

file identification; review of unusual events, field data sheets, and result reports; instrument performance checks.

Level I

Internal consistency tests – Identify values that appear atypical when compared to the values of the entire dataset.

Level II/III

External consistency tests– Identify values in the data that appear atypical when compared to other datasets – Continued evaluation of the data as part of the data interpretation process. Outliers are values that lie outside most of the other values in a set of data. Outliers treated as valid/suspect until proven invalid. The first assumption upon finding a measurement that is inconsistent with physical expectations is that the unusual value is due to a measurement error. If upon tracing the path of the measurement, nothing unusual is found, the value can be assumed to b

e a valid result of an environmental cause.

2.4.3 Considerations in Evaluating AAQ Data

- Levels of other pollutants
- Time of day/year
- Observations at other sites
- Audits and inter-laboratory comparisons
- Instrument performance history
- Calibration drift
- Site characteristics
- Meteorology
- Exceptional events

Visual Data Review: Time Series are visually inspected for the below:

- Jumps, dips.
- Periodicity of peaks
- Calibration gas, carryover
- Expected diurnal pattern.
- Expected relationships.
- High concentrations of less abundant species or low concentrations of more abundant species

Data is put into perspective of:

- Local, regional, or national averages
- Trends over time
- Comparison to nearby sites, similar areas
- Detection limits

2.4.4 Reporting

The reported data is provided in a Microsoft Excel spreadsheet named:
"Ambient air quality monitoring survey report -2024.xls"

The data contained in these reports is based on Kingdom of Saudi Arabia (KSA) time.

3) Ambient Air Quality Standards

The air quality monitoring station's data has been compared to the NCEC's 2020 ambient air quality standards.

Table 5 summarize the NCEC's 2020 ambient air quality standards for the pollutants studied. Note that CO and O_3 averages are rolling averages whereas all other averages are fixed averages.

Table 5: KSA NCEC Ambient Air Quality Standards

Parameter	Time Period	Exceedance Level	Units	Number of Allowable Exceedances
SO_2	1 Hour	441	µg/m³	24 times per year
	24 Hour	217	µg/m³	3 time per annum
	1 Year	65	µg/m³	None
CO	1 Hour	40,000	µg/m³	1 time per annum
	8 Hour	10,000	µg/m³	2 times in 30 days
O_3	8 Hour	157	µg/m³	25 time per annum
NO_2	1 Hour	200	µg/m³	24 times per year
	1 Year	100	µg/m³	None
PM_{10}	24 hours	340	µg/m³	24 times per year
	1 Year	80	µg/m³	None
$PM_{2.5}$	24 Hour	35	µg/m³	24 times per year
	1 Year	15	µg/m³	None
Source		Pollutant		Emissions maximum Limit

4) Calibrations and Maintenance

4.1. Maintenance

Regular maintenance was carried out by BSA. Sample inlets of all analyzers were cleaned before installation and on a weekly basis. Filters of gas analyzers were changed before the start of monitoring. Meteorological sensors cleaned before installation. In addition, the regular maintenance program conducted as per standard or operation manual such as: meteorological sensors should be cleaned after rain because the dust particles stick to the meteorological sensors. After every sandstorm, inlets of all analyzers as well as manifolds of the gas analyzers should be cleaned to protect analyzers from particulate matter.

4.2. Calibration

Multipoint calibration of the instruments monitoring gaseous pollutants was conducted one time during the monitoring period. The instruments were calibrated in full accordance with the manufacturer's recommendations and conform to the requirements of USEPA. Calibrations were performed at the monitoring site by allowing the analyzer to sample a gaseous standard containing a known pollutant concentration. Calibration data were recorded by the same data acquisitions system. Mast wind direction system were oriented at South direction as per manufacture operation manual.

5) Results and discussion

5.1. Air Quality Summary

Tables 6 to 16 compare monitoring results for AAQMS for the period:

- **Point 1**: January 16-17, 2024 at 1:00 pm to 12:00 pm
- **Point 2**: January 17-18 ,2024 at 2:00 pm to 1:00 pm

The results are explained as follows:

- Air Pollutants Monitored results

5.1.1. Sulphur Dioxide (SO_2):

The levels of Sulphur dioxide (SO_2) in ambient air are typically directly related to the concentration of Sulphur in fuel and the quantity of fuel being combusted. Upon combustion, approximately 98% of the Sulphur in the fuel will oxidize to form SO_2, with the remaining 2% producing Sulphur trioxide (SO_3). The emitted SO_2 can also further oxidize to SO_3 and react with water to produce acid rain in the form of sulphury acid (H_2SO_4). Short-term exposures to SO_2 have shown adverse respiratory effects including bronchoconstriction and increased asthma symptoms.

The recorded data of Sulphur dioxide (SO_2) was captured for two days at two locations, The results were summarized in the following table (Table 6), and represented on a graphs (Figure 4 :Figure 5) which includes the maximum permissible limits in NCEC's 2020 ambient air quality standards Accordingly, the results did not exceed the permissible limits in NCEC daily and hourly standards.

Table 6: Summary of SO_2 Results

SO_2	Concentration at sampling point		NCEC Exceedance Level µg/m³	
	Point 1	Point 2	1 Hour	24 Hour
Percentage data capture (Hourly Values)	100	100	441	217
Hourly Maximum (µg/m3)	5.1	5.3		
Hourly Minimum (µg/m3)	2.1	1.9		
Daily Average (µg/m3)	2.5	2.7		
Hourly value > 441 (ug/M³)	0	0		

*There were no exceedances of NCEC standards

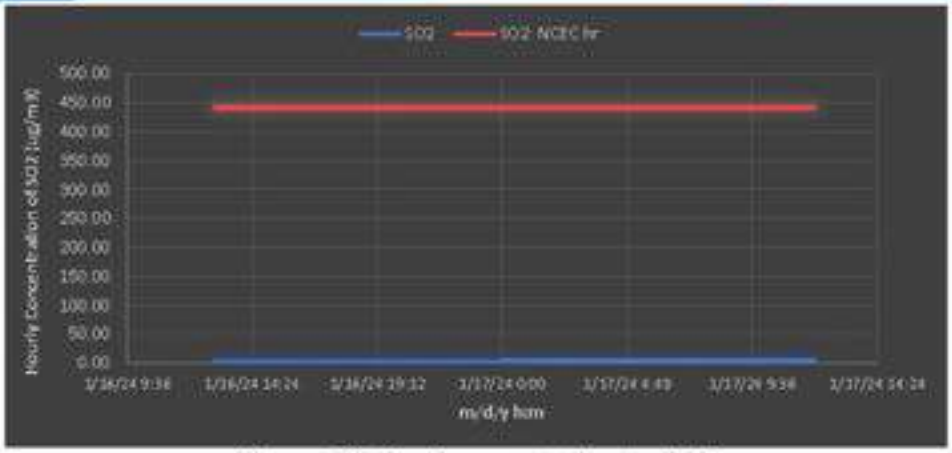

Figure 4: SO_2 hourly concentration at point 1.

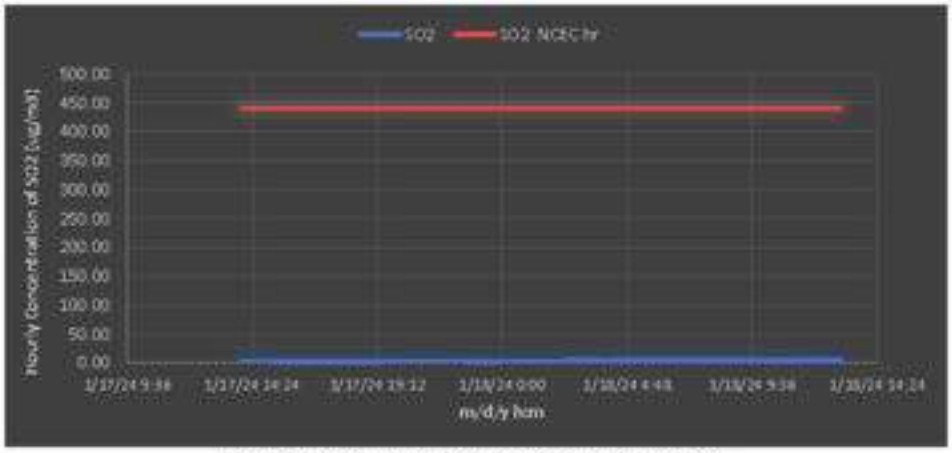

Figure 5: SO_2 Hourly Concentration at point 2.

5.1.2. Oxides of Nitrogen (NO, NO_2, NO_x):

In a combustion process, NOx is produced through two mechanisms, namely thermal NOx, fuel NOx and prompt NOx. Thermal NOx is the primary source of NOx and is formed as a high temperature dissociation and subsequent reaction of nitrogen (N_2) and oxygen (O_2). It is produced in the hottest part of the flame and its formation increases exponentially with the flame temperature. The control of thermal NOx is generally achieved through reducing the flame temperature, reducing the residence time, or by operating under fuel rich conditions. Fuel NOx is formed by the reaction of nitrogen compounds chemically bound in liquid or solid

fuels with oxygen in the combustion air. In the combustion of such fuels, fuel NOx can account for up to 50% of the total NOx emissions. Prompt NOx is formed from the rapid reaction of atmospheric nitrogen with hydrocarbon radicals, and typically under partially fuel-rich conditions. It can be reduced through combustion staging or by operating under highly oxidizing combustion conditions.

NO2 is the primary component of concern in NOx emissions. Generally, up to 10% of the NOx emitted from the combustion of fuel is emitted as NO_2. The remainder is emitted as NO, which is subsequently converted to NO_2 in reactions with various oxidants and ozone as the plume is transported downwind from the source. The rate of NO_2 formation varies with time of day, season, temperature, wind speed, solar radiation, and the availability of oxidants to help drive the chemical reactions. NO_2 is a reddish-brown gas with a pungent Odor, which upon reaction with other atmospheric compounds, becomes a major contributor to smog, acid rain, inhalable particulates and reduced visibility. At significant levels and exposure, inhalation may result in irritation and burning to the skin and eyes, nose, and throat. Prolonged exposure may result in permanent lung damage.

The recorded data of Oxides of Nitrogen (NO, NO_2, NOx) was captured for two days at two locations, The results were summarized in the following table (Table 7), and represented on a graph (Figure 8:Figure 9) which includes the maximum permissible limits in NCEC's 2020 ambient air quality standards. Accordingly, the results did not exceed the permissible limits in NCEC daily & Hourly standards

Table 7: Summary of (NO, NO_2, NOx) Results.

NO_2	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	1 Hour
Percentage data capture (Hourly Values)	100	100	200
Hourly Maximum (ug/M³)	17.5	27.6	
Hourly Minimum (ug/M³)	0.03	1.8	
Hourly value > 200 (ug/M³)	0	0	
Daily average (ug/M³)	6.2	7.5	
NO			1 Hour
Percentage data capture (Hourly Values)	100	100	NA
Hourly Maximum (µg/m3)	7.8	6.1	
Hourly Minimum (µg/m3)	1.0	1.5	
Daily Average (µg/m3)	4.6	3.2	
NOX			1 Hour
Percentage data capture (Hourly Values)	100	100	NA
Hourly Maximum (µg/m3)	29.7	35.8	
Hourly Minimum (µg/m3)	1.7	4.5	
Daily Average (µg/m3)	13.4	12.5	

*There were no exceedances of NCEC standards.

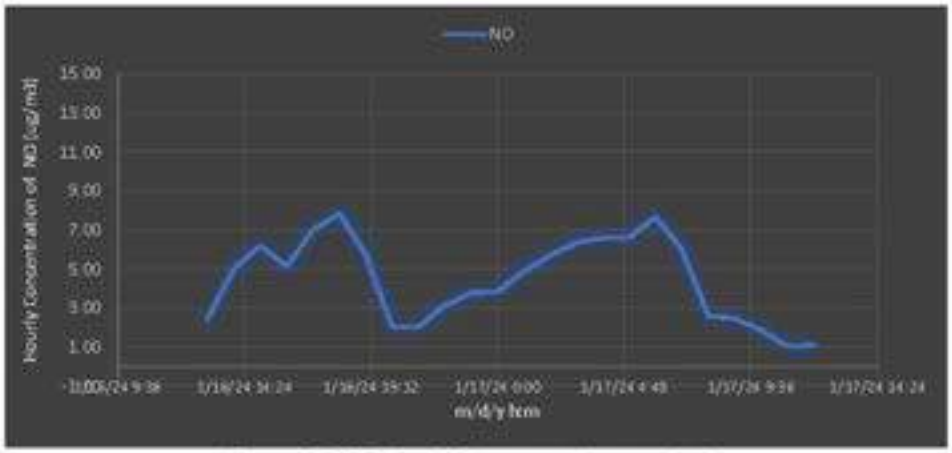

Figure 6: NO Hourly Concentration at point 1.

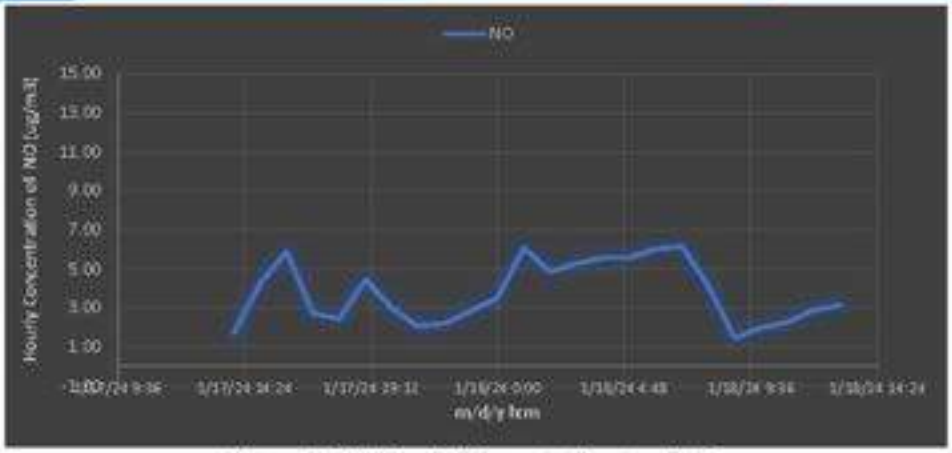

Figure 7: NO Hourly Concentration at point 2.

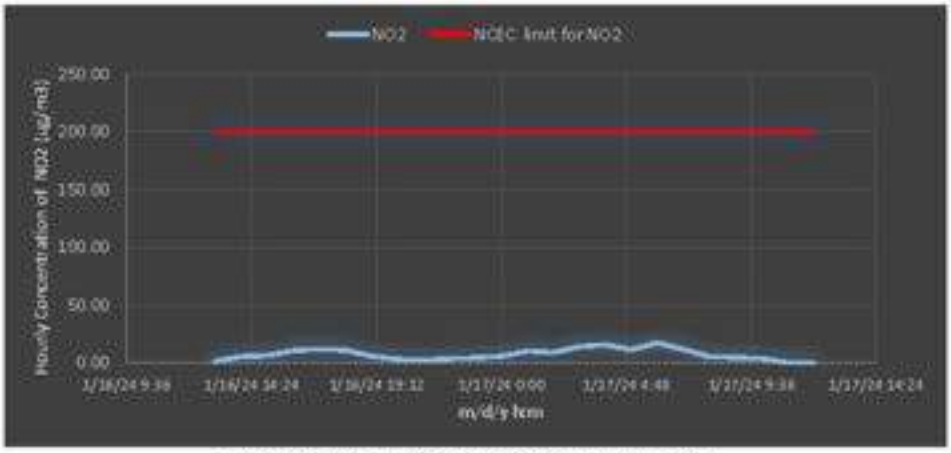

Figure 8: NO_2 Hourly Concentration at point 1.

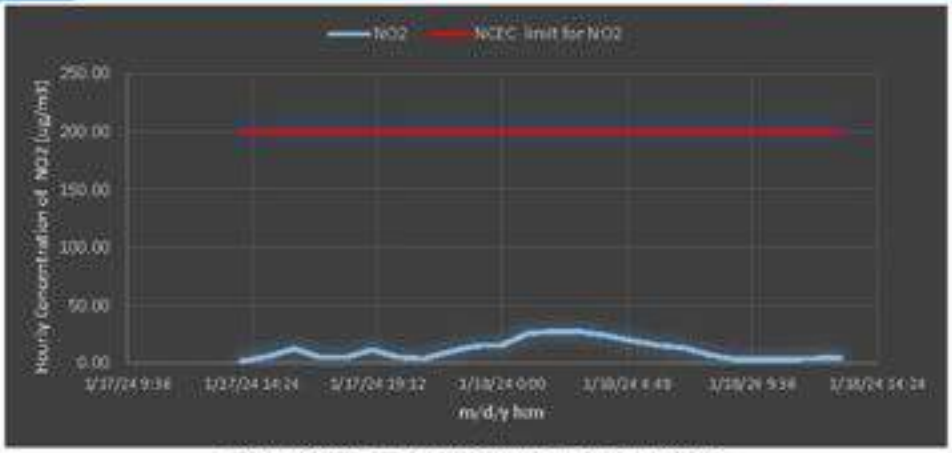

Figure 9: NO_2 Hourly Concentration at point 2.

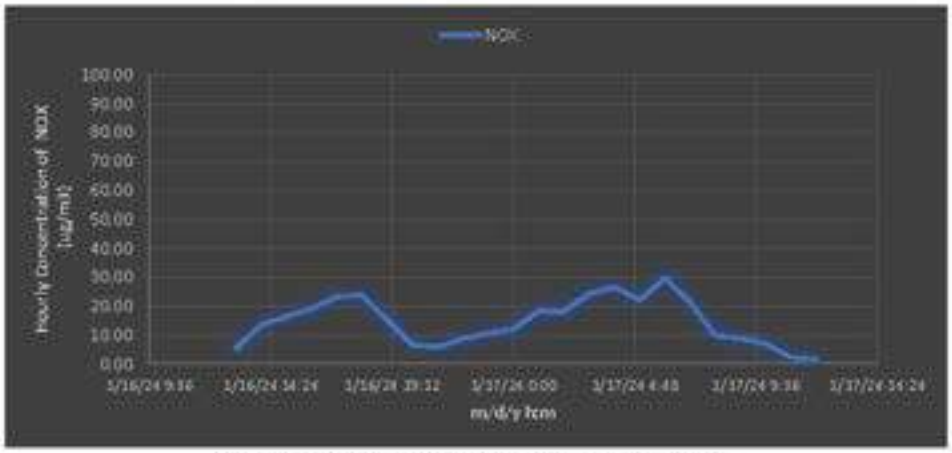

Figure 10: NOx Hourly Concentration at point 1.

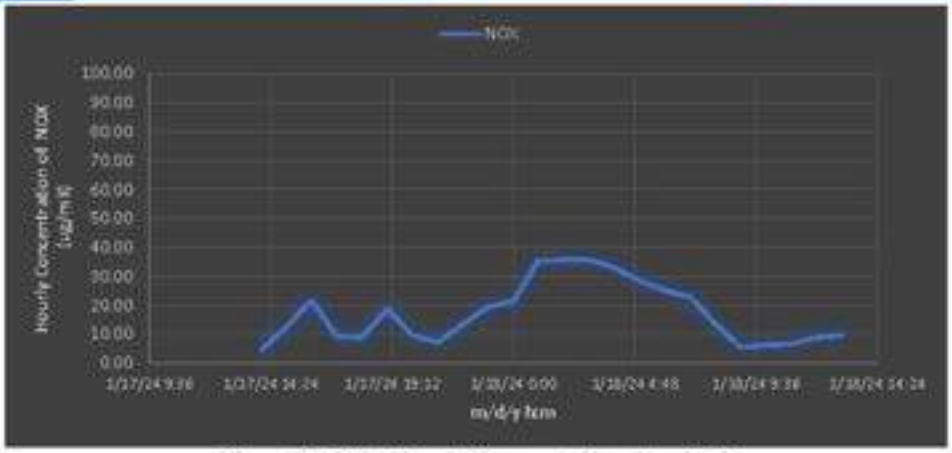

Figure 11: NOx Hourly Concentration at point 2.

5.1.3. Carbon Monoxide (CO):

Carbon monoxide is a colorless and odorless gas which reduces the delivery of oxygen to the body's organs. For those with heart disease, exposure to low doses can result in chest pain. For healthier people, exposure to higher levels affects the central nervous system. Incomplete oxidation of fuel results in the formation of CO. In simplified terms, the generic stoichiometric combustion equation for complete combustion is:

$$HC + O_2 \rightarrow CO_2 + H_2O$$

However, if sufficient oxygen (O_2) is not present to complete the combustion of the hydrocarbon fuel (HC), then the oxidation to carbon dioxide (CO_2) and water (H_2O) is not completed and hence CO is emitted.

The recorded data of Carbon Monoxide (CO) was captured for two days at two locations, The results were summarized in the following table (Table 8), and represented on a graph (Figure 12:Figure 13) which include the maximum permissible limits in NCEC's 2020 ambient air quality standards.

In addition, the average concentration of Carbon Monoxide (CO) was calculated for 8 hours to be compared to the permissible NCEC's limits and the result represented on a graph (Figure 14:Figure 15). Accordingly, the results did not exceed the permissible limits in NCEC daily & hourly standards.

Table 8: Summary of CO Results.

CO	Concentration at sampling point		NCEC Exceedance Level µg/m³	
	point 1	point 2	1 Hour	8 Hour
Percentage data capture (Hourly Values)	100	100	40,000	10,000
Hourly Maximum (ug/M³)	160.0	340.1		
Hourly Minimum (ug/M³)	30.0	60.0		
8 Hour Maximum (ug/M³)	126.3	242.5		
8 Hour Minimum (ug/M³)	79.8	102.5		
Hourly value > 40000 (ug/M³)	0	0		
8-Hourly rolling average value > 10000 (ug/M³)	0	0		
Daily average (ug/M³)	106	115		

*There were no exceedances of NCEC standards

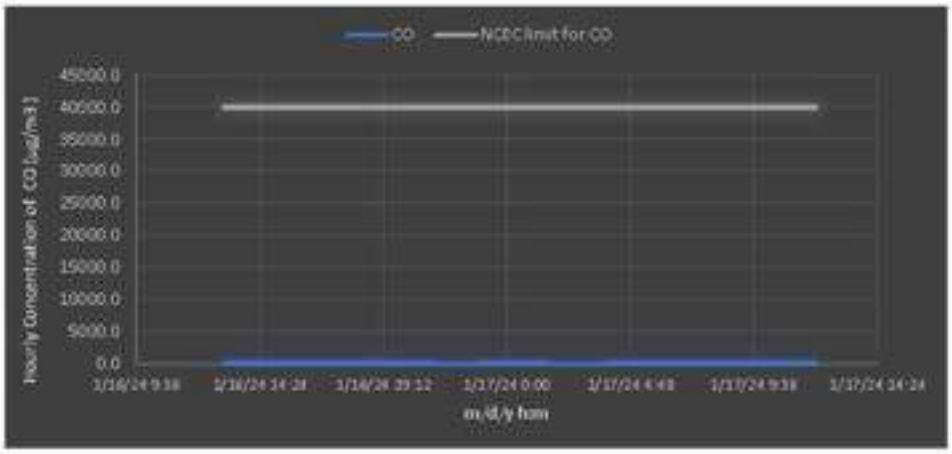

Figure 12: CO Hourly Concentration at point 1.

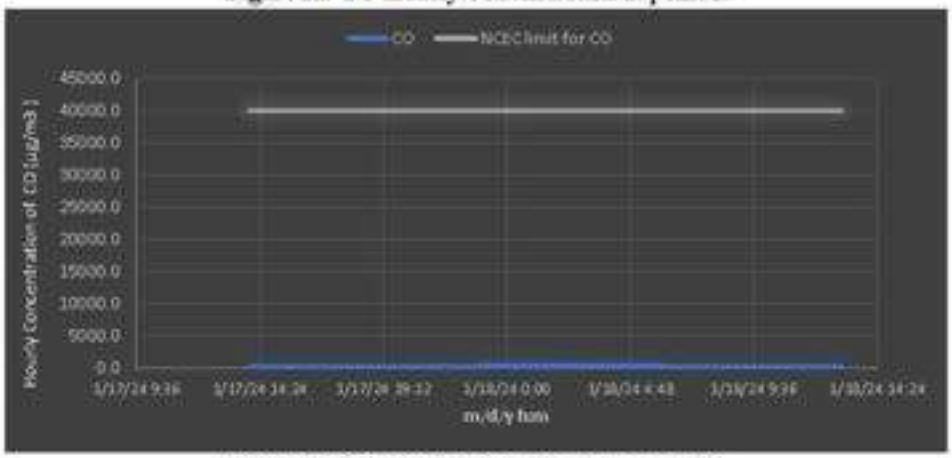

Figure 13: CO Hourly Concentration at point 2.

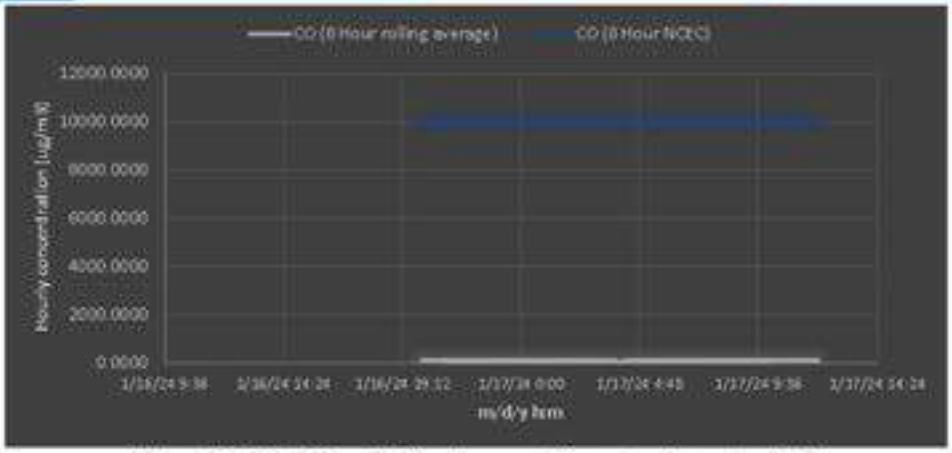

Figure 14: CO 8 Hour Rolling Average Concentrations at point 1.

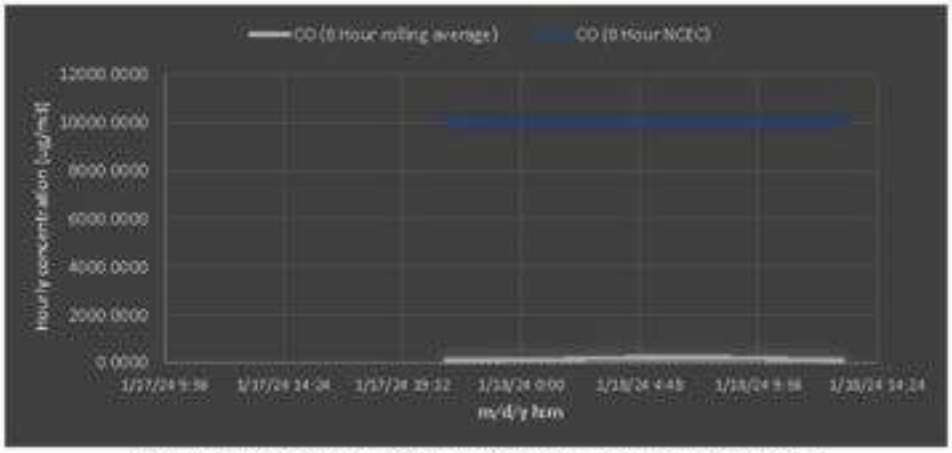

Figure 15: CO 8 Hour Rolling Average Concentrations at point 2.

5.1.4. Ozone (O3):

Ozone is composed of one oxygen atom. It forms a protective layer which prevents entry of harmful ultraviolet radiation into the earth. The ground ozone is very harmful to human beings and the environment.

It is released from industries, automobile emissions, gasoline vapors, solvents, chemicals, and electronic devices. Nitrogen oxides (NOx) and total Volatile Organic Compounds (TVOCs) also contribute to ground ozone formation.

Ground ozone interferes with the plant's respiration process and enhances environmental stressor susceptibility. When ozone is inhaled by humans, reduced

lung function, inflammation of airways, and irritation in the eyes, nose & throat are seen. The recorded data of Ozone (O_3) was captured for two days at two locations, The results were summarized in the following table (Table 9) and represented on a graph (Figure 16: Figure 17). In addition, the average concentration of Ozone (O_3) was calculated for 8 hours to be compared with the permissible NCEC's limits and the result represented on a graph (Figure 18:Figure 19)Accordingly, the results did not exceed the permissible limits in NCEC daily standards.

the relation between NO_2 and O_3 concentration during the daytime and nighttime which noted increase the concentration of O_3 and decrease the concentration of NO_2 at the same time during the daytime and decrease the O_3 concentration and increase of NO_2 concentration. This might be due to dissociation of NO_2 by solar rays to free O and NO and then react O with O_2 to produce O_3 during the daytime. the relation between NO_2 and O_3 concentration was represented on a graph (Figure 20:Figure 21). Accordingly, the results did not exceed the permissible limits in NCEC 8-hour for ozone standards for location 1(point 1) & location 2 (point 2)

Table 9: Summary of O3 Result.

Ozone	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	8 Hour
Percentage data capture (Hourly Values)	100	100	157
Hourly Maximum (ug/M³)	81.8	82.0	
8 Hour Maximum (ug/M³)	68.2	76.5	
8 Hour value > 157 (ug/M³)	0	0	
Daily average (ug/M³)	55.3	56.9	

*There were no exceedances of NCEC standards

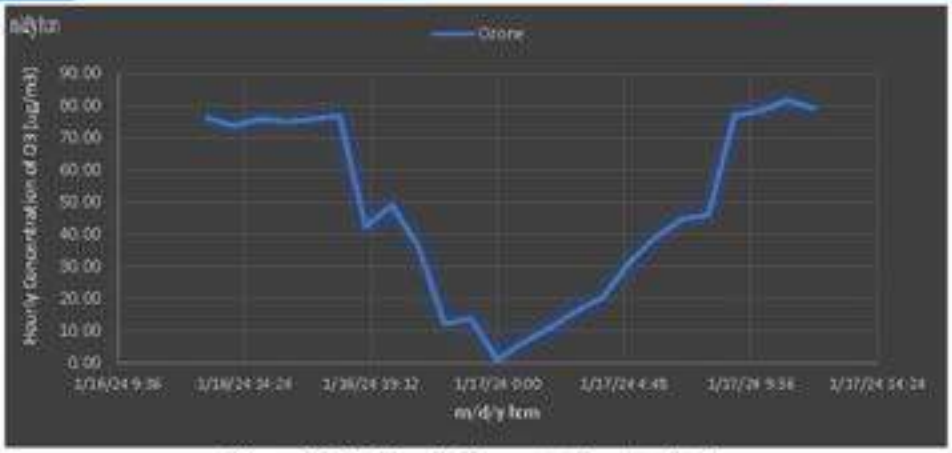

Figure 16: O_3 Hourly Concentration at point 1.

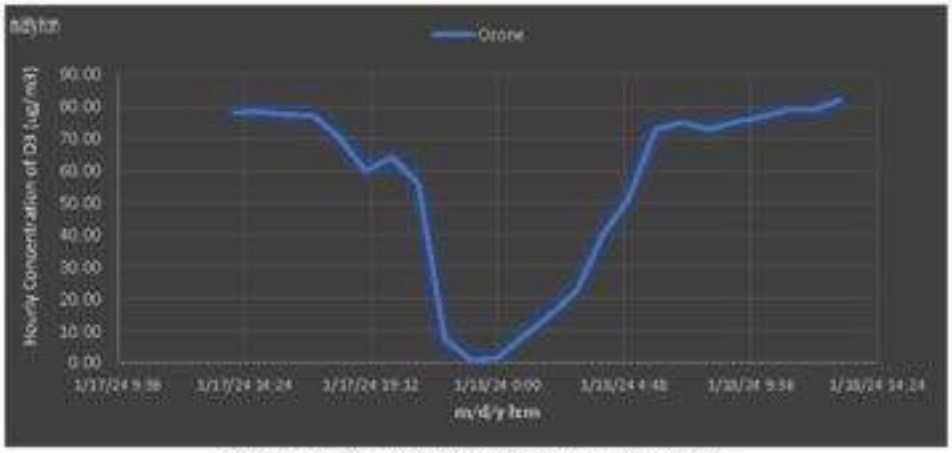

Figure 17: O_3 Hourly Concentration at point 2.

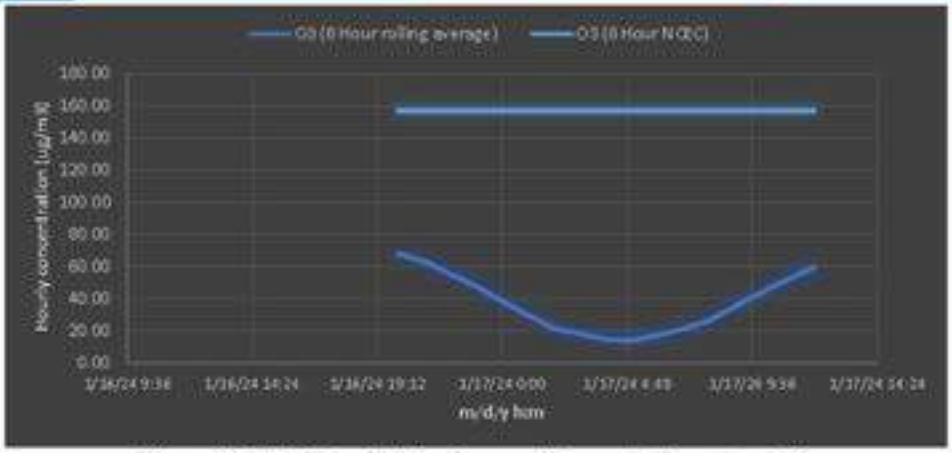

Figure 18: O_3 8 Hour Rolling Average Concentrations at point 1.

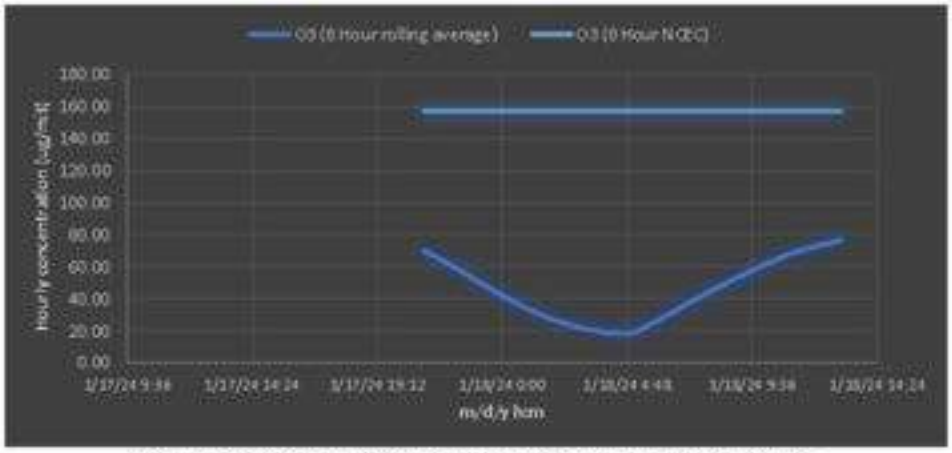

Figure 19: O_3 8 Hour Rolling Average Concentrations at point 2.

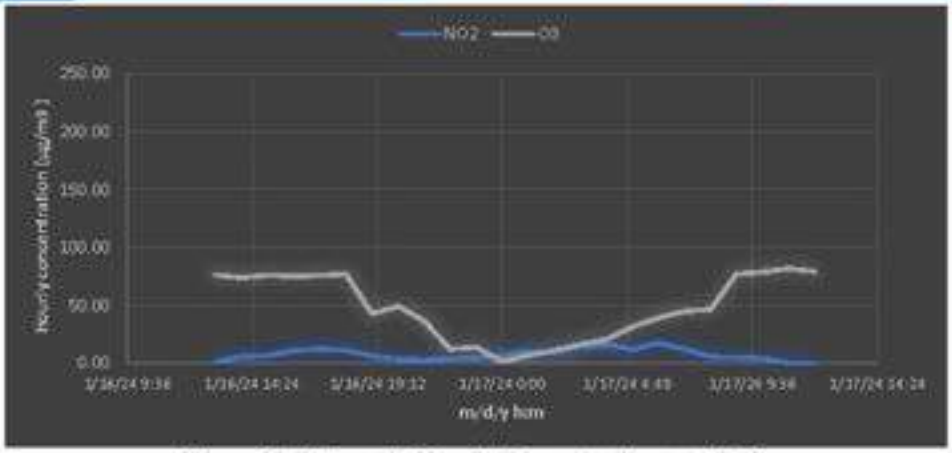

Figure 20: NO_2 vs. O_3 Hourly Concentrations at point 1.

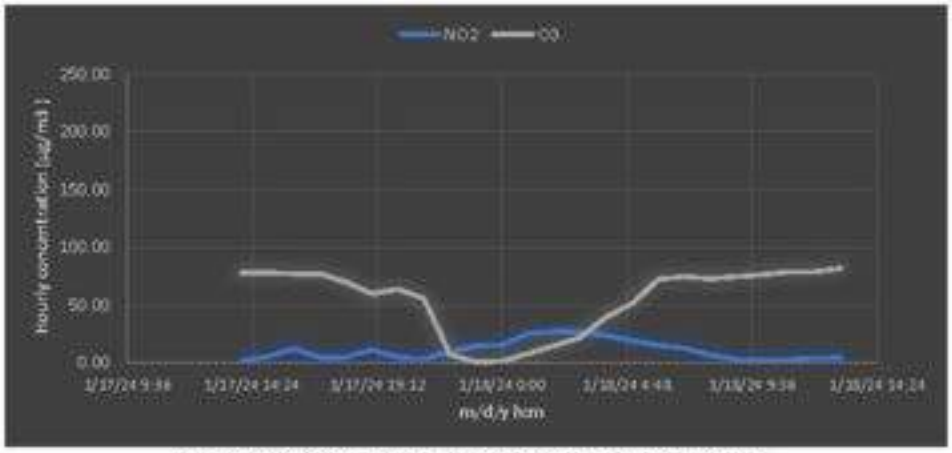

Figure 21: NO_2 vs. O_3 Hourly Concentrations at point 2.

5.1.5. Particulate Matter (PM_{10} & $PM_{2.5}$):

A mixture of particles with liquid droplets in the air forms particulate matter. PM 10 are particles that have a size of less than or equal to 10 microns whereas PM2.5 are ultra-fine particles having a size of less than or equal to 2.5 microns.

Particulate Matter is released from constructions, smoking, cleanings, renovations, demolitions, constructions, natural hazards such as earthquakes, volcanic eruptions, and emissions from industries such as brick kilns, paper & pulp, etc.

These particles, when inhaled, can penetrate deeper into the respiratory system, and cause respiratory ailments such as asthma, coughing, sneezing, irritation in the airways, eyes, nose, throat irritation, etc. Studies have also shown links between PM exposure and diabetes.

The recorded data of Particulate Matter (PM_{10} & $PM_{2.5}$) was captured for two days at two locations, The results were summarized in the following table (Table 10, Table 11), and represented on a graph (Figure 22:Figure 23:Figure 24:Figure 25). the results did not exceed the permissible limits in NCEC daily standards.

Table 10: Summary of PM_{10} Results.

PM_{10}	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	24 Hour
Percentage data capture (Hourly Values)	100	100	340
Hourly Maximum (ug/M³)	114.0	147.6	
Hourly Minimum (ug/M³)	37.1	38.6	
Daily Values >340 (ug/M³)	0	0	
Daily average (ug/M³)	48.0	68.9	

*There were no exceedances of NCEC standards

Table 11: Summary of $PM_{2.5}$ Results.

$PM_{2.5}$	Concentration at sampling point		NCEC Exceedance Level µg/m³
	point 1	point 2	24 Hour
Percentage data capture (Hourly Values)	100	100	35
Hourly Maximum (ug/M³)	30.3	31.6	
Hourly Minimum (ug/M³)	11.3	13.8	
Daily Values >35 (ug/M3)	0	0	
Daily average (ug/M³)	14.5	18.7	

*There were no exceedances of NCEC standards

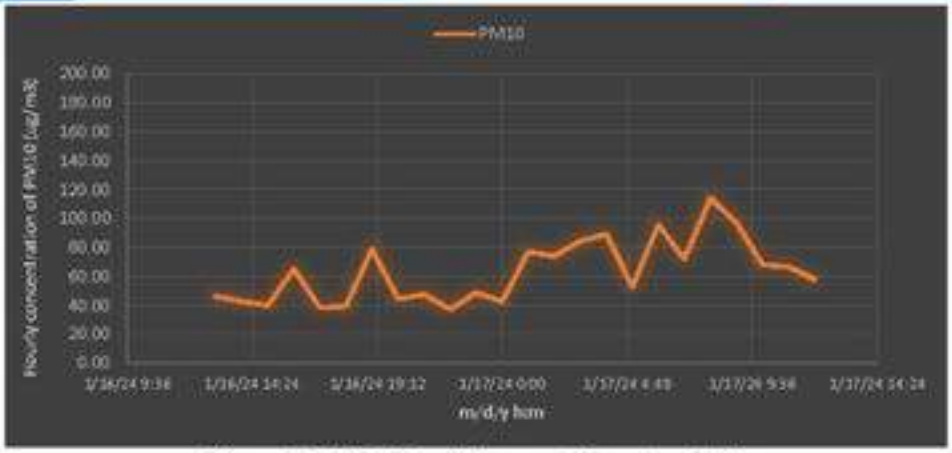

Figure 22: PM_{10} Hourly Concentrations at point 1.

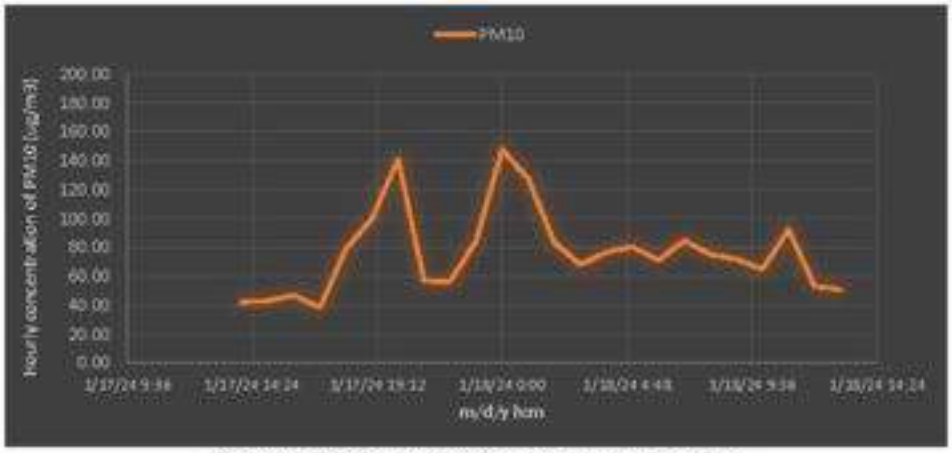

Figure 23: PM_{10} Hourly Concentrations at point 2.

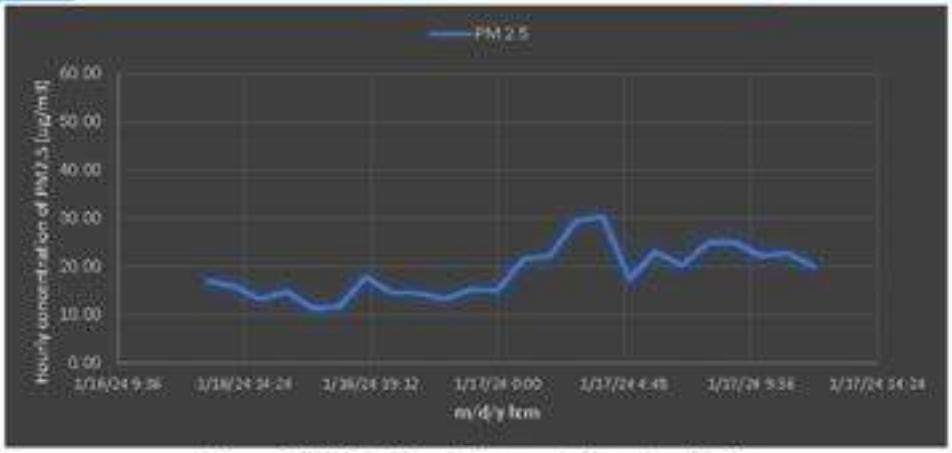

Figure 24: $PM_{2.5}$ Hourly Concentrations at point 1.

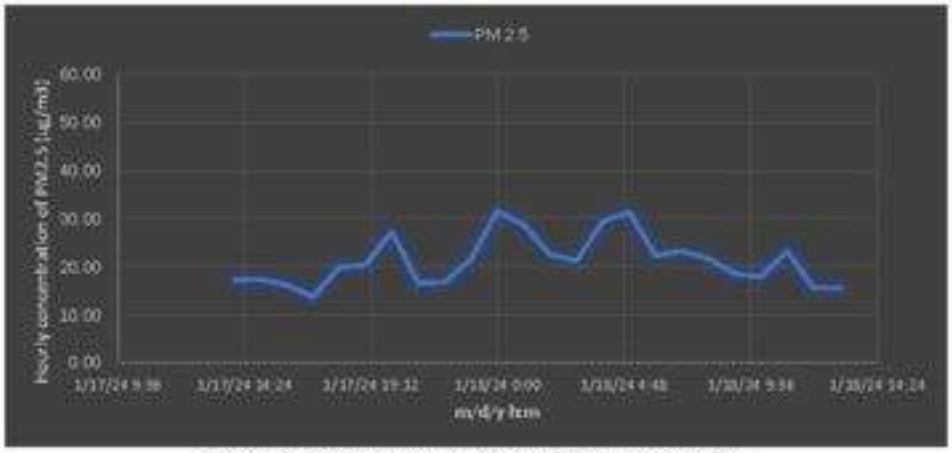

Figure 25: $PM_{2.5}$ Hourly Concentrations at point 2.

- Meteorological Parameters Monitored result:

The evaluation and interpretation of gas emission measurements is only possible in comparison with meteorological data acquired concurrently. The structure of the atmosphere close to the ground is extremely important for the local climate. Knowing solar radiation as well as the air humidity and air temperature is necessary to evaluate chemical reactions of pollutants in the air.

5.1.6. Temperature and humidity:

Temperature and humidity play a significant role in gas emission measurements.

The recorded data of temperature and humidity was captured for two days, The results for the tow location were summarized in the following table and represented on a graph (Figure 26:Figure 27:Figure 28:Figure 29).

5.1.7. Barometric pressure:

To predict the weather, it must be the first understanding how atmospheric pressure works. The higher the barometric pressure, the better it is for good weather conditions. Conversely, low pressures generally bring in more clouds and moisture, leading to poor visibility and even precipitation or snowfall.

The recorded data of Barometric pressure was captured for two days, The results for the two location were summarized in the following table and represented on a graph (Figure 30:Figure 31).

5.1.8. Wind speed and direction:

Wind speed describes how fast the air is moving past a certain point. This may be an averaged over a given unit of time, or an instantaneous speed, which is reported as a peak wind speed, wind gust or squall.

Wind direction describes the direction on a compass from which the wind emanates, for instance, from the North or from the West. Wind speed and direction are important for monitoring and predicting weather patterns and global climate. Wind speed and direction have numerous impacts on surface water. These parameters affect rates of evaporation, mixing of surface waters, and the development of seiches and storm surges. Each of these processes has dramatic effects on water quality and water level.

The recorded data of Wind speed and direction was captured for 24 hours at the location, The results were summarized in the following table, and represented on a graph (Figure 32). Also, the Wind speed and direction were represented as a wind rose (Figure 34, Figure 36), and the wind frequency count and distribution was mentioned in (Table 13,Table 15). wind rose is a graphic tool used by meteorologists to give a succinct view of how wind speed and direction are typically distributed at a particular location. Historically, wind roses were predecessors of the compass rose, as there was no differentiation between a cardinal direction and the wind which blew from such a direction. Using a polar coordinate system of gridding, the frequency of winds over a period is plotted by wind direction, with color bands showing wind speed ranges. The direction of the longest spoke shows the wind direction with the greatest frequency.

Table 12: Monitored Meteorological Parameters result.

Ambient Temperature	Point 1	Point 2
Percentage data capture (Hourly Values)	100.0	100.0
Hourly Maximum (°C)	24.8	26.2
Hourly Minimum (°C)	11.2	10.1
Relative Humidity	Point 1	Point 2
Percentage data capture (Hourly Values)	100.0	100.0
Hourly Maximum (%)	83.3	49.7
Hourly Minimum (%)	19.5	21.4
Barometric Pressure	Point 1	Point 2
Percentage data capture (Hourly Values)	100.0	100.0
Hourly Max (hPa)	928.0	931.0
Hourly Minimum (hPa)	923.0	927.0
Wind Parameters	Point 1	Point 2
Percentage data capture (Hourly Values)	100.0	100.0
Wind Speed Hourly Maximum (m/s)	6.0	6.1
Wind Speed Hourly Minimum (m/s)	1.4	1.2
Mean Wind Speed(m/s)	3.7	3.2
Prevailing Wind Direction	NW/SW	

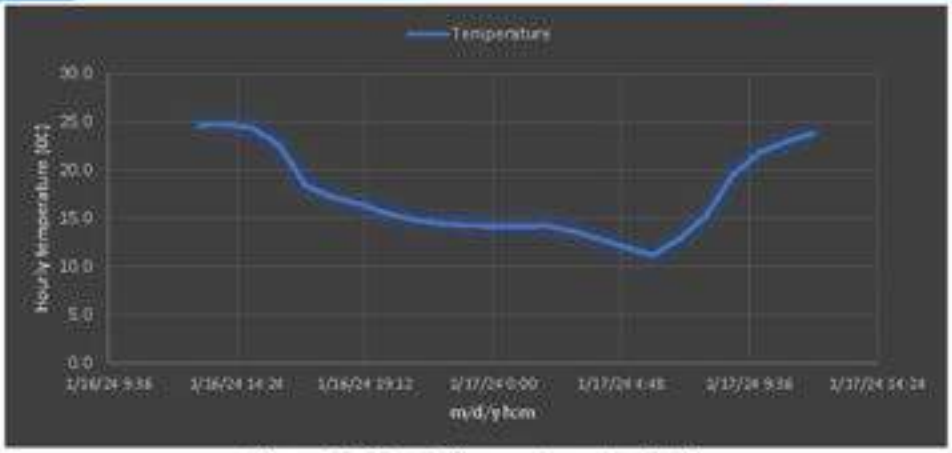

Figure 26: Hourly Temperature at point 1.

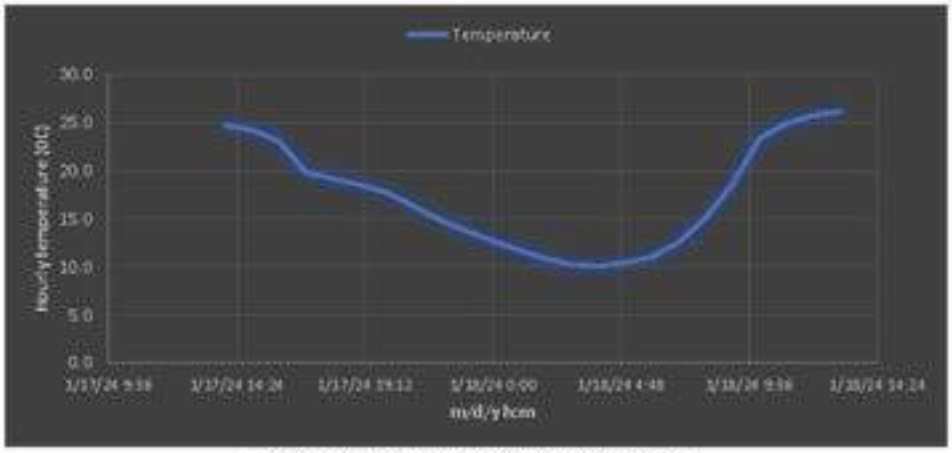

Figure 27: Hourly Temperature at point 2.

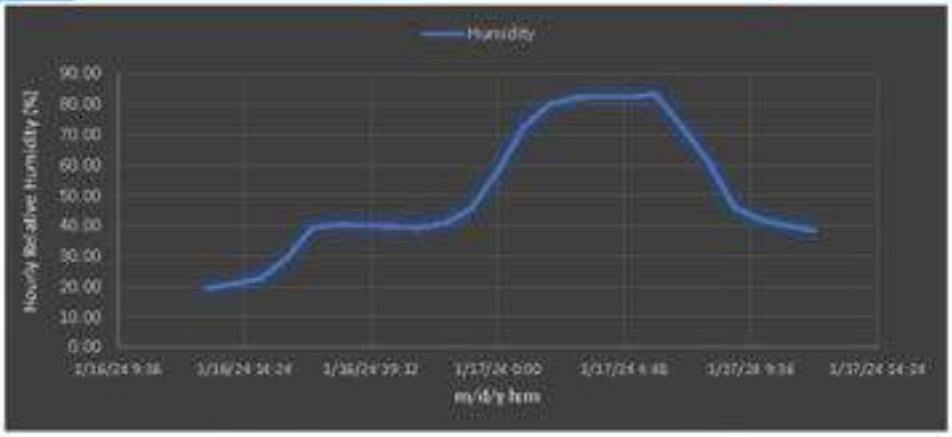

Figure 28: Hourly Relative Humidity at point 1.

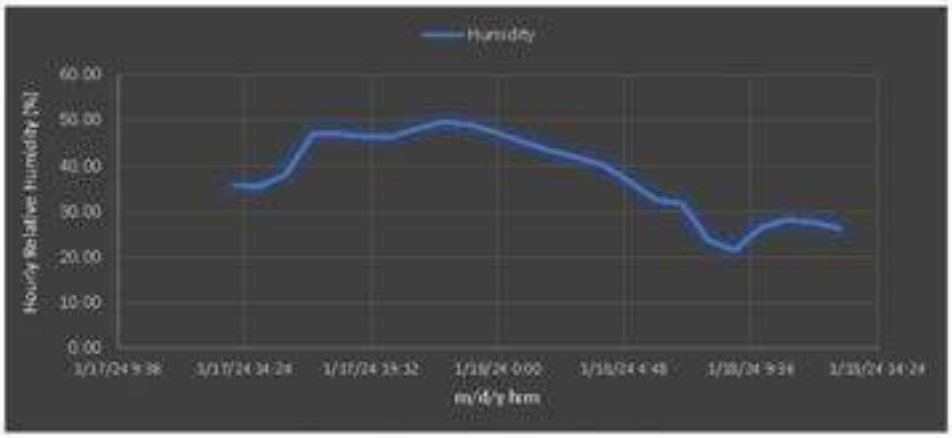

Figure 29: Hourly Relative Humidity at point 2.

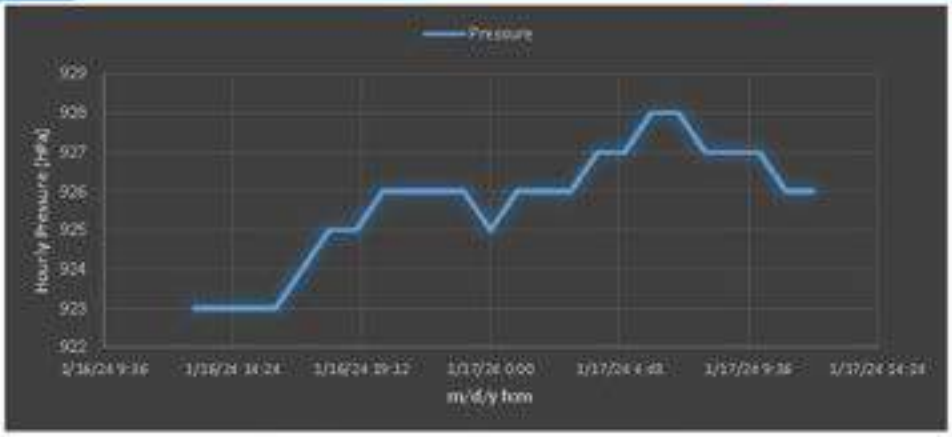

Figure 30: Hourly Pressure at point 1.

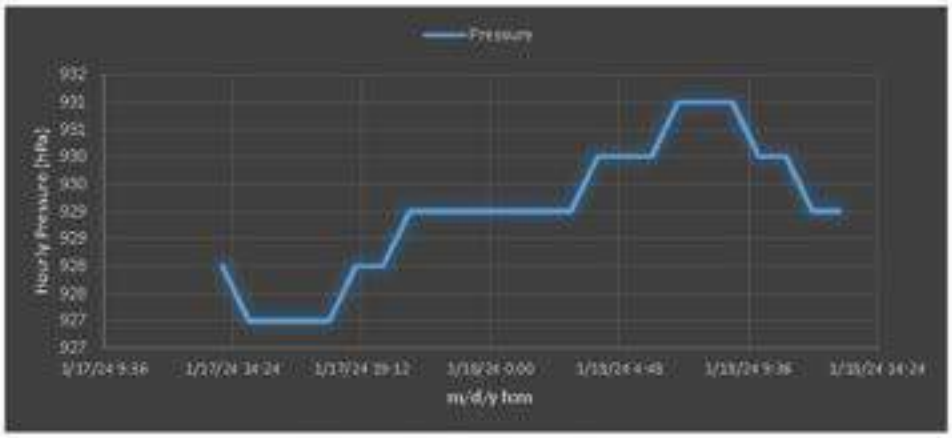

Figure 31: Hourly Pressure at point 2

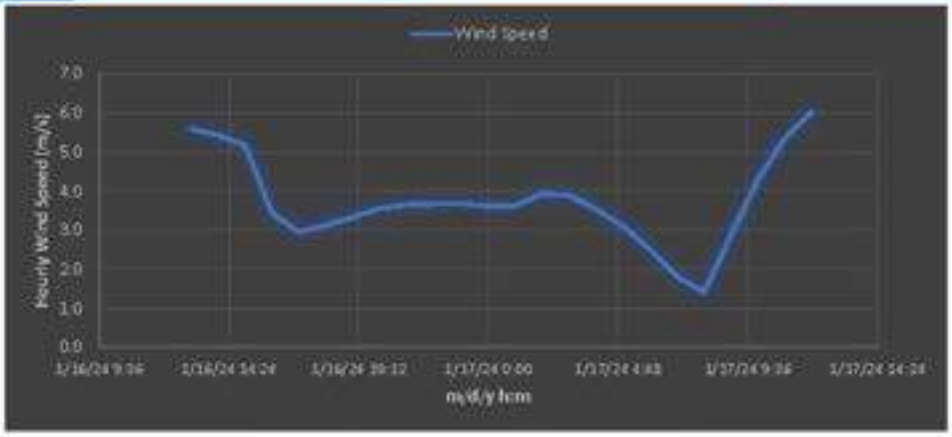

Figure 32: Hourly Wind Speed at point 1

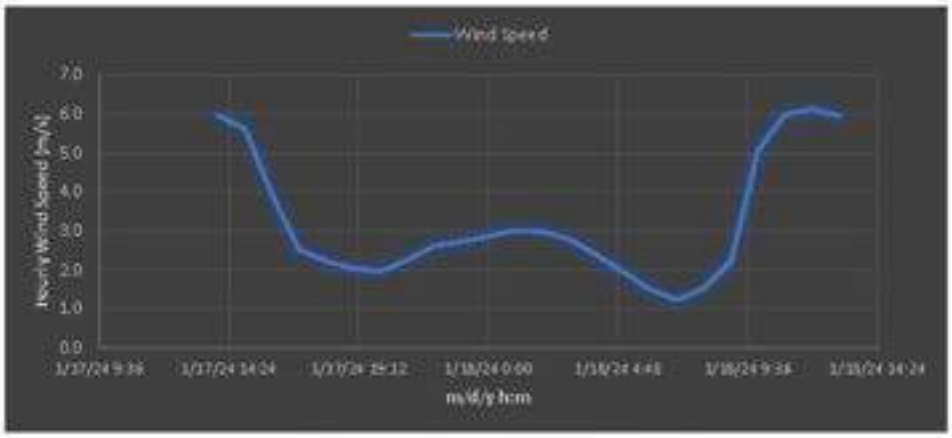

Figure 33: Hourly Wind Speed at point 2

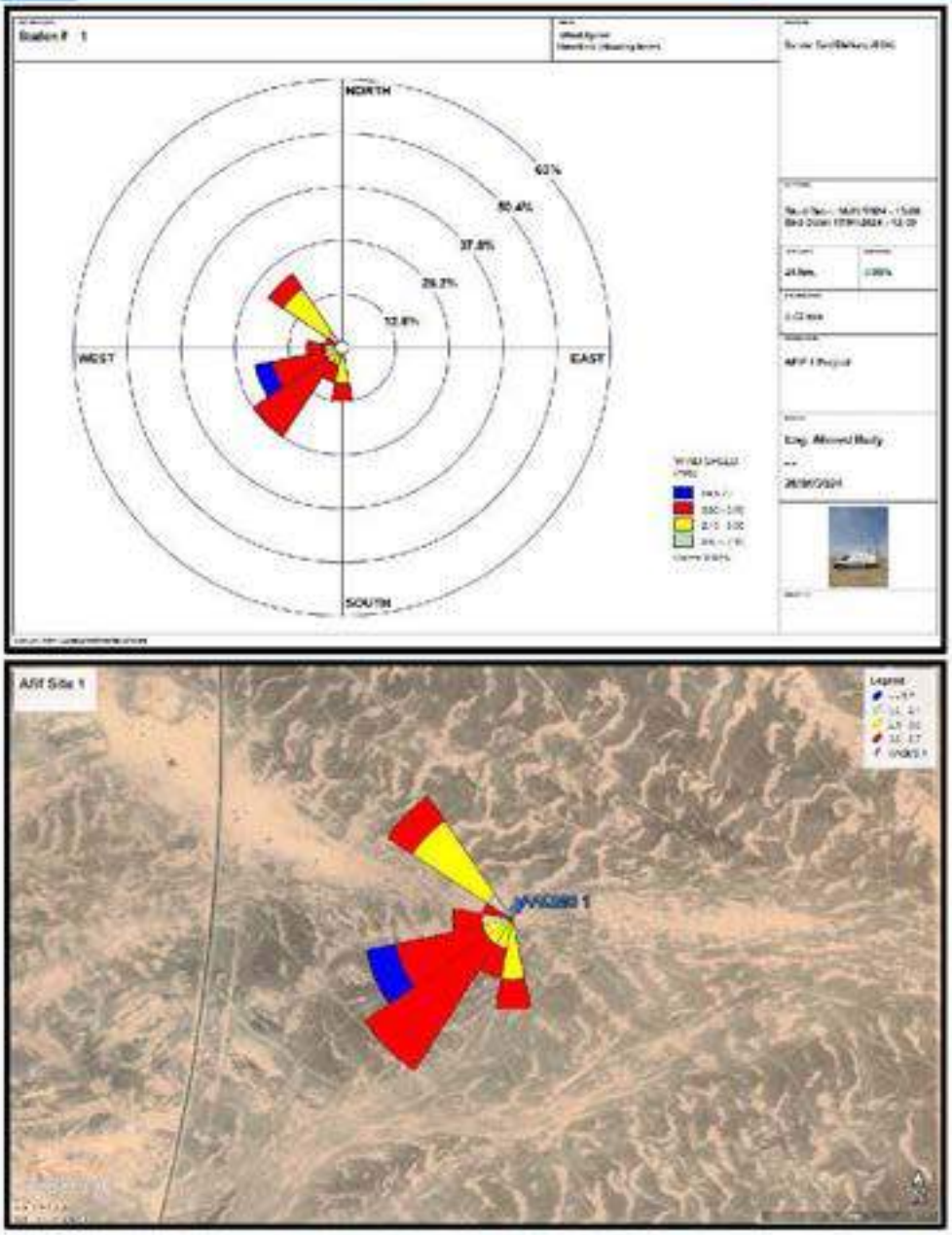

Figure 34: Wind Rose at point 1

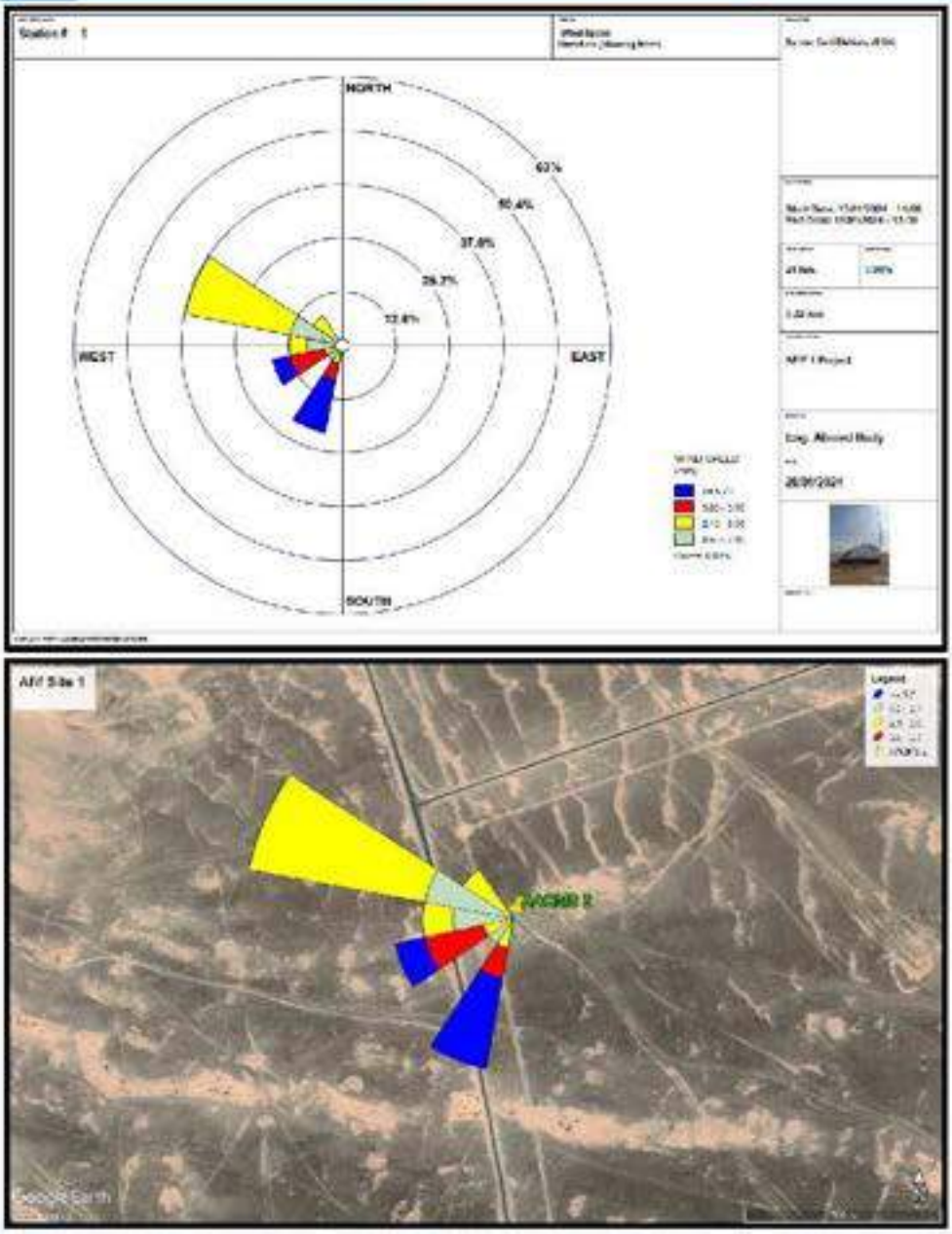

Figure 35: Wind Rose at point 2

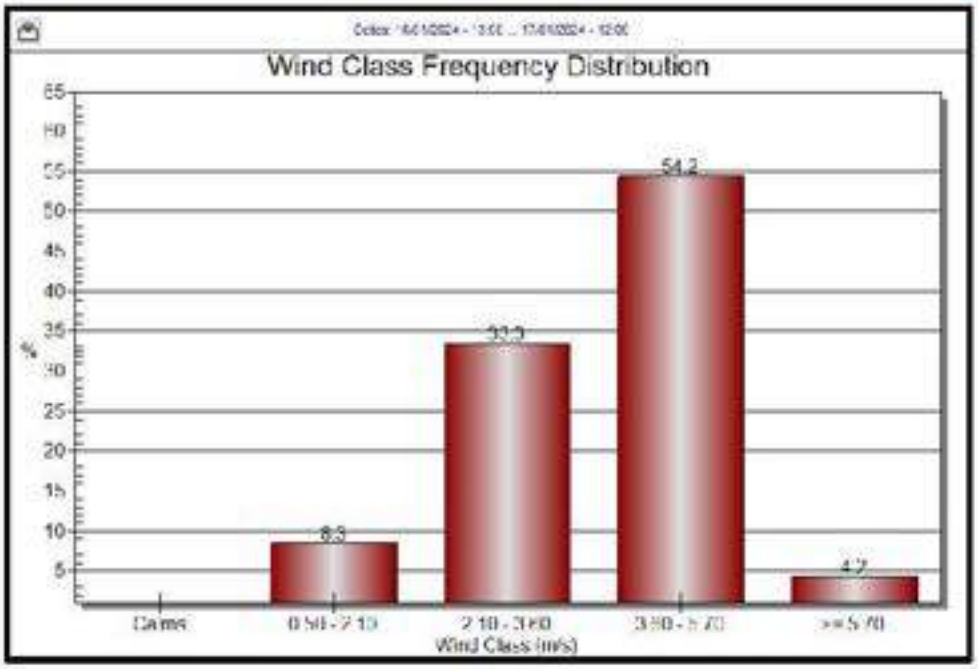

Figure 36: wind class frequency distribution graph at point 1

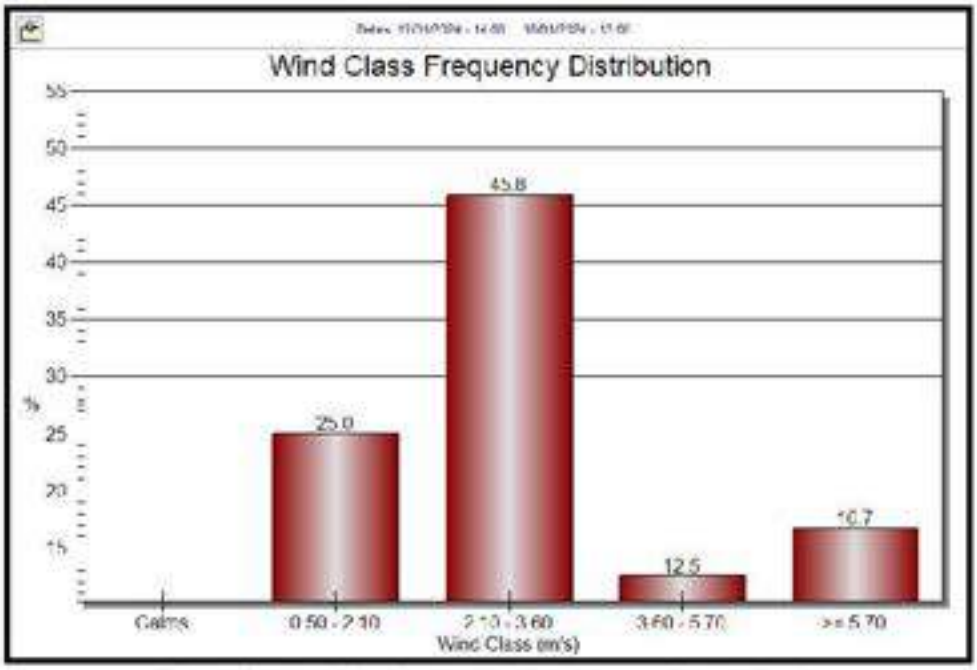

Figure 37: wind class frequency distribution graph at point 2

Table 13: wind class frequency distribution at point 1

	Directions / Wind Classes (m/s)	0.50 - 2.10	2.10 - 3.60	3.60 - 5.70	>= 5.70	Total (%)
1	N	0	0	0	0	0
2	NNE	0	0	0	0	0
3	NE	0	0	0	0	0
4	ENE	0	0	0	0	0
5	E	0	0	0	0	0
6	ESE	0	0	0	0	0
7	SE	0	0	0	0	0
8	SSE	0	0	0	0	0
9	S	0	8.33	4.17	0	12.5
10	SSW	0	4.17	4.17	0	8.33
11	SW	0	4.17	20.83	0	25
12	WSW	0	4.17	12.5	4.17	20.83
13	W	4.17	0	4.17	0	8.33
14	WNW	0	0	4.17	0	4.17
15	NW	4.17	12.5	4.17	0	20.83
16	NNW	0	0	0	0	0
	Sub-Total	8.33	33.33	54.17	4.17	100
	Calms					0
	Missing/Incomplete					0
	Total					100

Table 14: wind class frequency distribution at point 2

	Directions / Wind Classes (m/s)	0.50 - 2.10	2.10 - 3.60	3.60 - 5.70	>= 5.70	Total (%)
1	N	0	0	0	0	0
2	NNE	0	0	0	0	0
3	NE	0	0	0	0	0
4	ENE	0	0	0	0	0
5	E	0	0	0	0	0
6	ESE	0	0	0	0	0
7	SE	0	0	0	0	0
8	SSE	0	0	0	0	0
9	S	0	0	0	0	0
10	SSW	0	4.17	4.17	12.5	20.83
11	SW	4.17	0	0	0	4.17
12	WSW	0	4.17	8.33	4.17	16.67
13	W	8.33	4.17	0	0	12.5
14	WNW	12.5	25	0	0	37.5
15	NW	0	8.33	0	0	8.33
16	NNW	0	0	0	0	0
	Sub-Total	25	45.83	12.5	16.67	100
	Calms					0
	Missing/Incomplete					0
	Total					100

Table 15: wind class count at point 1

	Directions / Wind Classes (m/s)	0.50 - 2.10	2.10 - 3.60	3.60 - 5.70	>= 5.70	Total
1	N	0	0	0	0	0
2	NNE	0	0	0	0	0
3	NE	0	0	0	0	0
4	ENE	0	0	0	0	0
5	E	0	0	0	0	0
6	ESE	0	0	0	0	0
7	SE	0	0	0	0	0
8	SSE	0	0	0	0	0
9	S	0	2	1	0	3
10	SSW	0	1	1	0	2
11	SW	0	1	5	0	6
12	WSW	0	1	3	1	5
13	W	1	0	1	0	2
14	WNW	0	0	1	0	1
15	NW	1	3	1	0	5
16	NNW	0	0	0	0	0
	Sub-Total	2	8	13	1	24
	Calms					0
	Missing/Incomplete					0
	Total					24

Table 16: wind class count at point 2

	Directions / Wind Classes (m/s)	0.50 - 2.10	2.10 - 3.60	3.60 - 5.70	>= 5.70	Total
1	N	0	0	0	0	0
2	NNE	0	0	0	0	0
3	NE	0	0	0	0	0
4	ENE	0	0	0	0	0
5	E	0	0	0	0	0
6	ESE	0	0	0	0	0
7	SE	0	0	0	0	0
8	SSE	0	0	0	0	0
9	S	0	0	0	0	0
10	SSW	0	1	1	3	5
11	SW	1	0	0	0	1
12	WSW	0	1	2	1	4
13	W	2	1	0	0	3
14	WNW	3	6	0	0	9
15	NW	0	2	0	0	2
16	NNW	0	0	0	0	0
	Sub-Total	6	11	3	4	24
	Calms					0
	Missing/Incomplete					0
	Total					24

6) Conclusions

The recorded data of air quality and meteorological factors at two selected sampling locations in area under study during the period of:

- **Point 1**: January 16-17, 2024 at 1:00 pm to 12:00 pm
- **Point 2**: January 17-18 ,2024 at 2:00 pm to 1:00 pm

the results were presented as indicated in figures No. 4 to 37. The Key points of results arising from the examination of recorded data are summarized as follow:

- Daily average concentrations of **PM_{10}** were 48 µg/m³ for point 1, 68.9 µg/m³ for point 2. Accordingly, the results of the data did not exceed the permissible limits in NCEC daily standards.
- Daily average concentrations of **$PM_{2.5}$** were 14.5 µg/m³ for point 1, 18.7 µg/m³ for point 2. Accordingly, the results did not exceed the permissible limits in NCEC daily standards.
- Daily average concentrations of **SO_2** were 2.5 µg/m³ for point 1, 2.7 µg/m³ for point 2. Accordingly, the results did not exceed the permissible limits in NCEC daily standards.
- Daily average concentrations of **NO_2** were 6.2 µg/m³ for point 1, 7.5 µg/m³ for point2. Accordingly, the results did not exceed the permissible limits in NCEC daily standards.
- Figure 20, Figure 21 show the **relation between NO_2 and O_3** concentration during the day time and night which noted increase the concentration of O_3 and decrease the concentration of NO_2 in the same time during the day time and decrease the O_3 concentration and increase of NO_2 concentration. This might be due to dissociation of NO2 by solar rays to free O and NO and then react O with O_2 to produce O_3 during the day time.
- Daily average concentrations of **CO** were 106 µg/m³ for point1, 115 µg/m³ for point 2. Accordingly, the results did not exceed the permissible limits in NCEC daily standards.
- Daily Average concentrations of **O_3** were 55.3 µg/m³ for point1, 56.9 µg/m³ for point 2. Accordingly, the results did not exceed the permissible limits in NCEC daily standards.

- Hourly Maximum and minimum **temperatures** at point 1 were 24.8 °C and 11.2 °C, respectively.
- Hourly Maximum and minimum **temperatures** at point 2 were 26.2 °C and 10.1 °C, respectively.
- Hourly Maximum and minimum **relative humidity** at point 1 were 83.3 % and 19.5 %, respectively.
- Hourly Maximum and minimum **relative humidity** at point 2 were 49.7 % and 21.4 %, respectively.
- Prevailing **wind direction** at the site was NW/ SW.

Appendix 1 Valid Data Exception

No Data Exception due to the short period of monitoring and all maintenance and multipoint calibration took place before and after the monitoring time.

Appendix 2 Valid Data Terms

Span / zero check. A manual zero calibration check is performed whereby air is passed through filter element, removing particulates, before entering the sensor in the analyzer. Data is invalidated when these checks occur.

Multipoint Calibration. To perform multipoint calibration, span and zero gases are passed through filter element, removing particulates, before entering the sensor in the analyzer. Data is invalidated when calibration occurs.

Instrument fault refers to a period when the instrument was not in the normal operating mode and did not measure a representative value of the existing conditions.

Data Communication Issue refers to a period when instrument is not connected to data logger (Configuration lost)

Power Interruption refers to no power to the AAQMS therefore no data was collected at that time.

Appendix 3 Calibration certificates

RICI

Certificate of Calibration

شهادة المعايرة

Certificate No.	23-58891	Page	1 of 2
Environmental Conditions During Test:			
Temperature	23 ± 2 °C		
Humidity	50 ± 10 % RH		

Customer Details:

Name: Bandar Saeed Laboratory For Environmental Consultation Est.

Address: Jeddah, Kingdom of Saudi Arabia

This calibration certificate has been issued after the completion of all the tests & calibrations of the equipment listed below. The standards used for testing &/or calibration are traceable to national & international standards having accuracies derived from the accepted values of natural physical constant or by ratio-type of self-calibration techniques. The test results of the equipment are followed on the continuation sheet(s) of this certificate.

Validity of this certificate is considered null & void without the signatures of the respected authorized personnel.

This calibration certificate applies only to the following item listed below.

Unit Under Calibration (UUC) Details:			
Description:	Mobile Lab/Carbon Monoxide	Identification No.	7682 8808
Manufacturer:	Teledyne	Calibration Date	October 31, 2023
Serial No.	3410	Suggested Due Date:	October 30, 2024
Model No.	T300	Calibration Site:	KSD-site

Measurement Uncertainty:

The reported Expanded Uncertainty of Measurement is stated as the Standard Uncertainty of Measurement multiplied by the Coverage Factor k=2 providing a Level of Confidence of approximately 95%.

Calibration Method:

Unit Under Calibration (UUC) is calibrated by measuring and comparing its indication with RICI Co Ltd. Reference Equipment.

Calibrated By: [redacted]
(Calibration Engineer)

Approved By: [redacted]
(Technical Manager)

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السجل التجاري: ٢٠٥٠٢٤١٢٤٩ | هاتف: +٩٦٦ ١٣٨٥٨٦٤٠١٨٤ | فاكس: +٩٦٦ ١٣٨٥٨٦٤٠١٨٥
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Certificate No.	23-58891	Page	1 of 2

UUC Tested for Gas Span Calibrated Value

Description	Measurement Value (Concentration)
CO (ppm)	25
UUC Test Result.	Passed

Expanded Uncertainty, Up : ± 2% (k = 2, CPL = 95%)

Standard Equipments Used:

Standard Used

Calibrated Gas Component	Concentration	Uncertainty	Due Date
Ozone	1	± 2%	November 11, 2024
Sulphur Dioxide	2.5		
Hydrogen Sulfide	25 ppm		
Carbon Monoxide	25.00		
Oxygen	21.00%		

Traceability of Standard Equipments Used:
The above measurements have been made using RICI Co Ltd. Standards which are traceable to International Standards in line with ISO 17025:2017.

Reference Standards:
1. Calibration Procedure LABC-021

Calibrated By :
(Calibration Engineer)

Approved By :
(Technical Manager)

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Certificate of Calibration

شهادة المعايرة

Certificate No.	[illegible]	Page	1 of 2
Environmental Conditions During Test:			
Temperature	23 ± 2 °C		
Humidity	50 ± 10 % RH		

Customer Details:

Name: Barbir Saeed Laboratory For Environmental Consultation Est.

Address: Jeddah, Kingdom of Saudi Arabia

This calibration certificate has been issued after the completion of all the tests & calibrations of the equipment listed below. The standards used for testing &/or calibration are traceable to national & international standards having accuracies derived from the accepted values of natural physical constant or by ratio type of self-calibration techniques. The test results of the equipment are followed on the continuation sheet(s) of this certificate.

Validity of this certificate is considered null & void without the signature of the respected authorized personnel.

This calibration certificate applies only to the following item listed below.

Unit Under Calibration (UUC) Details			
Description	Mobile Lab (Gases	Identification No.	TAO 1008
Manufacturer	Tellafirm	Calibration Date	October 31, 2023
Serial No.	2504	Suggested Due Date	October 30, 2024
Model No.	1000	Calibration Site	Off-site

Measurement Uncertainty:

The reported Expanded Uncertainty of Measurement is stated as the Standard Uncertainty of Measurement multiplied by the Coverage Factor k=2 providing a Level of Confidence of approximately 95%.

Calibration Method:

Unit Under Calibration (UUC) is calibrated by measuring and comparing its indication with RICI Co Ltd. Reference Equipment.

Calibrated By:
(Calibration Engineer)

Approved By:
(Technical Manager)

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Certificate No.	23-58892	Page	2 of 3

Description	Measurement Value (Concentration)
Zero(ppb)	3
IAQC Test Result	Passed

Expanded Uncertainty, U p : ± 3% (k = 2, CFL = 95%)

Standard Equipments Used:
Standard Used

Calibrated Gas Component	Concentration	Uncertainty	Due Date
Ozone	5	± 5%	November 11, 2024
Sulphur Dioxide	2.5		
Hydrogen Sulfide	25 ppm		
Carbon Monoxide	100.0 PPM		
Oxygen	21.00%		

Traceability of Standard Equipment Used:
The above measurements have been made using RICI's IAC Standards which are traceable to International Standards in line with ISO 17025:2017.

Reference Standards:
1. Calibration Procedure LAB/C-023

Calibrated By:
(Calibration Engineer)

Approved By:
(Technical Manager)

CAL/C-20 Rev.02
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Certificate of Calibration

شهادة المعايرة

Certificate No.	23-58893	Page	1 of 2
Environmental Conditions During Test:			
Temperature	23 ± 2 °C		
Humidity	50 ± 10 % RH		

Customer Details:

Name: Bandar Saeed Laboratory For Environmental Consultation Est.

Address: Jeddah, Kingdom of Saudi Arabia

This calibration certificate has been issued after the completion of all the tests & calibrations of the equipment listed below. The standards used for testing &/or calibration are traceable to national & international standards having accuracies derived from the accepted values of natural physical constant or by ratio-type of self-calibration techniques. The test results of the equipment are followed on the continuation sheet(s) of this certificate.

Validity of this certificate is considered null & void without the signatures of the respected authorized personnel.

This calibration certificate applies only to the following item listed below.

Unit Under Calibration (UUC) Details			
Description	Mobile Lab Sulphur Dioxide	Identification No.	7482 BRB
Manufacturer	Teledyne	Calibration Date	October 11, 2023
Serial No.	1454	Suggested Due Date	October 10, 2024
Model No.	T100	Calibration Site	Off-site

Measurement Uncertainty:

The reported Expanded Uncertainty of Measurement is stated as the Standard Uncertainty of Measurement multiplied by the Coverage Factor k=2 providing a Level of Confidence of approximately 95%.

Calibration Method:

Unit Under Calibration (UUC) is calibrated by measuring and comparing its indication with RICI Co Ltd. Reference Equipment.

Calibrated By: [redacted]
(Calibration Engineer)

Approved By: [redacted]
(Technical Manager)

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Certificate No.	23-58893	Page	1 of 7

UUC Tested for Gas Span Calibrated Value

Description	Measurement Value (Concentration)
Sulphur Dioxide	2.5
UUC Test Result	Passed

Expanded Uncertainty, Up : < 2% (k = 2, CL = 95%)

Standard Equipments Used:

Standard Used:

Calibrated Gas Component	Concentration	Uncertainty	Due Date
Ozone	5	±2%	November 11, 2024
Sulphur Dioxide	2.5		
Hydrogen Sulfide	25 ppm		
Carbon Monoxide	100.0 PPM		
Oxygen	21.00%		

Traceability of Standard Equipments Used:
The above measurements have been made using RICI Co Ltd. Standards which are traceable to International Standards in line with ISO 17025:2017

Reference Standards:
1. Calibration Procedure LAB/CAL/23

Calibrated By: (Calibration Engineer)

Approved By: (Technical Manager) RICI COMPANY LTD.

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Certificate of Calibration

شهادة المعايرة

Certificate No.	23-08894	Page	1 of 2
Environmental Conditions During Test:			
Temperature	23 ± 2 °C		
Humidity	50 ± 10 % RH		

Customer Details:

Name: Bendir Saeed Laboratory For Environmental Consultation Est.

Address: Sakkak, Kingdom of Saudi Arabia

This calibration certificate has been issued after the completion of all the tests & calibrations of the equipment listed below. The standards used for testing & /or calibration are traceable to national & international standards having accuracies derived from the accepted values of natural physical constant or by ratio-type of self-calibration techniques. The test results of the equipment are followed on the continuation sheet(s) of this certificate.

Validity of this certificate is considered null & void without the signatures of the respected authorized personnel.

This calibration certificate applies only to the following item listed below.

Unit Under Calibration (UUC) Details			
Description	Mobile Lab Nitrogen dioxide	Identification No.	7482-8800
Manufacturer	Teledyne	Calibration Date	October 31, 2023
Serial No.	4255	Suggested Due Date	October 30, 2024
Model No.	T200	Calibration Site	Off-site

Measurement Uncertainty:

The reported Expanded Uncertainty of Measurement is stated as the Standard Uncertainty of Measurement multiplied by the Coverage Factor k=2 providing a Level of Confidence of approximately 95%.

Calibration Method:

Unit Under Calibration (UUC) is calibrated by measuring and comparing its indication with RICI Co Ltd. Reference Equipment

Calibrated By:
(Calibration Engineer)

Approved By:
(Technical Manager)

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Certificate No.	23-58894	Page	2 of 2

UUC Tested for this Span Calibrated Value

Description	Measurement Value (Concentration)
Nitrogen (%)	18.0
UUC Test Result.	Passed

Expanded Uncertainty, Up : ± 2% (k = 2, CL = 95%)

Standard Equipments Used:

Standard Used

Calibrated Gas Component	Concentration	Uncertainty	Due Date
Ozone	4	± 3%	November 11, 2024
Sulphur Dioxide	2.9		
Hydrogen Sulfide	25 ppm		
Carbon Monoxide	100.0 PPM		
Oxygen	21.00%		

Traceability of Standard Equipments Used:
The above measurements have been made using RICI Co Ltd. Standards which are traceable to International Standards in line with ISO 17025:2017

Reference Standards:
1. Calibration Procedure LAB/-025

Calibrated By
(Calibration Engineer)

Approved By
(Technical Manager)

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Certificate of Calibration

شهادة المعايرة

Certificate No.	23-58917	Page	1 of 1
Environmental Conditions During Test:			
Temperature	23 ± 2 °C		
Humidity	50 ± 10 % RH		

Customer Details:

Name: Bandar Saeed Laboratory For Environmental Consultation Est.

Address: Jeddah, Kingdom of Saudi Arabia

This calibration certificate has been issued after the completion of all the tests & calibrations of the equipment listed below. The standards used for testing & we calibration are traceable to national & international standards having accuracies derived from the accepted values of natural physical constant or by ratio-type of self-calibration techniques. The test results of the equipment are followed on the continuation sheet(s) of this certificate.

Validity of this certificate is considered null & void without the signatures of the respected authorized personnel.

This calibration certificate applies only to the following item listed below.

Unit Under Calibration (UUC) Details			
Description	Mobile Lab Hydrogen Sulphide	Identification No.	NRG 6808
Manufacturer	Teledyne	Calibration Date	October 31, 2023
Serial No.	387	Suggested Due Date	October 30, 2024
Model No.	T101	Calibration Site	Field site

Measurement Uncertainty:

The reported Expanded Uncertainty of Measurement is stated as the Standard Uncertainty of Measurement multiplied by the Coverage Factor k=2 providing a Level of Confidence of approximately 95%.

Calibration Method:

Unit Under Calibration (UUC) is calibrated by measuring and comparing its indication with RICI Co.Ltd. Reference Equipment.

Calibrated By: (Calibration Engineer)

Approved By: (Technical Manager)

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Certificate No.	23-5891*	Page	2 of 2

Description	Measurement Value (Concentration)
Hydrogen Sulphide(ppm)	25.0
IAQC Test Result.	Passed

Expanded Uncertainty, Up : ± 2% (k = 2, CFL = 95%)

Standard Equipment Used:

Standard Used:

Calibrated Gas Component	Concentration	Uncertainty	Due Date
Ozone	1	± 5%	November 11, 2024
Sulphur Dioxide	2.5		
Hydrogen Sulfide	25 ppm		
Carbon Monoxide	100.0 PPM		
Oxygen	21.00%		

Traceability of Standard Equipments Used:
The above measurements have been made using RICI Co Ltd. Standards which are traceable to International Standards in line with ISO 17025:2017.

Reference Standards:
1. Calibration Procedure LAB/C-005

Calibrated By: (Calibration Engineer)

Approved By: (Technical Manager)

IAQC - 01 Rev.01
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ترخيص بيئي
الختم
المدير التنفيذي للتراخيص و عمليات الالتزام
م. أحمد عمر هب الريح

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Ambient Air Quality Monitoring Report For
Haradh Project

المركز الوطني للرقابة على الالتزام البيئي

اشتراطات العمل في مجال الرصد والمختبرات البيئية

اسم المرفق	مؤسسة بندر سعيد النحياني للخدمات البيئية
النشاط	رصد ومراقبة الملوثات لجودة الهواء للبيئة المحيطة ، رصد ومراقبة الملوثات لجودة الهواء من المصدر
رقم الطلب	1443/17060
رقم السجل التجاري	1010583688

- الالتزام بالنظام البيئة ولوائحه التنفيذية والقرارات والاشتراطات والمتطلبات والمعايير البيئية والتوجيهات الصادرة من المركز الوطني للرقابة على الالتزام البيئي.
- الالتزام بالتقيد بضوابط واشتراطات الترخيص البيئي والصادر بقرار إداري.
- الالتزام بالتقدم لتجديد شهادة الترخيص البيئي قبل انتهائها بثلاث أشهر.
- الالتزام بالأنظمة واللوائح ذات العلاقة في توطين الكادر الفني.
- الالتزام بتقديم الخدمات بجودة عالية وصورة متقنة وفقاً لأفضل الطرق والأساليب العلمية الصحيحة والحديثة.
- تلتزم كافة الجهات التي تقدم خدمات بيئية إخطار المركز عن أي تغييرات أو مستجدات تطرأ على أوضاعها أو كوادرها الفنية أو العلمية أو تغيير ملكية السجل التجاري أو على البيانات والمعلومات المسجلة لدى المركز وذلك خلال شهر من تاريخ هذا التغيير كحد أقصى.
- لا يجوز التنازل عن الترخيص إلا بعد موافقة المركز وتحقيق جميع المتطلبات والشروط الخاصة بالنشاط.
- يجب على الجهات المرخصة التي تنفذ أعمال بيئية بواسطة جهات أخرى التأكد من حصول هذه الجهات على الترخيص البيئي في مجال العمل من المركز.
- الافصاح عن أي تضارب مصالح، والقيام بكل ما هو ضروري ولازم لعدم حدوث ذلك.
- الالتزام بتنفيذ جميع الاشتراطات المذكورة وفي حال الإخلال بها سيعرض المنشأة لإيقاع العقوبة عليها حسب النظام البيئي ولوائحه التنفيذية.

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الأجهزة المستخدمة في رصد ومراقبة الملوثات لجودة الهواء البيئة المحيطة:

العناصر والمركبات التي يتم قياسها	طريقة القياس المعتمدة	الرقم التسلسلي	اسم الجهاز
Cirrus LAeq, LA90, LA10,LAmax	IEC & IEC 61672-1:2013 61672- 1:2002	G300932	Cirrus Noise Meter Type I
PM10, PM2.5	EQPM-1102-150 150	CM13361012	Thermo Scientific Model 5014i Beta Continuous Particulate Monitor
CO	RFCA-0981-054	0515011468	Thermo Electron or Thermo Environmental Instruments 48C
O3	EQOA-0880-047	Thermo Electron or Thermo Environmental Instruments, 49C	Thermo Electron or Thermo Environmental Instruments, 49C
SO2	EQSA-0486-060	1153170025	Thermo Electron 43A, 43C-TLE, 43i, 43i-TLE, 43iQ, 43iQTL
NOx	RFNA-1289-074	1324258454	Thermo Environmental Instr. 42, 42C, 42i, 42i-TL 42iQ
High Volume sampler (PM10)	Equivalent to USEPA RFPS-0202-141	BHV735	High Volume Sampler
PM2.5&PM10	Confirms to 40 PM-10 CFR, Part 50 Appendix J D PM-2.5 of USEPA Confirms to 40 CFR, Part Appendix L of USEPA 50	FDS/2015-16/1503162/253	INSTRUMEX AIR SAMPLER
CO	RFCA-1093-093	3410	CO Teledyne T300
NOx	RFNA-1194-099	4255	NOx Teledyne T200
O3	EQOA-0992-087	3504	O3 Teledyne T400
SO2	EQSA-0495-100	3434	SO2 Teledyne T100
H2S	EQSA-0495-100 per 40 CFR Part 53	587	Teledyne H2S T101

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Ambient Air Quality Monitoring Report For
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المركز الوطني للرقابة على الالتزام البيئي

الأجهزة المستخدمة في رصد ومراقبة الثبوت لجودة الهواء من المصدر:

EPA method	العنصر المراد قياسها	الرقم التسلسلي	الموديل	إسم الجهاز
EPA Methods 0031	Sampling of volatile organic compounds	412	PEM-SMS4	Stack monitoring system
EPA Methods 23	Sampling of Dioxin and furan	0121	PEM-DFSS2	DIOXIN FURAN SAMPLING MODULE
EPA Methods 1-5	Sampling of Particulate Matter	521	PEM-HFB2	HEATED FILTER BOX
PA Methods 29	Sampling of Heavy metals	421	SMS4PUMP	PUMP INTERFACE
EPA Methods 6-8	Sampling of NOX and stack gas phase	3219	PEM-NOS2	NOX SAMPLING SYSTEM
USEPA Verified Methods	NOX, SOX, CO, O2, CO2, Gas velocity, gas temp, effeciency	03579068	TESTO350	PORTABLE-DEVICE FOR STACK EMISSION
& CTM-030 CTM-034, ASTM D6522, ZZZZ, JJJJ, SQAQMD SCAQMD ,1110.2 1146.1, MSAPR testing	NOx-Sox-CO-O2-CO2	12281	J2KN	ECOM STACK GASES

8.3.2. Annex nº 3.2. Waste National Standards

Material Recovery and Recycling of Waste (2012)

This Guidance Document relates to the recovery and recycling of waste materials and follows the internationally recognized waste management 'hierarchy' of prevention (incorporating waste avoidance and waste reduction), recycling (incorporating reuse, recovery, and waste utilization), treatment, disposal (as the last resort).

There are three categories of hazardous recyclable wastes: batteries, CFCs, and waste oils.

Waste Handling and Storage (2012) and Storage and Material Reclamation Facilities-Design and Operation (2012).

The objective of Waste Handling and Store standard is to ensure the effective handling and storing of waste so as to prevent and minimize spills and leakages that may pose a threat to the environment and/or human health. This standard guide those handling and storing waste in good operating practices, in managing effective waste storage and segregation systems, and in detecting, containing, and cleaning up any leaks that may occur. This standard applies to Waste Handlers who handle and store waste from the point of generation through to the storage of waste where it is held at a facility prior to its onward transfer for recycling, treatment, or disposal This Standard must therefore be read in conjunction with the specific requirements for dedicated storage facilities which are detailed further in the Waste Storage and Material Recycling Facilities – Design and Operation Standard.

Waste Handling and Storage Standard specifies the requirements related on: Waste segregation and waste incompatibility; General storage requirements; Satellite storage areas; Main storage areas; Containers; Containment buildings; Tanks; Surface Impoundments; Waste Piles; Labelling; Safe handling of hazardous waste materials; Spill prevention; Emergency procedures.

This Standard include partial lists regarding chemical incompatibilities and potentially explosive combinations of some common reagents, as shown below:

Incompatible Chemicals

Chemical	Is incompatible with:	Chemical	Is incompatible with:
Acetic Acid	Nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates	Fluorine	All other chemicals
		Hydrocarbons	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury	Hydrocyanic acid	Nitric acid, alkalis
		Hydrofluoric acid	Ammonia, aqueous or anhydrous
Alkali Metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, the halogens	Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, oxidizing gases
Ammonia, Anhydrous	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid	Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials	Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
		Mercury	Acetylene, fulminic acid, ammonia
Aniline	Nitric acid, hydrogen peroxide	Nitric Acid	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Bromine	Same as chlorine: ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals	Oxalic acid	Silver, mercury
		Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, sulfuric acid, organics
		Potassium	Carbon tetrachloride, carbon dioxide, water
Butyl lithium	Water	Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Carbon, activated	Calcium hypochlorite, all oxidizing agents		
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials	Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds
		Sodium	Carbon tetrachloride, carbon dioxide, water
Chromic Acid	Naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids in general	Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Chlorine	Same as bromine: ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals	Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide		
Copper	Acetylene, hydrogen peroxide		
Cumene hydroperoxide:	Acids, organic or inorganic		
Cyanides (Na, K)	Acids		
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens, other oxidizing agents		

Figure 182. Incompatible Chemicals. Source: Waste Handling and Storage Standard (2012).

Potentially Explosive Chemicals

The following is a partial list of chemical compounds and mixtures that are known to have explosive properties.

- Alkali metal dinitrophenolates (dry or containing less than 15 percent water, by mass)
- Ammonium nitrate-fuel oil mixture
- Ammonium nitrate mixtures (containing more than 0.2 percent combustible substances)
- Ammonium perchlorate
- Ammonium picrate (dry or containing less than 10 percent water, by mass)
- Azobisisobutyronitrile (AIBN)
- Barium azide (dry or containing less than 50 percent water, by mass)
- Barium styphnate
- Cyclotetramethylenetetranitramine
- Cyclotrimethylenetrinitramine
- Deflagrating metal salts of aromatic nitro derivatives
- 2-Diazo-1-naphthol-4-sulfonyl chloride
- 1-Diazo-2-naphthol-4-sulfonyl chloride
- Diazodinitrophenol (containing less than 40 percent water or a mixture of alcohol and water, by mass)
- Diethylene glycol dinitrate
- Dinitroglycoluril (Dingu)
- Dinitrophenol (dry or containing less than 15 percent water, by mass)
- Dinitroresorcinol (dry or containing less than 15 percent water, by mass)
- N,N'-Dinitroso-N,N'-dimethylterephthalamide
- N,N'-Dinitrosopentamethylenetetraamine
- Dinitrosobenzene
- Dipicryl sulfide (dry or containing less than 10 percent water, by mass)
- Guanyl nitrosaminoguanylidene hydrazine (containing less than 30 percent water, by mass)
- Guanyl nitrosaminoguanyltetrazene (containing less than 30 percent water or a mixture of alcohol and water, by mass)
- Hexanitrodiphenylamine (Dipicrylamine; Hexyl)
- Hexanitrostilbene
- Hexatonal
- Hexolite (dry or containing less than 15 percent water, by mass)
- Lead azide (containing less than 20 percent water or a mixture of alcohol and water, by mass)
- Lead mononitroresorcinate
- Lead styphnate (lead trinitroresorcinate) (containing less than 20 percent water or a mixture of alcohol and water, by mass)
- Mannitol hexanitrate (Nitromannite) (containing less than 40 percent water or mixture of alcohol and water, by mass)
- 5-Mercaptotetrazol-1-acetic acid
- Mercury fulminate (containing less than 20 percent water or mixture of alcohol and water, by mass)
- Nitrourea
- 5-Nitrobenzotriazole
- Nitrocellulose (dry or containing less than 25 percent water or alcohol, by mass or plasticized with less than 18 percent plasticizing substance, by mass)
- Nitroglycerin (containing less than 40 percent of a non-volatile water insoluble desensitizer, by mass or containing less than 90 percent alcohol, by mass)
- Nitroguanidine (Picrite) (dry or containing less than 20 percent water, by mass)
- Nitrosoguanidine
- Nitrostarch (dry or containing less than 20 percent water, by mass)
- Nitrotriazolone (NTO)
- Octolite (Octol) (dry or containing less than 15 percent water, by mass)
- Pentaerythritol tetranitrate (pentaerythrite tetranitrate, PETN) (containing less than 25 percent water, by mass or containing less than 7 percent wax, by mass or containing less than 15 percent of a suitable desensitizer, by mass)
- Pentolite (dry or containing less than 15 percent water, by mass)
- Potassium salts of aromatic nitro-derivatives, explosive
- RDX and HMX mixtures (containing less than 15 percent water, by mass or containing less than 10 percent of a suitable desensitizer, by mass)
- Sodium dinitro-o-cresolate (dry or containing less than 15 percent water, by mass)
- Sodium picramate (dry or containing less than 20 percent water, by mass)
- Sodium salts of aromatic nitro-derivatives
- Tetranitroaniline
- Tetrazol-1-acetic acid
- Trinitro-m-cresol
- Trinitroaniline (picramide)
- Trinitroanisole
- Trinitrobenzene (dry or containing less than 30 percent water, by mass)
- Trinitrobenzenesulfonic acid
- Trinitrobenzoic acid (dry or containing less than 30 percent water, by mass)
- Trinitrochlorobenzene (picryl chloride)
- Trinitrofluorenone
- Trinitronaphthalene
- Trinitrophenetole
- Trinitrophenol (picric acid) (dry or containing less than 30 percent water, by mass)
- Trinitrophenylmethylnitramine (tetryl)
- Trinitroresorcinol (styphnic acid) (dry or containing less than 20 percent water, or mixture of alcohol and water, by mass)
- Trinitrotoluene (TNT) (dry or containing less than 30 percent water, by mass)
- Tritonal
- Urea nitrate (dry or containing less than 20 percent water, by mass)
- Zirconium picramate (dry or containing less than 20 percent water, by mass)

Figure 183. Potentially Explosive Chemicals. Source: Waste Handling and Storage Standard (2012)

Waste Acceptance Criteria (2012)

The provisions in this standard are relevant to waste destined for disposal at landfill after consideration of alternative waste management options.

This standard extends to all waste types including hazardous, non-hazardous and inert waste.

There are three classes of landfills:

- Class 1: Hazardous landfills which can only accept waste classified as hazardous and which meet the relevant Waste Acceptance Criteria (WAC).
- Class 2: Non-hazardous landfills which may accept any waste which is not hazardous including municipal waste and stable, non-reactive hazardous wastes within a separate cell.
- Class 3: Inert landfills may only accept inert wastes that meet the relevant WAC.

Wastes prohibited from landfills are the following:

- Any waste in liquid form (as defined in the Waste Classification Standard). A waste that flows slowly rather than near instantaneously into an indentation void is sludge and therefore not prohibited.
- Wastes which are, in the conditions of landfill, explosive, corrosive, oxidizing, highly flammable or flammable (as defined in the Waste Classification Standard).
- Hospital and other clinical wastes from medical establishments, which are infectious.
- Chemical substances arising from laboratory residues.
- Whole used tires, excluding those used as engineering material, and shredded used tires (excluding in both instances bicycle tires and those with an outside diameter above 1,400 mm).
- Untreated waste.

About hazardous waste, the standard includes the compliance of leaching limit values for the acceptance of wastes in hazardous waste landfills and the additional limit values for the acceptance of waste.

WAC for hazardous waste consists of numerical limits for leachable substances and organic content along with standards for physical stability. Hazardous wastes need to be tested against these parameters. The next table include the Leaching Limit Values for the Acceptance of Wastes in Hazardous Landfills.

Components	L:S = 10 l/kg
Arsenic	25
Barium	300
Cadmium	1
Chromium total	70
Copper	100
Mercury	0.4
Molybdenum	30
Nickel	40
Lead	50
Antimony	5
Selenium	7
Zinc	200
Chloride	25,000
Fluoride	500
Sulphate	50,000
TDS*	100,000
DOC**	1,000

**The values for TDS (Total Dissolved Solids) can be used alternatively to the values for non-dissolved Sulphate and Chloride.*

***If the waste does not meet these values for dissolved organic carbon (DOC) at its own pH, it may alternatively be tested at L:S = 10 l/kg and a pH of 7.5 – 8.0. The waste may be considered as complying with the acceptance criteria for DOC, if the result of this determination does not exceed 1000 mg/kg.*

L:S refers to liquid to solid ratios

Figure 184. Leaching limit values for the acceptance of wastes in hazardous landfills. Source: Waste Acceptance Criteria (2012

In addition to this leaching limit values above, hazardous wastes must meet the limit values shown in table below. These Additional Limit Values for the Acceptance of Wastes in Hazardous Landfills, ensure that these factors do not cause leaching to increase from wastes that otherwise meet the leaching limit values.

Parameter	Values
LOI*	10%
TOC	6%**
ANC (acid neutralisation capacity)	Must be evaluated between the pH of the waste in question, at pH6 and the pH of the site leachate

**Either Loss on Ignition (LOI) or Total Organic Carbon (TOC) must be used – which is up to the discretion of the Generator and TSD facility operators.*

***If this value is not achieved, a higher limit value may be permitted by the Competent Agency, provided that the DOC value of 1000 mg/kg is achieved at L:S10 at its own pH or pH7.5 – 8.0.*

Figure 185. Additional limit values for the acceptance of wastes in hazardous landfills. Source: Waste Acceptance Criteria (2012)

Asbestos Waste

a) Construction materials containing asbestos and other suitable asbestos waste may be accepted at non-hazardous landfills, without testing.

b) For non-hazardous landfills receiving construction materials containing asbestos and other suitable asbestos waste the following requirements must be fulfilled;

i) The waste shall contain no other hazardous substances than bound asbestos, including fibres bound by a binding agent or packed in plastic;
ii) Construction material containing asbestos or other suitable asbestos waste can only be accepted in a landfill dedicated to these wastes or in a separate cell of a non-dedicated non-hazardous landfill, if the cell is sufficiently self-contained;
iii) In order to avoid dispersion of fibres, the zone of deposit must be covered daily with appropriate material and, if the waste is not packed, must be regularly sprinkled.
It must be:
- Covered immediately to a depth of at least 250mm;
- Covered by the end of the working day to a depth of at least one metre on all flanks and surfaces;
- Final cover must be not less than two metres of suitable material, before placement of the restoration material;
- For all these purposes, suitable material must be used, comprising incombustible, granular material free from any objects capable of disrupting the waste or any packing;
iv) A final top cover shall be placed on the landfill or cell in order to avoid the dispersion of fibres;
v) No works shall be carried out on the landfill or cell that could lead to a release of fibres (for example, drilling of holes);
vi) A plan shall be kept of the location of deposits of asbestos waste. The plan shall be kept available after closure; and

vii) Details shall be provided to the landowner so that appropriate measures can be taken to limit the possible uses of the land after closure of the landfill in order to avoid human contact with the waste.

c) Wastes that contain asbestos but which are also hazardous by virtue of other components can only be sent for disposal in hazardous landfills appropriate to both the asbestos and the other hazards.

About hazardous waste in non-hazardous landfills

Hazardous waste may be accepted at non-hazardous landfills provided that;

i) it is stable, non-reactive hazardous waste;

ii) its leaching behaviour is equivalent to that of non-hazardous wastes which meet the relevant WAC; or

iii) it is not deposited in cells used, or intended to be used, for the disposal of biodegradable non-hazardous wastes.

As stated in these standards, the wastes must meet the leaching limit values provided in the following table, calculated at a liquid to solid ratio (L:S) of 10 l/kg for total release. Therefore, the Leaching Limit Values for the Acceptance of Hazardous Wastes in Landfills for Non-Hazardous Waste are:

Components	L:S = 10 l/kg
Arsenic	2
Barium	100
Cadmium	0.1
Chromium total	10
Copper	50
Mercury	0.02
Molybdenum	10
Nickel	10
Lead	10
Antimony	0.7
Selenium	0.5
Zinc	50
Chloride	15,000
Fluoride	150
Sulphate	20,000
TDS*	60,000
DOC**	800

**The values for TDS (Total Dissolved Solids) can be used alternatively to the values for non- dissolved Sulphate and Chloride.*

***If the waste does not meet these values for dissolved organic carbon (DOC) at its own pH, it may alternatively be tested at L:S = 10 l/kg and a pH of 7.5 – 8.0. The waste may be considered as complying with the acceptance criteria for DOC, if the result of this determination does not exceed 800 mg/kg.*

Wastes which are candidates for this disposal option must also meet the limit values in Table 4, which assist in evaluating whether the waste is stable and non-reactive.

Figure 186. Leaching limit values for the acceptance of hazardous wastes in landfills for non-hazardous waste. Source: Waste. Acceptance Criteria (2012)

The next table shows the Additional Limit Values for the Acceptance of Hazardous wastes in Landfills for Non-Hazardous Waste.

Parameter	Value
TOC	5%*
pH	Minimum 6
Acid Neutralisation Capacity	Must be evaluated between the pH of the waste in question, pH6 and the ph of the site leachate

**If this value is not achieved, a higher limit value may be permitted by the Competent Agency, KSA Presidency of Meteorology and Environment PME Reference Kingdom of Saudi Arabia Page 9 of 14 provided that the Dissolved Organic Carbon (DOC) value of 800 mg/kg is achieved or at a pH between 7.5 – 8.0*

Figure 187. Additional limit values for the acceptance of hazardous wastes in landfills for non-hazardous waste. Source: Waste Acceptance Criteria (2012)

Wastes Acceptable at Landfills for Inert Wastes only with Testing

If there is uncertainty whether the waste fulfils the definition of inert waste, or is uncontaminated, the waste must be tested. According to this Standard, the waste must not exceed the limit values, provided in the following two tables, for the total content of organic parameters, for the waste to be accepted at an inert landfill facility. The first of these tables corresponds to the Leaching Limit Values Landfills for Inert Waste.

Components	L:S = 10 l/kg
Arsenic	0.5
Barium	20
Cadmium	0.04
Chromium total	0.5
Copper	2
Mercury	0.01
Molybdenum	0.5
Nickel	0.5
Lead	0.5
Antimony	0.06
Selenium	0.01
Zinc	4
Chloride	800
Fluoride	10
Sulphate	1,000
TDS*	4,000
DOC**	1
DOC***	500

**If the waste does not meet these values for sulphate, it may still be considered as complying with the acceptance criteria if the leaching does not exceed either of the following values: 1,500 mg/l at L:S = 0.1 l/kg.*

*** The values for TDS (Total Dissolved Solids) can be used alternatively to the values for Sulphate and Chloride.*

Figure 188. Leaching limit values for landfills for inert waste. Source: Waste Acceptance Criteria (2012).

**** If the waste does not meet these values for DOC (Dissolved Organic Carbon) at its own pH value, it may alternatively be tested at L:S = 10 l/kg and a pH between 7.5 and 8.0. The waste may be considered as complying with the acceptance criteria for DOC, if the result of this determination does not exceed 500 mg/kg.*

In addition to the leaching limit values above, the following table includes Additional Limit Values for Landfills for Inert Waste:

Parameter	Value
	mg/kg
TOC	30000*
BTEX	6
PCBs (7 congeners)	1
Mineral oil (C10 to C40)	(C10 to C40) 500
Polycyclic aromatic hydrocarbons (total of 17)	100

**In the case of soils, a higher limit value may be admitted by the Competent Agency, provided the Dissolved Organic Carbon value of 500 mg/kg is achieved at L:S 10 l/kg at the pH of the soil or at a pH of between 7.5 and 8.0.*

Figure 189. Additional limit values for landfills for inert waste. Source: Waste Acceptance Criteria (2012)

Waste Classification (2012)

This standard establishes a national baseline Waste Classification System within the Kingdom of Saudi Arabia (KSA).

This Standard defines and classifies waste to be managed in KSA with respect to the form of the waste material and its associated impact on human health or the environment.

To establish whether a waste is classified as hazardous, it must be determined if the waste is Listed on the Hazardous Waste List as follows:

Hazardous Waste List

Y1	Clinical wastes from medical care in hospitals, medical centres and clinics
Y2	Wastes from the production and preparation of pharmaceutical products, drugs and medications
Y3	Wastes from the production, formulation and use of biocides and phyto-pharmaceuticals
Y4	Wastes from the manufacture, formulation and use of wood preserving chemicals
Y5	Wastes from the production, formulation and use of organic solvents
Y6	Wastes from heat treatment and steel tempering operations containing cyanides
Y7	Waste mineral oils unfit for their originally intended use
Y8	Waste oils/water, hydrocarbons/water mixtures, emulsions
Y9	Waste substances and articles containing (greater than 50 ppm) polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)
Y10	Waste tarry residues arising from refining, distillation and any pyrolysis treatment
Y11	Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish
Y12	Wastes from production, formulation and use of resins, latex, plasticizers, glues and adhesives
Y13	Waste chemical substances arising from research and development or teaching activities which are not known and are new and whose effects on human health and the environment are not yet known
Y14	Wastes of an explosive nature not subject to other regulations or standards
Y15	Wastes from production, formulation and use of photographic chemicals and processing materials
Y16	Wastes resulting from surface treatment of metals and plastics
Y17	Residues arising from industrial waste disposal operations
Y18	Petroleum refinery wastewater treatment sludges

Figure 190. Hazardous Waste List. Source: Waste Classification Standard (2012).

If the waste is not listed, a waste Generator must then establish whether the waste contains any of the hazardous constituents listed in the next table. These constituents pose a threat to human health and the environment.

Hazardous Waste Constituents

Y19	Metal carbonyls
Y20	Beryllium and beryllium compounds
Y21	Hexavalent chromium compounds
Y22	Copper compounds
Y23	Zinc compounds
Y24	Arsenic and arsenic compounds
Y25	Selenium and selenium compounds
Y26	Cadmium and cadmium compounds
Y27	Antimony and antimony compounds
Y28	Tellurium and tellurium compounds
Y29	Mercury and mercury compounds
Y30	Lead and lead compounds
Y31	Inorganic fluorine compounds excluding calcium fluoride
Y32	Inorganic cyanides
Y33	Acidic solutions or acids in solid form
Y34	Basic solutions or bases in solid form
Y35	Asbestos (dust and fibres)
Y36	Organic phosphorus compounds
Y37	Organic cyanide compounds
Y38	Phenols and phenol compounds, including chlorophenol compounds
Y39	Ether compounds
Y40	Halogenated organic solvents
Y41	Organic solvents other than halogenated solvents
Y42	Any congener of polychlorinated dibenzo-furan
Y43	Any congener of polychlorinated dibenzo-p-dioxin
Y44	Organic halogen compounds other than substances referred to in this Table

Figure 191. Hazardous Waste Constituents. Source: Waste Classification Standard (2012).

If the waste is not listed in the Hazardous Waste List or does not contain one of the hazardous waste constituents, the assessor of the waste must determine the waste's composition to establish whether it contains a hazardous property, as listed in the following table.

Hazardous Property List

H1 Explosive	Substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene
H2 Oxidising	Substances and preparations which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances
H3 Highly Flammable	(a) liquid substances and preparations having a flashpoint below 21°C (b) substances and preparations which may become hot and finally catch fire in contact with air at ambient temperatures without any application of energy (c) solid substances and preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition (d) gaseous substances and preparations which are flammable in air at normal pressure (e) substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities
H3B Flammable	Liquid substances and preparations having a flashpoint >=21°C and <=55°C
H4 Irritant	Non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation
H5 Harmful	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may involve limited health risks
H6 Toxic	Substances and preparations (including very toxic substances and preparations) which, if they are inhaled or ingested or if they penetrate the skin, may involve serious, acute or chronic health risks and even death
H7 Carcinogenic	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence
H8 Corrosive	Substances and preparations which can readily corrode or dissolve flesh, metal or other materials
H9 Infectious	Substances containing viable micro-organisms or their toxins which are known or reliably believed to cause disease in man or living organisms
H10 Toxic for Reproduction	Substances or preparations which, if they are inhaled or ingested or if they penetrate the skin, may produce or increase the incidence of non-heritable adverse effects in the progeny and/or of male or female reproductive functions or capacity
H11 Mutagenic	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence
H12 Toxic Gas Release	Substances or preparations which release toxic or very toxic gases in contact with water, air or an acid
H13 Ecotoxic	Substances or preparations which present or may present immediate or delayed risks for one or more sectors of the environment
H14	Substances and preparations capable by any means, after disposal, of yielding another substance, for example leachate, which possesses any of the characteristics H1 to H13

Figure 192. Hazardous Property List. Source: Waste Classification Standard (2012).

Toxic compounds or elements can leach into underground drinking water supplies and expose users of the water to hazardous chemicals and constituents. A waste is toxic if it is likely to leach dangerous concentrations of toxic chemicals into groundwater. The Toxicity Property Leaching Procedure (TPLP)

requires that a liquid leachate is created from a hazardous waste sample. It must then be determined whether the leachate contains any of the toxic chemicals in amounts above the specified levels listed in in the table below:

Toxicity Property Leaching Procedure Regulatory Levels

Contaminant	Concentration mg/l
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Carbon Tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
o-Cresol*	200.0
m-Cresol*	200.0
p-Cresol*	200.0
Total Cresols	200.0
2,4-D	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichlorobenzene	0.5
1,1-Dichlorobenzene	0.7
2,4-Dichlorobenzene	0.13
Endrin	0.02
Heptachlor (and its epoxide)	0.0008
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lidane	0.4
Mercury	0.2
Methoxychlor	10.0
Methyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentachlorophenol	100.0
Pyridine	5.0
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.5
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-TP (Silvex)	1.0
Vinyl Chloride	0.2

* if 0-, m- and p-cresols cannot be individually measured, the level for total cresols is used.

Figure 193. Toxicity Property Leaching Procedure Regulatory Levels. Source: Waste Classification Standard (2012).

Landfill – Design and Operation (2012) will be applied only in case of a new Inert Landfill

Three landfill types have been identified which require different levels of detailed design depending upon their potential to impact on human health or the wider environment. These are:

i) Class 1 Landfills - Hazardous Landfills which may only accept Hazardous wastes which satisfy site specific acceptance criteria;

ii) Class 2 Landfills - Non-Hazardous Landfills which may accept any wastes which are considered to be non-Hazardous including municipal waste, commercial waste, stable non-reactive hazardous wastes, inert wastes and others as demonstrated through appropriate investigation and risk assessment; and

iii) Class 3 Landfills - Inert Landfills which may only accept waste which is known to be inert (that is, physically, chemically or biologically unreactive).

Environmental Assessment

An Environmental Assessment will be required prior to the development of a landfill site for both Class 1 and Class 2 landfills. As a minimum requirement the Environmental Assessment should include the items below:

Pre-Design Report Requirements for Authorisation

The report must describe the design parameters of the landfill site and must contain as a minimum details of the following:

(i) Legal details for ownership of the site

(ii) An up to date plan and description of the site and the area within 500 metres of the site that covers:
   a. all property and property boundaries
   b. all buildings, roads and utility corridors
   c. land contours, surface water drainage, water bodies, rights-of-way and other easements,
   d. forested areas,
   e. land uses and land use designations, and
   f. property conditions not otherwise covered in subclauses (a) to (e)

(iii) A plan and description of the waste fill area, base contours for waste disposal, base contours for any leachate collection system, top contours for waste disposal and top contours with final cover

(iv) Details of the total waste disposal volume

(v) A materials balance between the sources of soils, on or off the site, and the uses of soils on the site

(vi) A full hydrogeological assessment of the suitability of the site for the landfilling of municipal waste or other waste that considers the geologic and hydrogeologic conditions of the site, the design of the site and the monitoring and contingency plans

(vii) A full geotechnical assessment of the suitability of the site for the landfilling of municipal waste or other waste that considers bearing capacity, differential settlement and slope stability during construction, operation and after closure, and that addresses the potential effects on any liner or leachate collection system

(viii) A description of the expected quality and quantity of leachate

(ix) Detailed plans, specifications and descriptions of any liner system necessary to control leachate, including construction and quality assurance and quality control procedures for the liner materials and liner system installation

(x) Detailed plans, specifications and descriptions of any leachate collection, treatment and disposal system necessary to control leachate, including construction and quality assurance and quality control procedures for the system components and system installation

(xi) An assessment of the potential for subsurface migration of landfill gas at the site and of any control system necessary for monitoring or controlling the migration

(xii) A detailed assessment of the potential impacts on surface water features that may be caused by the site or operations at the site

(xiii) Detailed plans, specifications and descriptions of any system necessary for controlling landfill gas by venting it or by collecting and burning or using it, including construction and quality assurance and quality control procedures for the system components and system installation

(xiv) Detailed plans, specifications and descriptions of the system for collecting, directing and discharging surface water, including details of any sediment control or other features and including construction, quality assurance and quality control procedures for the system components and system installation

(xv) Detailed plans, specifications and descriptions of monitoring facilities for leachate, ground water, surface water and, where appropriate, landfill gas

(xvi) An assessment of potential noise impacts due to operations at the site and to local trucking related to operations at the site, including an evaluation of any proposed noise control measures

(xvii) An assessment of potential visual impacts on nearby properties due to the site and site operations

(xviii) Detailed plans, specifications and descriptions of the buffer area and ancillary facilities, including any screening, landscaping, fencing, weigh scales, buildings, structures, access roads, internal roads, holding areas for cover material, holding areas for rejected waste or materials for recycling, and other holding areas

(xix) Detailed plans, specifications and descriptions of the contaminant attenuation zone, if one is necessary

(xx) An estimate of the contaminating life span of the site with respect to contaminants involved in the subsurface migration of landfill gas and an estimate of the service life of any engineered facilities associated with the subsurface migration of landfill gas

(xxi) An estimate of the contaminating life span of the site with respect to contaminants in leachate

(xxii) An estimate of the service life of every engineered facility associated with leachate

(xxiii) Details of any facilities intended to control or change the contaminating life span of the landfilling site

(xxiv) Contingency plans that can be implemented to control and dispose of leachate produced in a quantity greater than expected or with a quality worse than expected, including specifications and descriptions in sufficient detail to demonstrate the feasibility of the plans

(xxv) Contingency plans that can be implemented to control and dispose of landfill gas migrating in the subsurface in a quantity greater than expected or with a quality worse than expected, including specifications and descriptions in sufficient detail to demonstrate the feasibility of the plans.

(xxvii)	A description of the source, nature and quality of daily cover, including, with respect to material not normally used for daily cover, a discussion of its benefits and limitations, a description of quality assurance and quality control procedures for daily cover and a description of application rates and application procedures for daily cover, including the frequency and timing of application of daily cover if other than at the end of each working day
(xxviii)	A description of the nature, quality and quantity of final cover, including construction details and quality assurance and quality control procedures for the materials to be used and their installation
(xxix)	A site closure plan, including details of the proposed end use of the site, the appearance of the site after closure, revegetation, landscaping, the construction of new facilities, and the removal of existing facilities to facilitate closure, post-closure care and site end use
(xxx)	A summary of the main characteristics of the landfilling site, including the maximum daily quantity of waste that will be accepted for disposal, the estimated annual average quantity of waste that will be accepted for disposal, the area of the landfilling site, the area of the waste fill area, the total waste disposal volume, the estimated waste disposal capacity in tonnes, any subcategories of municipal waste that are not expected to be received or that will not be accepted for disposal, and the estimated date of site closure.

Environmental Assessment Requirements

An environmental assessment of the site proposed for landfill is required to gain a thorough understanding of the existing environment at the site in order to develop a sound landfill design. This assessment must examine the impact of the proposed landfill on the air, groundwater, surface water and noise environments, and should be based on at least two to three years of data.

If, following an environmental assessment, the site is identified as unsuitable for a landfill, the proposal should not proceed any further. For the purposes of siting a landfill site, an environmental assessment should contain:

(i) Meteorological data, including monthly rainfall, monthly evaporation, seasonal wind strength and direction.

(ii) Hydrogeological assessment in accordance with EPA Publication Hydrogeological Assessments (Groundwater Quality), which includes:
- a. local and regional geology
- b. spatial distribution of groundwater (local and regional if watertable is artificially depressed)
- c. depth to groundwater (current and after any rebound if the watertable is artificially depressed) and watertable elevation (mAHD)
- d. groundwater gradient and flow direction
- e. description of groundwater interaction with
- f. local surface waters
- g. aquifer physical properties:
  - i. permeability
  - ii. aquifer thickness
  - iii. saturated thickness
  - iv. porosity.
- h. aquifer chemical properties:
  - i. mineralogy
  - ii. cation exchange and sorption capacity.
- i. groundwater quality (local and regional if aquifer is likely to have been impacted on by previous activities)
- j. beneficial uses of groundwater to be protected
- k. groundwater use in the surrounding area
- l. predicted extent and degree of impacts on groundwater quality during and after the landfill operation
- m. verification that beneficial uses are not adversely impacted at the site, or at the boundary of an attenuation zone where designated.

(iii) Water Management, including:
- a. water balance for the site and estimated volume of leachate to be generated
- b. leachate collection, storage facilities, treatment and disposal

ut-off
drains and storage dams
- d. fire-fighting equipment and water supply
- e. wheel washes.

(iv) Landfill gas and odour control, including:
- a. availability of cover material onsite
- b. anticipated volume and rate of landfill gas generation
- c. potential users of landfill gas
- d. impacts of landfill gas on greenhouse gas emissions
- e. risk posed by migration of gas.

Figure 194. Details of the requirements for landfills. Source: Landfill – Design and operation (2012)

Site Location

Careful consideration must be given to the location of sensitive receptors down wind/ down gradient of any newly proposed landfill to ensure adequate protection of the environment and human health.

When locating a landfill site consideration must be given to the:

i) distance from the site boundary to sensitive receptors such as recreation areas, residential properties and associated community establishments (schools, hospitals, etc) (>250 metres), coastal water resources (>100 metres) and agricultural areas (>100 metres), pipelines and highways (>30 metres), aviation runways (3.3 km);

ii) presence of groundwater, surface water, coastal water or nature conservation zones;

iii) geological and hydrogeological conditions underlying the site; and

iv) other undetermined local factors which could be impacted by a proposed landfill site and which will be identified at the local level during the Environmental Assessment.

Site Specific Design Considerations

All new landfill sites must be designed with the desire for the least possible local impact and where possible they must blend in with the local surroundings.

Site factors which affect landfill design include (but are not limited to):

i) topography;

ii) size and shape of the property area;

iii) subsurface geological and hydrogeological conditions;

iv) surrounding land use;

v) local availability of cover materials;

vi) local ecological aspects;

vii) seismic considerations; and

viii) access and ease of transport to the site.

A detailed pre-construction plan must be provided to the Competent Agency a minimum of six months prior to construction along with the submittal of the Environmental Assessment. Details of the requirements for this plan are provided in the previous figure.

A fence (or elevated earth berm in remote areas) must be constructed around the perimeter of the landfill to:

i) reduce onsite trespass, especially from vulnerable members of the population, and animals;

ii) provide a screen for the landfill;

iii) delineate the property lines; and

iv) provide a control for litter blow.

Fences must be a minimum of 2 metres tall around the entire perimeter of the site. However, higher fences may be required downwind of the site to limit litter blow off site, especially where there are potentially sensitive land uses downwind of the site. Alternatively, portable litter fences over 3 metres in height which are placed near to and downwind of the open landfill face may suffice.

Drainage and Landfill Capping

Drainage measures must be designed to contain and control rainfall runoff.

Landfills for inert waste will not normally require a cap, as shown in the following table:

Table 3: Landfill Capping Requirements

Landfill Category	Inert	Non Hazardous	Hazardous
Gas Drainage Layer	Not Required	Required	Not Required
Artificial Sealing Liner	Not Required	Not Required	Required
Impermeable Mineral Layer	Not Required	Required	Required
Drainage Layer ≥ 0.5 metres	Not Required	Required	Required
Top Soil Cover ≥ 1 metre	Not Normally Required	Required	Required

Figure 195. Landfill Capping Requirements. Source: Landfill- Design and Operation (2012).

Best Practicable Environmental Option for Waste Disposal (2012)

This Guidance provides a range of options for waste disposal, comparing the advantages and disadvantages, to develop options that best addresses KSA's objectives for waste management.

The possible methods for managing waste are presented under seven category headings: waste minimization; collection and transfer; reuse; recycling; composting; energy recovery; and final disposal.

The next figure includes Ten Step Best Practicable Environmental (BPEO) Process.

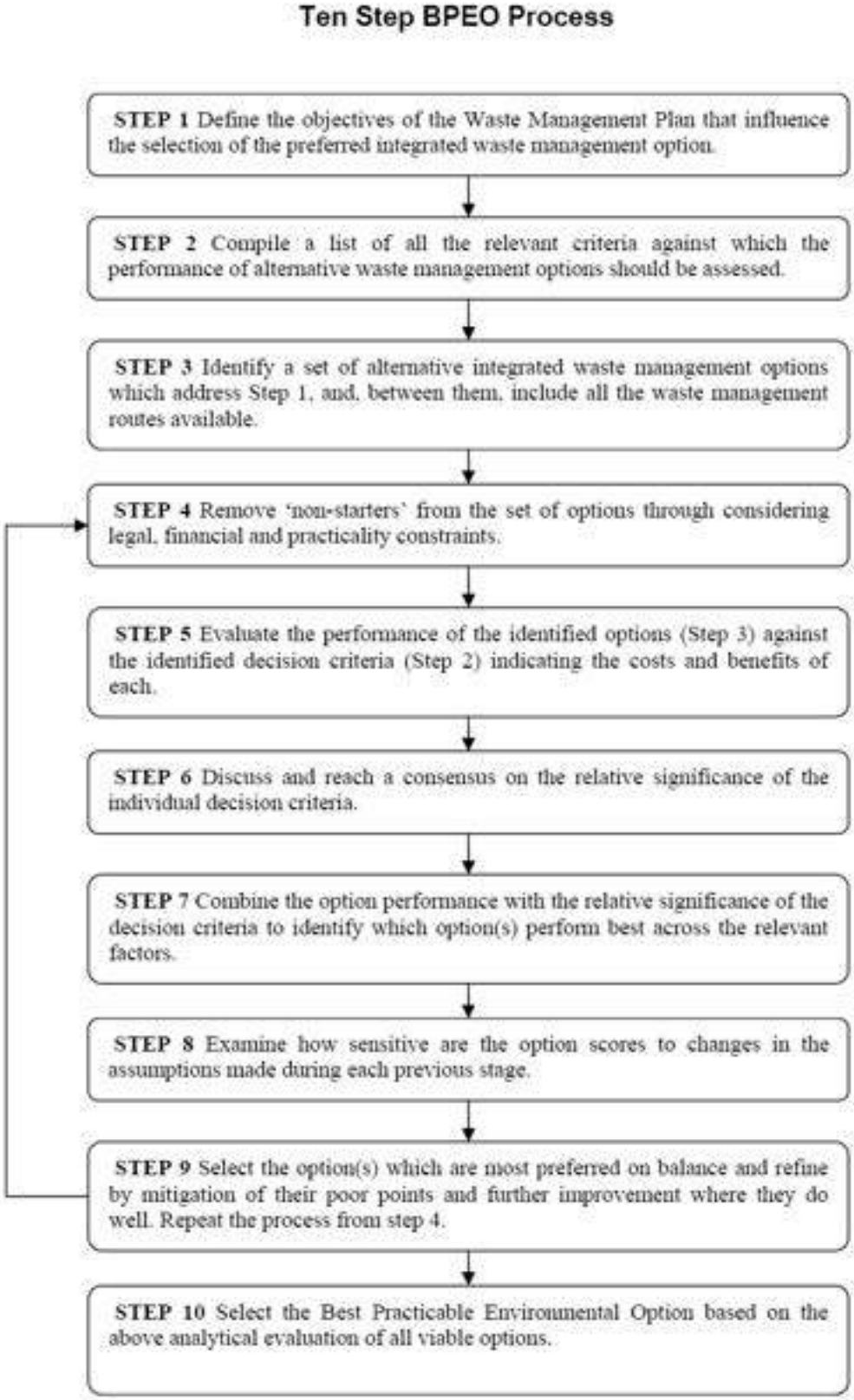

Figure 196. Ten Step BPEO Process. Source: Best Practicable Environmental Option for Waste Disposal (2012)

Waste Regulatory Control and Compliance (2012)

This standard applies to all Generators, Transporters and TSD (treatment, storage and/or disposal facility, including recycling facilities) operators in Kingdom of Saudi Arabia (KSA).

This standard extends to all waste types including hazardous, non-hazardous, and inert waste.

Waste Generators shall be responsible for identification of the types of waste and hazardous waste they generate, as well as for ensuring that such wastes are stored, treated, and disposed of in an environmentally sound manner that does not cause its dispersal and also does not cause any detrimental effect on human health, safety and welfare or the environment and the natural resources.

Registration of Waste Transporters: Transporters of waste must be registered with the Competent Agency in order to transport waste by rail, boat, air or on the highway.

General Licensing Requirements: No persons or agencies may treat, store or dispose of waste materials without a license from the Competent Agency in accordance with the procedures and requirements as prescribed in this Standard. New facilities constructed after the requirements in this Standard are implemented must obtain a license before they can operate. Exemptions to the licensing requirements: Generators who store no more than 1,000 kg of waste on site at any one time and TSD facilities which accumulate less than 1,000 kg of hazardous waste at any one time. An Operational Plan must accompany any waste license application.

Responsibilities of Waste Generators

a) Waste Tracking Form (see following table)

The Generator must give the prescribed information to the Transporter and, within fourteen days of the transfer, give the information to the Competent Agency on the completed form. The following information must be provided on the form:

i) The Generator's name, address, municipality and contact details.

ii) The name, address, and contact details of the person to whom the waste is to be transported.

iii) The day and time the Generator gives the waste to the transporter for transporting.

iv) The type and number of containers if the waste is hazardous; and

v) The following waste details:

The type of waste.

The amount in kilograms, tonnes, cubic meters or litres.

Its physical nature (liquid or solid).

Its hazardous waste code, if relevant (see Waste Classification Standard).

b) Record Keeping

The Generator is required to record and keep for a minimum period of five years the following information:

i) the information detailed in the waste tracking form; and

ii) the Transporter's name, address, and contact details.

Part A

Question	Details
Name of waste generator	*The person/company/partnership/body corporate generating the waste – if applicable, generator ID number*
Address/postcode	*Site address where waste is held*
Name of emergency contact/phone	*Refers to an authorised representative of the generator*
Nominated receiving facility	*Name of facility specified to the transporter as the receiver of waste*
Description of waste	*General description of the waste*
Hazardous waste code	*See Waste Classification Standard*
Waste origin	*See Appendix A — Waste Origin Codes*
Bulk/no. and types of packages	*Whether the waste is transported in bulk, or number and types of packages*
Amount of waste	*This specifies the amount of waste in kgs or litres*
Name and position /signature /date	*This refers to an authorized representative of the generator.*

Part B

Question	Details
Name of transporter	*The person/company/partnership/body corporate transporting the waste – preferably the name under which the Competent Agency has issued the Registration Certificate*
Address	*Registered business address is preferred*
Mode of transport	*Road/rail/air/sea*
Vehicle registration number	
Name/signature/date	*This refers to the driver of the vehicle in which the waste is being transported*

Part C

Question	Details
Name of receiving facility	*The person/company/partnership/body corporate receiving the waste — if applicable, receiver ID number*
Address	*Site address*
Site ID Number	*If relevant for a hazardous waste facility*
Waste Receiver Code	*See Appendix B – Table 1 and 2*
Waste Licence Number	*Issued with Waste Licence for waste facility*
Name/signature/date	*Refers to an authorised representative of the receiver*
Discrepancy	*Details of any discrepancy between the waste described in Part A and the waste being received*

Figure 197. Waste Tracking Form. Source: Waste Regulatory Control and Compliance (2012)

Waste Transportation (2012)

The objective of this standard is to establish the requirements necessary to ensure that the transportation of waste in KSA is undertaken in a responsible manner to safeguard the protection of the environment and the community against potential accident, spills and pollution.

The transport of dangerous goods is regulated in order to prevent, as far as reasonably practicable, accidents to persons or property and damage to the environment, the means of transport employed or to other goods.

The Transporter must register with the Competent Agency for approval to operate as a waste transporter, covering hazardous waste, as required under the Waste Regulatory Control and Compliance Standard.

Class	Classification	Hazardous Property	Hazard Sign	Examples
Class 1 Explosive Substances		These materials will explode		
Class 2 Gases	Class 2.1 Flammable Gas	These are gases which will burn		Hydrogen LPG
	Class 2.2 Non-flammable gas Non-toxic gas	These gases are usually compressed and so are a source of stored energy and some may also present an anoxic hazard (that is, they will exclude oxygen and so kill through asphyxiation). These containers may rocket if valves are damaged or containers are involved in a fire		Air Carbon Dioxide Nitrogen
	Class 2.3 Poisonous Gas	These gases are toxic. Being gases, they will rapidly disperse if there is a leak. This may reduce the concentration and the hazard - but it will also spread the gas further, so increasing the risk of poisoning more people		Chlorine Methyl Bromide Nitric Oxide
Class 3 Flammable Liquids		These liquids all burn		Petrol Kerosene
Class 4 Flammable Solids	Class 4.1 Flammable solids, self-reactive and related substances and desensitised explosives	Solids easily ignited and readily combustible. These are ordinarily flammable solids which don't fit into Class 4.2 or 4.3.		Sulphur Phosphorus Picric Acid
	Class 4.2 Spontaneously Combustible	These materials will catch fire if exposed to air without any heat being applied (that is, the heat from the normal air is sufficient for them to catch fire - no other source of heat is required).		Charcoal (non-activated)

	Class 4.3 Dangerous when wet	This class is also known as 'Emits flammable gases when wet'. This class has a particular hazard: not only can moisture from the air cause a fire, but if water or foam is used to extinguish them, it will make the situation worse.		Calcium Carbide
Class 5 Oxidising Substances	Class 5.1 Oxidising Agent	These are all oxidising agents other than organic peroxides. When substances burn in air, they combine with oxygen and so are said to have been oxidised. Other chemicals have a similar 'burning' effect and so are said to be oxidising agents. The largest group of these are the organic peroxides.		Chlorine Calcium Hypochlorite Sodium Peroxide
	Class 5.2 Organic peroxides (liquid or solid)	These are a particular class of oxidising agent. They have all the normal hazards of oxidising agents (that is, they will cause a 'chemical burning'). In addition, they will often be explosive under certain conditions - especially, if they are allowed to dry out.		Benzoyl Peroxides Methyl Ethyl Ketone Peroxides (MEKP)
Class 6 Poisonous and Infectious Substances	Class 6.1 Poisons	These are liable to cause death or serious injury to human health if inhaled, swallowed or absorbed through the skin. It is acceptable to use the word 'toxic' to replace the word 'poison'.		Cyanides Lead Arsenic
	Class 6.2 Infectious Substances	Substances containing viable micro-organisms that may cause disease in humans or animals.		Diagnostic Specimens or Live Vaccines
Class 7 Radioactive Substances		Materials or combinations of materials which spontaneously emit ionising radiation. (included here for recognition purposes)		Uranium Radio Isotopes Plutonium
Class 8 Corrosive Substances		These chemicals will corrode a wide range of materials including some materials of construction for tanks and eyes and skin. Care must be taken to ensure the containers and packages are made from the right materials and the chemicals do not come into contact with clothes, skin or eyes. Special protective equipment needs to be worn.		Hydrochloric acid Sodium Hypochlorite (liquid pool chlorine) Sodium Hydroxide (caustic soda)
Class 9 Miscellaneous Goods		Substances and articles which have potentially dangerous properties that are relatively minor, or are not covered by any of the classes already described.		Aerosols Polyester Beads

Figure 198. Hazard Warning Diamonds. Source: Waste Transportation (2012)

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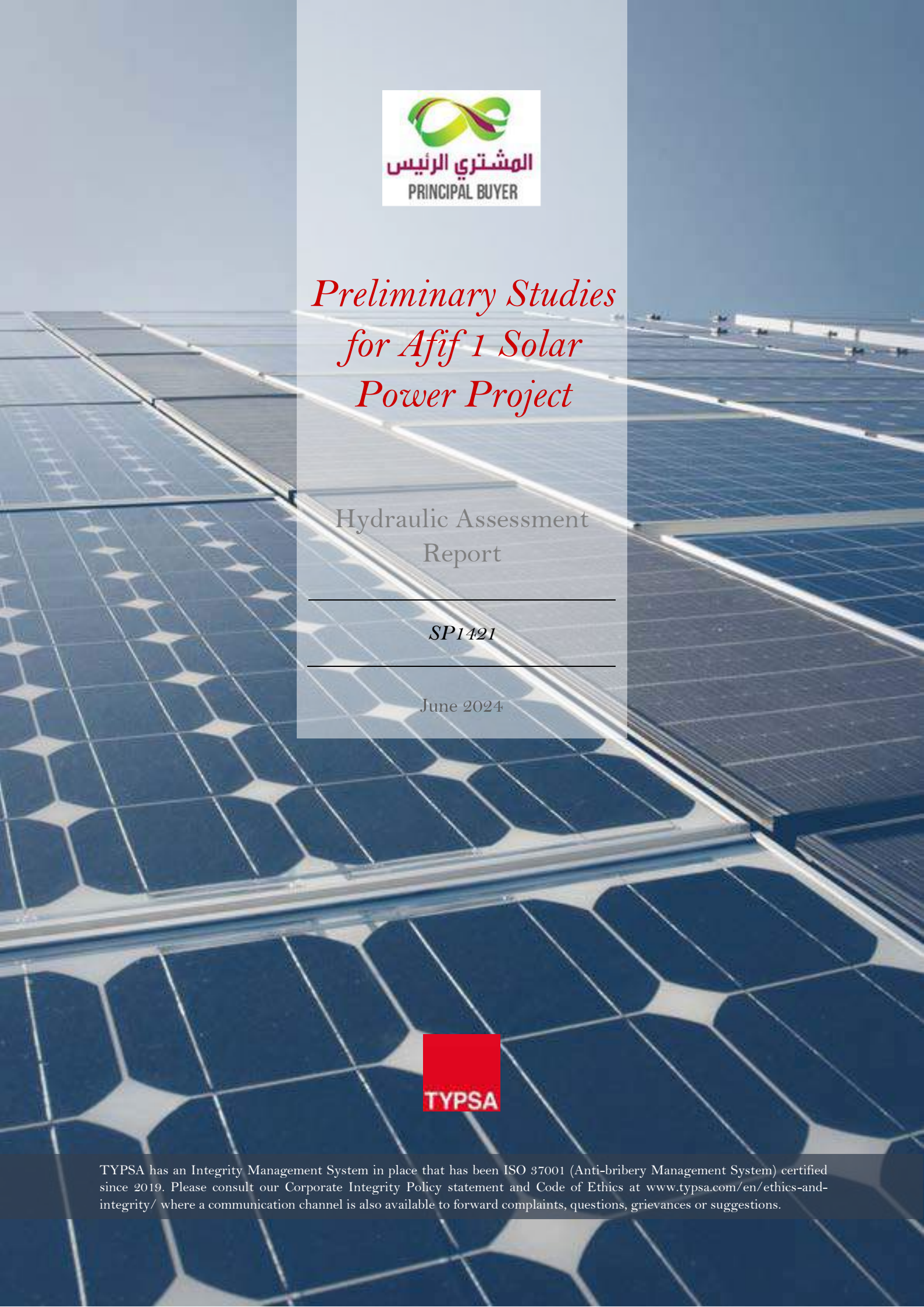
8.3.3. Annex nº 3.3 Hydrological Report



المشتري الرئيس
PRINCIPAL BUYER

Preliminary Studies for Afif 1 Solar Power Project

Hydraulic Assessment Report

SP1421

June 2024

TYPSA

TYPSA has an Integrity Management System in place that has been ISO 37001 (Anti-bribery Management System) certified since 2019. Please consult our Corporate Integrity Policy statement and Code of Ethics at www.typsa.com/en/ethics-and-integrity/ where a communication channel is also available to forward complaints, questions, grievances or suggestions.

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Table of contents

Hydrological Report 9
1. Introduction 9
1.1. Location 9
1.2. Objective 11
1.3. Data collection 12
2. Methodology 13
3. Hydrometeorological analysis 15
3.1. Intensity-Duration-Frequency Curves (IDF) 15
4. Hydrological analysis 16
4.1. Delimitation and physical characteristics of the basins 17
4.1.1. Time of concentration 20
4.1.2. Morphology analysis 21
4.2. Rational Method 22
4.2.1. Runoff coefficient 23
4.2.2. Average rainfall intensity 25
4.3. HEC-HMS and Soil Conservation Service Method 26
4.3.1. Sub-basins and model definition 26
4.3.2. Hyetograph definition 28
4.3.3. Curve Number and runoff threshold 30
5. Flooding analysis 32
5.1. Hydraulic modeling 32
5.2. Previous workflow process 33
5.2.1. Initial conditions 34
5.2.2. Boundary conditions 34
5.2.3. Roughness 40
5.2.4. Infiltration losses 40
5.2.5. Mesh calculation 41
5.3. Simulation 43
5.4. Post-Process 44
5.5. Results 44
5.6. Flood hazard 47
5.6.1. Water depth 48

5.6.2. Velocities 48
5.6.3. Combination depth and velocity 49
5.6.4. Flooding hazard areas 50
6. Mitigation strategies 51
6.1. Substation 52
7. Conclusions 54
ANNEX A. IDF Curves 56
ANNEX A. IDF Curves 56
ANNEX B. Hyetograph Definition 59
ANNEX B. Hyetograph definition 59
1. U004 - Kuraa Almarw Atajarob - Hyetograph for 25 years return period 59
2. U004 - Kuraa Almarw Atajarob - Hyetograph for 50 years return period 60
3. U004 - Kuraa Almarw Atajarob - Hyetograph for 100 years return period 62
4. U002 - Uclat As Suqur - Hyetograph for 25 years return period 63
5. U002 - Uclat As Suqur - Hyetograph for 50 years return period 64
6. U002 - Uclat As Suqur - Hyetograph for 100 years return period 66
ANNEX C. HEC-HMS Model 68
ANNEX C. HEC-HMS Model 69
1. OUTFALL 1 71
2. OUTFALL 2 71
3. OUTFALL 3 72
4. OUTFALL 4 72
5. OUTFALL 5 73
6. OUTFALL 6 73

List of figures

Figure 1. Location of Afif 1. 10
Figure 2. Representative images of the study area. 11
Figure 3. Rain gauges provided by SPPC. 13
Figure 4. Hydrological Report Methodology. 15
Figure 5. Afif 1 PV Project location and meteorological stations available. 16
Figure 6: AFIF Solar Plant Watersheds and Area. 18
Figure 7: Slope analysis. 19
Figure 8. World Land Cover according to European Space Agency. 21
Figure 9. Hydrological Soil Group classification for Curve Number-Based Runoff Modelling provided by the NASA. 22
Figure 10. Runoff coefficient distribution for Afif1 basins. 25
Figure 11. AFIF1 Sub-Basin and model definition. 28
Figure 12. Design hyetograph for different return periods of U004 - Kuraa Almarw Atajarob. 29
Figure 13. Design hyetograph for different return periods of U002 - Uclat As Suqur. 30
Figure 14. Infiltration losses. 32
Figure 15. NURBS area for the hydraulic model. 34
Figure 16.Inlet boundary conditions. 35
Figure 17. Inlet Hydrograph 1 at AFIF-01_02 35
Figure 18. Inlet Hydrograph 2 at AFIF-01_09 36
Figure 19. Inlet Hydrograph 3 at AFIF-01_10 36
Figure 20. Inlet Hydrograph 4 at AFIF-01_11 36
Figure 21. Inlet Hydrograph 5 at AFIF-01_08 37
Figure 22. Inlet Hydrograph 6 at AFIF-01_06 37
Figure 23. Inlet Hydrograph 7 at AFIF-02_06 37
Figure 24. Inlet Hydrograph 8 at AFIF-06_06 38
Figure 25. Inlet Hydrograph 9 at AFIF-06_02 38
Figure 26. Inlet Hydrograph 10 at AFIF-06_07. 38
Figure 27. Outlet boundary condition. 39
Figure 28. Roughness Coefficient 40
Figure 29. Infiltration losses. 41
Figure 30. Hydraulic model mesh. 42
Figure 31. Hydraulic model mesh with elevation. 43
Figure 32. Maximum Water Depth for a 25-years return period. 44
Figure 33. Maximum Water Velocity for a 25-years return period. 45
Figure 34. Maximum Water Depth for a 50-years return period. 45
Figure 35. Maximum Water Velocity for a 50-years return period. 46
Figure 36. Maximum Water Depth for a 100-years return period. 46
Figure 37. Maximum Water Velocity for a 100-years return period. 47
Figure 38. Depths over 0.5 m for 100-year return period. 48
Figure 39. Velocities over 1 m/s for 100-year return period. 49
Figure 40. Combination Depths & Velocities over 0.5m2/s for 100-year return period. 50
Figure 41. Flood Hazard areas. 51

Figure 42. Maximum Water Depth for a 100-years return period within the proposed substation. 53
Figure 43. Maximum Water Velocity for a 100-years return period within the proposed substation. 54
Figure 44. Intensity-Duration-Frequency curve for U004 - Kuraa Almarw Atajarob. 57
Figure 45. Intensity-Duration-Frequency curve for U002 - Uclat As Suqur. 58
Figure 46. Hyetograph for 25 years return period. 59
Figure 47. Hyetograph for 50 years return period. 60
Figure 48. Hyetograph for 100 years return period. 62
Figure 49. Hyetograph for 25 years return period. 63
Figure 50. Hyetograph for 50 years return period. 64
Figure 51. Hyetograph for 100 years return period. 66
Figure 52. HEC-HMS model. 69
Figure 53. Outlet AFIF1-01 hydrograph. 71
Figure 54. Outlet AFIF1-02 hydrograph. 71
Figure 55. Outlet AFIF1-03 hydrograph. 72
Figure 56. Outlet AFIF1-04 hydrograph. 72
Figure 57. Outlet AFIF1-05 hydrograph. 73
Figure 58. Outlet AFIF1-06 hydrograph. 73

List of tables

Table 1. Afif 1 PV Project main characteristics 9
Table 2. Rain gauges provided by SPPC. 13
Table 3. Physiographic basins data. 20
Table 4. Main stream average slope and time of concentration for each basin. 21
Table 5. Peak flow results for AFIF1 main basins by Rational Method. 23
Table 6. Typical C (rural areas coefficients), KSA - Highways Design Manual - Vol 1. 24
Table 7. Runoff coefficient for Afif 1 basins. 24
Table 8. Intensity data. 26
Table 9. Peak flow results for AFIF1 basins by HEC-HMS Method. 26
Table 10. Sub-Catchments / streams average slope, time of concentration, curve number and Runoff threshold. 27
Table 11. SCS TR-55 Table 2-2d – Runoff curve numbers for arid and semiarid rangelands. 31
Table 12. Roughness values. 40
Table 13. Hyetograph table for 25 years return period. 60
Table 14. Hyetograph table for 50 years return period. 61
Table 15. Hyetograph table for 100 years return period. 63
Table 16. Hyetograph table for 25 years return period. 64
Table 17. Hyetograph table for 50 years return period. 65
Table 18. Hyetograph table for 100 years return period. 67
Table 19. Physiographic sub-basins data. 70

Hydrological Report

1. Introduction

The Ministry of Energy of the Kingdom of Saudi Arabia (MoE) has promoted the "National Renewable Energy Program (NREP)" aimed at diversifying local energy sources, maximize installed power capacity, and boost renewable energies.

The initiative is aligned with "Vision 2030" goals and "King Salman Renewable Energy Initiative", which sets targets towards developing a solid renewable energy industry for the country while fulfilling the Kingdom's commitments to reduce carbon dioxide emissions. The strategy of this initiative is to encourage establishing local jobs and driving the growth of economy outside the oil-economy.

With that program, SPPC together with the Ministry of Energy has appointed TYPSA to provide expertise and assistance to complete the pre-development studies for the Afif 1 solar energy park.

1.1. Location

In this context, the Saudi Power Procurement Company (SPPC), together with the Ministry of Energy proposes to develop a Photovoltaic Solar Plant in the Afif governorate, located in the Ar-Riyadh province. The project covers a total area of 39.87 km^2. The area allocated for the Project is about 23 km south-east of the Afif city and 8 km north of Almardamah city.

Solar Power plant	Available surface (km^2)	X (WGS84/UTM Z 38N)	Y (WGS84/UTM Z 38N)	Elevation (m.a.s.l.)
Afif 1	39.87	311,794.12	2,632,476.74	978

Table 1. Afif 1 PV Project main characteristics

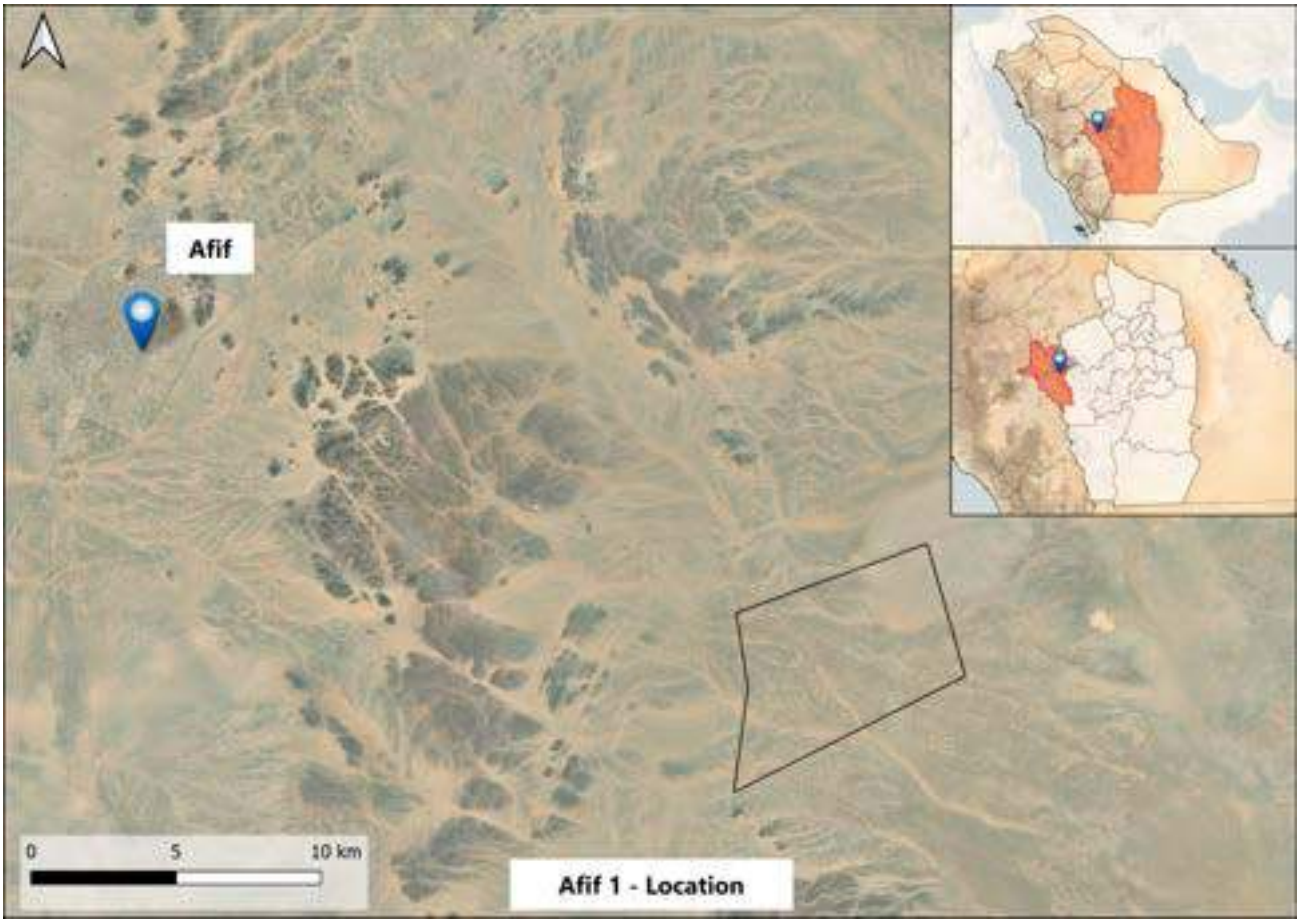


Figure 1. Location of Afif 1.

The region is characterized by a desert landscape, where extensive plains coexist with modest mountain ranges. The project finds its location nestled at the base of the encompassing mountain ranges, primarily covering the western horizon.

In this regard, it is possible to observe through aerial photography how these landforms significantly shape the hydrodynamics of the area. The marks of water flow can be seen in the image, originating in the mountainous areas, and subsequently meandering through the plains. Consequently, the terrain brighter hues indicate the torrential character of the storm events in this area. Additionally, the heightened density of trees and bushes in these areas supports the hypothesis of water flow in these specific regions.

The darker areas of the orthophoto correspond to low-elevation mountainous regions. However, the areas with shades of brownish gray are due to a higher concentration of coarse sand, pebbles, or gravel boulders.

Furthermore, positioned at an average elevation of 978 m.a.s.l., the project is strategically positioned within the plain situated at the base of the mountains. Here, the topography gently slopes towards south-east, in stark contrast to the location of the mountain ranges.

Below are some representative images of the study area.

Figure 2. Representative images of the study area.

1.2. Objective

The aim of the current report, developed by TYPSA, is to optimize the location of the Afif 1 Solar Park by determining the areas that are under potential risk of flooding. In order to optimize its location, a hydrological and hydraulic assessment of the study area has been carried out.

For this purpose, the site topography will be studied to analyze and identify natural watersheds and its runoffs, which have important influence inside and outside the plot. Then, the peak flow rate of the main streams that might have influence around Afif 1 PV Plant will be assessed for different return periods (25, 50 and 100 years).

Finally, 2D Hydrodynamic analysis will be carried out to simulate the water behaviour after different rainfall scenario. As a result, the simulation provides depth and velocity evolution maps, which helps to identify potential flood hazard and erosion areas.

Consequently, the objective of this study is to analyze the hydrodynamic behavior of the project area during design rainfall events. For this purpose, the current state of the terrain prior to the construction of the solar

plant is taken into account. Based on the results of the hydrodynamic simulation, considering the current state of the terrain, the suitability of the future project will be evaluated. Based on the results, mitigation measures will be planned for flood-prone locations.

1.3. Data collection

To carry out a good hydrological and hydraulic study, the first step is to collect all the required data. Key information to develop a hydrological and a hydraulic assessment is:

- Topographical information. It is the base of any hydrological or hydraulic model; therefore, the reliability of the results is directly linked to the quality of the topographical information.
- Aerial imagery data.
- Land cover and land use information to determine the hydrological and hydraulic parameters.
- Rainfall and flow discharge information.

For the purposes of this study, this information has been obtained as follows:

- Section 2.07 Hydrology, Volume 1 Highways Design Manual by Ministry of Communication of the Kingdom of Saudi Arabia, and the Federal Highway Administration of the United States of America.
- Rainfall Data (IDF Curves) found in the academic paper "Development of intensity–duration–frequency curves for the Kingdom of Saudi Arabia" by Geomatics, Natural Hazards and Risk, published in November 2016.
- Digital Terrain Model, 12.5x12.5 pixels obtained from ALOS PALSAR DEM of NASA´s web page.
- Digital Terrain Model, 30x30 pixels obtained from SRTM DEM of NASA´s web page.
- Detailed topographic information caried out during the topographic survey. This topography has a pixel resolution of 1 m.
- HEC-HMS Software by the Hydrologic Engineering Center of the US Army Corps of Engineers to modeling hydrologic drainage system and other processes affecting watersheds systems.
- IBER Software by the Centre for Hydrographic Studies (CEDEX, Spanish Public Administration), GEAMA, Flumen Institute and CIMNE to build two-dimensional model for the simulation of free surface flow.

Availability of historical rainfall information for the site was requested by Saudi Power Procurement Company (SPPC) to Ministry of Environment, Water and Agriculture (MEWA). In this context, SPPC has provided meteorological data from stations in the project's vicinity. These stations record daily precipitation measurements. However, the historical series are relatively recent, with measurements dating from 2015 to the present day.

LOCATION	STATION CODE	HISTORICAL LENGTH
Ad Dawadimi	RDCC00012	2020-2023
Afifa	RDCO00001	2016-2020
Afif	RDRO00040	2015-2018
Al Ghrabah	RDRS00018	2021-2023
Al Khasrah	RDRS00033	2020-2023
Nifi	RDRS00056	2021-2023
Al-Quway'iyah	RDRS00468	2021-2023

LOCATION	STATION CODE	HISTORICAL LENGTH
Al-Quway'iyah	RDRM00051	1963 (Incomplete)

Table 2. Rain gauges provided by SPPC.

Figure 3. Rain gauges provided by SPPC.

However, as indicated in SP1421-AF1-REP-004-DESIGN_BASIS_&_SITE_PLAN, the short duration of the available historical data series has been considered insufficient for conducting a meteorological analysis. To ensure greater precision, rainfall data from the academic research "Development of intensity–duration–frequency curves for the Kingdom of Saudi Arabia" by Geomatics, Natural Hazards and Risk, published in November 2016, will be employed.

2. Methodology

Two different methods have been used to determine maximum flow values for the studied basins:

- On one hand, Rational Method to determine runoffs peak discharge proposed in "Section 2.07 Hydrology, Volume 1 Highways Design Manual by Ministry of Communication of the Kingdom of Saudi Arabia".
- On the other hand, it has been used the methodology defined by the Soil Conservation Service (SCS) of the United States. This empiric procedure is also implemented in software Hec-HMS, developed by the US Army Corps of Engineers.

The present hydrological study has been carried out by following the next steps:

- Meteorological analysis by statistical methods. Calculation of the maximum daily precipitation from weather station data.
- Determination of the most suitable IDF (Intensity-Duration-Frequency) curve for the studied site based on data from meteorological stations and different academic research.
- Basins and sub-basins delimitation inside and outside the project area. In the first instance, the basins will be delimited according to the information acquired from the 30x30 pixels Digital Terrain Model, obtained from Aster DEM of NASA´s web page. Subsequently, catchment boundaries will be refined with the detailed topographic information of the site.
- Definition of physical characteristics of the previous delimitated basins: area, length of the longest stream and average slope.
- Assessment of the basins morphology: hydrogeology and ground cover, using different data sources such as Google Earth images, ESA World Land Cover or NASA Global Hydrologic Soil Groups. Definition of the runoff coefficient value and curve number CN.
- Calculations of peak flow values and hydrographs for each defined sub-basin and stream considering different return periods. The selection of the return periods to be used has been carried out in accordance with the common industry practice as well as local regulations. In accordance with the Saudi Building Code, defines the flood hazard area as the flood having a 1% chance of being equaled or exceeded in any given year, year, on other words the 100-year return period rainfall event has been considered. Additionally, the Saudi Highway Design Manual establish the return periods of 25, 50 and 100-years as threshold to dimension different protection elements associated to the roads. Consequently, the present report will consider the return periods of 25, 50 and 100-years.
- Baseflow is not considered for calculations. Only superficial drainage is considered in peak flow and hydrographs determination.
- Flooding analysis is performed using a bidimensional simulation software. In this report, IBER Hydrological Modelling Software will be used. The model carried out with the program allows to simulate the flows that ran through terrain natural channels.
- Identification of potential flooding and erosion areas. Recommend zones to avoid or improve regarding the hydrological behavior to minimize the risk of suffering any damage on structures or installations. Any mitigation measure will be defined to avoid the hydraulic risk.

The methodology followed in this report is summarized in the image below:

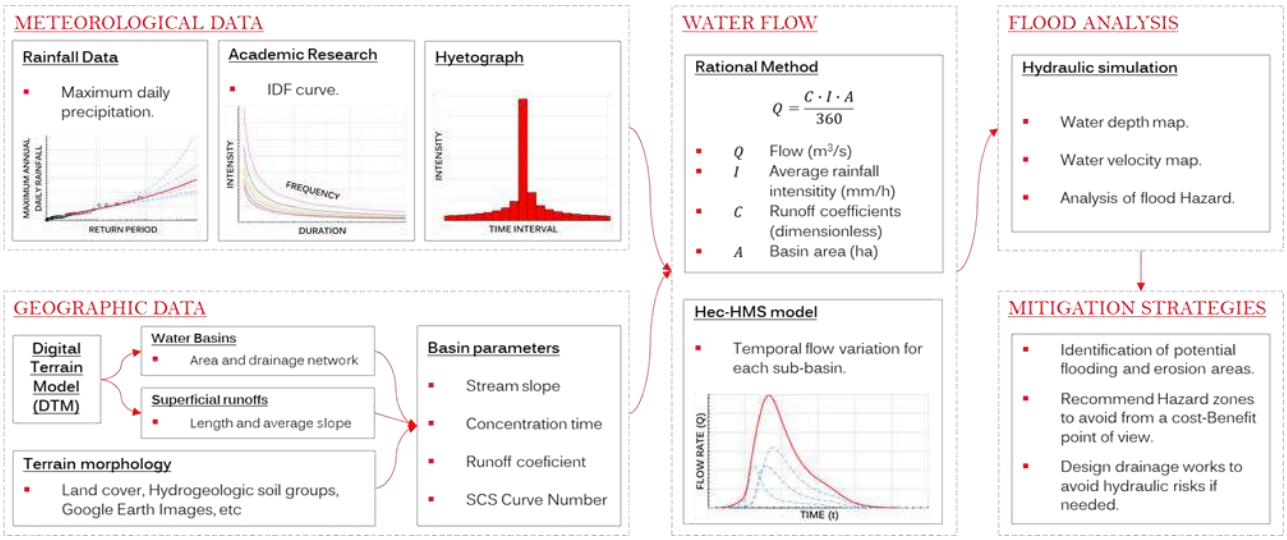


Figure 4. Hydrological Report Methodology.

3. Hydrometeorological analysis

Except for the south-west region of Saudi Arabia, the climate of KSA is classified as arid. It is characterized by extreme heat during the day, a temperature drops at night and slightly erratic precipitation. Rainfall is generally unevenly distributed and is the only type of precipitation. The entire year's rainfall may consist of one or two torrential outbursts that flood the wadis. The average rainfall is 100 mm per year.

An accurate quantification of the precipitation associated with the intensity and occurrence of flood hazards is crucial. The purpose of a hydrometeorological analysis is to determine the occurrence, intensity, and evolution of hydrometeorological extreme events that cause floods in the area based on monitoring and historical records.

With this purpose, the Intensity-Duration-Frequency and the duration and distribution of the rainfall event must be estimated.

3.1. Intensity-Duration-Frequency Curves (IDF)

The intensity–duration–frequency (IDF) relationship is a mathematical relationship between the rainfall intensity i, the duration D and the return period T. IDF relationships are crucial for the design of flood mitigation measures, water engineering projects and water resources engineering designs. Such relationships are used to develop design storms (DS) to obtain peak flows and hydrograph's shape in any hydraulic design.

The present study has been based on the IDF curves obtained from the publication "Development of intensity-duration-frequency curves for the Kingdom of Saudi Arabia", Hatem A. Ewea, Amro M. Elfeki & Nassir S. Al-Amri (2016), which presents the derivation of the intensity–duration–frequency (IDF) curves for the Kingdom of Saudi Arabia.

These curves were obtained based on rainfall events measured in 28 meteorological stations distributed throughout the Kingdom of Saudi Arabia. For a 20 to 28 years period, 2027 rainfall storms of durations ranging from 10 min to 24 hours were collected and analyzed. Both, the Institute of Hydrology model (IH-Flood) and the Excel-sheet program are used for developing IDF equations for every station. The method of least squares was used to get relationships for the parameters of the IDF formulas. The calculated goodness of fit shows

strong correlations ranging between 0.99 and 0.98 for one of the parameters, and between 0.92 and 0.74 for the other parameters, indicating that IDF formulas are robust for practical use.

Regionalization of the IDF parameters for the 13 different regions of the Kingdom has been developed. In addition, an average of IDF parameters is made over the complete Kingdom to be used in regions of no rainfall records. The resulting IDF curves are usually used for flood estimation in urban/rural watersheds. Using this IDF curves is highly recommended for rigorous, efficient and safe design of hydraulic structures and flood protection works.

As indicated in SP1421-AF1-REP-004-DESIGN_BASIS_&_SITE_PLAN, the IDFs of the area of U004 – Kuraa Almarw Atajarob were used in this study. However, since the site is very close to the boundary between the area of U004 and U002, the contributing watersheds of the plant to shift between influence zones. For that purpose, the IDF curves of U002- Uclat As Suqur were also used.

For more information of the Afif 1 IDF Curves, see ANNEX A. IDF Curves.

Figure 5. Afif 1 PV Project location and meteorological stations available.

4. Hydrological analysis

The objective of this section is to determine the daily rainfall amount present in the area, as well to illustrate the predictable peak flows for different return periods. The peak flow rates for each basin have been assessed by two methodologies, the Rational Method, and the Soil Conservation Service (SCS) Method.

Both methodologies are widely used for water flow estimation. Saudi Highway Design Manual establish the use of the Rational Method for calculating hydraulic elements of protection such as ditches or cross-drainage works on roads. However, this methodology only allows for peak flow calculations. Alternatively, the SCS Method, integrated within the HEC-HMS software, allows for the temporal evolution study of flows in the basins, taking into account a more detailed analysis of the geometry and topography, of them. This enables the examination of flow changes over time at specific locations within the basin, referred to as control points.

Therefore, for conducting 2D hydrodynamic simulations, the results from the SCS method will be employed as they allow for the assessment of temporal flow evolution. Additionally, the peak flows calculated by the Rational Method will also be included for future reference in sizing the drainage works of the facilities.

4.1. Delimitation and physical characteristics of the basins

Basins have been delimited using the available cartographic information. In a first approach, the watersheds have been bounded according to ALOS PALSAR DEM of NASA, with 12.5x12.5 pixels resolution, and SRTM DEM of NASA, with 30x30 pixels resolution. Subsequently, catchment boundaries have been refined with the detailed topographic information of the site. Besides, aerial photographs of the area have verified that there were no significant modifications due to pre-existing infrastructure.

The watersheds have been delimited upstream and with north-west border of the park. This delimitation determines the geometry of the incoming basins (area, slope), that could have an impact on the water runoff, flows and velocities. The outcoming water flows and discharge points will remain since there is no change in the current situation because of the implementation of a new PV plant.

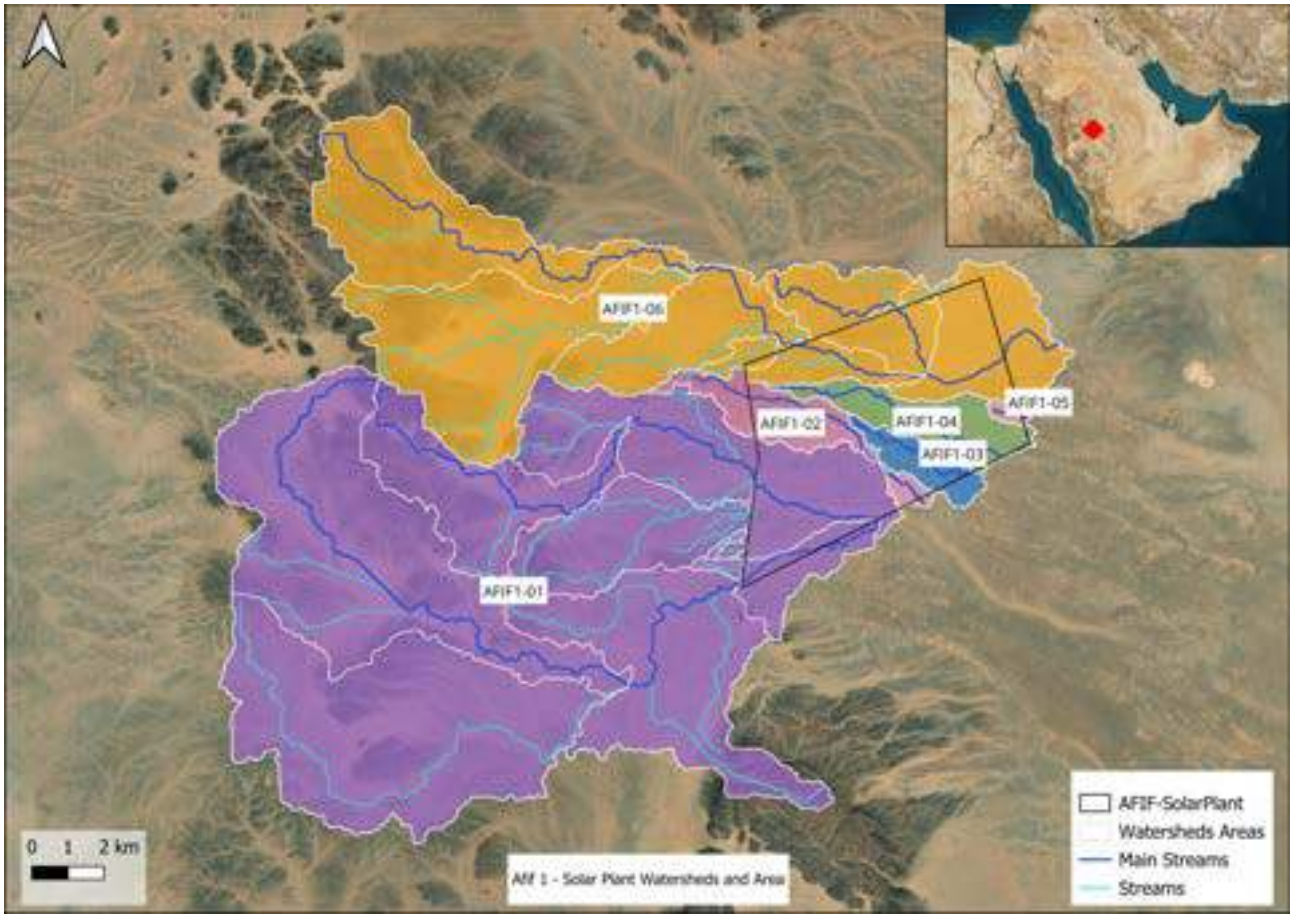


Figure 6: AFIF Solar Plant Watersheds and Area.

Once the previous information was collected, the next step has been the identification of natural drainage paths and main streams to provide further information about the physical characteristics of the watersheds.

The process to define the runoff system has been challenging, due to the flatness and the lack of slopes over all the area. As can be seen in the image below, a slope analysis has been carried out. The results show that nearby project terrain is extremely flat. In particular, within the solar plant slopes are mainly between 0 to 3%, with some steeper slopes (>13.5%) in the upper part of the hills located to the northwest and south of the project site.

However, based on the slopes, it is possible to slightly define the hydrodynamics of the area. The site is characterized for being located in a floodplain, where water meanders gently across the terrain. With very low to negligible slopes, the water flow will normally be calm and dispersed. Consequently, it is expected a gentle water flow in the area, with a thin water layer moving at low velocities.

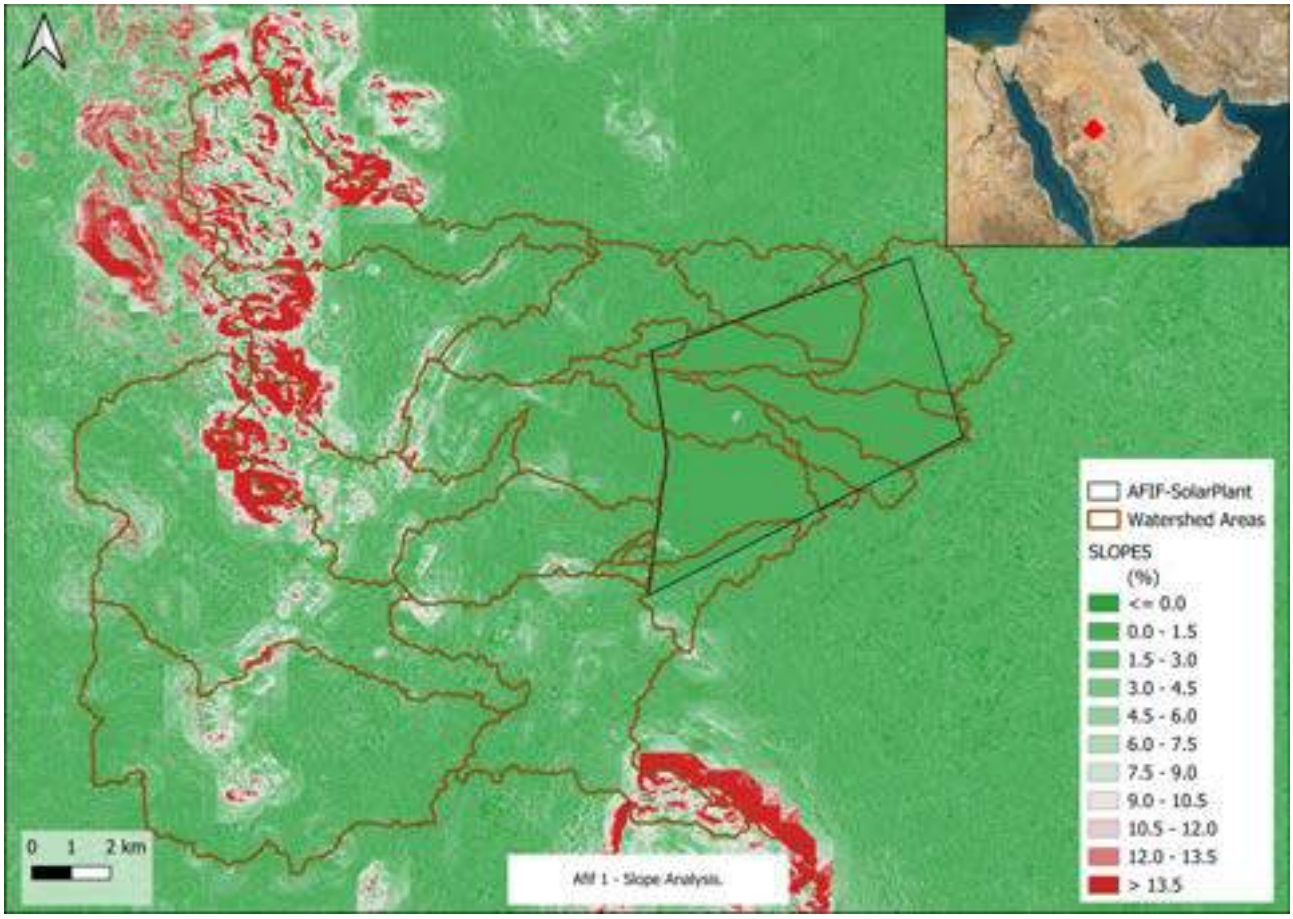


Figure 7: Slope analysis.

The drainage system at the AFIF 1 Solar Plant and catchments areas is mainly defined by the existing surface water overland flow paths (streams), that originate in the hills to the northwest and south of the solar plant and flows through the plains and solar plant to the southwest of the project site. This drainage pattern can also be identified in the marks of water flow (erosion and superficial deposits) that can be seen in the available orthophoto.

Additionally, and considering the very low slopes in the plant area, part of the drainage system at the AFIF 1 Solar Plant and main catchments areas is diffuse, and during rainfall events surface water runoff does not concentrate in the main streams but flow slowly and scattered, being stored on site before it drains away.

Finally, the physiographic characteristics of each watershed have been obtained measuring directly the dimensions and elevations in the topography, such as: area, length, maximum elevation, and minimum elevation.

Table 3 shows the physiographic characteristics of each watershed:

Basin	Area (m^2)	Main stream	Length (m)	H_{Upper} (masl)	H_{Lower} (masl)
AFIF1-01	169,106,294.90	**MS-01**	32,048.98	1,173.11	976.35
AFIF1-02	7,167,171.00	**MS-02**	9,306.96	998.36	974.17
AFIF1-03	3,374,341.19	**MS-03**	4,697.17	982.09	973.55
AFIF1-04	7,486,613.21	**MS-04**	9,786.12	989.67	970.39
AFIF1-05	573,322.08	**MS-05**	1,412.59	974.05	970.84
AFIF1-06	86,205,450.62	**MS-06**	30,678.01	1,156.41	968.22

Table 3. Physiographic basins data.

4.1.1. Time of concentration

Time of concentration is defined as the time required for storm runoff to travel from the hydraulically most remote point of the drainage basin to the point of interest.

An assumption made in some of the hydrologic methods for estimating peak discharge, is that maximum flow occurs when rainfall of uniform intensity falls over the entire watershed area for a duration that matches the watershed's time of concentration. In other words, the assumption intends to consider that every part of the watershed receives the same amount of rainfall per unit of time and that the duration of the rainfall event lasts long enough for the entire watershed to contribute to the flow at the discharge point simultaneously.

Basically, this means that the highest possible flow at the outlet is when rain falls uniformly throughout the basin and lasts long enough for the water from the farthest point to reach the outlet.

The concentration time depends on the maximum length that water must run to drain away the basin and the average speed that it reaches; this speed depends on the slopes of the terrain, the natural channels and the roughness of the surface.

$$t_C = \frac{0.115 \cdot {L_C}^{0.77}}{S^{0.385}}$$

Where:

- t_C (min) Concentration time.
- L_C (m) Main stream length.
- S (dimensionless) Average slope of the main stream expressed in percentages.

Table 4 shows main stream watersheds characteristics obtained for each case and the concentration time in hours and minutes.

Basin	Area (km^2)	Main stream	Length (m)	H_{Upper} (masl)	H_{Lower} (masl)	Slope (m/m)	t_C (min)	t_C (h)
AFIF1-01	169.106	**MS-01**	32,048.98	1,173.11	976.35	0.0061	409.02	6.82
AFIF1-02	7.167	**MS-02**	9,306.96	998.36	974.17	0.0026	219.77	3.66
AFIF1-03	3.374	**MS-03**	4,697.17	982.09	973.55	0.0018	148.96	2.48
AFIF1-04	7.487	**MS-04**	9,786.12	989.67	970.39	0.0020	254.15	4.24
AFIF1-05	0.573	**MS-05**	1,412.59	974.05	970.84	0.0023	54.20	0.90

Basin	Area (km^2)	Main stream	Length (m)	H_{Upper} (masl)	H_{Lower} (masl)	Slope (m/m)	t_C (min)	t_C (h)
AFIF1-06	86.205	**MS-06**	30,678.01	1,156.41	968.22	0.0061	395.61	6.59

Table 4. Main stream average slope and time of concentration for each basin.

4.1.2. Morphology analysis

When defining the characteristics of a basin, another important part is to study its edaphology. For this purpose, the terrain will be analyzed on the nature of this topsoil layer and its hydrogeological capacities.

To correctly define the covers within the basins, it has been used the information corresponding to the European Space Agency (ESA) 2021, which collects information about land uses around the world. Although this classification is not very precise, it gives a large-scale view of the land cover in the area and endorses the findings of the site visit.

As it can be seen in Figure 8, vegetation around the project is bare / sparse, except for small, localised spots where shrubland and cropland have been detected. In addition, the ESA has detected the built-up infrastructures, such as exiting roads and buildings. In the AFIF1 watersheds terrain is very arid with bare vegetation.

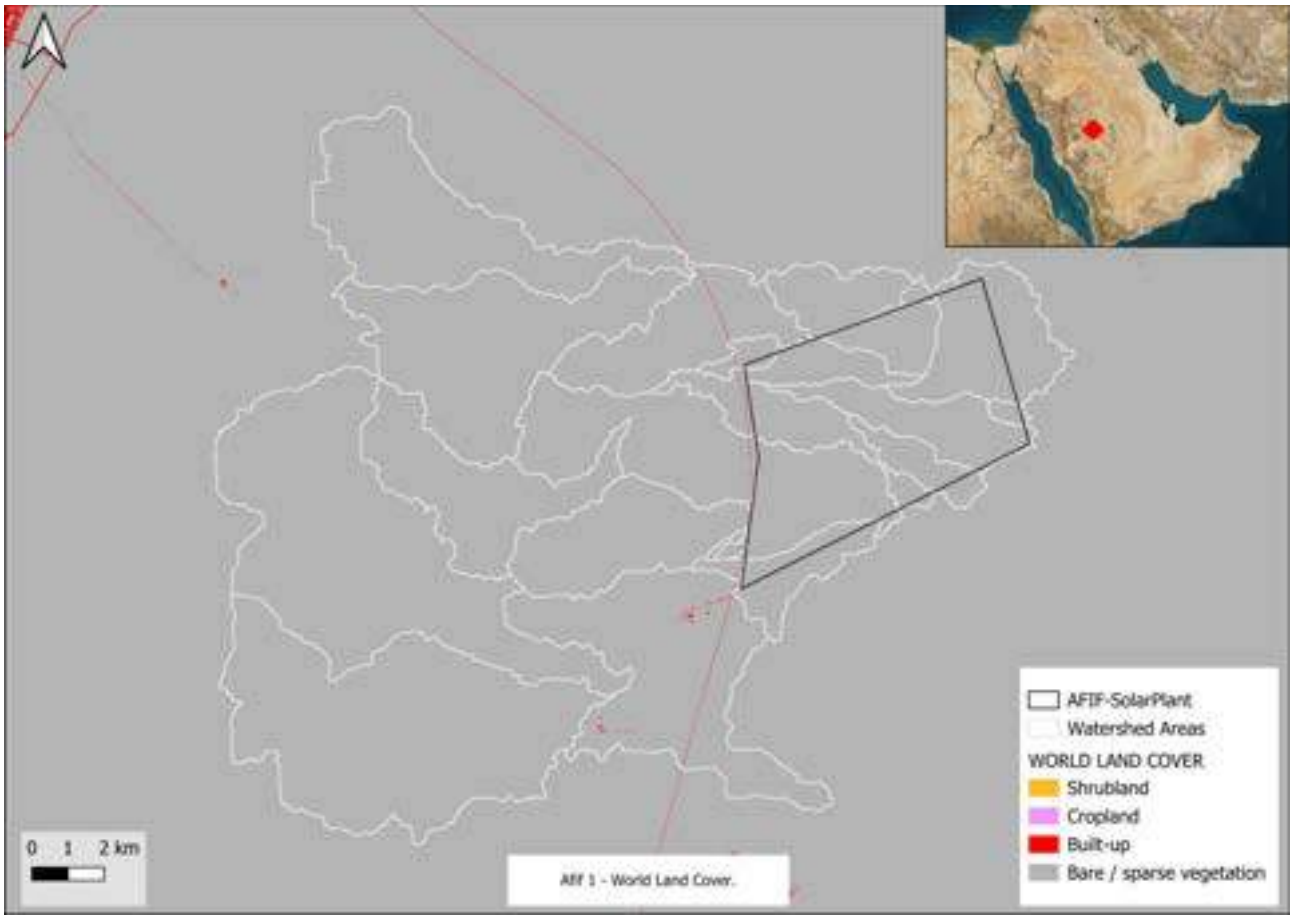


Figure 8. World Land Cover according to European Space Agency.

In terms of hydrogeology, the information of the NASA Global Hydrologic Soil Groups has been used. They classify the terrain according to its composition and runoff potential. This classification will be very important

for the future definition of the curve number and the runoff threshold within the basin, a parameter which allows to study water infiltration into the terrain during rainfall events by the SCS method.

Inside the studied basins, the dominant hydrological soil group is Type B. This soil class is defined by a sandy loam or loamy sand texture, a composition that contains between 10 to 20% clay and 50 to 90% sand and a moderately low runoff potential.

Additionally, the upper part of the hills located to the northwest and south of the development site present a soil group Type C. This soil class is defined by a Clay loam, Silty clay loam, Sandy clay loam, Loam, Silty loam and Silt textures, a composition that typically contains between 20 to 40% clay and less than 50% sand and a moderately high runoff potential.

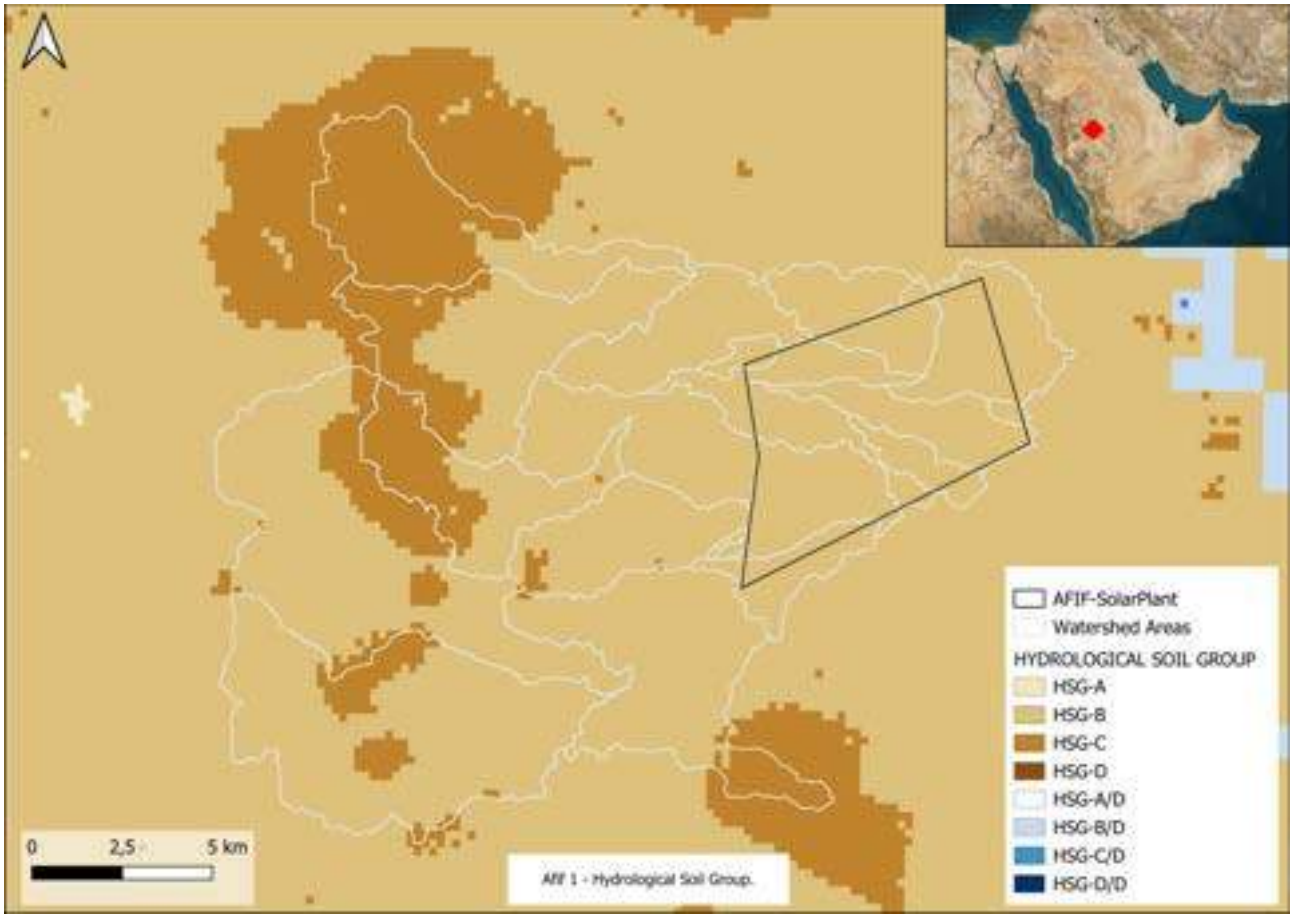


Figure 9. Hydrological Soil Group classification for Curve Number-Based Runoff Modelling provided by the NASA.

4.2. Rational Method

The Rational Method is one of the oldest and most widely used methods to assess flow rates after a defined precipitation event, due to its simplicity and accuracy. The idea behind the method is that rainfall begins instantaneously and continues indefinitely with constant intensity. The runoff rate will increase until the concentration time, when all of watershed is contributing to flow at the outlet. The discharge flow is calculated with the following equation:

$$Q = \frac{C \cdot i \cdot A}{360}$$

Where:

- Q (m^3/s) Flow rate calculated by the Rational Method.
- C (dimensionless) Runoff coefficient.
- i (mm/h) Average rainfall intensity for a duration equal to the basin concentration time.
- A (ha) Basin area

The results for the peak flows for the return periods of 25, 50 and 100 years are:

			25 years		50 years		100 years	
Basin	Area (km^2)	C_e	i_{25} (mm/h)	Q_{25} (m^3/s)	i_{50} (mm/h)	Q_{50} (m^3/s)	i_{100} (mm/h)	Q_{100} (m^3/s)
AFIF1-01	169.106	0.576	4.862	**131.460**	5.738	**155.154**	6.684	**180.736**
AFIF1-02	7.167	0.550	8.931	**9.787**	10.521	**11.529**	12.314	**13.494**
AFIF1-03	3.374	0.550	11.114	**5.730**	13.019	**6.712**	15.150	**7.811**
AFIF1-04	7.487	0.550	8.230	**9.415**	9.716	**11.115**	11.396	**13.037**
AFIF1-05	0.573	0.551	19.627	**1.721**	22.649	**1.986**	25.966	**2.277**
AFIF1-06	86.205	0.598	5.438	**77.802**	6.428	**91.979**	7.514	**107.520**

Table 5. Peak flow results for AFIF1 main basins by Rational Method.

The following sections detail the calculation of the runoff coefficient and the average rainfall intensity involved in the peak flow calculation.

4.2.1. Runoff coefficient

The runoff coefficient is the least precise variable of the rational method. Its use in the formula implies a fixed ratio of peak runoff rate to rainfall rate for the drainage basins, which is not the case. The proportion of the total rainfall that will reach the storm drains depends on percent imperviousness, slope, and ponding character of the surface. The runoff coefficient is also dependant on the character and condition of the soil. The infiltration rate decreases as rainfall continues and is also influenced by the antecedent moisture condition of the soil.

As seen above, the characteristics of the basins affecting the plant are very homogeneous, therefore the runoff coefficient will be equal in all watersheds. It is a rural wasteland with very flat topography where the drainage system is not clearly defined.

For rural areas, the coefficient is defined from the table below, where the runoff coefficient is the addition of the sub-coefficient accounting for watershed relief, soil infiltration, vegetal cover, and surface storage.

Typical C Rural Areas Coefficients			
A Watershed relief	B Soil infiltration	C Vegetal cover	D Surface storage
0.40	**0.20**	**0.20**	**0.20**
Steep rugged terrain; average slopes greater than 30%.	No effective soil cover; either rock or thin soil mantle negligible infiltration capacity.	No effective plant cover; bare or very sparse soil cover.	Negligible; surface depression few and shallow; drainage ways steep and small, no ponds or marshes.

Typical C Rural Areas Coefficients			
A Watershed relief	B Soil infiltration	C Vegetal cover	D Surface storage
0.30	**0.15**	**0.15**	**0.15**
Hilly with average slopes of 10 to 30%.	Slow to take up water; clay, or other soil of low infiltration capacity such as heavy gumbo.	Poor to fair; clean cultivated crops or poor natural cover; less than 10% of area.	Low; well defined system of small drainage ways, no ponds, or marshes.
0.20	**0.10**	**0.10**	**0.10**
Rolling with average slopes of 5 to 10%.	Normal, deep loam.	Fair to good; about 50% of area in good grass land, woodland, or equivalent cover.	Normal; considerable surface depression storage; typical of prairie lands; lakes, ponds, and marshes less than 20% area.
0.10	**0.05**	**0.05**	**0.05**
Relatively flat land average slopes o to 5%.	High, deep sand or other soil that takes up water readily and rapidly.	Good to excellent; about 50% of area in good grass land; woodland or equivalent cover.	High; surface depression storage high; drainage system not sharply defined, large flood plain storage; large number of ponds and marshes.

Table 6. Typical C (rural areas coefficients), KSA - Highways Design Manual - Vol 1.

The selected values for each basin and category have been determined through a weighted average of the area of each basin. These coefficients had been defined based on an analysis of various factors including slopes, land use, hydrological soil group and topography, within the watershed boundaries.

Basin	Typical C Rural Areas Coefficients				Runoff Coefficient
	A Relief	B Soil Infiltration	C Vegetal cover	D Surface storage	
AFIF1-01	0.12	0.11	0.20	0.15	**0.58**
AFIF1-02	0.10	0.10	0.20	0.15	**0.55**
AFIF1-03	0.10	0.10	0.20	0.15	**0.55**
AFIF1-04	0.10	0.10	0.20	0.15	**0.55**
AFIF1-05	0.10	0.10	0.20	0.15	**0.55**
AFIF1-06	0.14	0.11	0.20	0.15	**0.60**

Table 7. Runoff coefficient for Afif 1 basins.

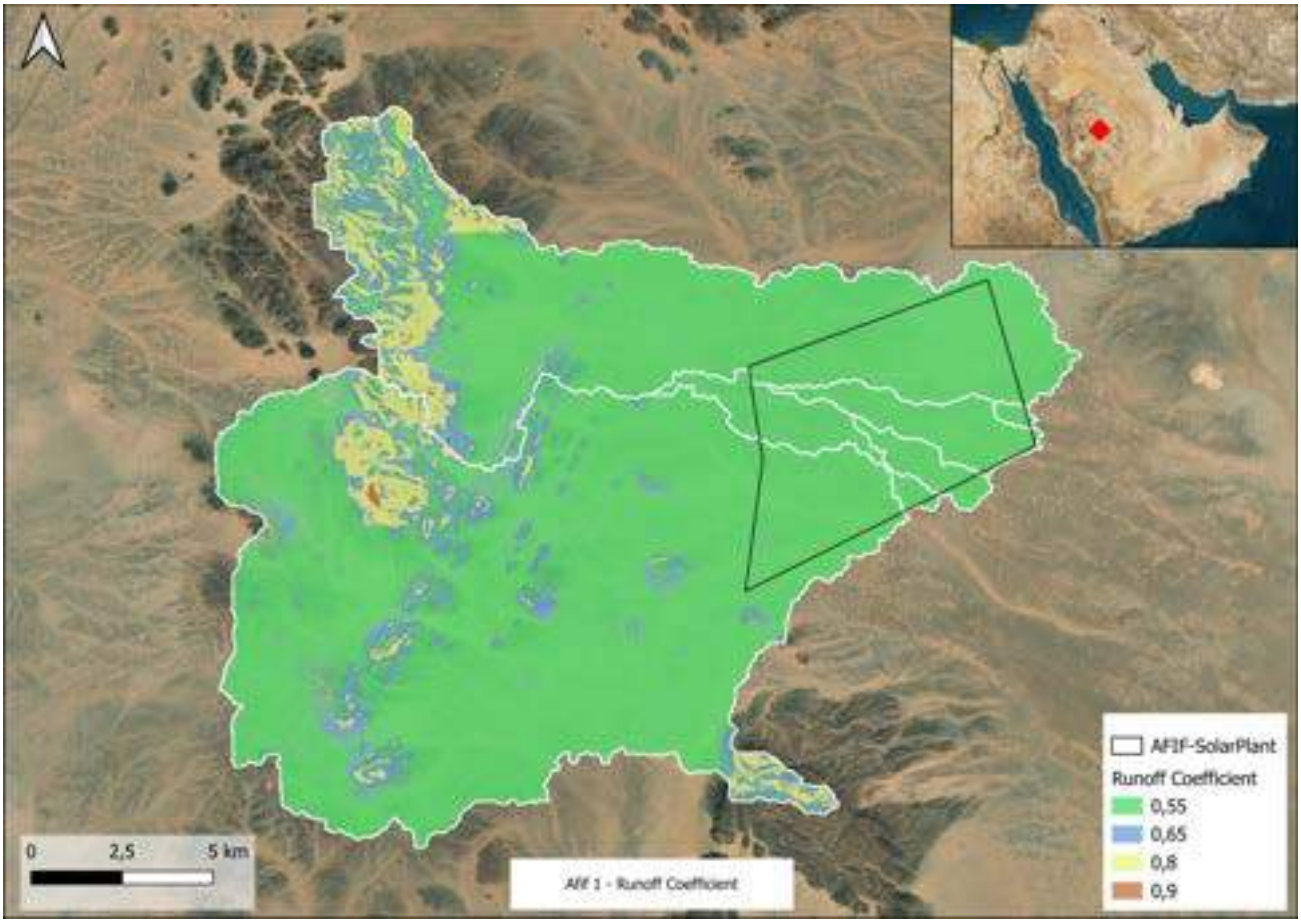


Figure 10. Runoff coefficient distribution for Afif1 basins.

4.2.2. Average rainfall intensity

The rainfall intensity is the average rainfall rate for a particular watershed. It is selected based on the design rainfall duration and return period. As rainfall duration is usually an unknown parameter, the method considers that the design duration is equal to time of concentration. This is assumed because to runoff reach a peak at the time of concentration when the entire watershed is contributing to flow at the outlet.

Therefore, to obtain the average rainfall intensity value for each basin, the expression of the IDF curve is employed, with the storm duration fixed at the time of concentration of the watershed. As indicated in SP1421-AF1-REP-004-DESIGN_BASIS_&_SITE_PLAN, the IDFcurves of the areas of U004 – Kuraa Almarw and U002 – Uclat As Suqur were used in this study. For more information of the Kuraa Almarw and Uclat As Suqur IDF Curves, see ANNEX A. IDF Curves.

As a result, the following expression is obtained:

$$I_T(T, D) = a \cdot {t_c}^b$$

Where:

- I_T (mm/h) — Average rainfall intensity in a range of duration equal to the watershed concentration time for a given recurrence interval.
- a (dimensionless) — Parameter. The value of this parameter varies according to the return period. For more information of a parameter for U004–Kuraa Almarw and U002–Uclat As Suqur IDF Curves, see ANNEX A. IDF Curves.

- t_c (min) Concentration time.
- b (dimensionless) Parameter. The value of this parameter varies according to the return period. For more information of b parameter for U004–Kuraa Almarw and U002–Uclat As Suqur IDF Curves, see ANNEX A. IDF Curves.

		Intensity, i (mm/h)		
Basin	t_c (min)	25	50	100
AFIF1-01	409.02	4.86	5.74	6.68
AFIF1-02	219.77	8.93	10.52	12.31
AFIF1-03	148.96	11.11	13.02	15.15
AFIF1-04	254.15	8.23	9.72	11.40
AFIF1-05	54.20	19.63	22.65	25.97
AFIF1-06	395.61	5.44	6.43	7.51

Table 8. Intensity data.

4.3. HEC-HMS and Soil Conservation Service Method

The application of this procedure is based on the initial abstraction or runoff threshold, that is, the initial precipitation that does not produce direct runoff. HEC-HMS has been used to apply the method to the AFIF1 drainage system. This software enables the analysis of the evolution of flow rates over time inside watersheds. Also, it includes many traditional hydrologic analysis procedures such as event infiltration, unit hydrographs, and hydrologic routing.

The results for the peak flows for the return periods of 25, 50 and 100 years are shown in the table below. For model partial results and hydrographs, see ANNEX C. HEC-HMS Model.

Basin	Area (m^2)	Q_{25} (m^3/s)	Q_{50} (m^3/s)	Q_{100} (m^3/s)
AFIF1-01	169,106,294.90	64.70	84.80	108.70
AFIF1-02	7,167,171.00	6.00	7.90	10.30
AFIF1-03	3,374,341.19	3.60	4.70	6.10
AFIF1-04	7,486,613.21	5.90	7.80	10.10
AFIF1-05	573,322.08	1.00	1.30	1.60
AFIF1-06	86,205,450.62	20.10	26.20	33.20

Table 9. Peak flow results for AFIF1 basins by HEC-HMS Method.

The following sections detail the steps followed to calculate the parameters involved in the SCS methodology.

4.3.1. Sub-basins and model definition

For better definition of the drainage system and to obtain better more reliable results, the main basins previously studied have been divided into sub-basins. Specifically, the AFIF-01 basin has been divided into 11 sub-basins, the AFIF-02 into 2 sub-basins and the AFIF-06 into 8 sub-basins. Below is a diagram of the drainage system for each watershed.

Basin	Area (km^2)	Main stream	Length (m)	Slope (m/m)	t_C (min)	Curve Number	Runoff threshold (mm)
AFIF1-01_01	42.139	MS-01_01	20,367.57	0.008	260.33	78.17	14.19
AFIF1-01_02	26.378	MS-01_02	6,300.92	0.0029	155.91	77.99	14.34
AFIF1-01_03	5.098	MS-01_03	5,380.89	0.0028	139.65	77.00	15.17
AFIF1-01_04	41.033	MS-01_04	20,453.21	0.0034	363.26	78.00	14.33
AFIF1-01_05	15.250	MS-01_05	12,489.07	0.0151	140.14	77.05	15.13
AFIF1-01_06	15.600	MS-01_06	4,918.93	0.003	127.37	85.00	8.96
AFIF1-01_07	9,4370	MS-01_07	4,550.02	0.0024	131.4	85.00	8.96
AFIF1-01_08	13,114	MS-01_08	9,247.02	0.0068	151.09	77.40	14.83
AFIF1-01_09	0.537	MS-01_09	1,487.29	0.0042	44.56	77.00	15.17
AFIF1-01_10	0.276	MS-01_10	817.22	0.0084	21.54	77.00	15.17
AFIF1-01_11	0.243	MS-01_11	1,335.10	0.0065	34.56	77.00	15.17
AFIF1-02_01	2.154	MS-02_01	2,629.86	0.0033	75.68	77.00	15.17
AFIF1-02_02	5.014	MS-02_02	7,483.41	0.0024	190.9	77.00	15.17
AFIF1-03	3.374	MS-03	4,697.17	0.0018	148.09	77.00	15.17
AFIF1-04	7.487	MS-04	9,786.10	0.002	254.2	77.00	15.17
AFIF1-05	0.573	MS-05	1,412.59	0.0021	55.99	77.00	15.17
AFIF1-06_01	22.598	MS-06_01	16,063.35	0.0099	199.78	77.03	15.15
AFIF1-06_02	12.187	MS-06_02	4,885.95	0.0023	140.05	85.00	8.96
AFIF1-06_03	3.790	MS-06_03	4,506.06	0.0023	132.69	77.00	15.17
AFIF1-06_04	11.555	MS-06_04	5,222.66	0.0017	165.93	77.00	15.17
AFIF1-06_05	24.907	MS-06_05	13,208.02	0.0146	148.24	77.02	15.16
AFIF1-06_06	1.362	MS-06_06	5,494.69	0.0025	149.25	77.00	15.17
AFIF1-06_07	5.954	MS-06_07	5,184.48	0.0024	145.52	77.00	15.17
AFIF1-06_08	3.853	MS-06_08	2,423.47	0.0012	105.55	77.00	15.17

Table 10. Sub-Catchments / streams average slope, time of concentration, curve number and Runoff threshold.

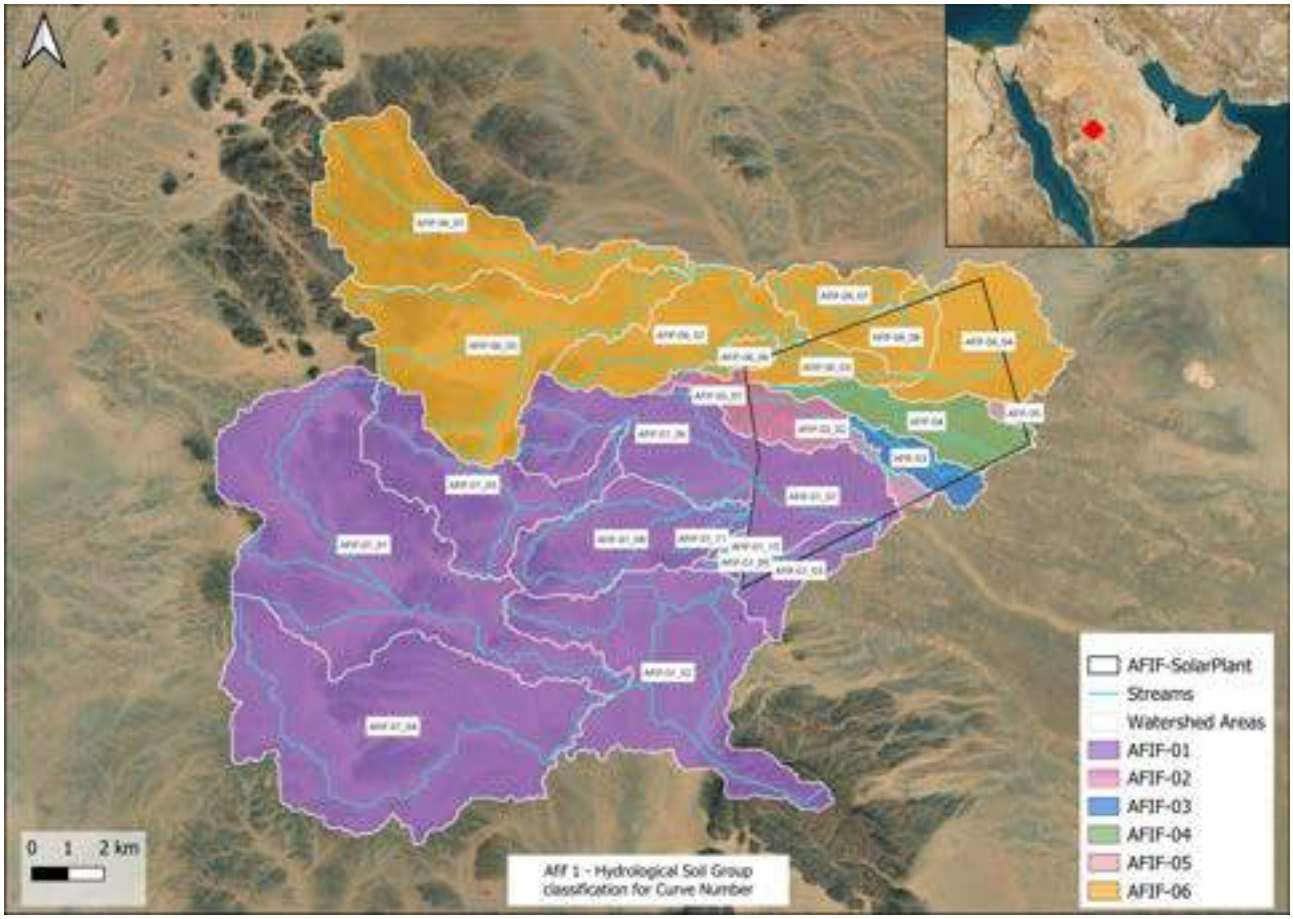


Figure 11. AFIF1 Sub-Basin and model definition.

As with the general basins, the next step is to determine their main characteristics. The data for each sub-basin are given in ANNEX C. HEC-HMS Model.

4.3.2. Hyetograph definition

In contrast to Rational Method, which only used the peak rainfall intensity, HEC-HMS software allows the analysis of the temporal evolution of the storm. Therefore, it is required to define a design hyetograph for the different return periods to be studied. The methodology to be followed is alternating block method due to it is a simple way of developing a design hyetograph from an intensity-duration-frequency curve. It specifies the precipitation depth occurring in successive time intervals of equal length over a total storm duration. The intensity is read from the IDF curve for each duration, and it is transformed into precipitation. The difference between successive precipitation is the amount of precipitation to be added for each additional unit. Finally, the blocks are reordered into a time sequence with the maximum at the centre and the remaining blocks arranged in descending order alternately to the right and left.

Hyetograph duration must be long enough to analyze the worst-case scenario where all basins are at full capacity. Since the basin AFIF-01 has a time of concentration of 409.02 minutes, storm duration must be at that time for this basin to reach its peak flow. As a result, it has been built a 420minutes (7hours) design hyetograph with a time interval of one hour. For calculations, see ANNEX B. Hyetograph definition.

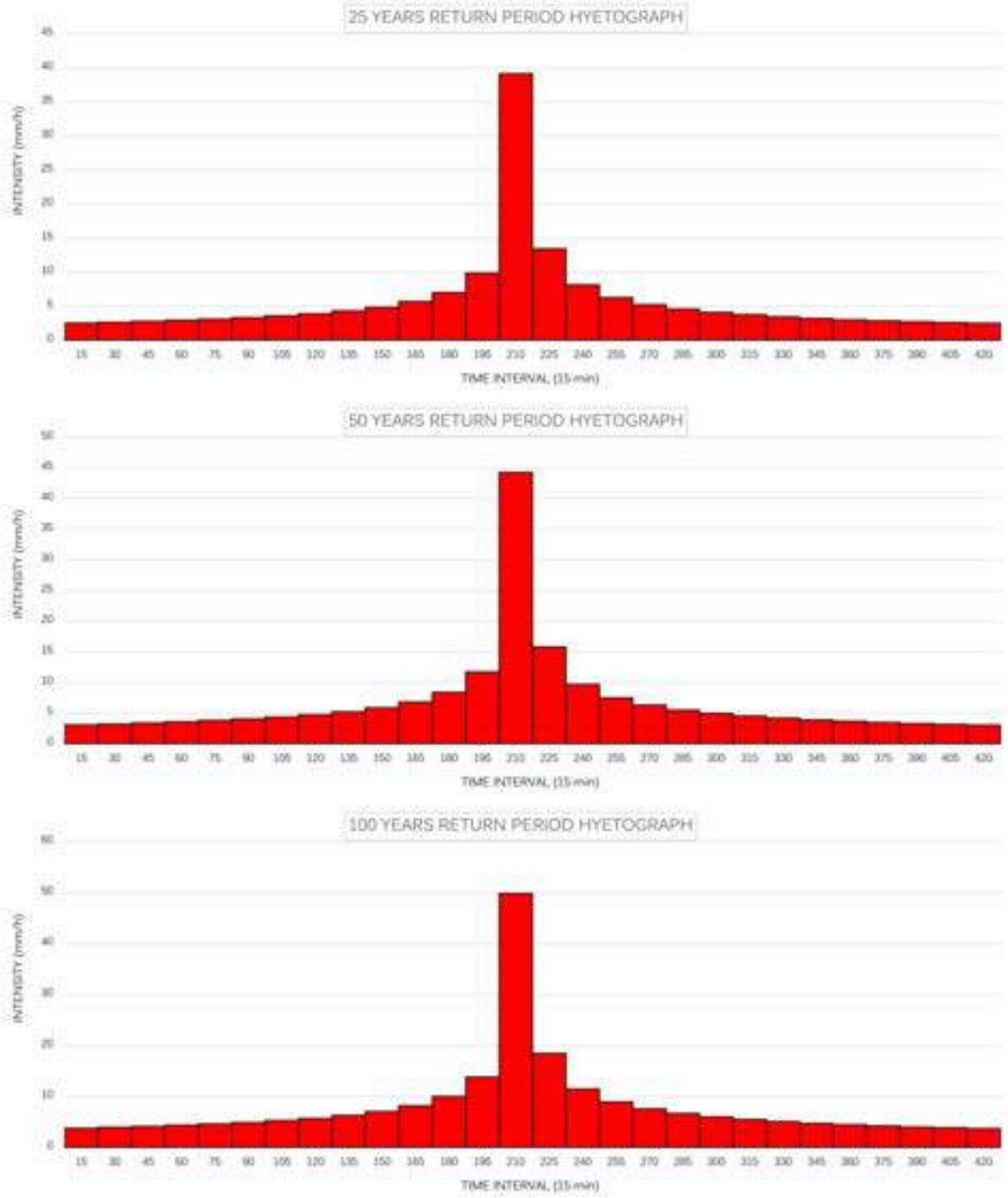


Figure 12. Design hyetograph for different return periods of U004 - Kuraa Almarw Atajarob.

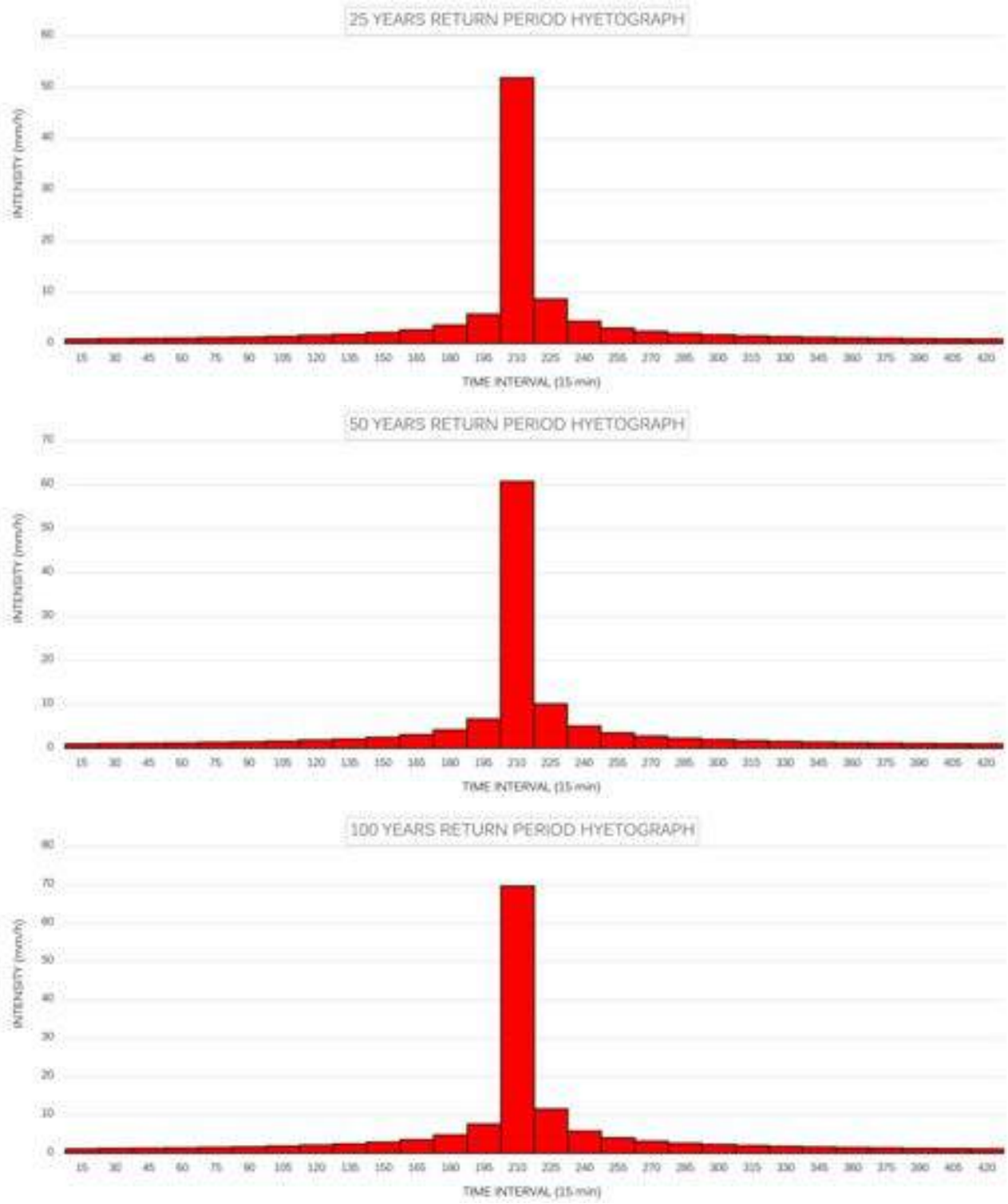


Figure 13. Design hyetograph for different return periods of U002 - Uclat As Suqur.

4.3.3. Curve Number and runoff threshold

The Curve Number (CN) takes a value between 0 and 100 depending on its ability to generate surface runoff. Values close to 0 represent very high permeability conditions, while values close to 100 represent impermeability conditions.

The Curve Number is tabulated by the Soil Conservation Service as a function of the soil hydrogeology, the terrain cover, treatment, hydrologic condition, antecedent runoff condition and impervious area in the watershed. Also, the SCS has different tables according to land uses (urban area, agricultural lands and arid and semiarid rangelands.

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition[1]	A[2]	B	C	D
Herbaceous – mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor	-	80	87	93
	Fair	-	71	81	89
	Good	-	62	74	85
Oak-aspen – mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush	Poor	-	66	74	79
	Fair	-	48	57	63
	Good	-	30	41	48
Pinyon-juniper – pinyon, juniper, or both; grass understory.	Poor	-	75	85	89
	Fair	-	58	73	80
	Good	-	41	61	71
Sagebrush with grass understory.	Poor	-	67	80	85
	Fair	-	51	63	70
	Good	-	35	47	55
Desert shrub – major plants include saltbrush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1] *Poor:* <30% ground cover (litter, grass, and brush overstory). *Fair:* 30 to 70% ground cover. *Good:* >70% ground cover.

[2] Curve numbers for group A have been developed only for desert shrub.

Table 11. SCS TR-55 Table 2-2d – Runoff curve numbers for arid and semiarid rangelands.

Based on the morphological analysis that has been made previously the dominant lowest and flatted areas of the main basins and project site can be associated to a Type B hydrologic soil group (Curve Number of 77), while the upper and steeper part of the hills can be associated to a Type C hydrologic soil group (Curve Number of 85). Therefore, the curve number for each basin has been calculated as a weighted average of the curve number and the area of each basin. The curve number mean for all sub-catchments is 78.15.

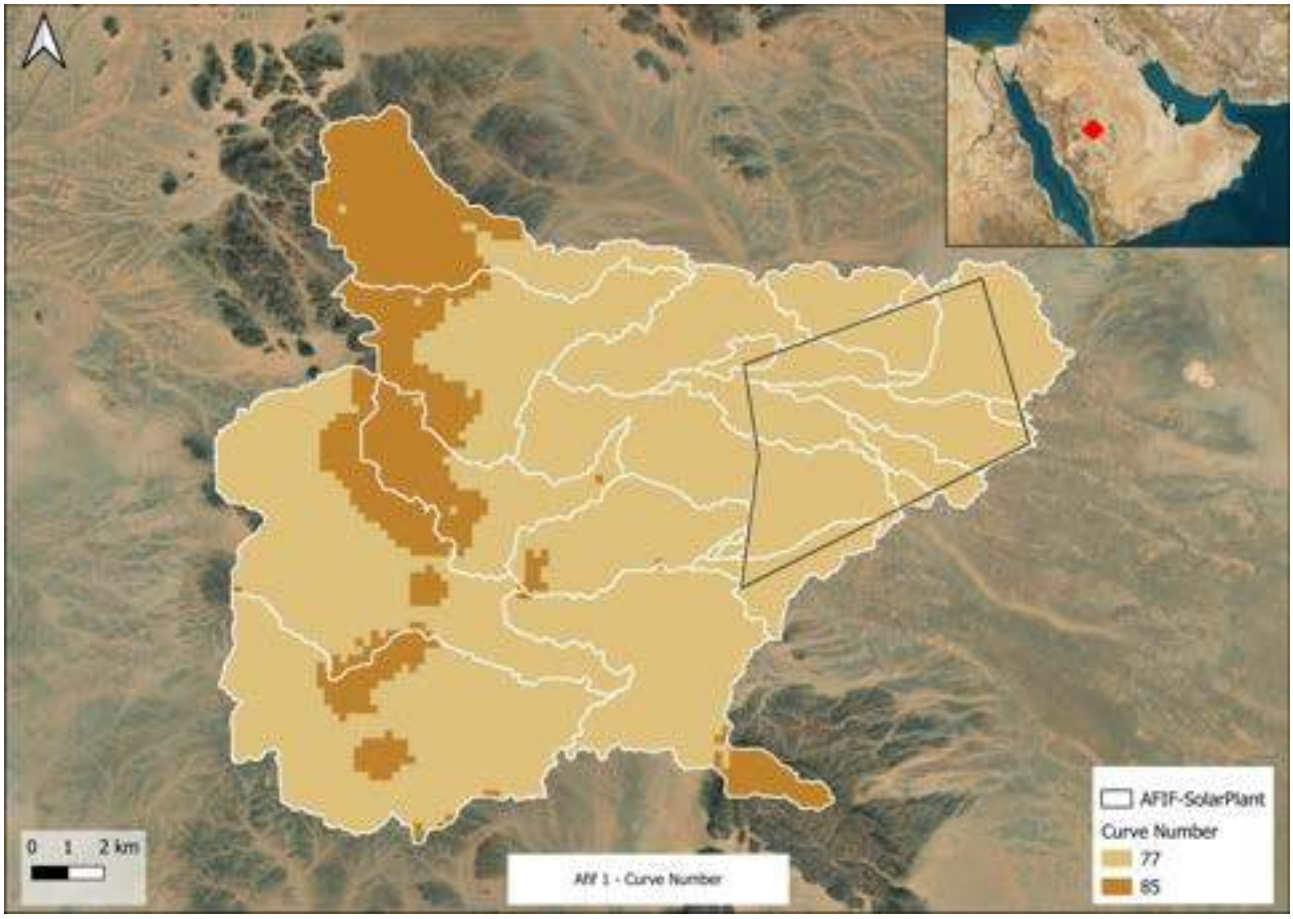


Figure 14. Infiltration losses.

The runoff threshold is the amount of storm rainfall that can be absorbed by the soil and surface before overland flow runoff normally occurs and it can be related to curve number. The runoff threshold or initial abstraction mean for all sub-catchments is 14.27.

$$P_0 = \frac{5080}{CN} - 50.8$$

Where:

- P_0 (mm) Runoff threshold or initial abstraction.
- CN (dimensionless) Curve number.

5. Flooding analysis

The objective of a Flood Study is to analyze and calculate, through a bidimensional simulation, the depths, and velocities of water flows for return periods of 25, 50 and 100 years. This will help us to verify the points that can be susceptible to erosion and could represent hazards inside the park area.

5.1. Hydraulic modeling

Iber methodology is a numerical model which simulates turbulent free surface unsteady flow and environmental processes in river hydraulics. The ranges of application of Iber cover river hydrodynamics, dam-break simulation, flood zones evaluation, sediment transport calculation and wave flow in estuaries.

Iber mathematical model solves full two-dimensional Shallow Water Equations (SWE) or Saint Venant 2D equations using the Finite Volume Method (FVM) based on Roe (1986) scheme. This model has been enhanced to be used as a hydrological model adding the precipitation and loss processes on the mass conservation equation. The hydrodynamic module shows the average depth of Shallow Water Equations (2D-SWE), also known as the two-dimensional St. Venant Equations. These equations consider a hydrostatic pressure distribution and a relatively uniform distribution of water depth and flow velocity.

Numerical models based on the 2D-SWE are now widely used in coastal and river dynamics studies, flood zones evaluation, sediment, and contamination transport calculations.

The following steps describe the stages to configure the hydraulic model and to collect results of the hydraulic modelling procedure.

5.2. Previous workflow process

To make a hydrodynamic simulation with Iber, the following steps are required:

- Create or import an area geometry.
- Assign a series of input parameters (bed roughness, turbulence model, etc.) Depending on the type of hydraulic model, not all the parameters are required).
- Assign boundary definition and initial area conditions.
- Set the data problem (time of calculation, numerical scheme parameters, additional modules requirements).
- Build a numerical mesh.
- Start a Simulation process.

Using the identified stream locations during the hydrological study and with satellite images support obtained from a Geographic Information System (GIS), the NURBS (non-uniform rational B-spline) geometry and surface characteristics were created.

Model boundaries and initial conditions as well as the main input parameters of the model should be assigned to the geometry or mesh that was created.

The simulation built covers approximately 39.87 km^2 as well as the NURBS surface used to develop the boundaries of the simulation.

The image below shows both, NURBS surface (pink) and the plant surface boundaries (blue). Although they are depicted separately, they occupy the same area, which is 39.87 km2. The difference in representation is due to the software utilities used.

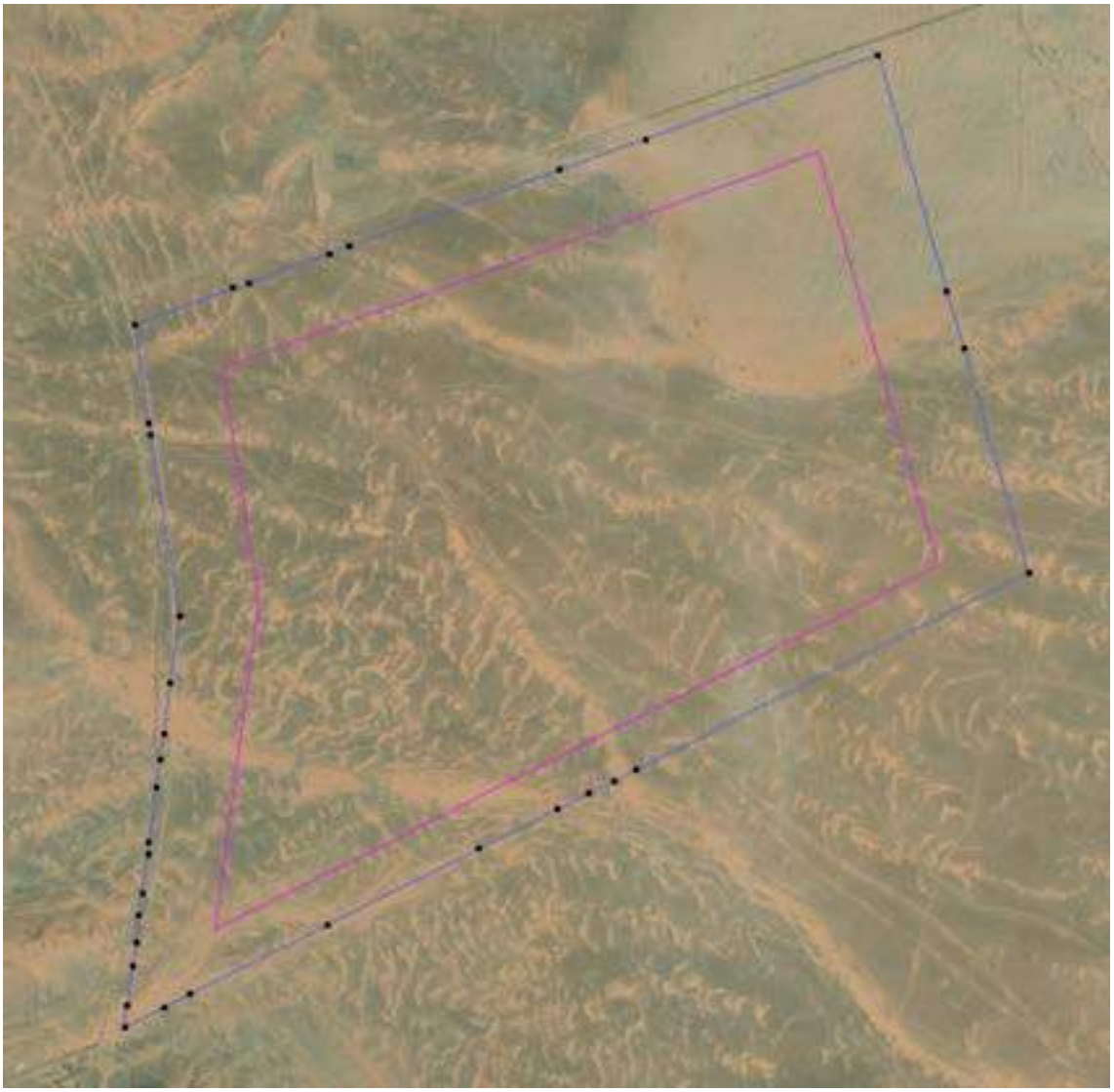


Figure 15. NURBS area for the hydraulic model.

5.2.1. Initial conditions

Initial conditions must be assigned to the whole study area. Users can choose either from water depth or water surface elevation.

For this study, a water depth value of zero meters was chosen over the entire NURBS.

5.2.2. Boundary conditions

- Inlet conditions: There is a possibility of assigning the total discharge value, the specific discharge (discharge per unit width), or the water level. For each case several parameters should be required depending on the flow subcritical, critical, or supercritical flow regime.
  The simulation domain has been selected to cover the maximum area of the basins.

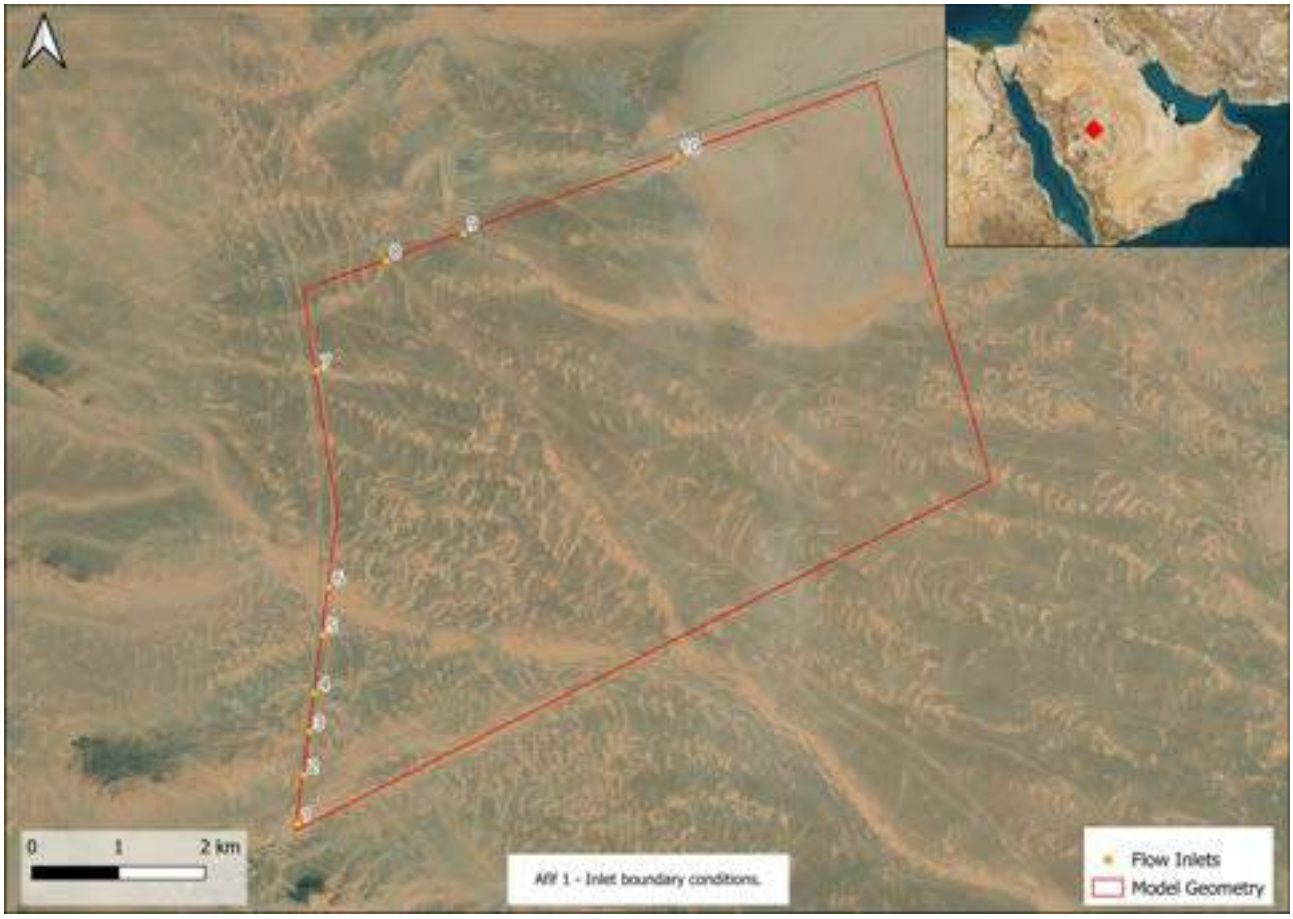


Figure 16.Inlet boundary conditions.

Flow inlets hydrograph:

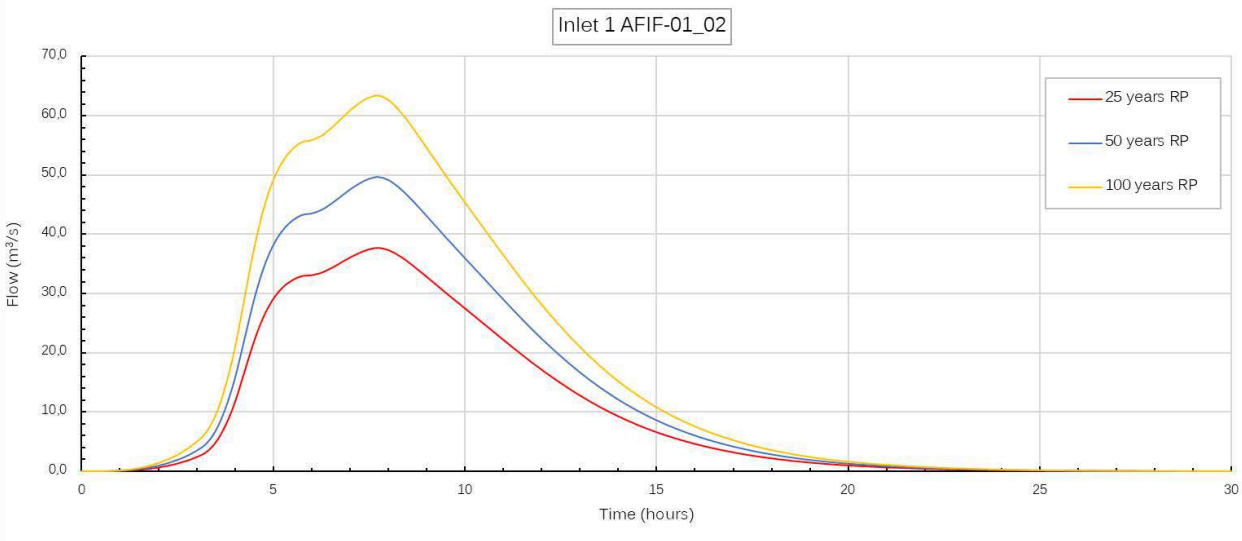


Figure 17. Inlet Hydrograph 1 at AFIF-01_02.

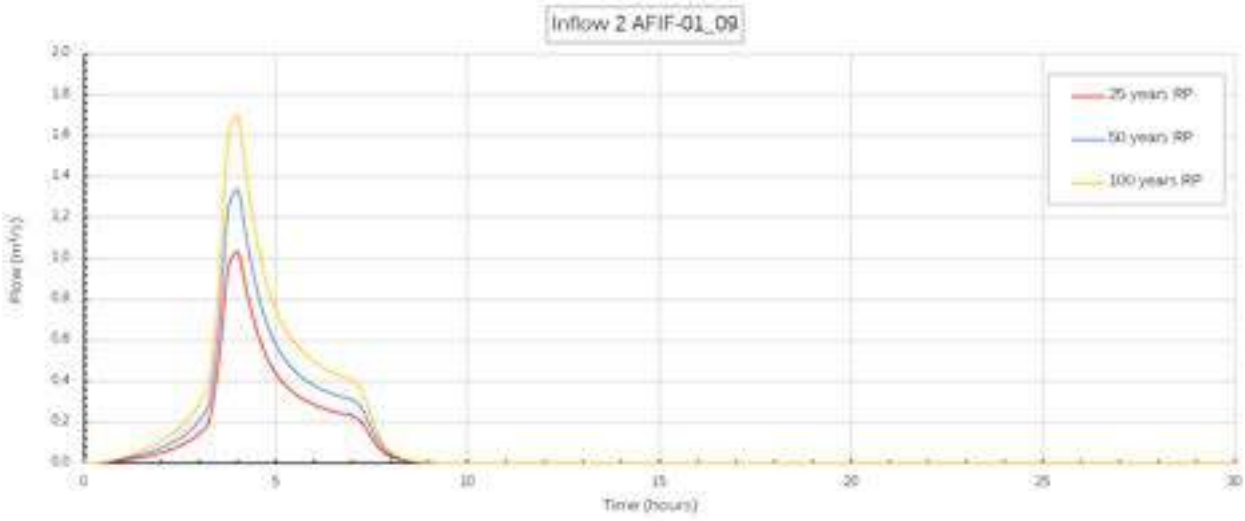


Figure 18. Inlet Hydrograph 2 at AFIF-01_09.

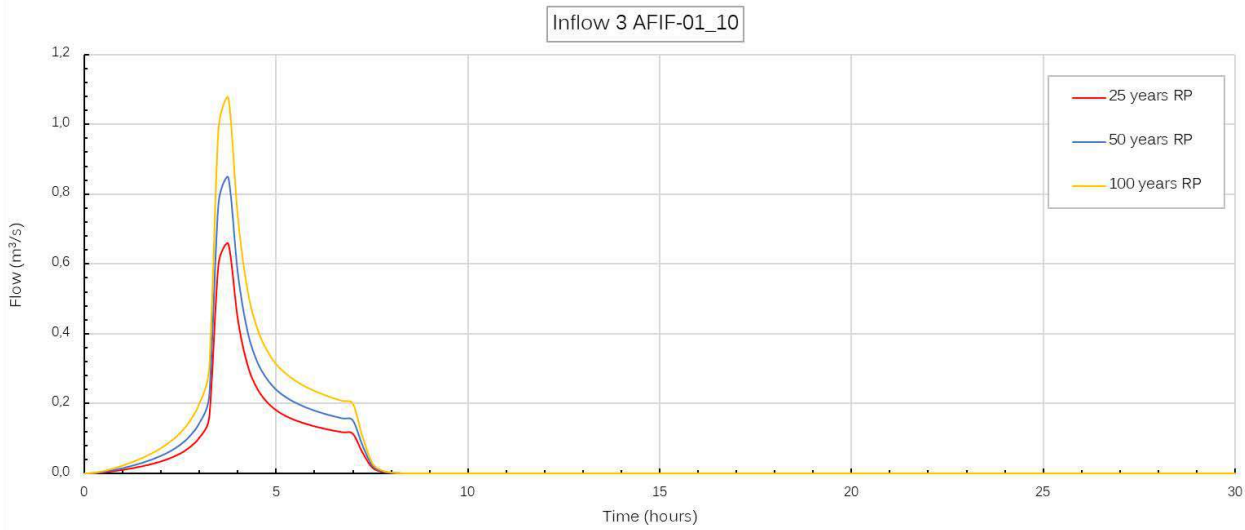


Figure 19. Inlet Hydrograph 3 at AFIF-01_10.

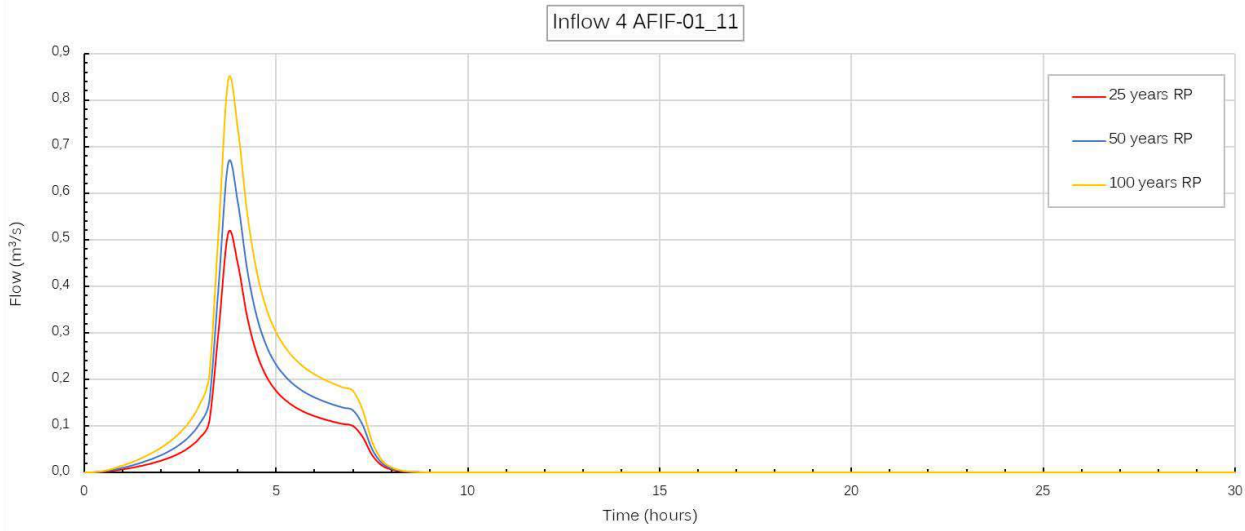


Figure 20. Inlet Hydrograph 4 at AFIF-01_11.

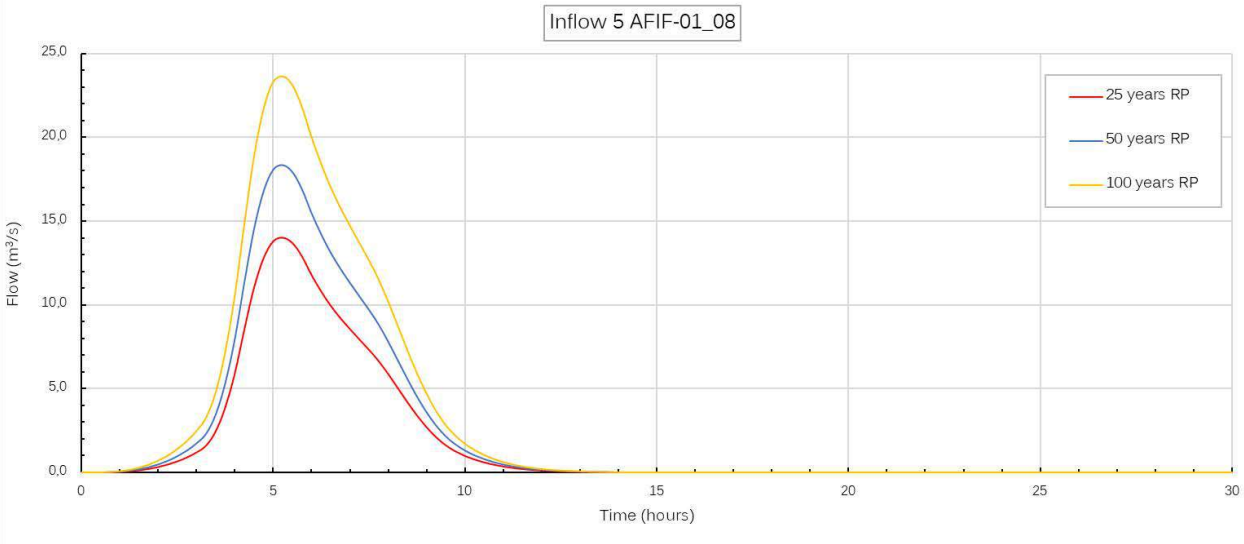


Figure 21. Inlet Hydrograph 5 at AFIF-01_08.

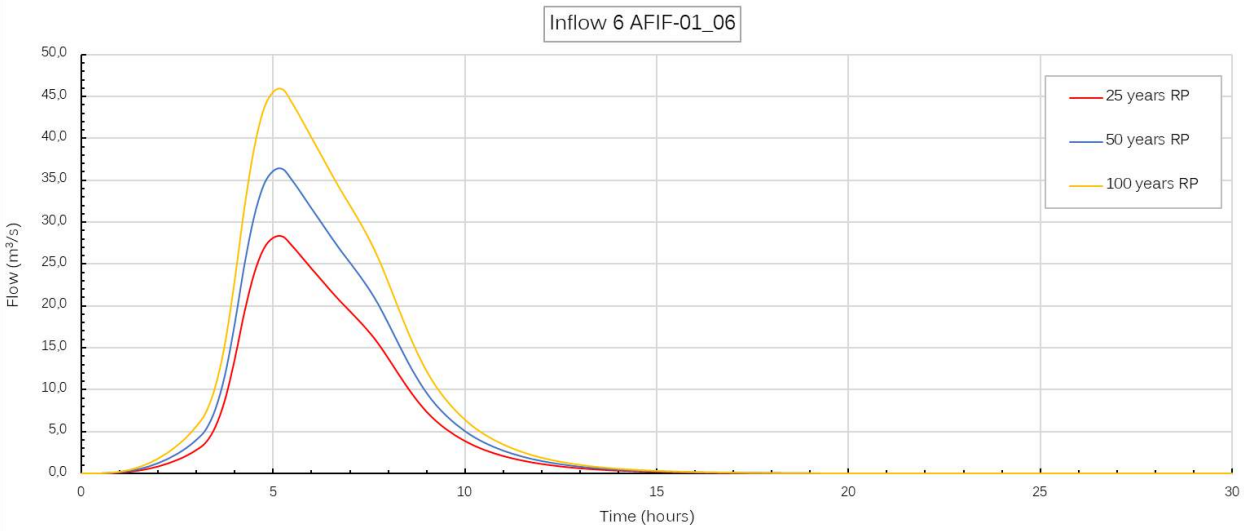


Figure 22. Inlet Hydrograph 6 at AFIF-01_06.

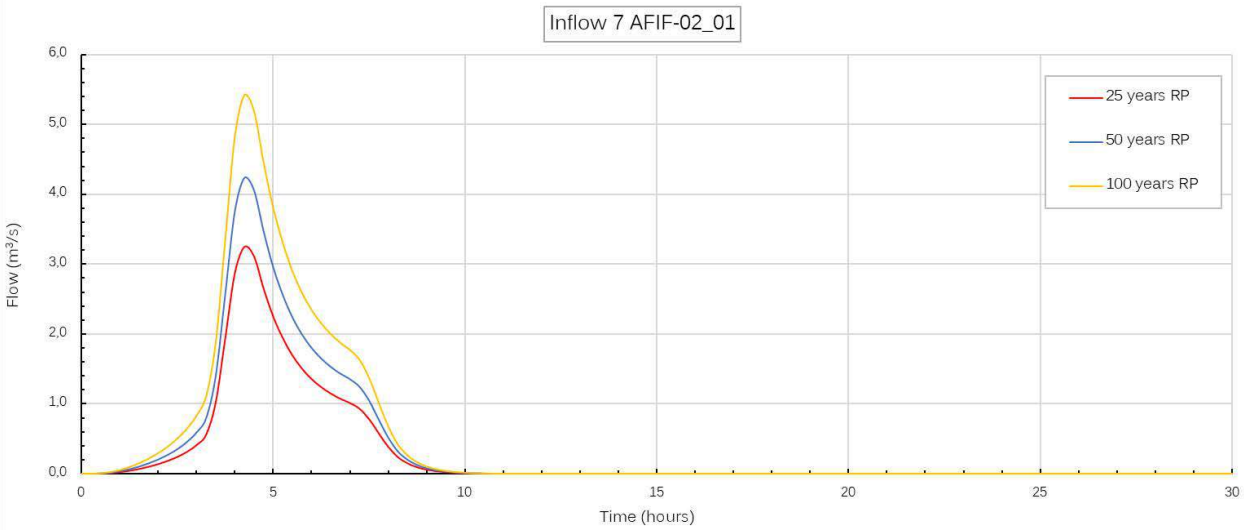


Figure 23. Inlet Hydrograph 7 at AFIF-02_06.

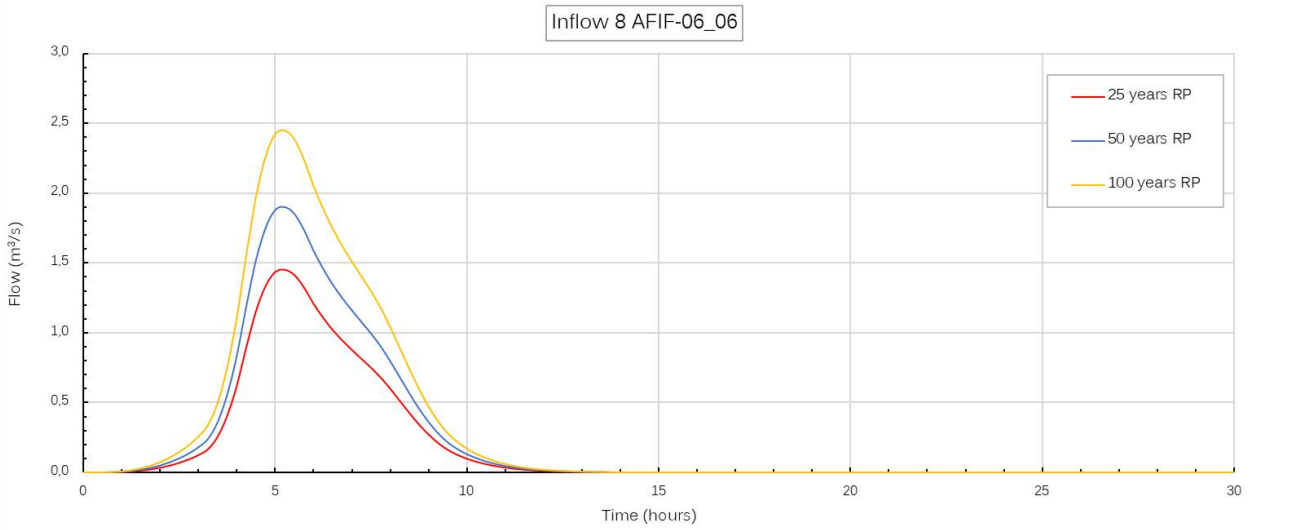


Figure 24. Inlet Hydrograph 8 at AFIF-06_06.

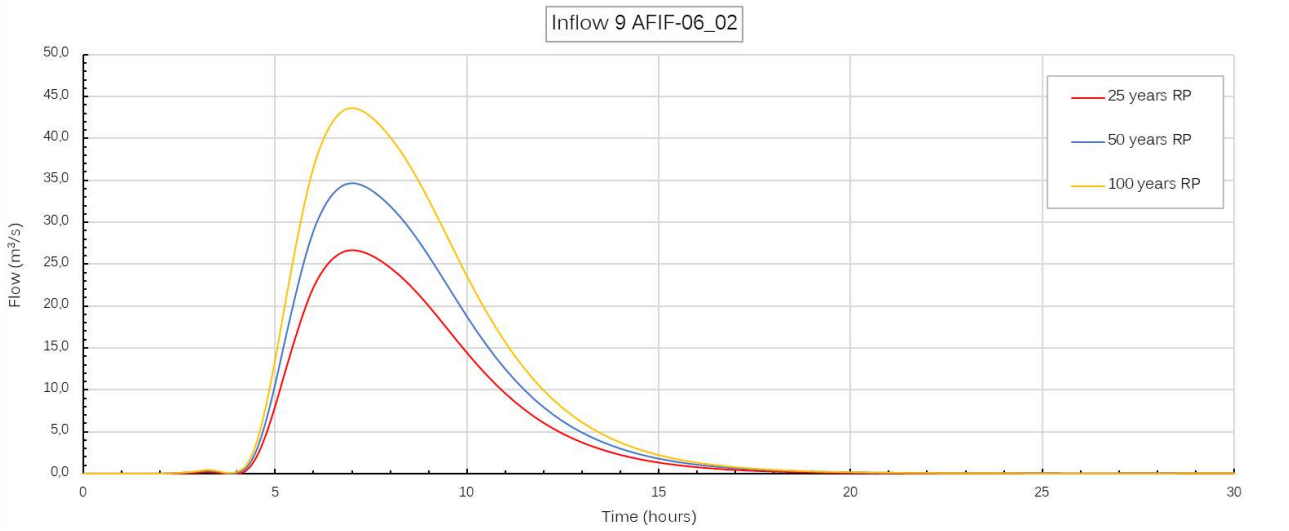


Figure 25. Inlet Hydrograph 9 at AFIF-06_02.

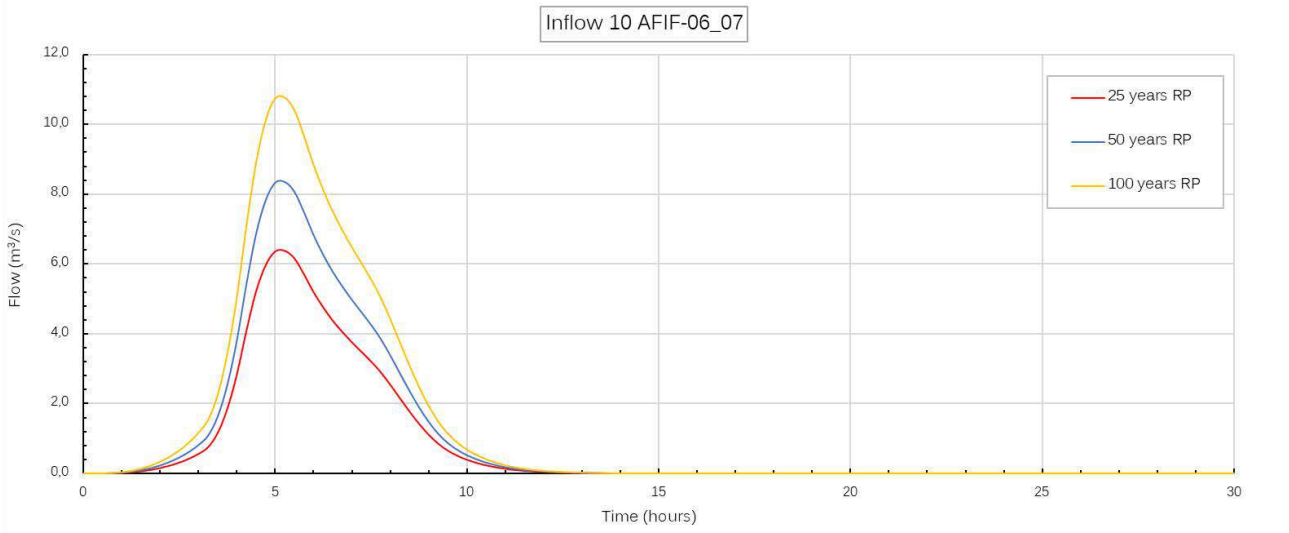


Figure 26. Inlet Hydrograph 10 at AFIF-06_07.

- Outlet conditions: By default, the program assumes that all edges of the simulation domain are impermeable walls through which water cannot exit. This assumption is not appropriate, as in reality, the terrain is continuous, and water flows freely across it. Therefore, when constructing a 2D hydrodynamic simulation, it is necessary to incorporate exit conditions. For simplicity and to prevent water from minor runoffs generated within the site from accumulating at the site boundaries, all boundary sections without designated Inlet conditions have been assigned Outlet conditions. In this regard, the sections along the boundary of the simulation domain, marked in red in the following image, have been identified as potential outlet boundary conditions.
  If the flow regime is subcritical, the user can choose between the following conditions: a weir type condition, a water level condition (water level or depth) or a rating curve. If the flow regime is critical or supercritical, it is not necessary to assign a detailed level as boundary condition. The model has been built by considering outlet conditions at those boundaries where no flow inputs have been detected.

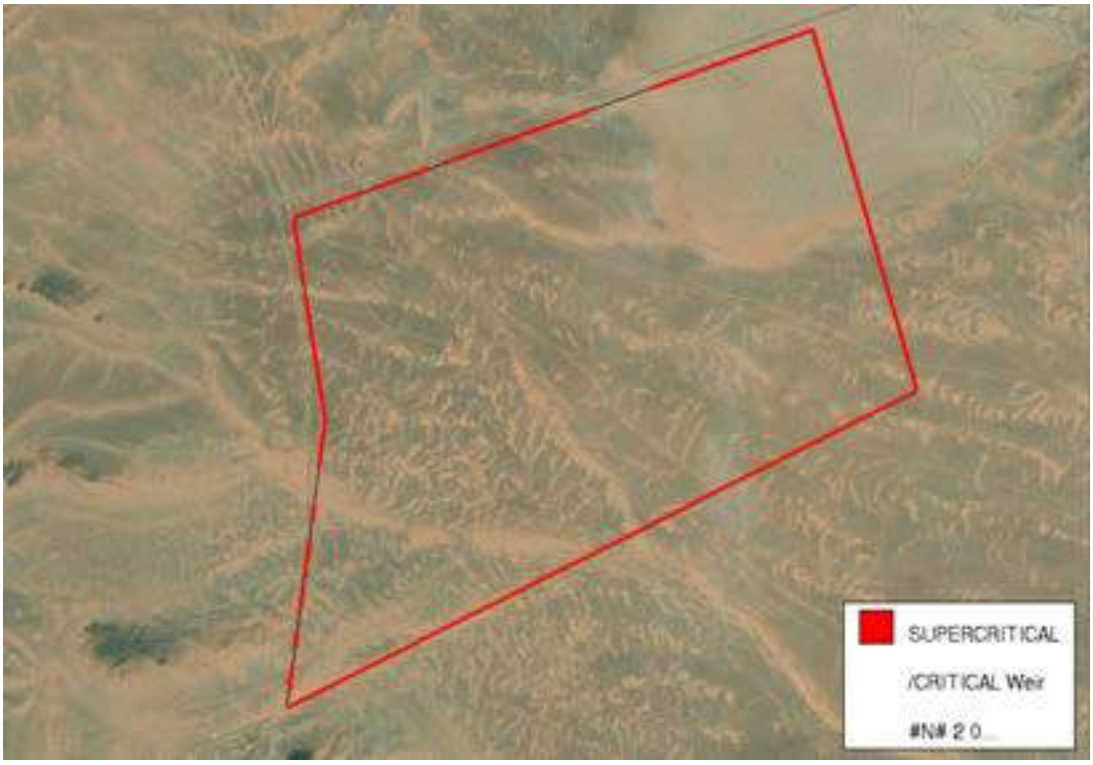


Figure 27. Outlet boundary condition.

- In addition to input and output conditions, design rainfall has also been included in the model. As mentioned above, the rainfall value is assigned as a hyetograph inside the area. Each time interval of the hyetograph indicates the beginning of a constant intensity block. A 420minutes design rainfall has been proposed with a time step of 15 minutes. Considering the plant location the U004 - Kuraa Almarw Atajarob hyetographs have been used for the modelling.

For additional information about hyetograph definition see ANNEX B. Hyetograph definition.

5.2.3. Roughness

The bed roughness is defined as a Manning roughness coefficient, which is assigned to each element of the mesh. For this study the roughness coefficient assigned is 0.027 for the NURBS area inside the park:

Surface Types	Manning's "n" for Overland Flow
Asphalt	0.012
Concrete Paving	0.014
Highly Compacted Natural Materials	0.025
Loose Sand	0.027
Light Turf	0.200
Dense Shrubbery and Forest Litter	0.400

Table 12. Roughness values.

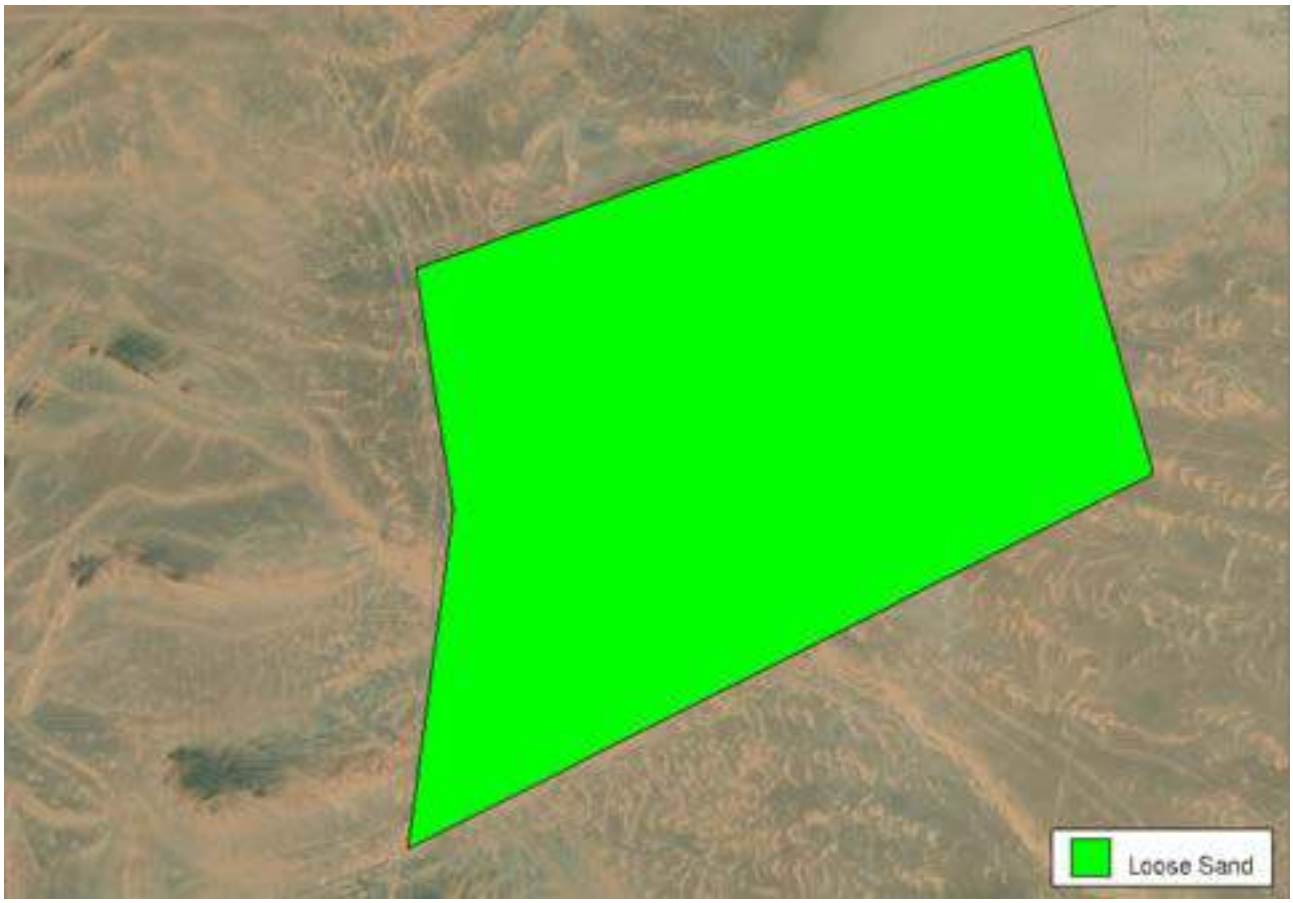


Figure 28. Roughness Coefficient.

5.2.4. Infiltration losses

To simulate rainfall events, it is necessary to consider water infiltration in non-saturated terrain to calculate runoff, therefore, an associated "N" curve number was assigned to all space domains with a value of 77. As described in Section 4.3.3, the Type B hydrologic soil group has been associated to a CN of 77, and the Type C hydrologic soil group to a CN of 85. The hydrologic soil groups are shown in Figure 9.

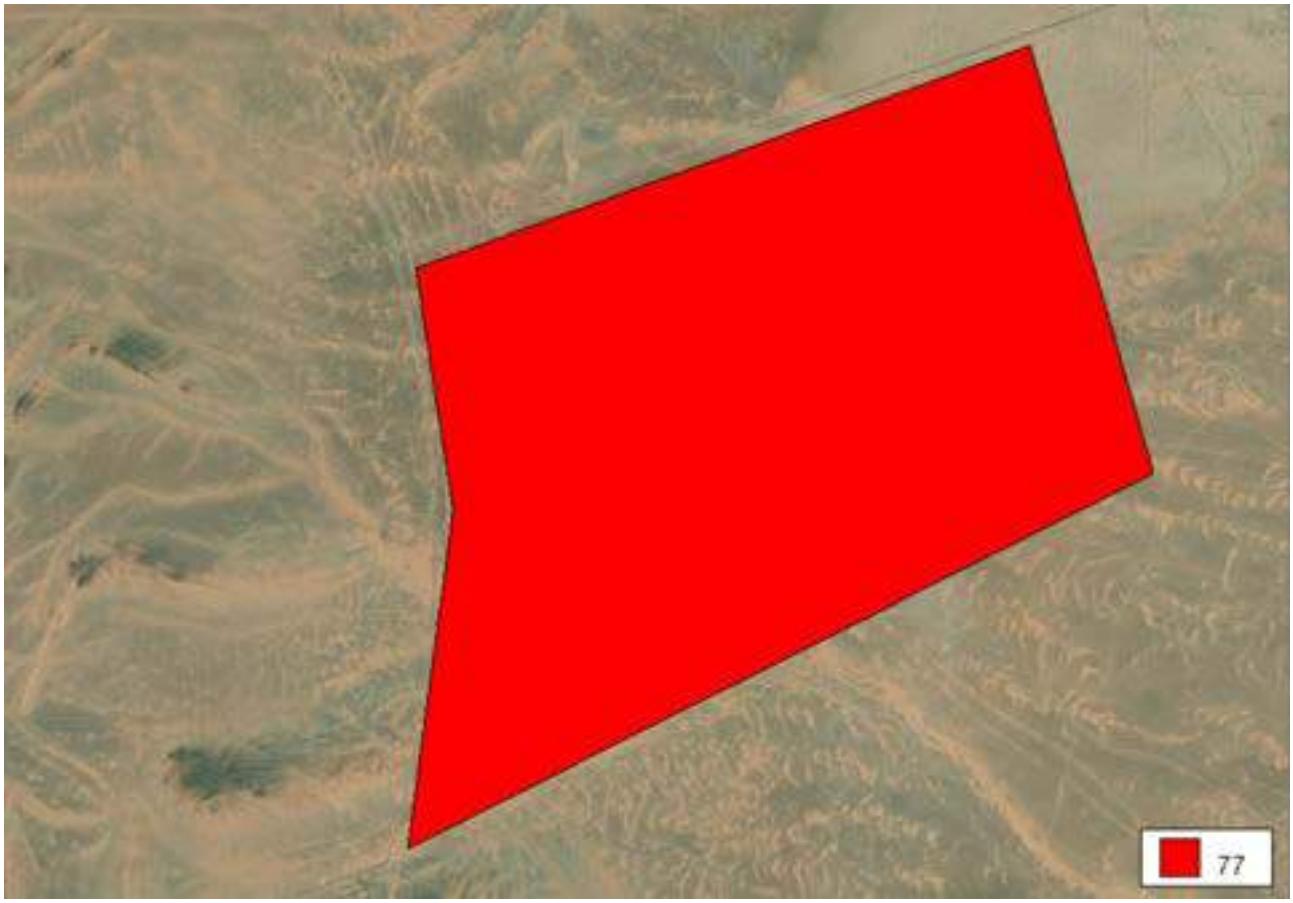


Figure 29. Infiltration losses.

5.2.5. Mesh calculation

Once the NURBS surface is defined, the initial and boundary conditions are set, as well as the roughness properties of each type of surface. The surface characteristics of the site is very homogeneous, so we proposed two sizes of meshes. The meshes sizes for the model is 5 m for the project area.

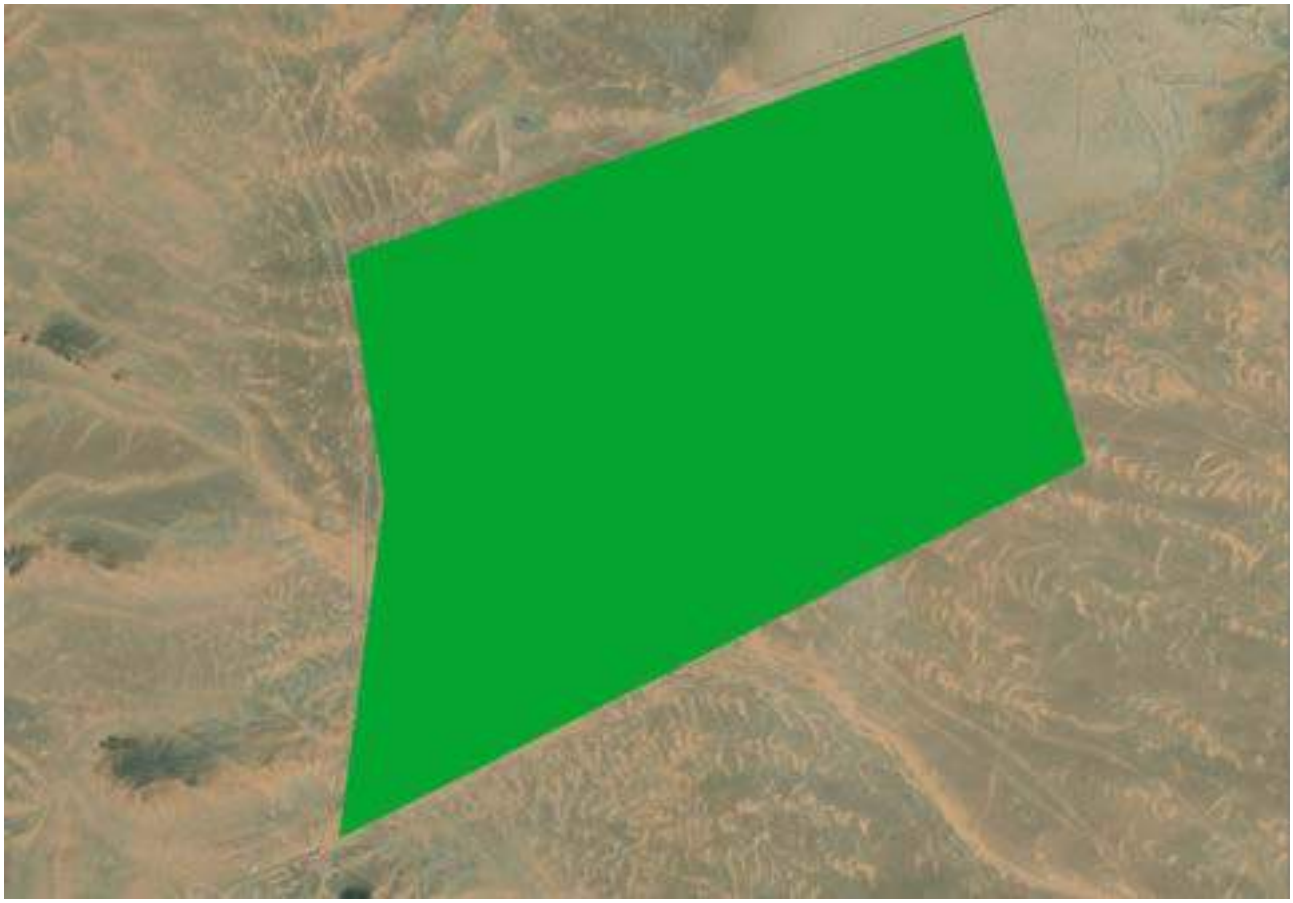


Figure 30. Hydraulic model mesh.

To solve a differential equation using the finite volume method, the space domain must be spatially discretized. To do that, the space domain is divided in relatively small cells (calculation mesh). Iber works with a non-structured mesh of elements that may have 3 or 4 sides. Irregular elements of 3 or 4 sides may be combined inside the same mesh. The main advantage of working with non-structured meshes is to ease off adaptations to any geometry, since it is not necessary for the mesh to have any type of internal structure or organization. This attribute makes them especially functional for surface runoff streams hydraulics.

Finally, the elevation is assigned to each mesh point.

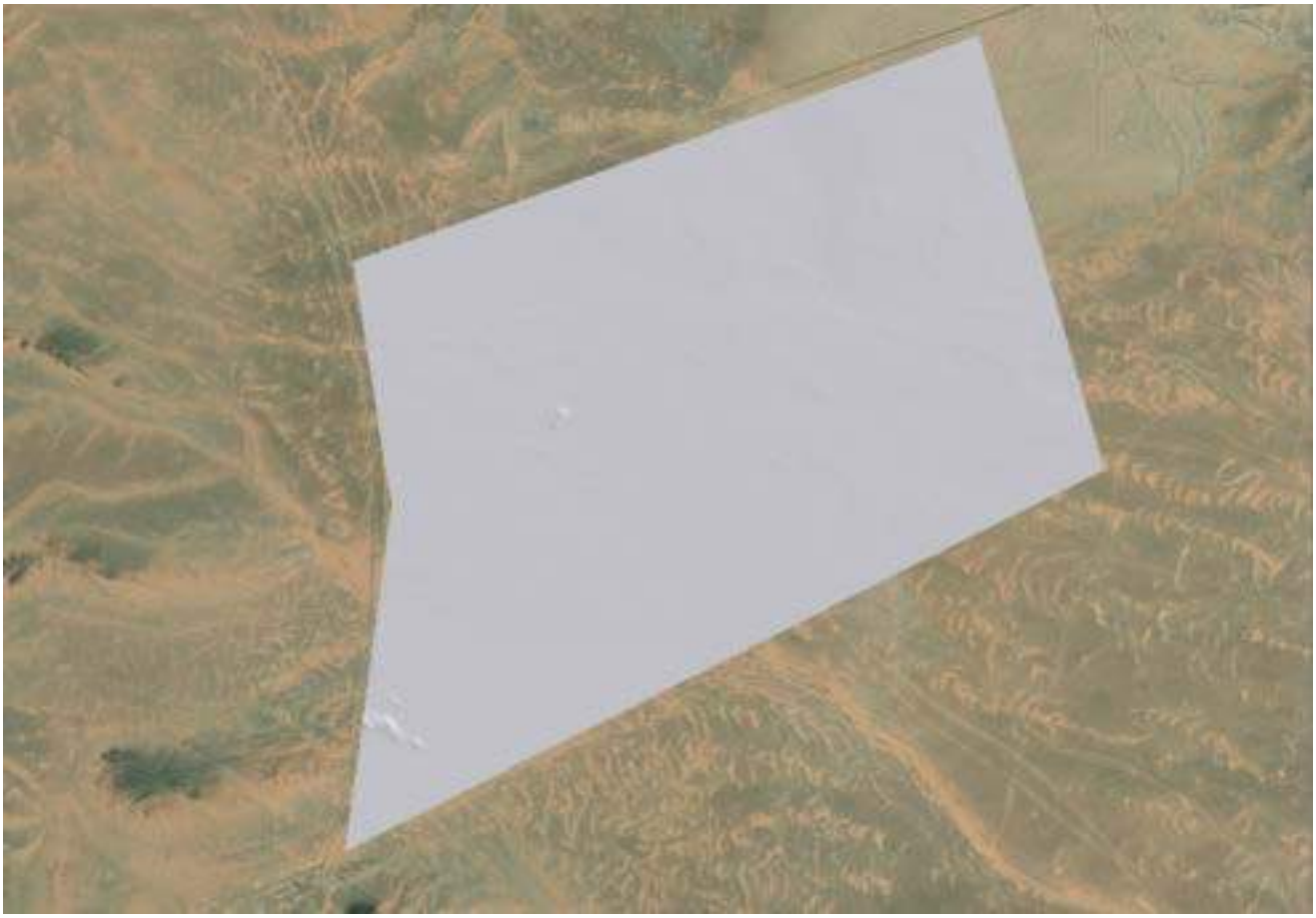


Figure 31. Hydraulic model mesh with elevation.

5.3. Simulation

To launch a simulation all input parameters should be set, the parameters used for the hydraulic simulation area are listed below:

- Computational parameters:
  - Flux Limiter Function: numerical schemes of first order
  - CFL: Value of the Courant-Friedrichs-Levy coefficient, 0.45
  - Wet-Dry Limit [m]: 0.001
  - Dry Element Storage Limit: Hydrological
  - Friction on walls: 0.025
  - Turbulence model: deactivated
- Time parameters:
  - Initial Time [s]: 0.00
  - Max Time increment [s]: 1.00
  - Max Simulation Time [s]: 129,600 (i.e. 36 hours or 1.5 days), enough time for the hydrographs of the watersheds to completely transit the plain.
  - Results Time Interval [s]: 1,800 (i.e. 0.5 hour).

5.4. Post-Process

Once the simulation is over the results are compiled and analyzed. The information can be extracted in graphs or data images. We can extract specific simulation periods if required. Analyzing this case, the maps of maximum values for water depths and velocity rates associated with each runoff event for a return period of 25, 50 and 100 years.

5.5. Results

The terrain of the AFIF1 project is extremely flat with some shallow and poorly defined main surface water overland flow paths (streams) crossing the site. The available orthophoto shows erosion marks and superficial deposits that have been created by the main existing surface water overland flow paths. These streams have also been identified by the available Lidar and subsequent analysis.

Since the slope is nearly negligible at the solar plant site, surface water runoff slowly flows over the ground into the main streams where it drains away. Additionally, surface water is stored in some parts at the low points of the ground before it drains away through infiltration and evaporation.

The hydraulic modeling shows similar results for all rainfall events with surface water flowing through the existing overland flow paths, with depths ranging 0.20 m to 0.40 m. Notably, certain areas along the main streams exhibit substantial increases in water depth and velocities. These zones may potentially experience water depths exceeding 0.5 m, accompanied by velocities ranging 0.8 m/s and 1.20 m/s. The following figures show the maximum flow and velocity result values for the different Return Periods analyzed:

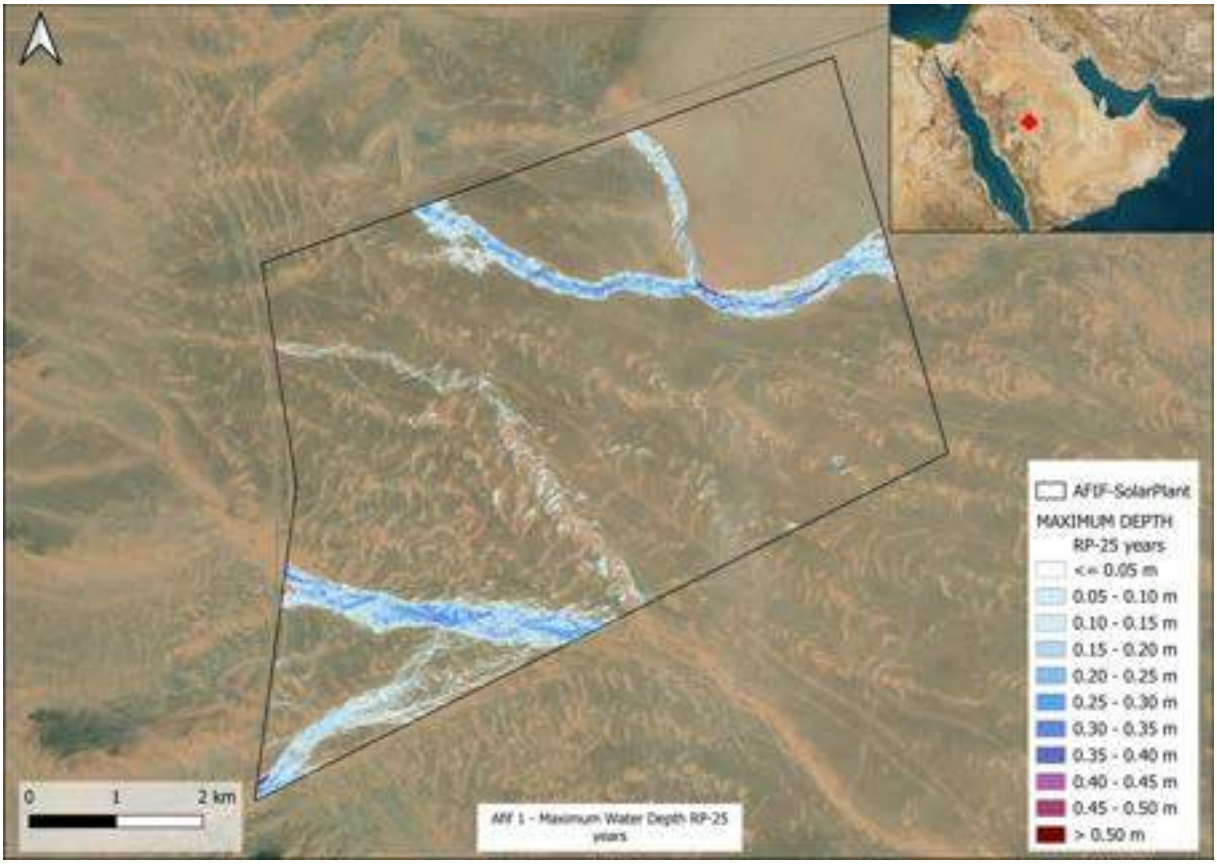


Figure 32. Maximum Water Depth for a 25-years return period.

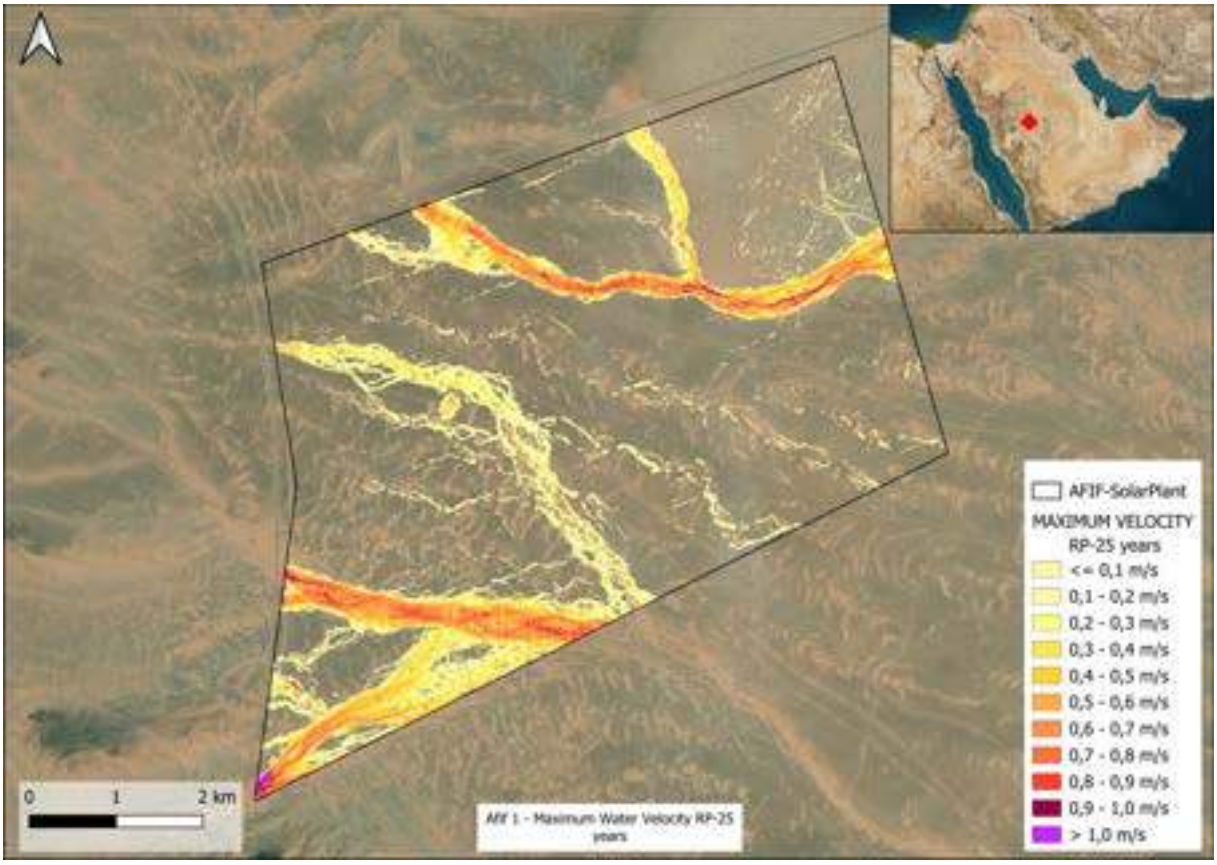


Figure 33. Maximum Water Velocity for a 25-years return period.

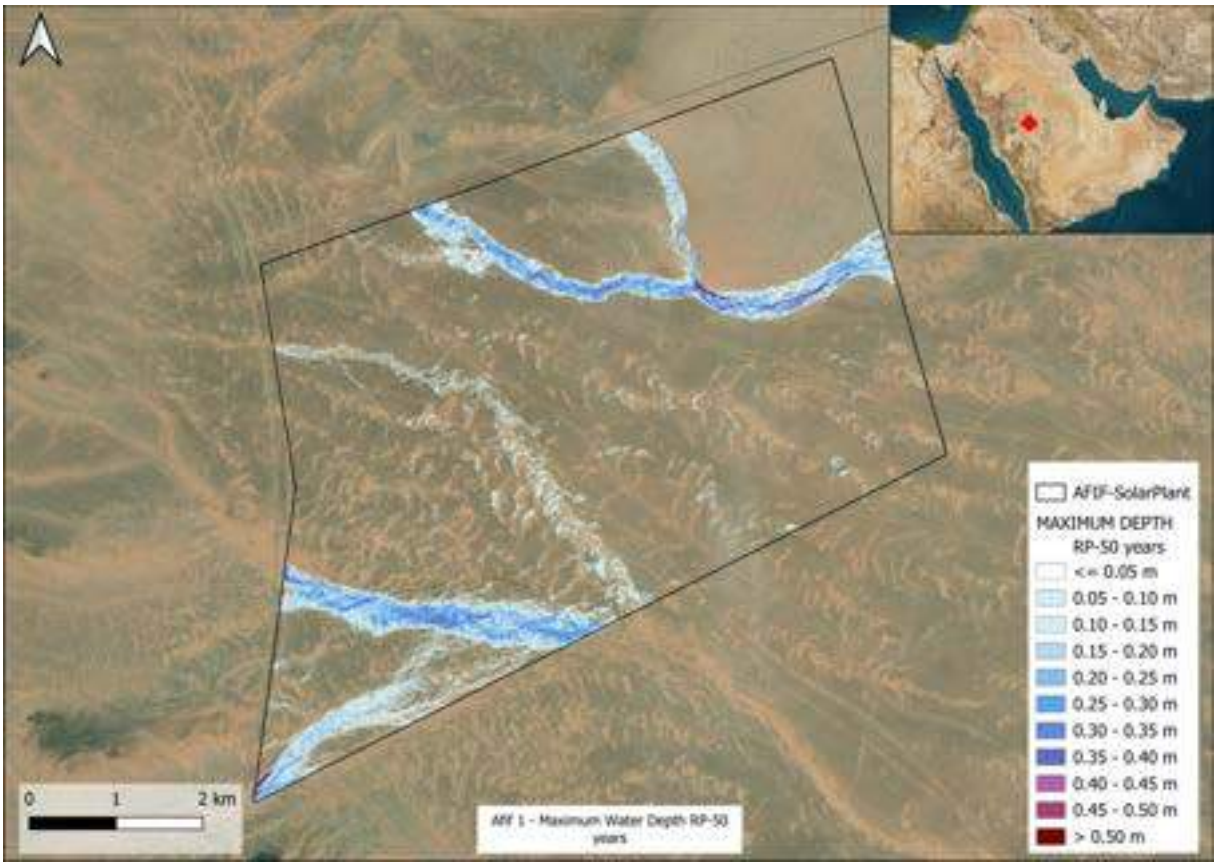


Figure 34. Maximum Water Depth for a 50-years return period.

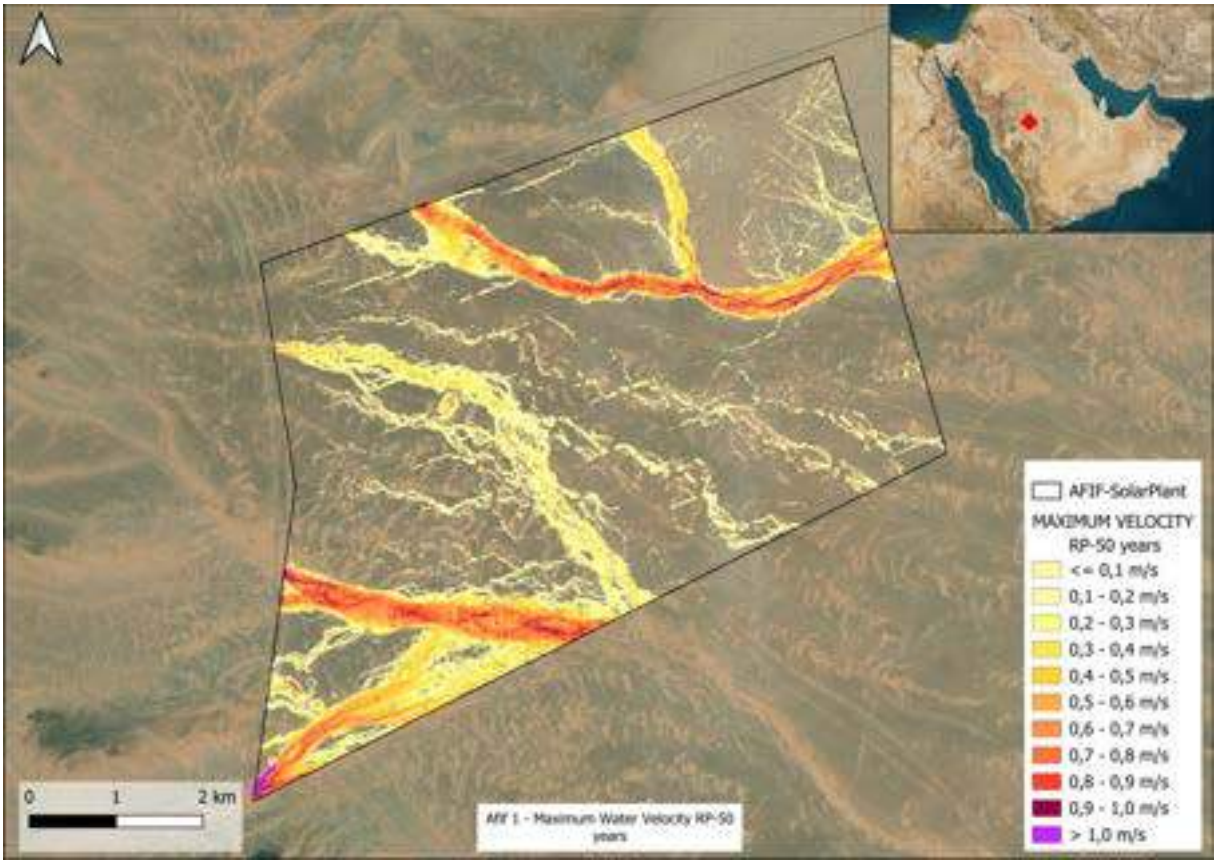


Figure 35. Maximum Water Velocity for a 50-years return period.

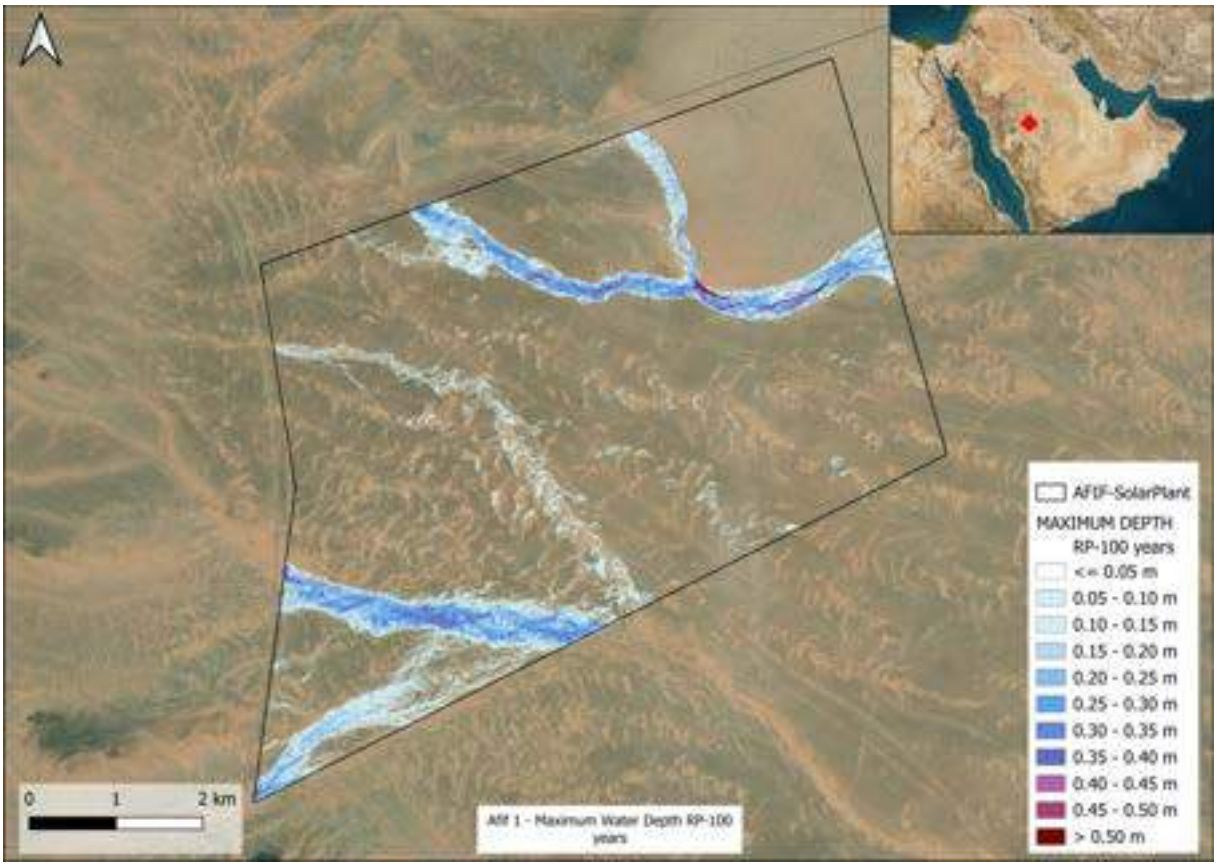


Figure 36. Maximum Water Depth for a 100-years return period.

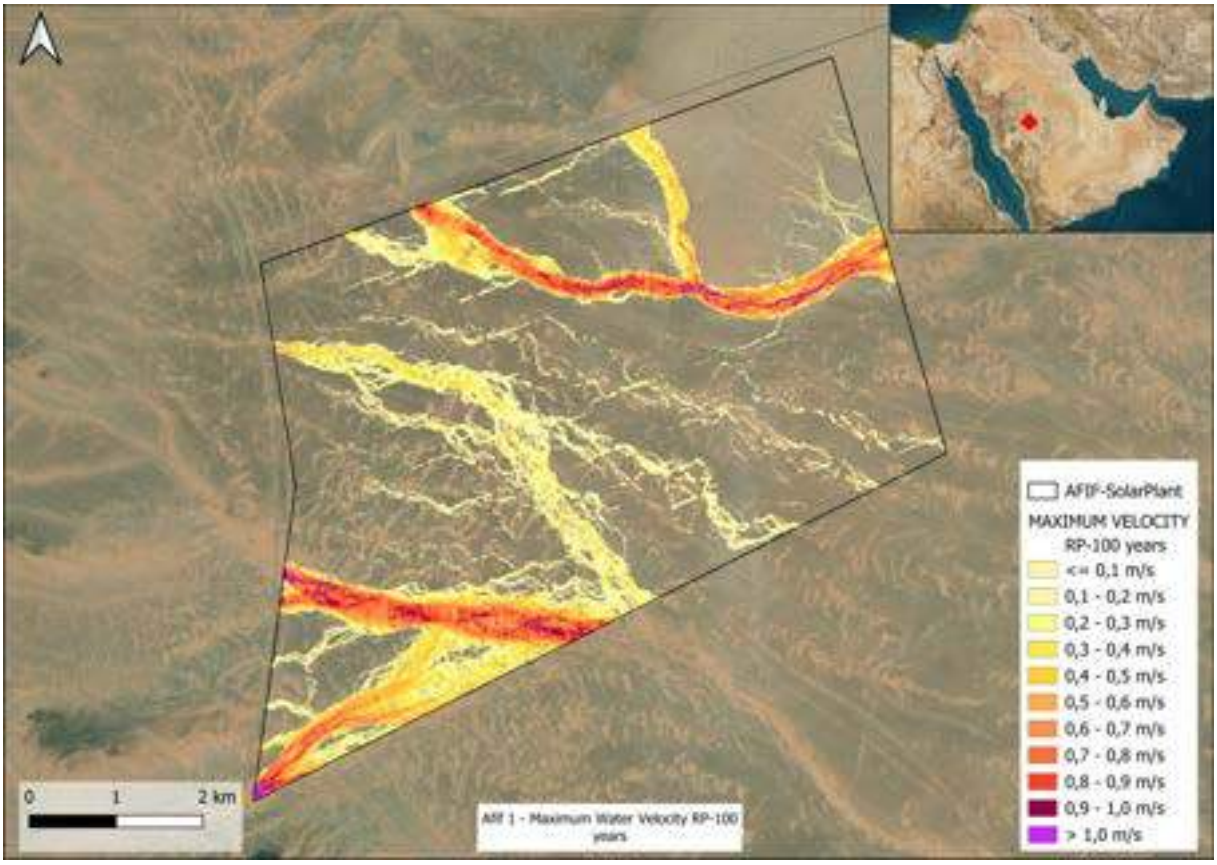


Figure 37. Maximum Water Velocity for a 100-years return period.

5.6. Flood hazard

Quantifying and classifying flood hazard require consideration of the relative hazard degree, and the underlying flood behavior (e.g., depth, speed, and depth and speed combined). The common industry practice dictates that when dealing with a small site and uniform flood behavior, a simplified method is often employed to quantify flood behavior on the floodplain. In these cases, a single point value of the combination between depths and velocities is appropriate (from now on we will refer to the product of Depth and Velocities as D × V) . However, in sites where there is significant variability in the flood behavior across the floodplain, a map of flood hazard assessing the spatial variability is more appropriate.

When interpreting flood hazard from model outputs, it's essential to consider the underlying assumptions of the model approach and the potential effects these assumptions might have on quantifying flood hazard. The modelling approach, model scale and resolution as well as the associated level of topographic detail incorporated in the model, may influence flood hazard estimates.

An estimation of the flooding hazard was performed by a geospatial analysis using three different raster files: flood flow, velocity, and the multiplication of both, for a return period of 100 years. Given the hydrological conditions discussed in the previous section, the most delimiting factor when studying the hazard level is the water velocity.

5.6.1. Water depth

The presence of water in the terrain usually has adverse effects on photovoltaic installations, such as those being studied for the site. In this sense, it is crucial to protect the more sensitive electromechanical equipment from contact with water, such as box string, power inverters, power stations, etcetera.

A common criterion in the industry is to avoid depths exceeding 50 cm since this is the minimum distance between the solar modules and the terrain given by the manufacturers.

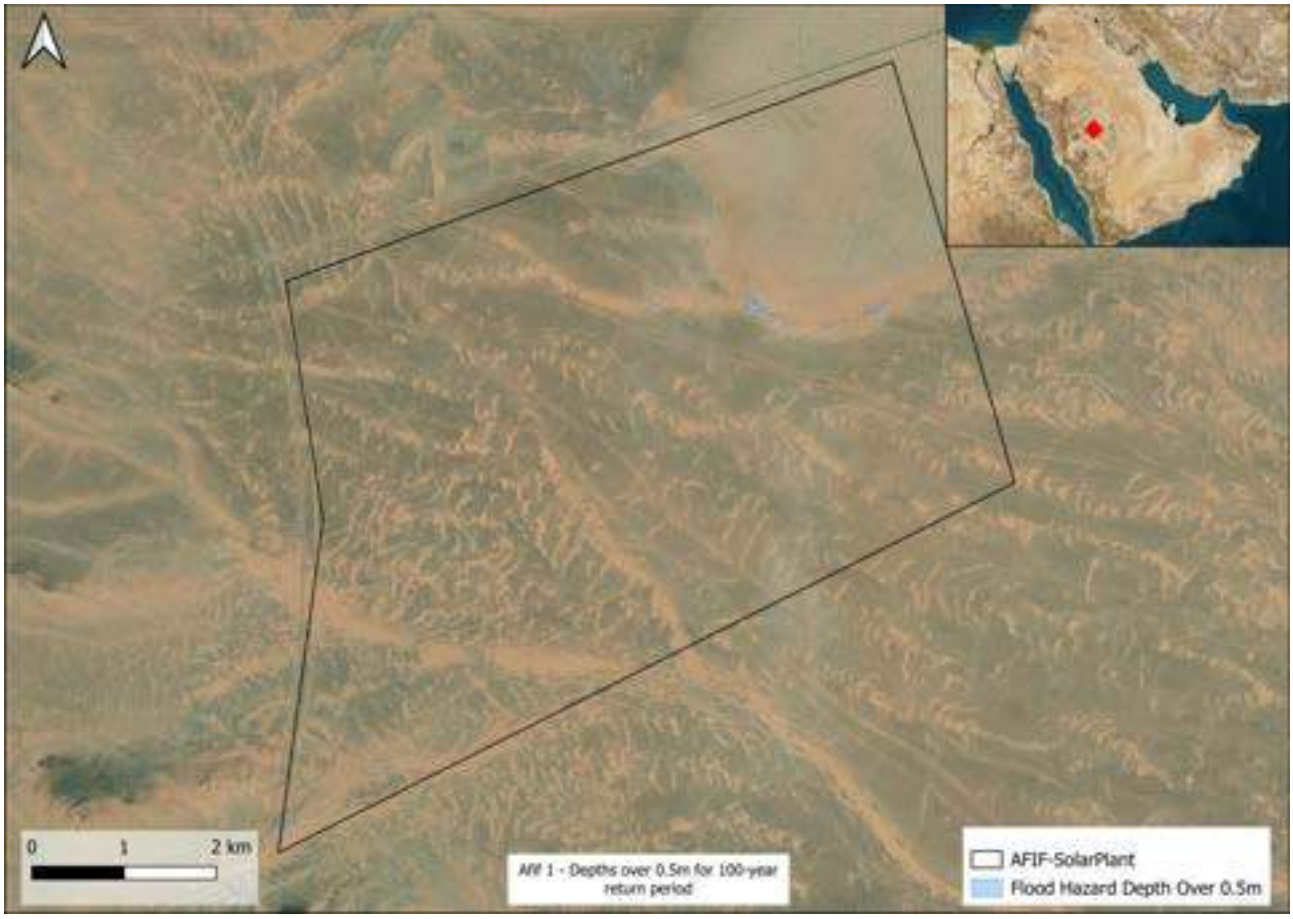


Figure 38. Depths over 0.5 m for 100-year return period.

5.6.2. Velocities

On the other hand, when water flows at high speeds, it possesses considerable destructive energy. In this regard, one of the most common effects is related to soil erosion and the undermining of steel profiles or concrete slabs. The water carries soil particles, leaving the elements unprotected and without any support.

This effect varies depending on the soil composition and vegetation cover. In this case, the terrain features a sandy surface layer mixed with scattered gravels, small rocky boulders, and a slight clay composition. This type of soil is characterized by a low cohesion between particles. However, the composition is not homogeneous through the site. Specifically, within the main runoffs the sand concentration is higher than outside them. This can be checked through the analysis of the aerial photography, where the runoffs present brighter hues due to the sand composition, while the areas outside them, the soil hue is darker due to the clay and gravels.

The loose sands have almost lack of cohesion; thus, it is more prone to erosion by water and wind. In contrast, areas with more cohesive materials, are slightly more resistant to erosion. Additionally, the reduced intensity of water flows in this area further diminishes the likelihood of such phenomena occurring.

Nevertheless, it is common to avoid velocities exceeding 1.0 m/s. After filtering the velocity results, Figure below presents those values above 1.0 m/s.

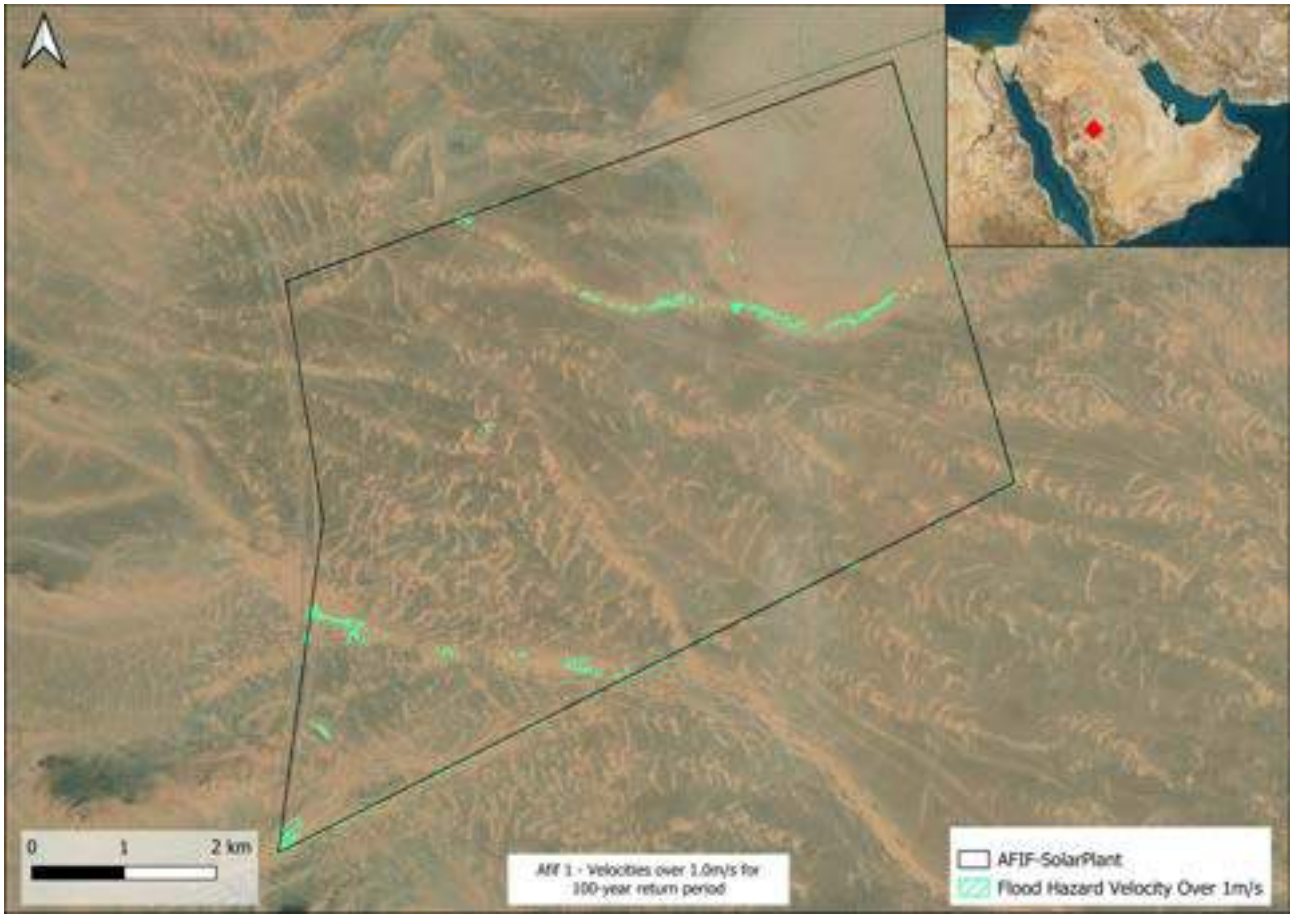


Figure 39. Velocities over 1 m/s for 100-year return period.

5.6.3. Combination depth and velocity

Additionally, another parameter that may lead to a good definition is by the combination of depths and velocities. Physically, it is often referred to as the specific discharge gradient, representing the volume of water passing through a given point per unit time. This parameter enables the quantification of areas where water flow is more likely to occur, indicative of potentially intense water action. A commonly used threshold for this parameter is 0.5 m^2/s.

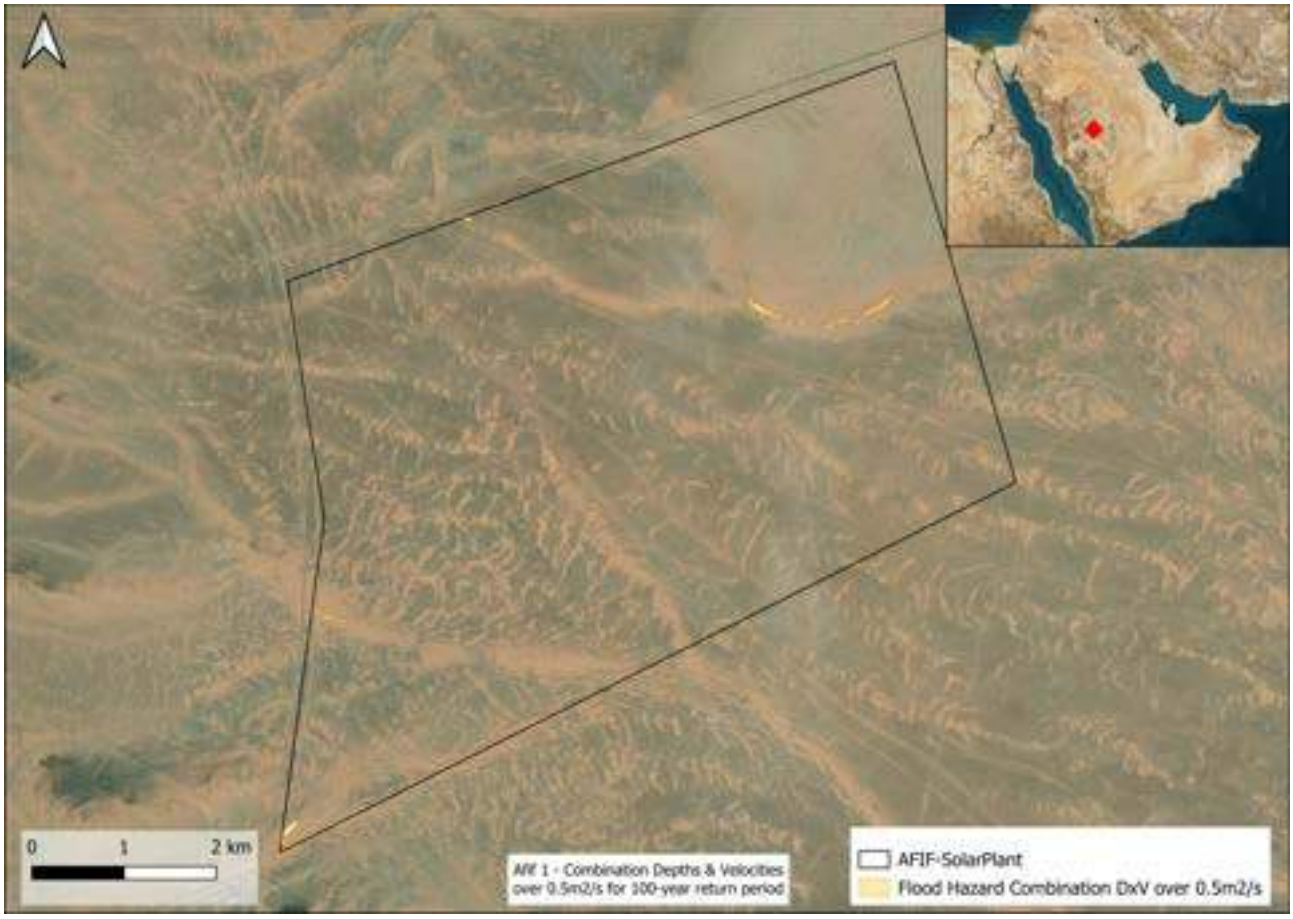


Figure 40. Combination Depths & Velocities over 0.5m2/s for 100-year return period.

5.6.4. Flooding hazard areas

Finally, the combination of all these constrains are proposed as hazardous areas for the project by overlapping the various results presented above. While these areas may pose a risk to the planned equipment and installations, it is not sufficient reason to consider them as zones to be avoided. In this case, the areas identified as risky are few and pose a low hazard.

Therefore, in the following section of this document, a series of mitigation measures will be proposed with the aim of minimizing the impact of water on the facilities, thereby maximizing the performance of the installations.

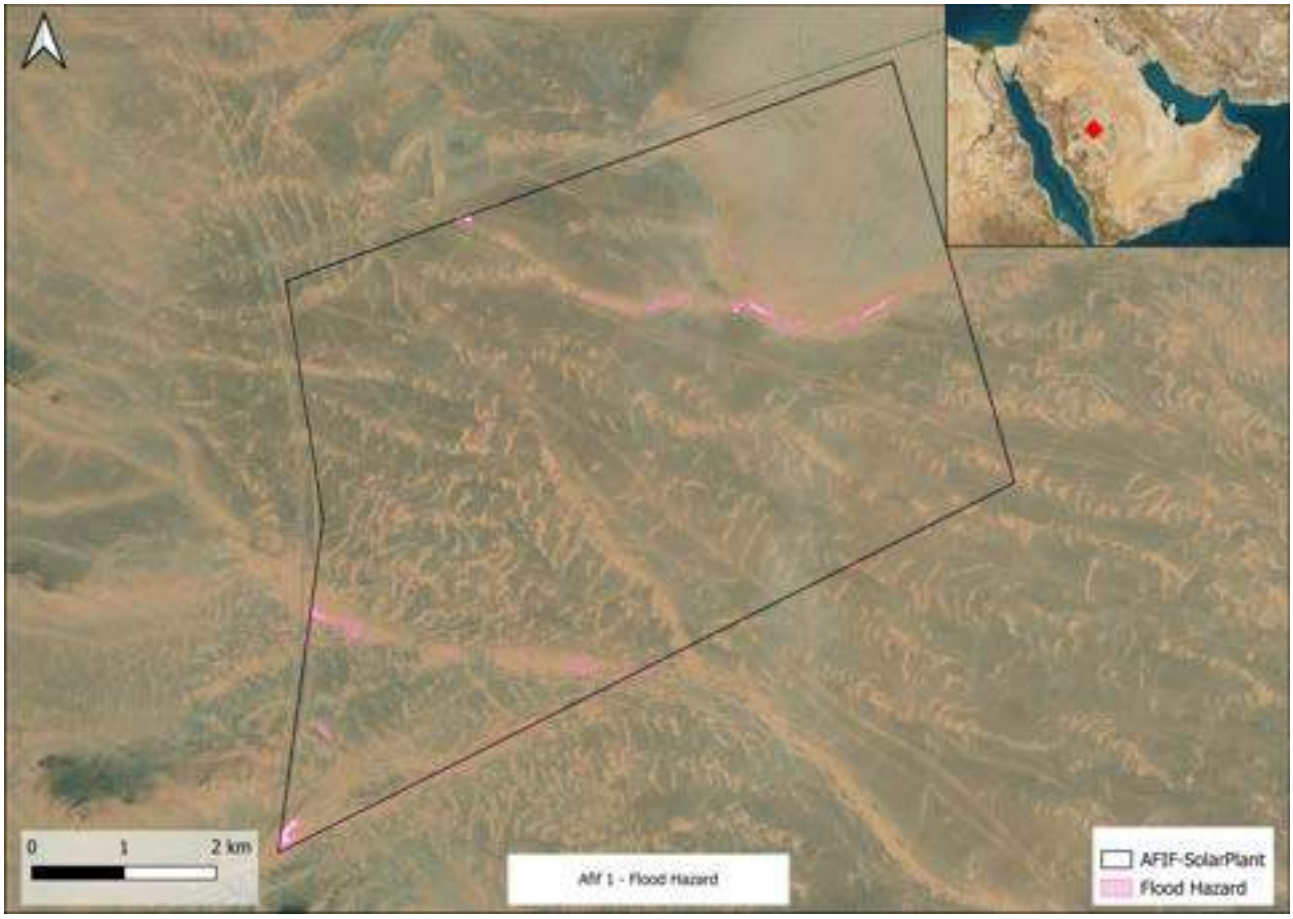


Figure 41. Flood Hazard areas.

6. Mitigation strategies

Based on the results of the hydrological simulations for the different return periods, the hydrological trend of the site shows that surface water is drained through the existing overland flow paths (streams). Additionally, some surface water is stored in the low areas of the ground before it drains away through infiltration and evaporation. Apart from some very localized flood hazards areas within the overland flow paths, that show maximum water depths above 0.5m and maximum water velocities above 1.0m/s, surface water runoff at the project site does not denote any potential danger for the project.

Although these localized flood hazards areas do not indicate any potential danger for the project, the mitigation measures described in this section should be included to remove any potential risk. These mitigation measures are common in the photovoltaic projects.

The hydraulic modeling results and subsequent hazard analysis shows that the most restrictive factor is the velocity along some sections of the existing streams. Therefore, it is important to introduce materials such as rocks or breakwater in those sections of the existing streams where the results show velocities above 1 m/s. This strategy will increase the roughness and head losses of the stream channels (n-manning), decreasing the velocities and hazards accordingly. These sections should include a localized management and maintenance to ensure that the applied mitigation measures remain operational over time.

Critical design elements such as transformers, inverters, substations or other any equipment should be placed and installed outside the flood hazards sections. Additionally, the electrical facilities trenches at the flood hazards areas should be concreted. For other electrical equipment located over zones where floods and high-water depths are more prone to happen, the recommendation is to place the equipment at certain level over ground level and, additionally, some waterproof protections to avoid damages.

The solar structures piles at the flood hazards sections should include local protections such as rocks surrounding them.

It is important to improve the terrain drainage capacities. The proposals must focus on enhancing the superficial water flow and shorten up the amount of waterlogged within the plot boundaries. The aim is to reduce the water retention time and minimize any possible damage to the facilities equipment.

Attending to the topography and the elevations of the low points where the water remains after the heavy rainfall episodes, carry out some grading could be a good technical option to increase the drainage capacity. These earthworks will reduce the differences between the highest and the lowest points. The purpose is not only to generate a homogeneous slope, as this would be very expensive, but reducing the water that can remain stored. Eventually, if the water level is lower, the evaporation effect will be faster.

To get the continuous slopes, balancing masses is relatively simple by filling the lower parts with the material of the highest parts.

Along the internal roads that will be defined within the park, a specific drainage system should be designed to protect the road from suffering damages by the water runoff during the heavy rainfall episodes. For the roads or linear works, a system of ditches and ford will be sufficient since the ditches are expected to collect the water and direct it to the natural channels. The road arranged over low zones where the water level is expected to be high, a minimum elevation for the road surface should be set to prevent the water from passing over the roads and avoid damages on shallow layers of the road.

In all scenarios, it can be assured that the drainage solution implemented in the park to protect the roads or the earthworks leveling to enhance the soil's drainage capacity will not result in any adverse effects on the downstream facilities. Due to the park topography, the water behavior has a well-defined path, catching the water from the north-west area and conduct it to the south-east part. Any change on the water behavior that can occur due to the drainage works inside the park will improve the drainage capacity, that means: less water or lower velocity runoffs.

6.1. Substation

Due to the expected large capacity of the plant, the power produced by the project will be injected at 380 kV. Saudi electrical Company (SEC) who will be responsible for the construction of the substation and the associated interconnection infrastructures to an existing substation.

The photovoltaic plants will generate at 33 kV (output voltage of the MV inverter-transformers). Due to the high capacity and extension of the plants, the voltage level of that produced energy shall be elevated through some internal HV network to limit transmission losses. Then, all those circuits will be collected in one 380 kV substation to be developed by SEC.

The electrical equipment required for this project, such as transformers, is highly susceptible to damage from exposure to water. Therefore, a thorough analysis of the area where this equipment will be situated is recommended.

From the results, it can be observed that the area is suitable for the installation of the substation. No instances of potential external runoff impacting the substation area have been identified on the northwestern side of the project site.

Furthermore, analyzing the results obtained for the 100-year return period hydrodynamic simulation, representing the most adverse scenario studied, reveals minimal water depths within the area. Only a minor puddle, with a depth not exceeding 10 cm, is presented. Consequently, velocities in the area remain low, with values below 0.20 m/s.

These findings are attributed to the negligible runoff generated in the area, primarily occurring near the selected substation site. Given the prevailing topography and soil composition, rainwater runoff flows calmly and gradually towards the east.

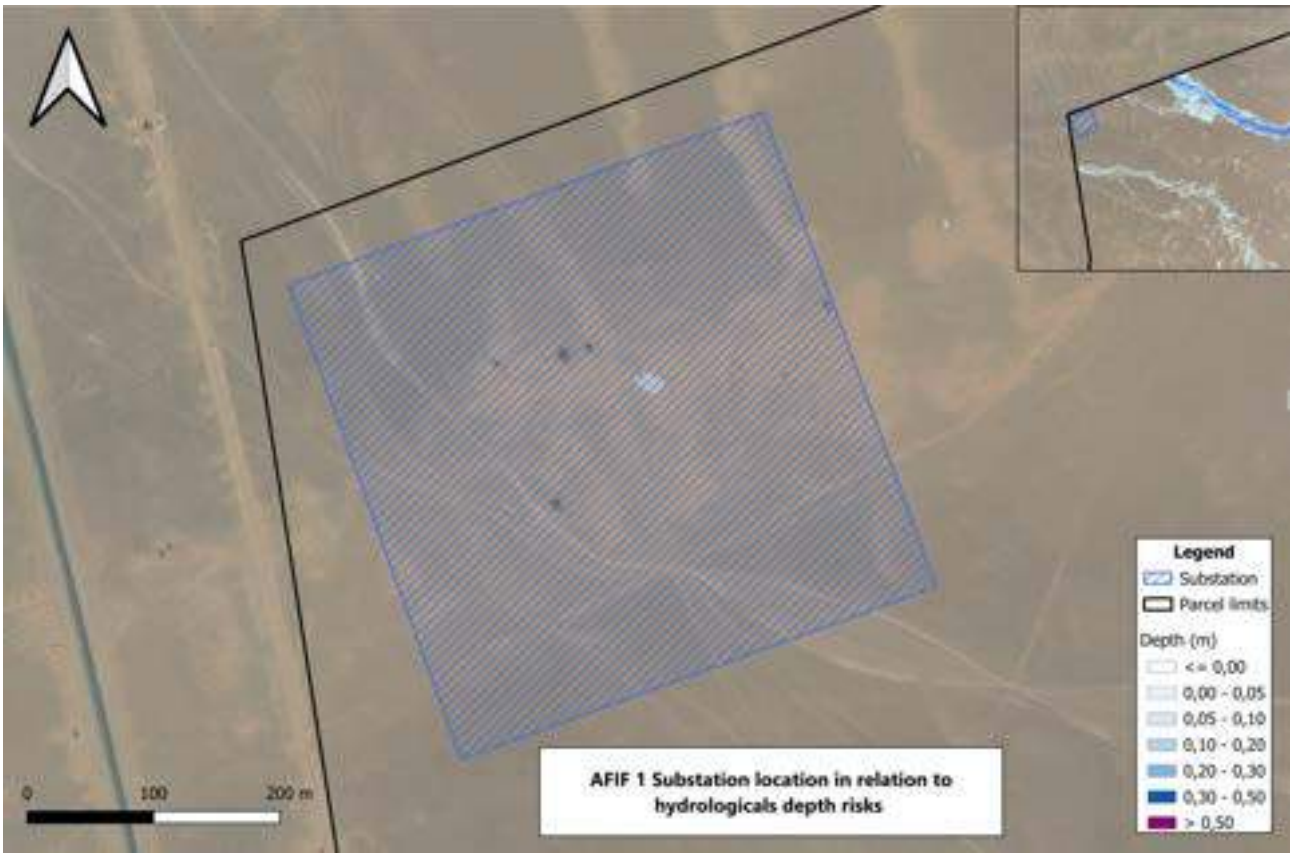


Figure 42. Maximum Water Depth for a 100-years return period within the proposed substation.

Figure 43. Maximum Water Velocity for a 100-years return period within the proposed substation.

For the installation of a substation, it is common practice to level the ground so that it is horizontal or with a minimum and constant slope. In some cases, with steeper terrain, an elevated platform is constructed. In both situations, the objective is to regularize and homogenize the terrain to provide a suitable surface for the installation of sensitive equipment. This homogenization of the terrain has a positive effect on the impact of water on the equipment. This is because the water, instead of concentrating in one area of the terrain as occurs naturally, flows uniformly through the terrain, resulting in lower water concentrations and, consequently, lower depths and velocities.

7. Conclusions

This report covers the hydrological assessment of the area where the AFIF1 PV project, is planned to be implemented and provide recommendations for the design of the plant and the associated water drainage system.

From a hydrological point of view, the Afif 1 area does not pose any major risk for the development of photovoltaic installations. Analyzing the results, slopes in the area are very low, between 0 to 3%. As a result, surface water runoff slowly flows over the ground into the main surface water overland flow paths (streams) where it drains away. Additionally, surface water is stored in some parts at the low points of the ground before it drains away through infiltration and evaporation. The hydraulic modeling shows similar results for all rainfall events with surface water flowing through the existing overland flow paths, with average depths ranging 0.20 m to 0.40 m. Notably, certain areas along the main streams exhibit substantial increases in water depth and

velocities. These zones may potentially experience water depths exceeding 0.5 m, accompanied by velocities ranging 0.8 m/s and 1.20 m/s.

Some of the water basins that drain into the site are large, that result in moderate to large volumes of water flowing through the existing streams. However, the identified surface runoff streams have a very low slope with values between 1.0% and 0.10%, so concentration times are relatively high. Moreover, the local terrain has a high runoff coefficient, thus a low infiltration rate. Altogether these factors moderate the impact that any extreme rainfall event might have on the site. Thus, rainfall and runoffs in the site will have a low velocity or erosive potential and therefore hydrological severe impacts are unlikely to occur. Moreover, the erosion of the area is expected to be very low as the small and diffuse runoffs detected are not strong enough to wash away soil particles.

The hydrological model shows that areas subjected to flood hazard risk (Figure 41) are entirely located within the existing streams, where the hydraulic modeling shows maximum water velocities around 1.0m/s and maximum water depths around 0.5m and have been found.

Although these hazard areas are very localized and unlikely to have any detrimental impact or potential risk to the development of photovoltaic installations at the Afif 1 project site, it is highly recommended to introduce materials in the existing streams such as rocks or breakwater, that will increase the roughness and head losses of the stream channels (n-manning), decreasing the velocities and hazards accordingly.

Critical design elements such as transformation centers, inverters, substations or other any equipment should be placed and installed outside the flood hazards sections. Additionally, the electrical facilities trenches at the flood hazards areas should be concreted. For other electrical equipment located over zones where floods and high-water depths are more prone to happen, the recommendation is to place the equipment at certain level over ground level and, additionally, some waterproof protections to avoid damages.

The solar structures posts at the flood hazards sections should include local protections such as rocks surrounding them.

Furthermore, it is recommended to develop mitigation strategies, such as some grading, that definitively improve the terrain drainage capacity, so exposure time to water is shorten up and reduce the potential flooding risks. For the roads or linear works, a system of ditches and ford will be sufficient since the ditches are expected to collect the water and direct it to the existing natural streams. The road arranged over low zones where the water level is expected to be high, a minimum elevation for the road surface should be set to prevent the water from passing over the roads and avoid damages on shallow layers of the road.

In all scenarios, it can be assured that the drainage solution implemented in the park to protect the roads or the earthworks leveling to enhance the soil's drainage capacity will not result in any adverse effects on the downstream facilities. Due to the park topography, the water behavior has a well-defined path, catching the water from the north-west area and conduct it to the south-east part. Any change on the water behavior that can occur due to the drainage works inside the park will improve the drainage capacity, that means: less water or lower velocity runoffs.

ANNEX A. IDF Curves

ANNEX A. IDF Curves

The scope of this Annex is to show obtained IDF curves and their empiric formula. According to the methodology exposed in the publication "Development of intensity-duration-frequency curves for the Kingdom of Saudi Arabia", Hatem A. Ewea, Amro M. Elfeki & Nassir S. Al-Amri (2016), the average rainfall intensity for a given time could be obtained from the following expression:

$$I_T(T, D) = a \cdot D^b$$

Where:

- I_T (mm/h) Average rainfall intensity in a range of duration D for a given recurrence interval.
- a (dimensionless) Parameter. The value of this parameter varies according to the return period.
- D (min) Rainfall duration of intensity.
- b (dimensionless) Parameter. The value of this parameter varies according to the return period.

The dimensionless parameters follow the bellow's formulas:

U004 – Kuraa Almarw

$$a = 23.518 \cdot \ln T + 109.69$$

$$b = 0.0213 \cdot \ln T - 0.6431$$

U002 – Uclat As Suqur

$$a = 106.73 \cdot \ln T + 82.179$$

$$b = -0.001 \cdot \ln T - 0.7737$$

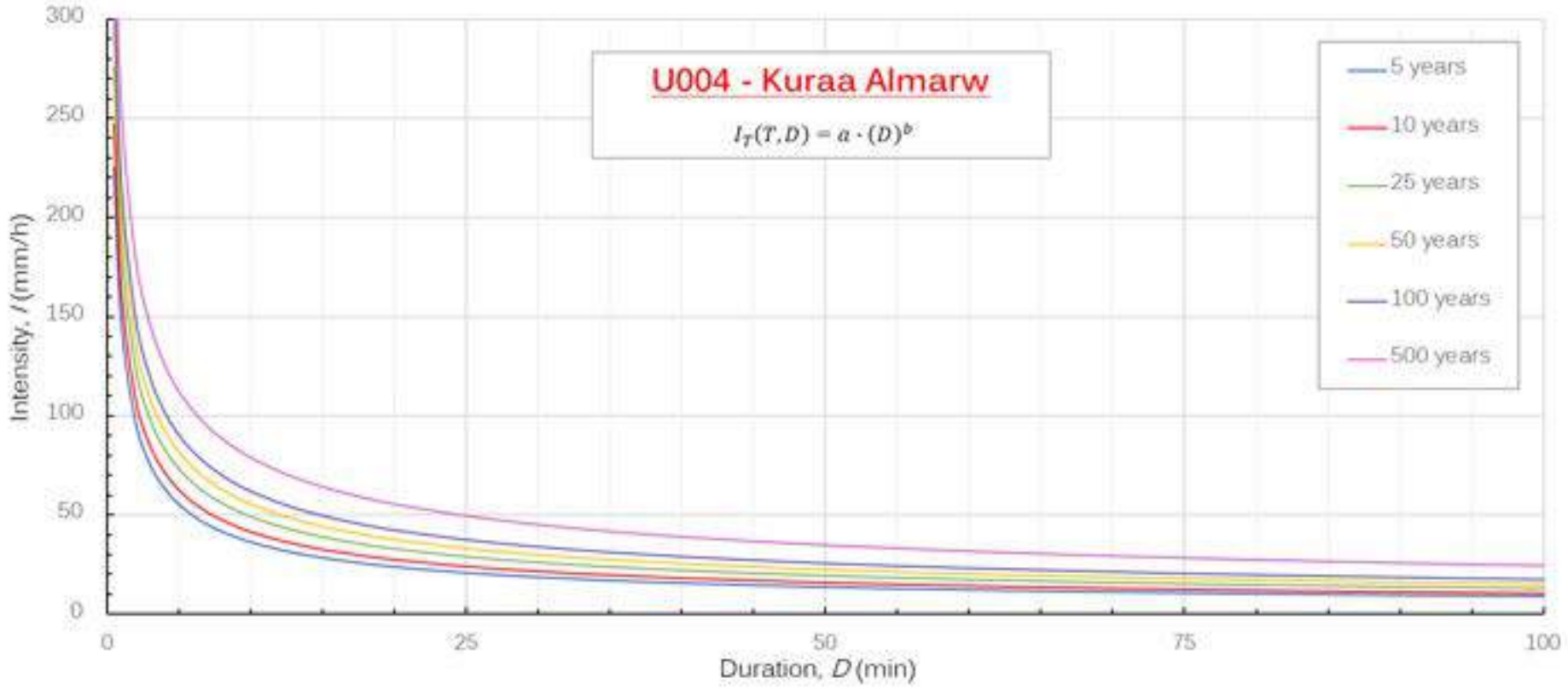


Figure 44. Intensity-Duration-Frequency curve for U004 - Kuraa Almarw Atajarob.

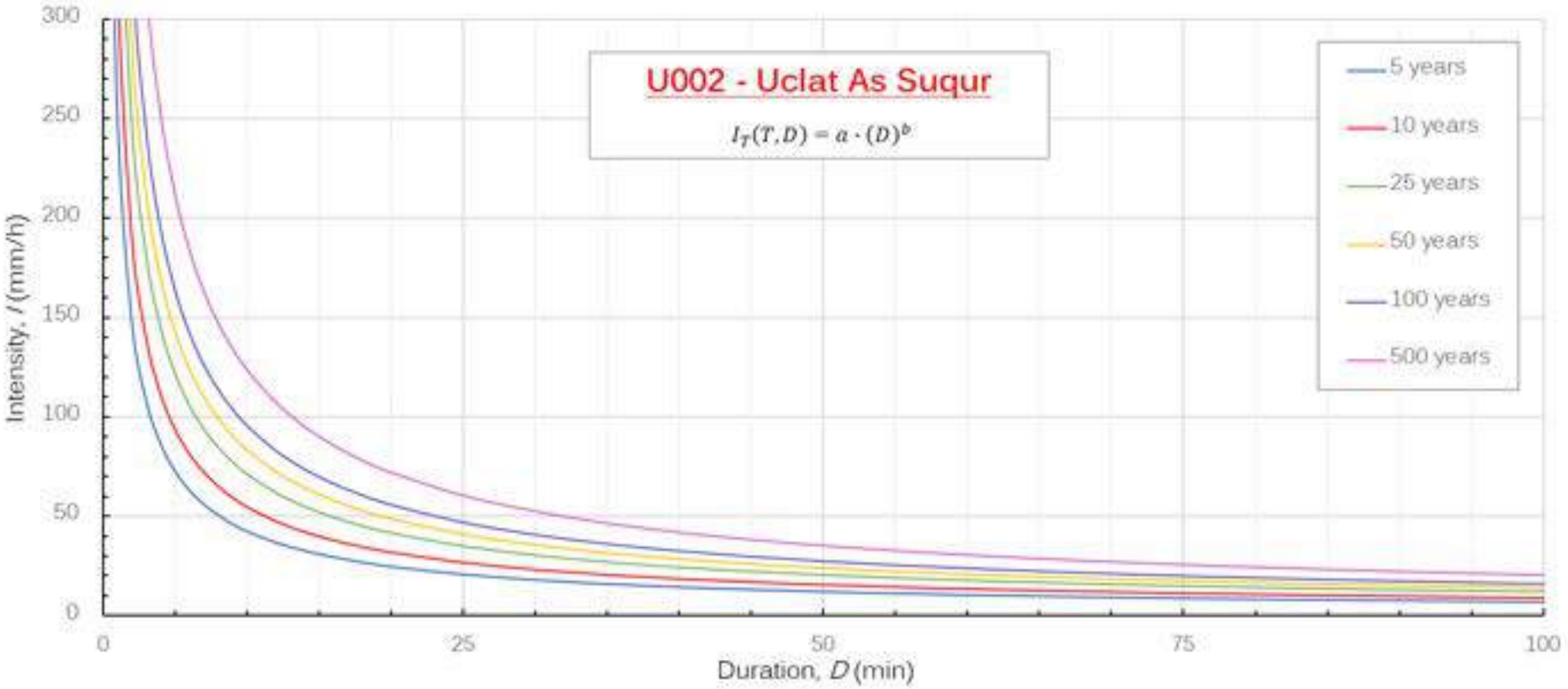


Figure 45. Intensity-Duration-Frequency curve for U002 - Uclat As Suqur.

ANNEX B. Hyetograph Definition

ANNEX B. Hyetograph definition

Using data from IDF curves, hyetographs have been calculated by the Alternate Blocks Method. These hyetographs have been used as input data for the HEC-HMS model and the IBER model.

1. U004 - Kuraa Almarw Atajarob - Hyetograph for 25 years return period

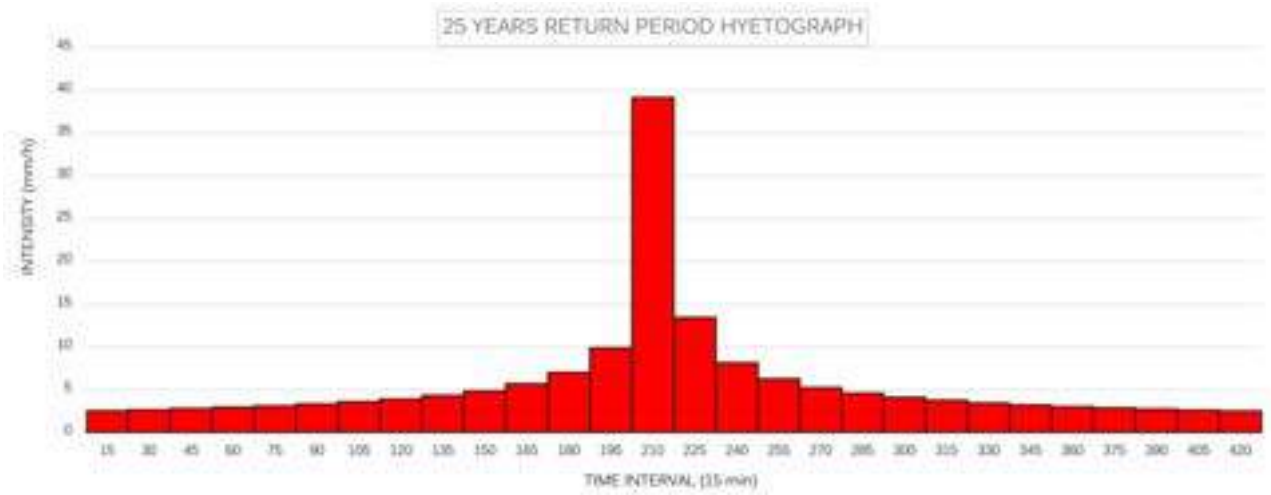


Figure 46. Hyetograph for 25 years return period.

Duration t (min)	Intensity I_{25} (mm/h)	Cumulative Depth $P_{25\ Cum}$ (mm)	Incremental Depth ΔP_{25} (mm)	Incremental intensity ΔI_{25} (mm/h)
15	39.12	9.78	9.78	39.118
30	26.27	13.134	3.354	13.418
45	20.81	15.607	2.473	9.892
60	17.64	17.639	2.032	8.128
75	15.52	19.396	1.757	7.027
90	13.97	20.96	1.564	6.258
105	12.79	22.381	1.421	5.683
120	11.84	23.689	1.308	5.233
135	11.07	24.907	1.217	4.869

Time (min)	Precipitation Alternating Block Method ΔP_{25} (mm)	Intensity Alternating Block Method ΔI_{25} (mm/h)
0-15	0.633	2.533
15-30	0.662	2.649
30-45	0.696	2.782
45-60	0.734	2.935
60-75	0.778	3.114
75-90	0.831	3.325
90-105	0.895	3.582
105-120	0.975	3.901
120-135	1.078	4.312

Duration t (min)	Intensity I_{25} (mm/h)	Cumulative Depth $P_{25\ Cum}$ (mm)	Incremental Depth ΔP_{25} (mm)	Incremental intensity ΔI_{25} (mm/h)
150	10.42	26.049	1.142	4.568
165	9.86	27.127	1.078	4.312
180	9.38	28.15	1.023	4.092
195	8.96	29.125	0.975	3.901
210	8.59	30.058	0.933	3.732
225	8.25	30.953	0.895	3.582
240	7.95	31.815	0.862	3.447
255	7.68	32.646	0.831	3.325
270	7.43	33.45	0.804	3.215
285	7.21	34.228	0.778	3.114
300	7.00	34.983	0.755	3.021
315	6.80	35.717	0.734	2.935
330	6.62	36.431	0.714	2.856
345	6.46	37.127	0.696	2.782
360	6.30	37.805	0.678	2.714
375	6.15	38.467	0.662	2.649
390	6.02	39.115	0.647	2.589
405	5.89	39.748	0.633	2.533
420	5.77	40.367	0.620	2.479

Time (min)	Precipitation Alternating Block Method ΔP_{25} (mm)	Intensity Alternating Block Method ΔI_{25} (mm/h)
135-150	1.217	4.869
150-165	1.421	5.683
165-180	1.757	7.027
180-195	2.473	9.892
195-210	9.780	39.118
210-225	3.354	13.418
225-240	2.032	8.128
240-255	1.564	6.258
255-270	1.308	5.233
270-285	1.142	4.568
285-300	1.023	4.092
300-315	0.933	3.732
315-330	0.862	3.447
330-345	0.804	3.215
345-360	0.755	3.021
360-375	0.714	2.856
375-390	0.678	2.714
390-405	0.647	2.589
405-420	0.620	2.479

Table 13. Hyetograph table for 25 years return period.

2. U004 - Kuraa Almarw Atajarob - Hyetograph for 50 years return period

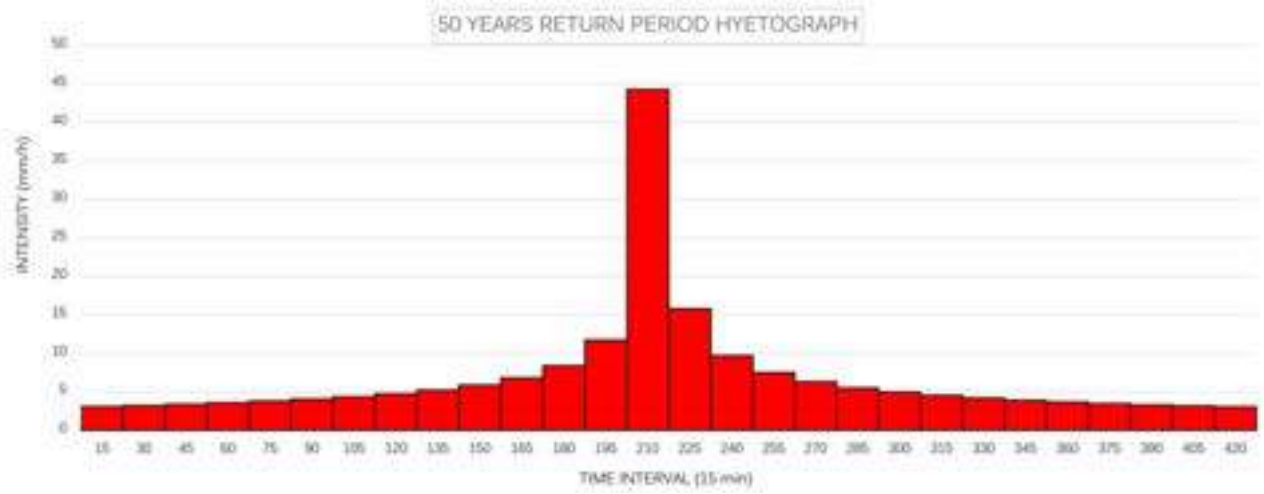


Figure 47. Hyetograph for 50 years return period.

Duration t (min)	Intensity I_{50} (mm/h)	Cumulative Depth $P_{50\ Cum}$ (mm)	Incremental Depth ΔP_{50} (mm)	Incremental intensity ΔI_{50} (mm/h)
15	44.29	11.074	11.074	44.294
30	30.05	15.025	3.951	15.805
45	23.95	17.961	2.936	11.744
60	20.39	20.386	2.425	9.700
75	17.99	22.490	2.104	8.417
90	16.25	24.370	1.880	7.518
105	14.9	26.081	1.711	6.845
120	13.83	27.66	1.579	6.316
135	12.95	29.132	1.472	5.888
150	12.21	30.515	1.383	5.532
165	11.57	31.822	1.308	5.230
180	11.02	33.065	1.243	4.970
195	10.54	34.251	1.186	4.744
210	10.11	35.387	1.136	4.543
225	9.73	36.478	1.091	4.365
240	9.38	37.529	1.051	4.205
255	9.07	38.544	1.015	4.060
270	8.78	39.527	0.982	3.929
285	8.52	40.479	0.952	3.808
300	8.28	41.403	0.924	3.698
315	8.06	42.302	0.899	3.596
330	7.85	43.177	0.875	3.501
345	7.66	44.031	0.853	3.413
360	7.48	44.863	0.833	3.331
375	7.31	45.677	0.814	3.254
390	7.15	46.472	0.796	3.182
405	7,00	47.251	0.779	3.114
420	6.86	48.013	0.763	3.050

Time (min)	Precipitation Alternating Block Method ΔP_{50} (mm)	Intensity Alternating Block Method ΔI_{50} (mm/h)
0-15	0.779	3.114
15-30	0.814	3.254
30-45	0.853	3.413
45-60	0.899	3.596
60-75	0.952	3.808
75-90	1.015	4.060
90-105	1.091	4.365
105-120	1.186	4.744
120-135	1.308	5.230
135-150	1.472	5.888
150-165	1.711	6.845
165-180	2.104	8.417
180-195	2.936	11.744
195-210	11.074	44.294
210-225	3.951	15.805
225-240	2.425	9.700
240-255	1.880	7.518
255-270	1.579	6.316
270-285	1.383	5.532
285-300	1.243	4.970
300-315	1.136	4.543
315-330	1.051	4.205
330-345	0.982	3.929
345-360	0.924	3.698
360-375	0.875	3.501
375-390	0.833	3.331
390-405	0.796	3.182
405-420	0.763	3.050

Table 14. Hyetograph table for 50 years return period.

3. U004 - Kuraa Almarw Atajarob - Hyetograph for 100 years return period

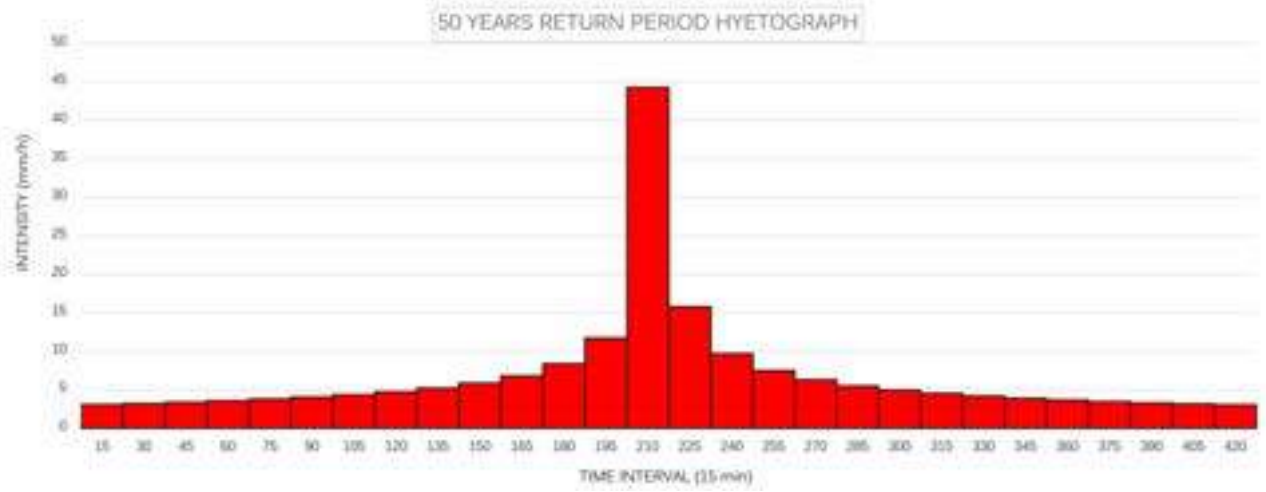


Figure 48. Hyetograph for 100 years return period.

Duration t (min)	Intensity I_{100} (mm/h)	Cumulative Depth $P_{100\,Cum}$ (mm)	Incremental Depth ΔP_{100} (mm)	Incremental intensity ΔI_{100} (mm/h)
15	49.83	12.457	12.457	49.827
30	34.15	17.075	4.619	18.474
45	27.38	20.535	3.459	13.838
60	23.41	23.406	2.872	11.487
75	20.73	25.908	2.501	10.005
90	18.77	28.148	2.241	8.963
105	17.25	30.194	2.045	8.181
120	16.04	32.085	1.891	7.565
135	15.05	33.851	1.766	7.065
150	14.21	35.514	1.662	6.649
165	13.49	37.087	1.574	6.296
180	12.86	38.585	1.498	5.991
195	12.31	40.016	1.431	5.724
210	11.83	41.389	1.372	5.489
225	11.39	42.708	1.32	5.279
240	11.00	43.981	1.273	5.091
255	10.64	45.211	1.230	4.92
270	10.31	46.402	1.191	4.765
285	10.01	47.558	1.156	4.623
300	9.74	48.681	1.123	4.492
315	9.48	49.774	1.093	4.371
330	9.24	50.839	1.065	4.259
345	9.02	51.877	1.039	4.155

Time (min)	Precipitation Alternating Block Method ΔP_{100} (mm)	Intensity Alternating Block Method ΔI_{100} (mm/h)
0-15	0.950	3.800
15-30	0.992	3.966
30-45	1.039	4.155
45-60	1.093	4.371
60-75	1.156	4.623
75-90	1.230	4.920
90-105	1.320	5.279
105-120	1.431	5.724
120-135	1.574	6.296
135-150	1.766	7.065
150-165	2.045	8.181
165-180	2.501	10.005
180-195	3.459	13.838
195-210	12.457	49.827
210-225	4.619	18.474
225-240	2.872	11.487
240-255	2.241	8.963
255-270	1.891	7.565
270-285	1.662	6.649
285-300	1.498	5.991
300-315	1.372	5.489
315-330	1.273	5.091
330-345	1.191	4.765

Duration t (min)	Intensity I_{100} (mm/h)	Cumulative Depth $P_{100\ Cum}$ (mm)	Incremental Depth ΔP_{100} (mm)	Incremental intensity ΔI_{100} (mm/h)
360	8.82	52.892	1.014	4.057
375	8.62	53.883	0.992	3.966
390	8.44	54.853	0.970	3.881
405	8.27	55.803	0.950	3.800
420	8.10	56.734	0.931	3.724

Time (min)	Precipitation Alternating Block Method ΔP_{100} (mm)	Intensity Alternating Block Method ΔI_{100} (mm/h)
345-360	1.123	4.492
360-375	1.065	4.259
375-390	1.014	4.057
390-405	0.970	3.881
405-420	0.931	3.724

Table 15. Hyetograph table for 100 years return period.

4. U002 - Uclat As Suqur - Hyetograph for 25 years return period

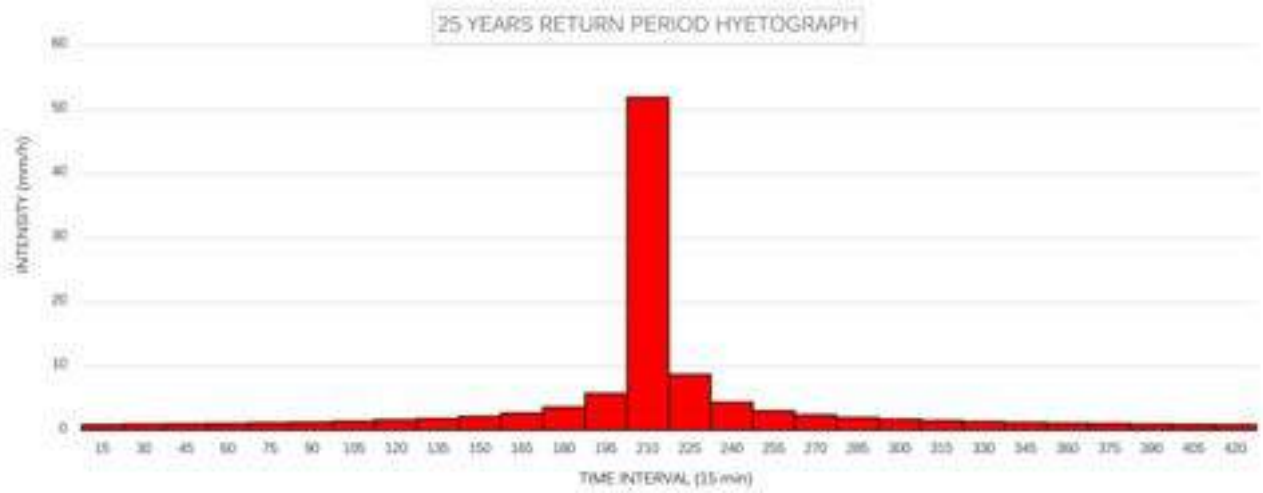


Figure 49. Hyetograph for 25 years return period.

Duration t (min)	Intensity I_{25} (mm/h)	Cumulative Depth $P_{25\ Cum}$ (mm)	Incremental Depth ΔP_{25} (mm)	Incremental intensity ΔI_{25} (mm/h)
15	51.93	12.982	12.982	51.929
30	30.31	15.153	2.171	8.684
45	22.12	16.588	1.435	5.738
60	17.69	17.687	1.099	4.398
75	14.87	18.590	0.903	3.611
90	12.91	19.361	0.772	3.087
105	11.45	20.039	0.677	2.710
120	10.32	20.645	0.606	2.424
135	9.42	21.194	0.550	2.199
150	8.68	21.698	0.504	2.016

Time (min)	Precipitation Alternating Block Method ΔP_{25} (mm)	Intensity Alternating Block Method ΔI_{25} (mm/h)
0-15	0.227	0.908
15-30	0.241	0.965
30-45	0.258	1.031
45-60	0.277	1.109
60-75	0.300	1.201
75-90	0.328	1.312
90-105	0.363	1.451
105-120	0.407	1.629
120-135	0.466	1.865
135-150	0.550	2.199

Duration t (min)	Intensity I_{25} (mm/h)	Cumulative Depth $P_{25\ Cum}$ (mm)	Incremental Depth ΔP_{25} (mm)	Incremental intensity ΔI_{25} (mm/h)
165	8.06	22.165	0.466	1.865
180	7.53	22.599	0.434	1.738
195	7.08	23.006	0.407	1.629
210	6.68	23.390	0.384	1.534
225	6.33	23.753	0.363	1.451
240	6.02	24.097	0.344	1.378
255	5.75	24.425	0.328	1.312
270	5.50	24.739	0.313	1.254
285	5.27	25.039	0.300	1.201
300	5.07	25.327	0.288	1.153
315	4.88	25.604	0.277	1.109
330	4.70	25.871	0.267	1.068
345	4.54	26.129	0.258	1.031
360	4.40	26.378	0.249	0.997
375	4.26	26.620	0.241	0.965
390	4.13	26.853	0.234	0.936
405	4.01	27.080	0.227	0.908
420	3.90	27.301	0.221	0.882

Time (min)	Precipitation Alternating Block Method ΔP_{25} (mm)	Intensity Alternating Block Method ΔI_{25} (mm/h)
150-165	0.677	2.710
165-180	0.903	3.611
180-195	1.435	5.738
195-210	12.982	51.929
210-225	2.171	8.684
225-240	1.099	4.398
240-255	0.772	3.087
255-270	0.606	2.424
270-285	0.504	2.016
285-300	0.434	1.738
300-315	0.384	1.534
315-330	0.344	1.378
330-345	0.313	1.254
345-360	0.288	1.153
360-375	0.267	1.068
375-390	0.249	0.997
390-405	0.234	0.936
405-420	0.221	0.882

Table 16. Hyetograph table for 25 years return period.

5. U002 - Uclat As Suqur - Hyetograph for 50 years return period

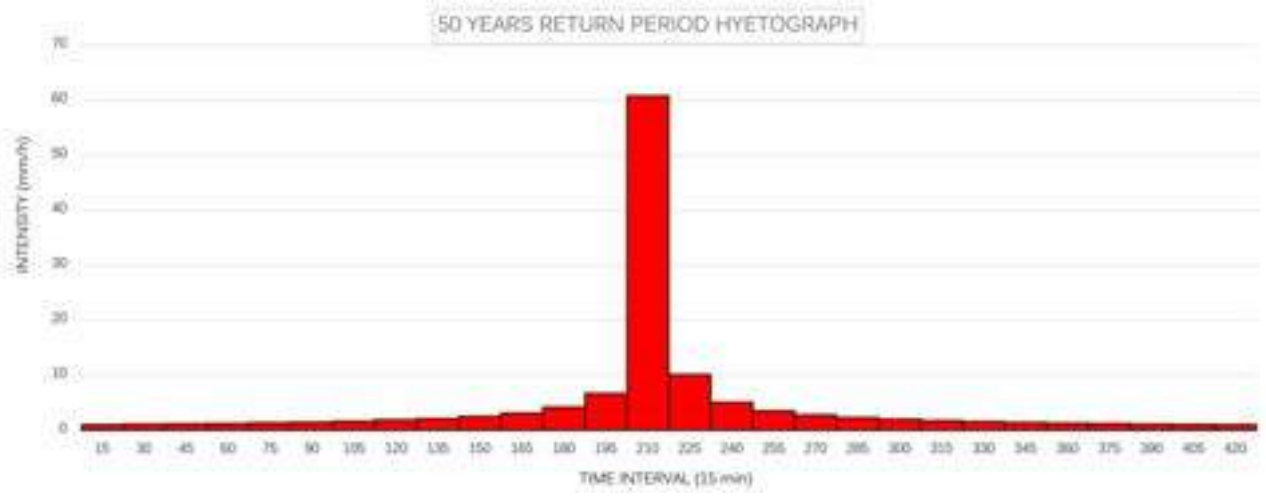


Figure 50. Hyetograph for 50 years return period.

Duration t (min)	Intensity I_{50} (mm/h)	Cumulative Depth $P_{50\ Cum}$ (mm)	Incremental Depth ΔP_{50} (mm)	Incremental intensity ΔI_{50} (mm/h)
15	60.84	15.209	15.209	60.838
30	35.49	17.744	2.535	10.139
45	25.89	19.419	1.674	6.697
60	20.70	20.702	1.283	5.132
75	17.40	21.755	1.053	4.213
90	15.10	22.655	0.900	3.601
105	13.40	23.445	0.790	3.160
120	12.08	24.152	0.707	2.827
135	11.02	24.793	0.641	2.564
150	10.15	25.381	0.588	2.351
165	9.43	25.924	0.544	2.175
180	8.81	26.431	0.507	2.026
195	8.28	26.906	0.475	1.899
210	7.82	27.353	0.447	1.788
225	7.41	27.776	0.423	1.692
240	7.04	28.177	0.402	1.606
255	6.72	28.56	0.382	1.530
270	6.43	28.925	0.365	1.461
285	6.16	29.275	0.350	1.400
300	5.92	29.611	0.336	1.343
315	5.70	29.934	0.323	1.292
330	5.50	30.245	0.311	1.245
345	5.31	30.545	0.300	1.202
360	5.14	30.836	0.290	1.162
375	4.98	31.117	0.281	1.125
390	4.83	31.390	0.273	1.090
405	4.69	31.654	0.265	1.058
420	4.56	31.911	0.257	1.028

Time (min)	Precipitation Alternating Block Method ΔP_{50} (mm)	Intensity Alternating Block Method ΔI_{50} (mm/h)
0-15	0.265	1.058
15-30	0.281	1.125
30-45	0.300	1.202
45-60	0.323	1.292
60-75	0.350	1.400
75-90	0.382	1.530
90-105	0.423	1.692
105-120	0.475	1.899
120-135	0.544	2.175
135-150	0.641	2.564
150-165	0.790	3.160
165-180	1.053	4.213
180-195	1.674	6.697
195-210	15.209	60.838
210-225	2.535	10.139
225-240	1.283	5.132
240-255	0.900	3.601
255-270	0.707	2.827
270-285	0.588	2.351
285-300	0.507	2.026
300-315	0.447	1.788
315-330	0.402	1.606
330-345	0.365	1.461
345-360	0.336	1.343
360-375	0.311	1.245
375-390	0.290	1.162
390-405	0.273	1.090
405-420	0.257	1.028

Table 17. Hyetograph table for 50 years return period.

6. U002 - Uclat As Suqur - Hyetograph for 100 years return period

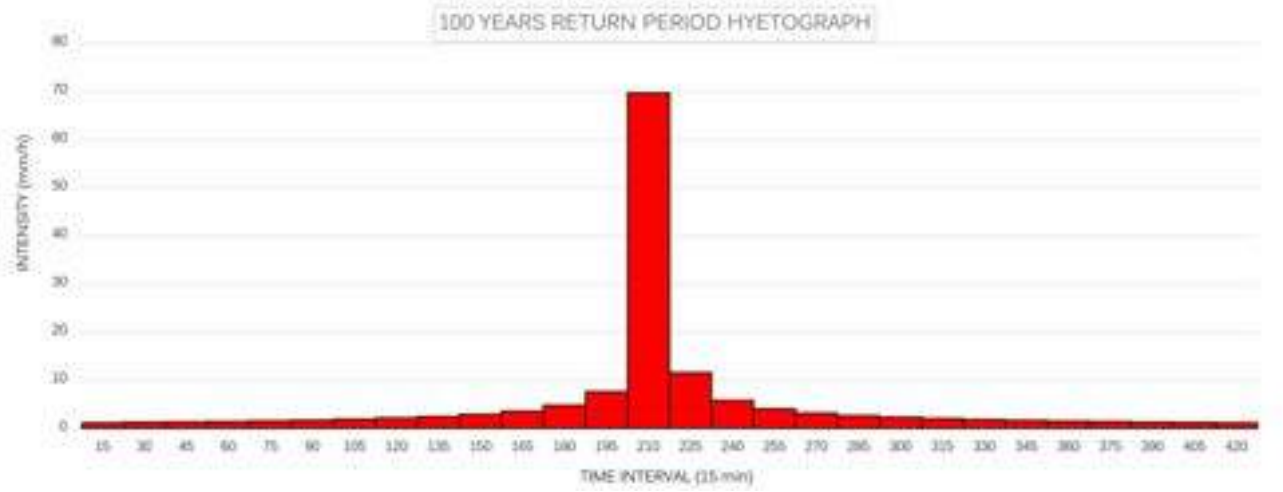


Figure 51. Hyetograph for 100 years return period.

Duration t (min)	Intensity I_{100} (mm/h)	Cumulative Depth $P_{100\,Cum}$ (mm)	Incremental Depth ΔP_{100} (mm)	Incremental intensity ΔI_{100} (mm/h)
15	69.71	17.428	17.428	69.714
30	40.65	20.323	2.895	11.58
45	29.65	22.235	1.911	7.646
60	23.70	23.699	1.464	5.857
75	19.92	24.901	1.202	4.807
90	17.29	25.928	1.027	4.108
105	15.33	26.829	0.901	3.606
120	13.82	27.636	0.806	3.224
135	12.61	28.367	0.731	2.924
150	11.61	29.037	0.670	2.682
165	10.78	29.657	0.620	2.480
180	10.08	30.235	0.578	2.311
195	9.47	30.776	0.541	2.165
210	8.94	31.286	0.510	2.039
225	8.47	31.768	0.482	1.929
240	8.06	32.226	0.458	1.831
255	7.69	32.662	0.436	1.744
270	7.35	33.079	0.417	1.666
285	7.05	33.477	0.399	1.596
300	6.77	33.860	0.383	1.531
315	6.52	34.228	0.368	1.473
330	6.29	34.583	0.355	1.419
345	6.07	34.926	0.342	1.370

Time (min)	Precipitation Alternating Block Method ΔP_{100} (mm)	Intensity Alternating Block Method ΔI_{100} (mm/h)
0-15	0.302	1.206
15-30	0.321	1.282
30-45	0.342	1.370
45-60	0.368	1.473
60-75	0.399	1.596
75-90	0.436	1.744
90-105	0.482	1.929
105-120	0.541	2.165
120-135	0.620	2.480
135-150	0.731	2.924
150-165	0.901	3.606
165-180	1.202	4.807
180-195	1.911	7.646
195-210	17.428	69.714
210-225	2.895	11.58
225-240	1.464	5.857
240-255	1.027	4.108
255-270	0.806	3.224
270-285	0.670	2.682
285-300	0.578	2.311
300-315	0.510	2.039
315-330	0.458	1.831
330-345	0.417	1.666

Duration t (min)	Intensity I_{100} (mm/h)	Cumulative Depth $P_{100\ Cum}$ (mm)	Incremental Depth ΔP_{100} (mm)	Incremental intensity ΔI_{100} (mm/h)
360	5.88	35.257	0.331	1.324
375	5.69	35.577	0.321	1.282
390	5.52	35.888	0.311	1.243
405	5.36	36.190	0.302	1.206
420	5.21	36.483	0.293	1.172

Time (min)	Precipitation Alternating Block Method ΔP_{100} (mm)	Intensity Alternating Block Method ΔI_{100} (mm/h)
345-360	0.383	1.531
360-375	0.355	1.419
375-390	0.331	1.324
390-405	0.311	1.243
405-420	0.293	1.172

Table 18. Hyetograph table for 100 years return period.

ANNEX C. HEC-HMS Model

ANNEX C. HEC-HMS Model

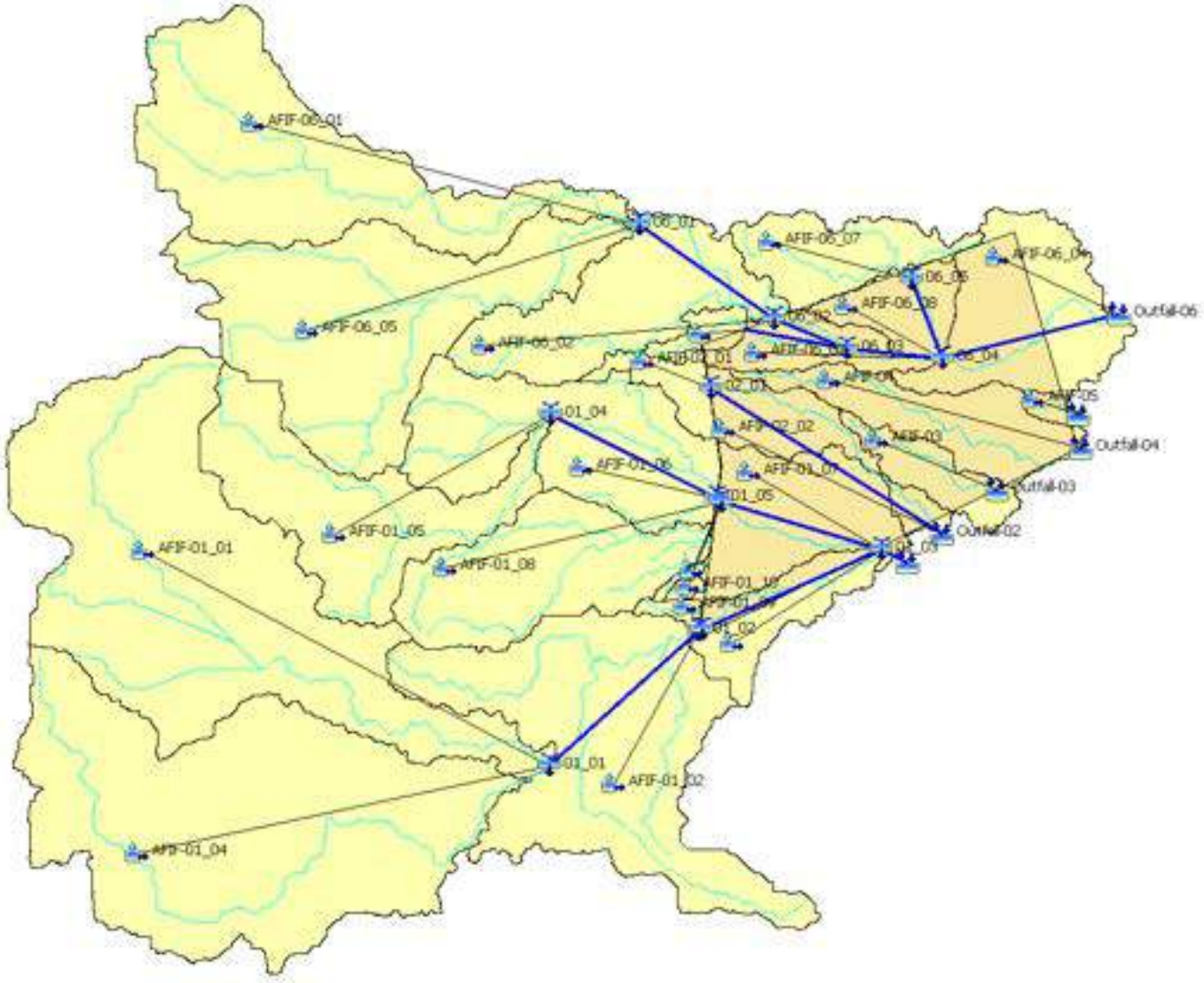


Figure 52. HEC-HMS model.

Sub-basin characteristics are described below

Basin	Area (km^2)	Main stream	Length (m)	H_{Upper} (masl)	H_{Lower} (masl)	Slope (m/m)	T_C (min)	T_C (h)	T_{Lag} (min)	T_{Lag} (h)
AFIF1-01	169.106	MS01	32,048.98	1,173.11	976.35	0.0061	409.02	6.82	269.96	4.50
AFIF1-01_01	42.139	MS-01_01	20,367.57	1,173.11	1,009.81	0.008	260.33	4.34	156.20	2.60
AFIF1-01_02	26.378	MS-01_02	6,300.92	1,009.81	991.50	0.0029	155.91	2.60	93.55	1.56
AFIF1-01_03	5.098	MS-01_03	5,380.89	991.50	976.32	0.0028	139.65	2.33	83.79	1.40
AFIF1-01_04	41.033	MS-01_04	20,453.21	1,079.41	1,009.81	0.0034	363.26	6.05	217.96	3.63
AFIF1-01_05	15.250	MS-01_05	12,489.07	1,189.89	1,001.80	0.0151	140.14	2.34	84.08	1.40
AFIF1-01_06	15.600	MS-01_06	4,918.93	1,001.80	987.07	0.003	127.37	2.12	76.42	1.27
AFIF1-01_07	9,4370	MS-01_07	4,550.02	987.07	976.32	0.0024	131.4	2.19	78.84	1.31
AFIF1-01_08	13,114	MS-01_08	9,247.02	1,049.37	986.58	0.0068	151.09	2.52	90.66	1.51
AFIF1-01_09	0.537	MS-01_09	1,487.29	996.36	990.13	0.0042	44.56	0.74	26.74	0.45
AFIF1-01_10	0.276	MS-01_10	817.22	996.36	989.53	0.0084	21.54	0.36	12.92	0.22
AFIF1-01_11	0.243	MS-01_11	1,335.10	996.50	987.78	0.0065	34.56	0.58	20.74	0.35
AFIF1-02	7.167	MS-02	9,306.69	998.36	974.17	0.0026	219.77	3.66	145.05	2.42
AFIF1-02_01	2.154	MS-02_01	2,629.86	1,001.14	992.44	0.0033	75.68	1.26	45.41	0.76
AFIF1-02_02	5.014	MS-02_02	7,483.41	992.44	974.31	0.0024	190.9	3.18	114.54	1.91
AFIF1-03	3.374	MS-03	4,697.17	982.09	973.55	0.0018	148.96	2.48	98.31	1.64
AFIF1-04	7.487	MS-04	9,786.10	989.67	970.39	0.0020	254.15	4.24	167.74	2.80
AFIF1-05	0.573	MS-05	1,412.59	974.05	970.84	0.0023	54.20	0.90	35.77	0.60
AFIF1-06	86.205	MS-06	30,678.01	1,156.41	968.22	0.0061	395.61	6.59	261.10	4.35
AFIF1-06_01	22.598	MS-06_01	16,063.35	1,158.01	998.67	0.0099	199.78	3.33	119.87	2.00
AFIF1-06_02	12.187	MS-06_02	4,885.95	998.67	987.39	0.0023	140.05	2.33	84.03	1.40
AFIF1-06_03	3.790	MS-06_03	4,506.06	987.39	977.21	0.0023	132.69	2.21	79.62	1.33
AFIF1-06_04	11.555	MS-06_04	5,222.66	977.21	968.34	0.0017	165.93	2.77	99.56	1.66
AFIF1-06_05	24.907	MS-06_05	13,208.02	1,190.95	998.67	0.0146	148.24	2.47	88.94	1.48
AFIF1-06_06	1.362	MS-06_06	5,494.69	996.67	983.07	0.0025	149.25	2.49	89.55	1.49
AFIF1-06_07	5.954	MS-06_07	5,184.48	992.37	980.17	0.0024	145.52	2.43	87.31	1.46
AFIF1-06_08	3.853	MS-06_08	2,423.47	980.17	977.30	0.0012	105.55	1.76	63.33	1.06

Table 19. Physiographic sub-basins data.

1. OUTFALL 1

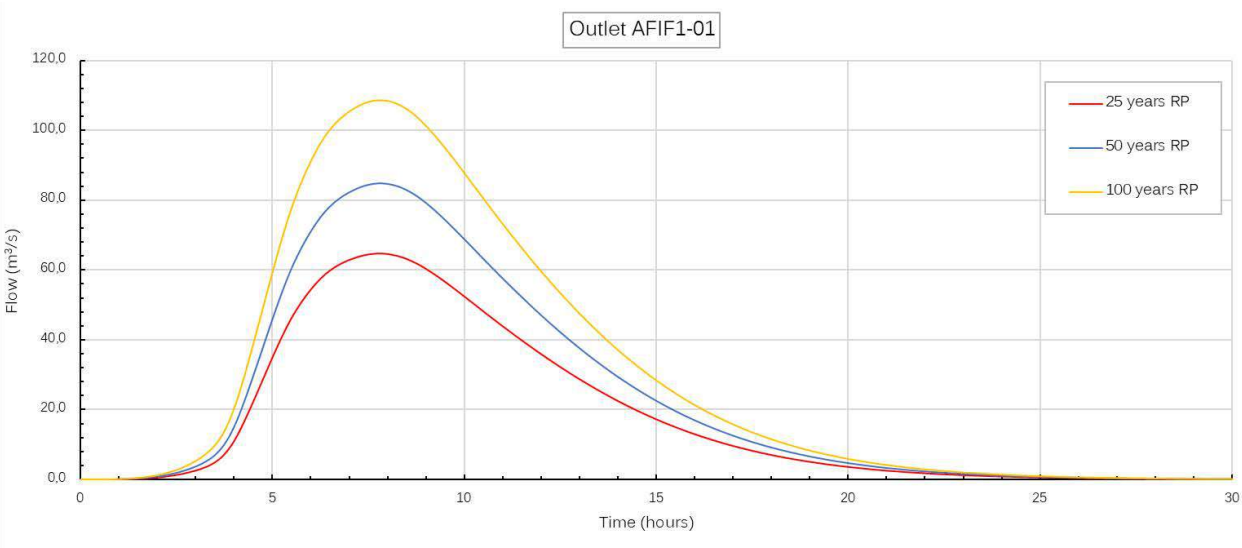


Figure 53. Outlet AFIF1-01 hydrograph.

2. OUTFALL 2

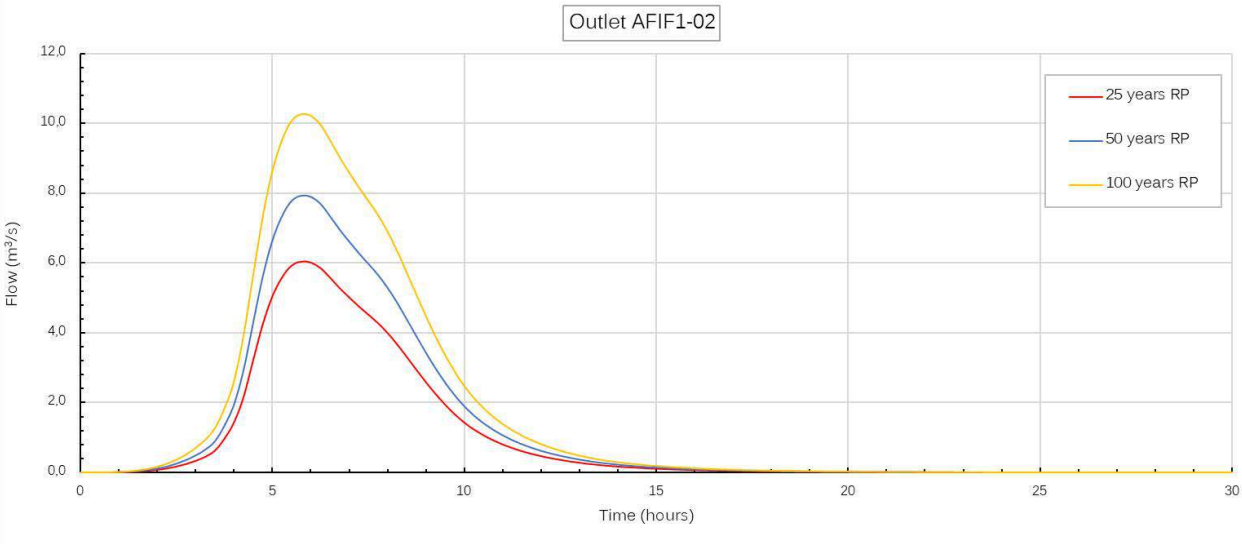


Figure 54. Outlet AFIF1-02 hydrograph.

3. OUTFALL 3

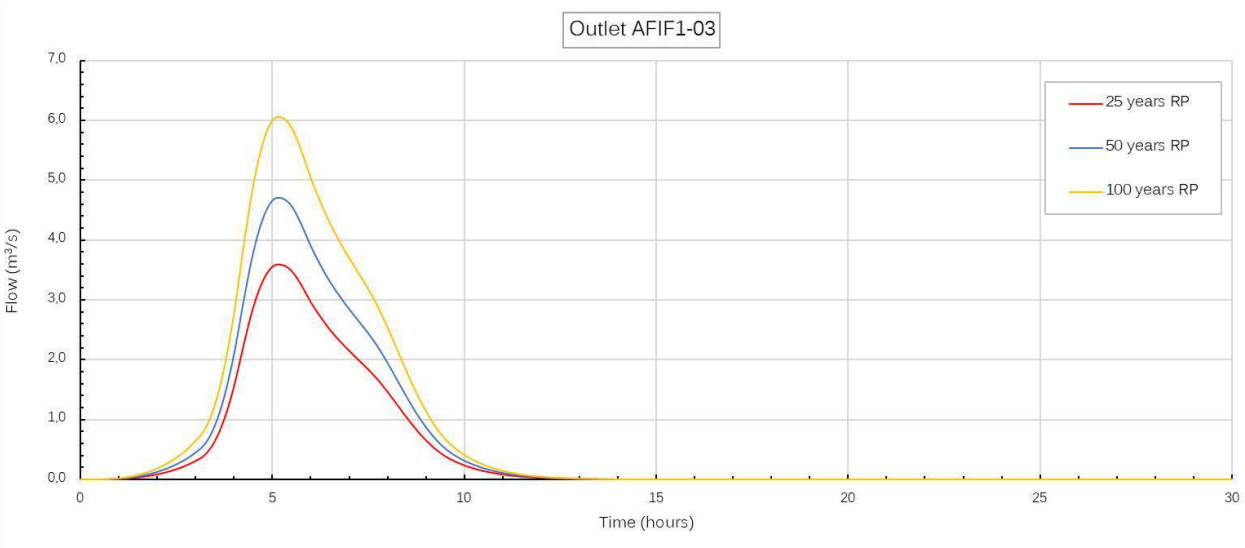


Figure 55. Outlet AFIF1-03 hydrograph.

4. OUTFALL 4

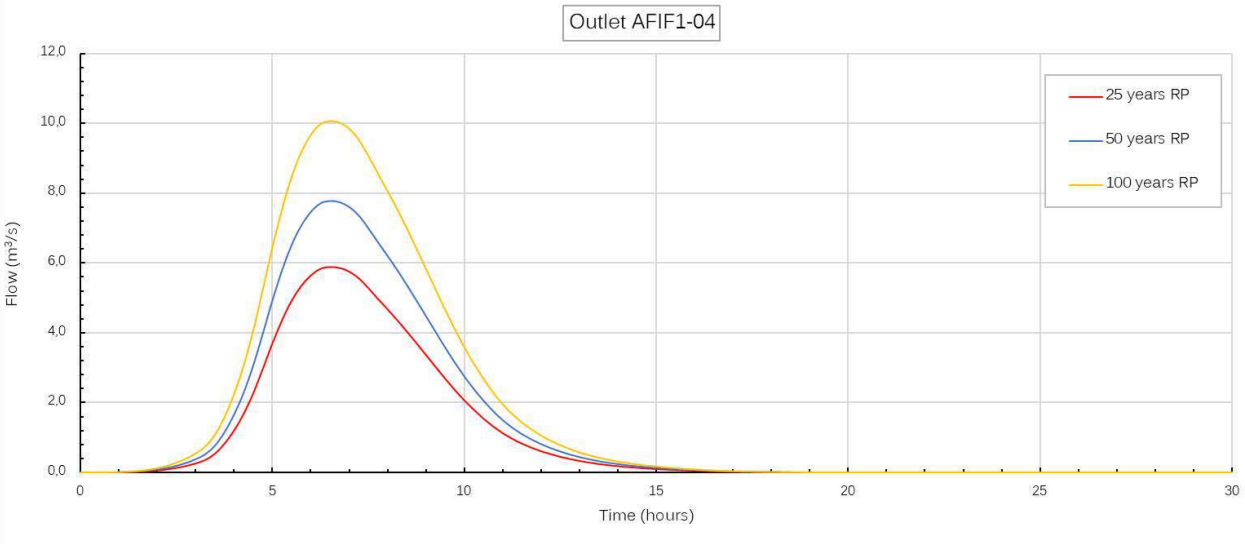


Figure 56. Outlet AFIF1-04 hydrograph.

5. OUTFALL 5

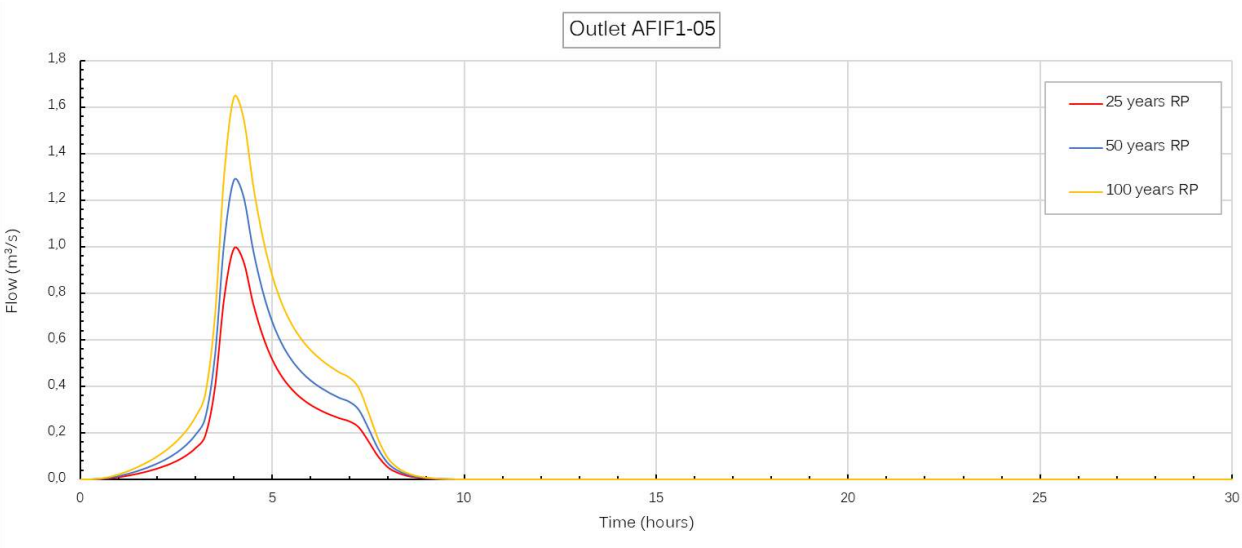


Figure 57. Outlet AFIF1-05 hydrograph.

6. OUTFALL 6

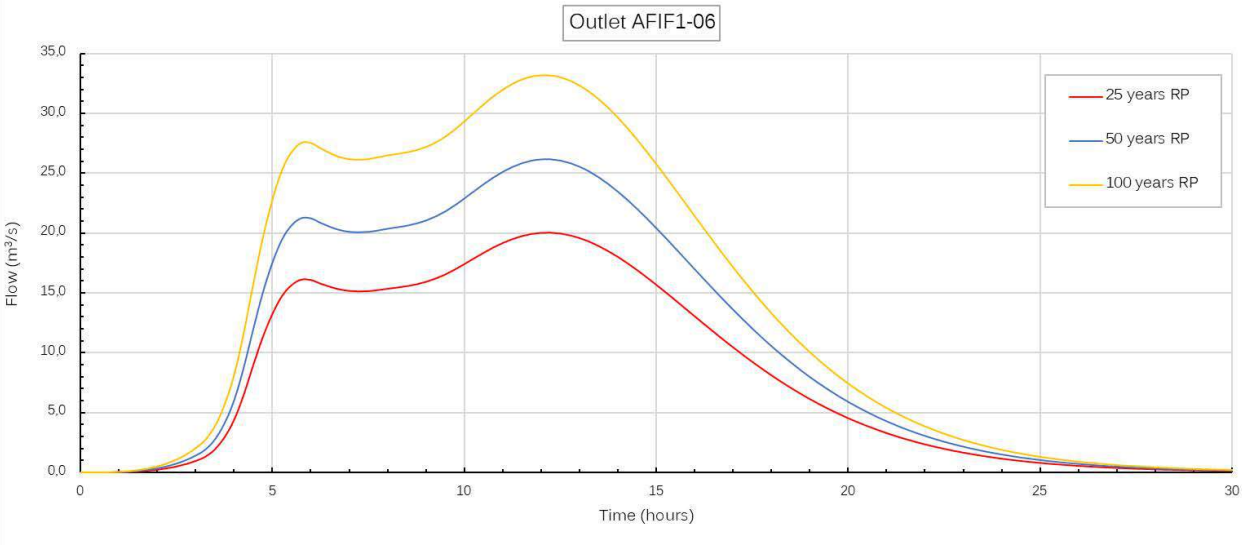
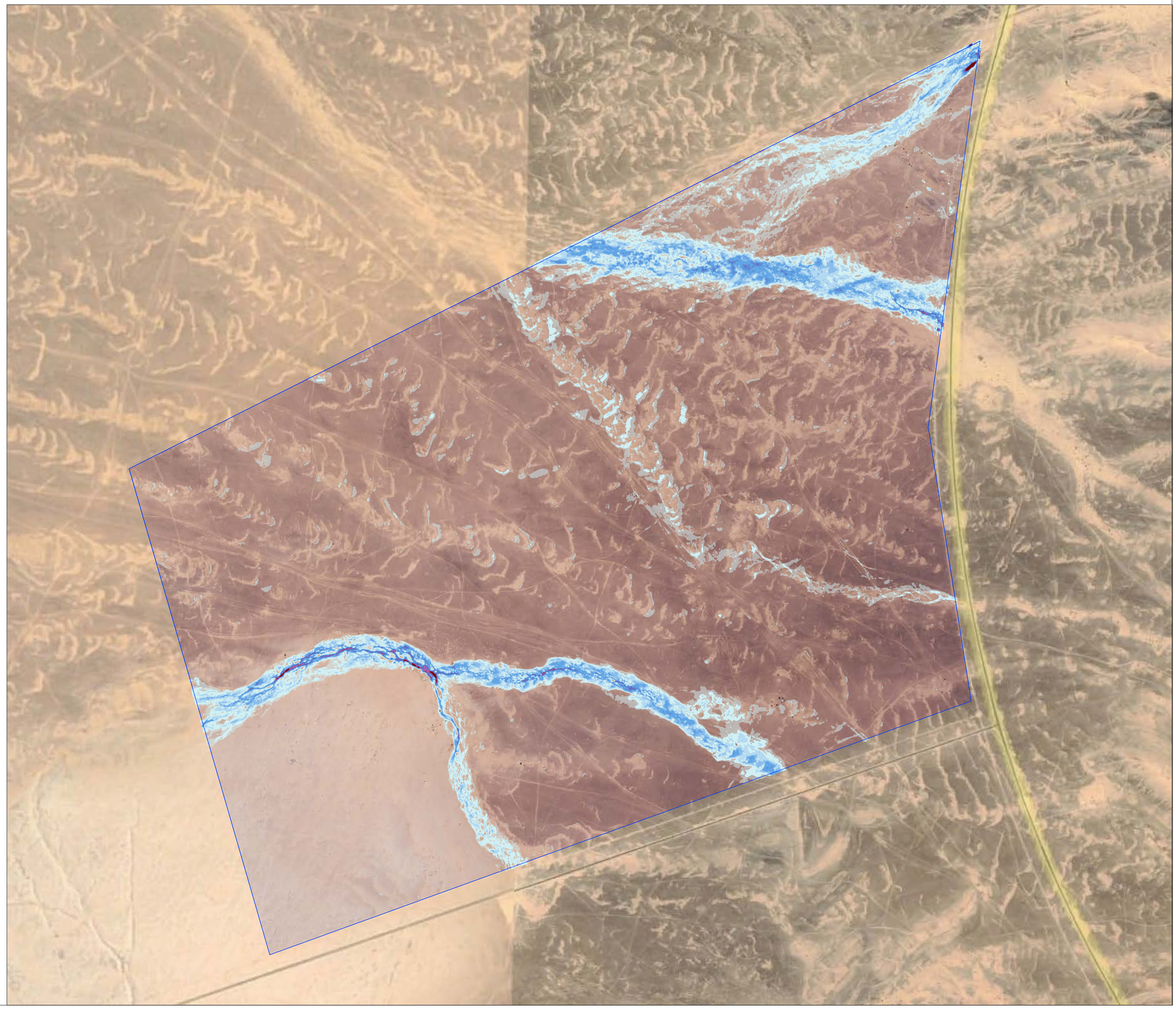


Figure 58. Outlet AFIF1-06 hydrograph.



Rev.	Date	Designed	Drawn	Checked	Approved	Description
0	APRIL-2024	SPD	MBH	JAL	LRT	First Issue

Drawing Status:

Client:

Engineering:

Project:

AFIF 1 PV PLANT

Drawing Title:

MAXIMUM DEPTH RP-25 YEARS

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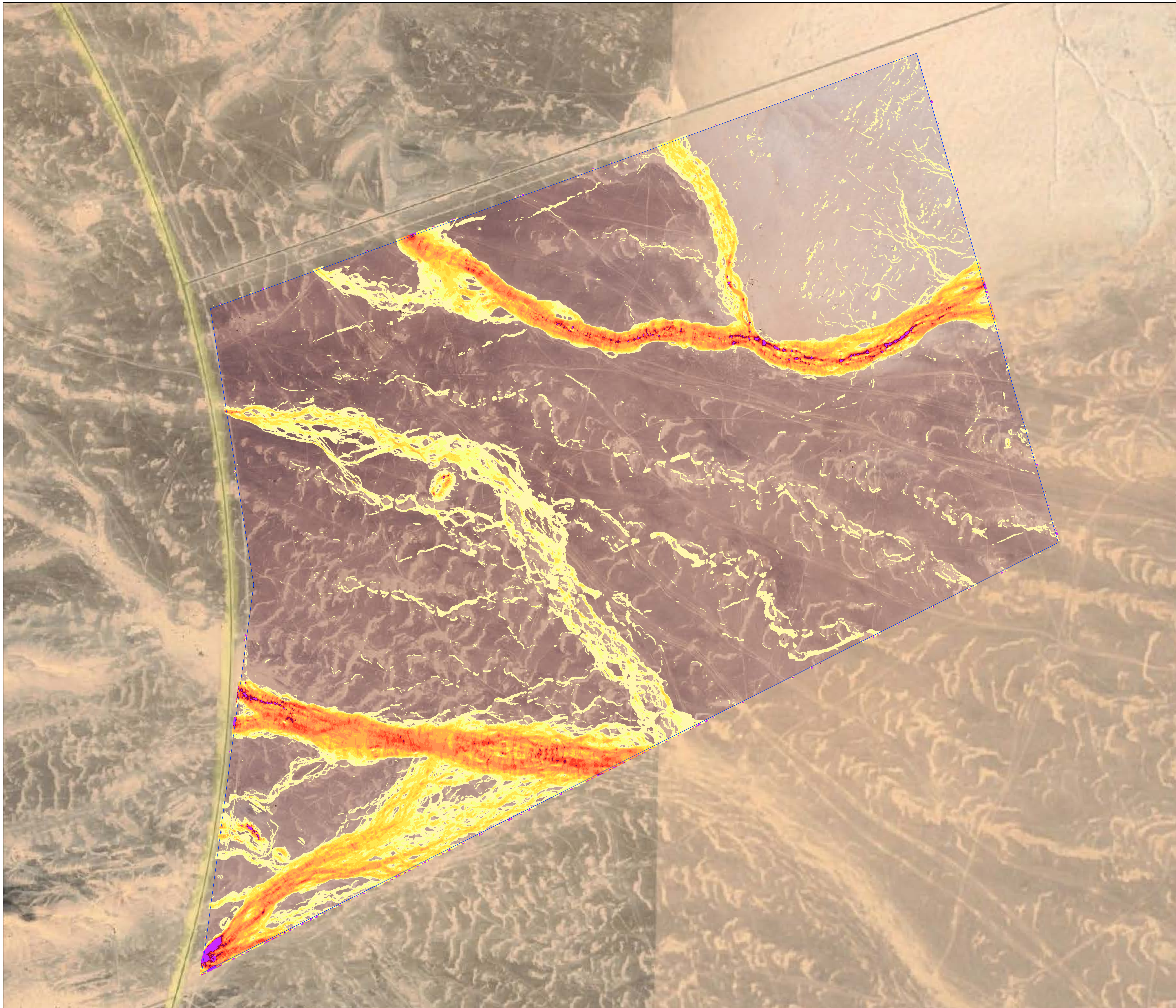

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Engineering: TYPSA INGENIEROS CONSULTORES Y ARQUITECTOS

Project:

AFIF 1 PV PLANT

Drawing Title:

MAXIMUM VELOCITY RP-25 YEARS

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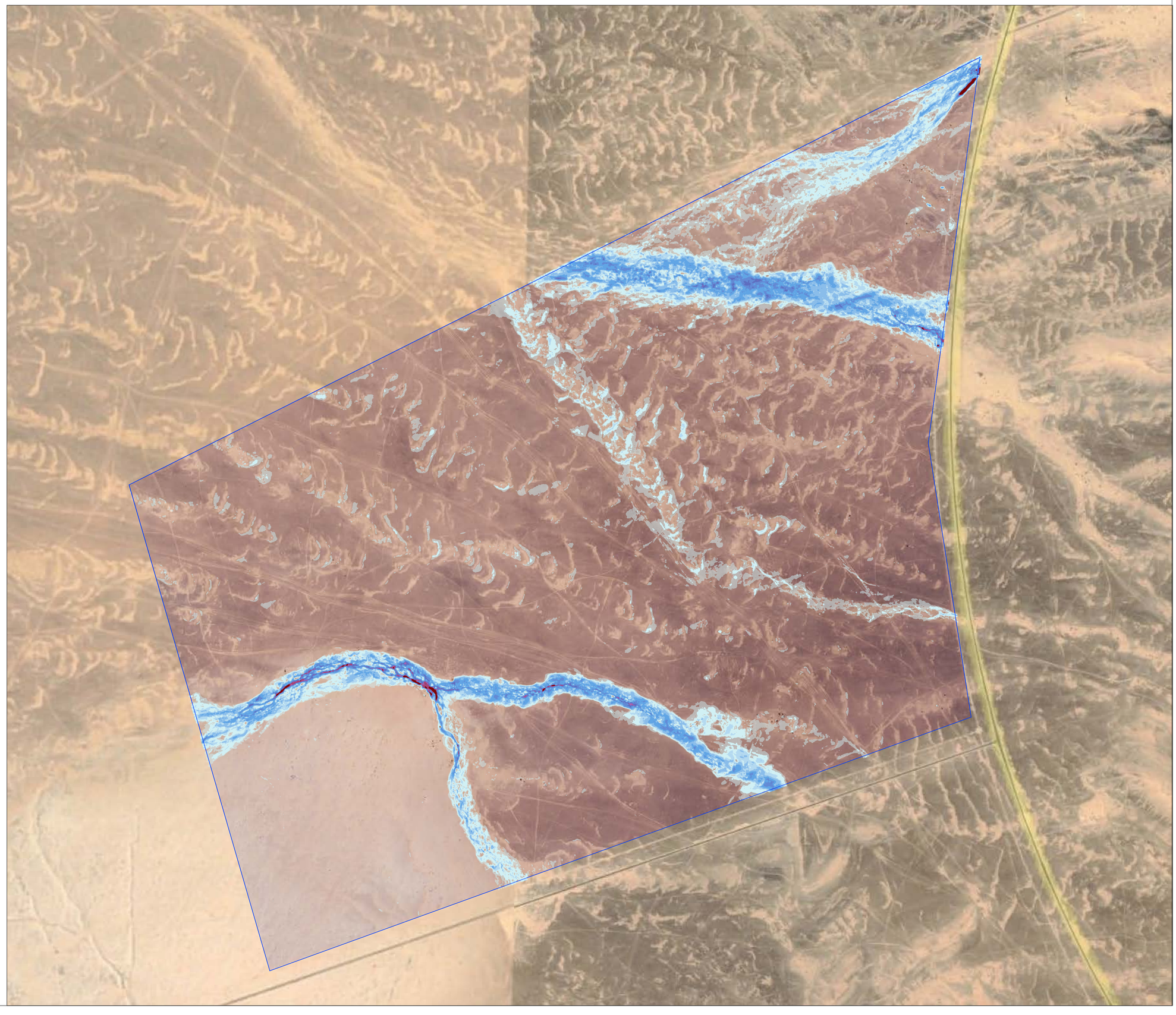

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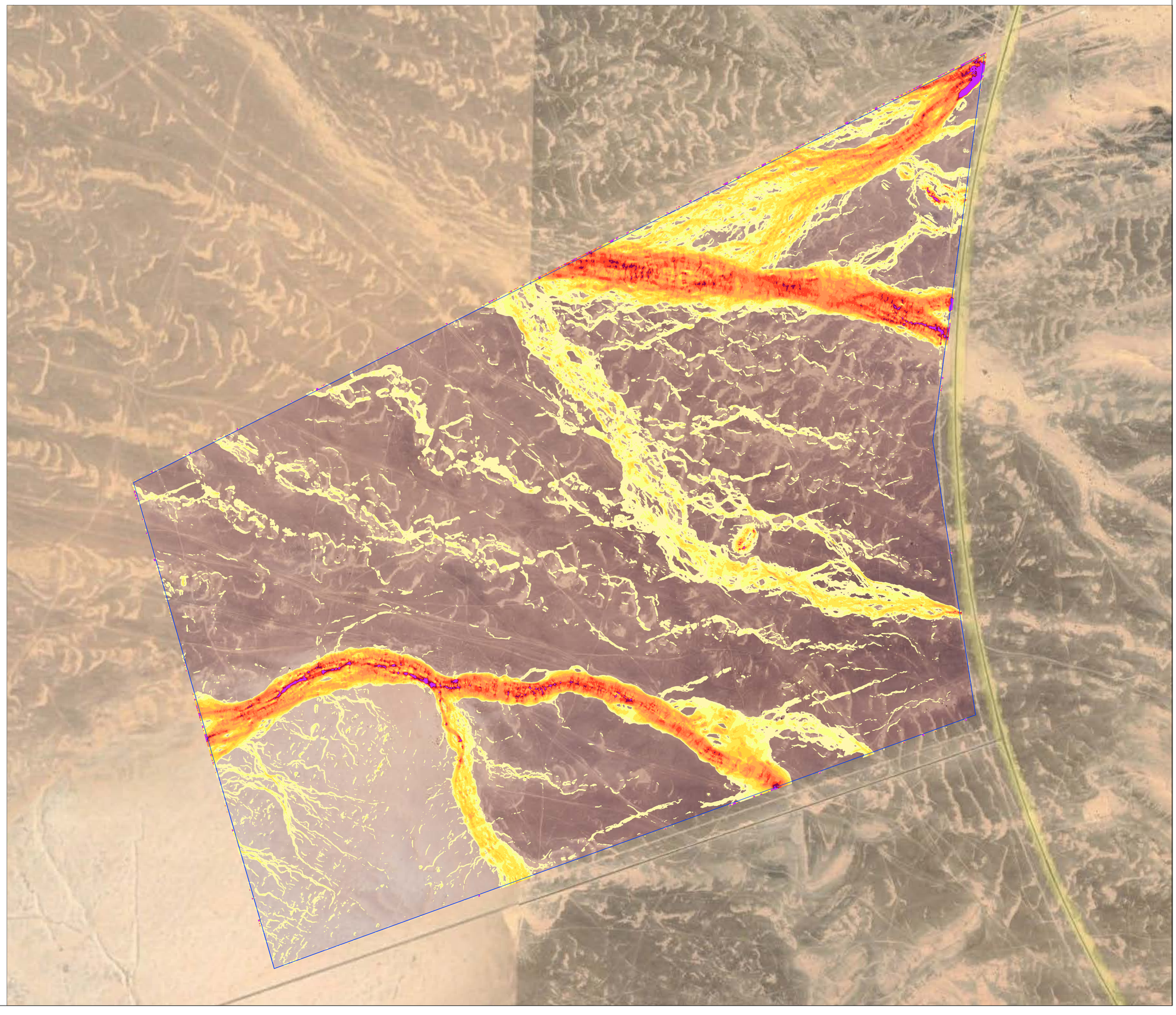

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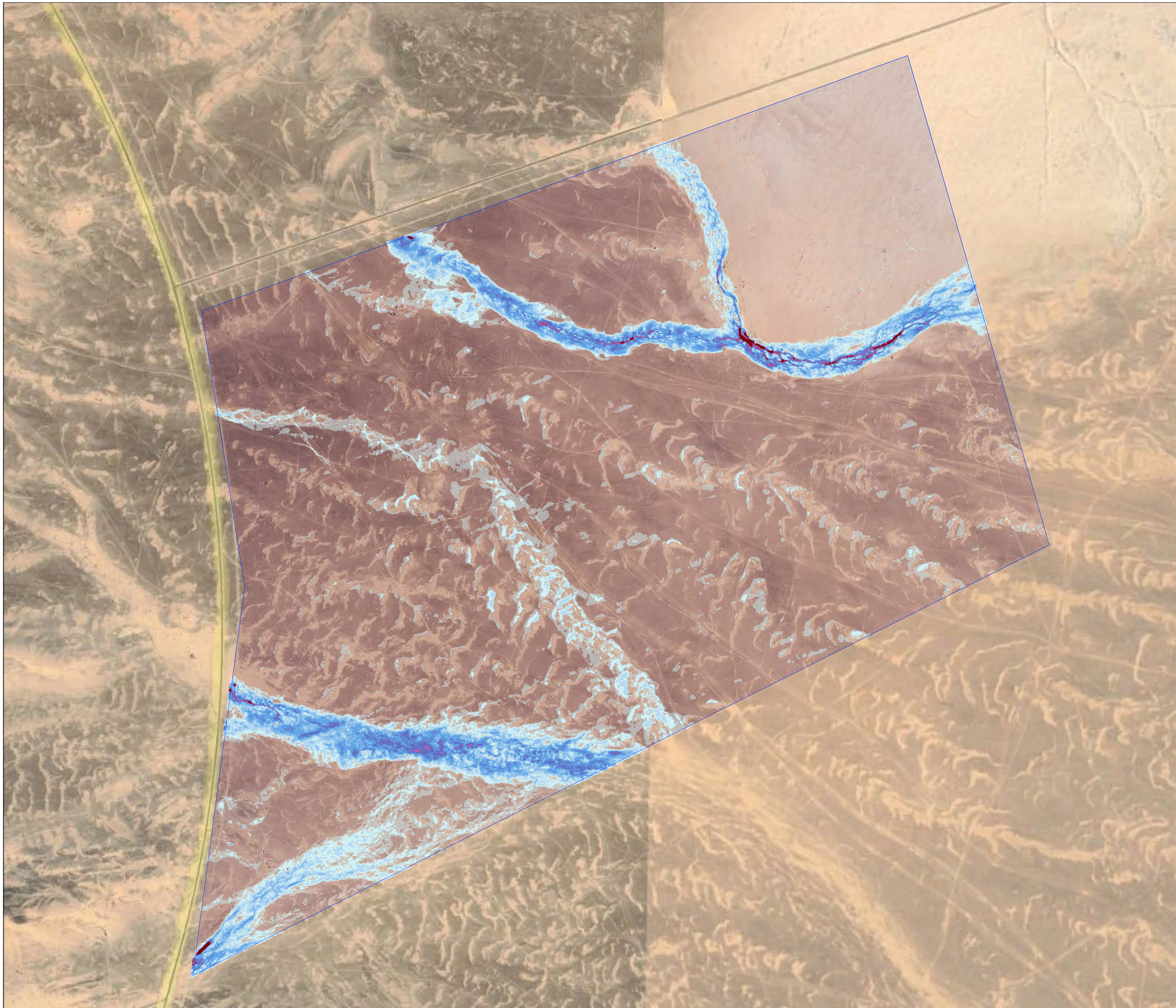

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MAXIMUM DEPTH RP - 100 YEARS

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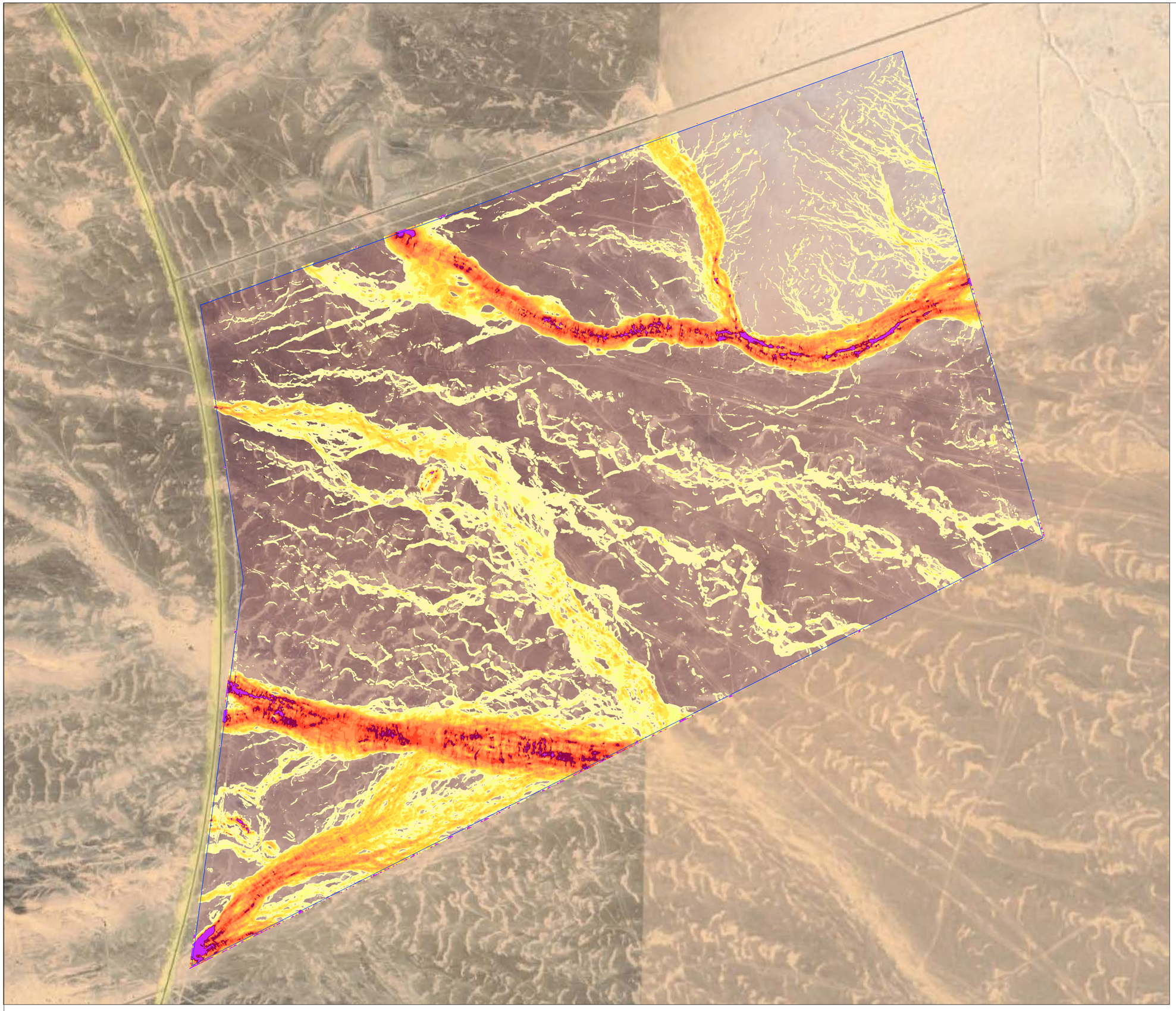

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Engineering: TYPSA INGENIEROS CONSULTORES Y ARQUITECTOS

Project:

AFIF 1 PV PLANT

Drawing Title:

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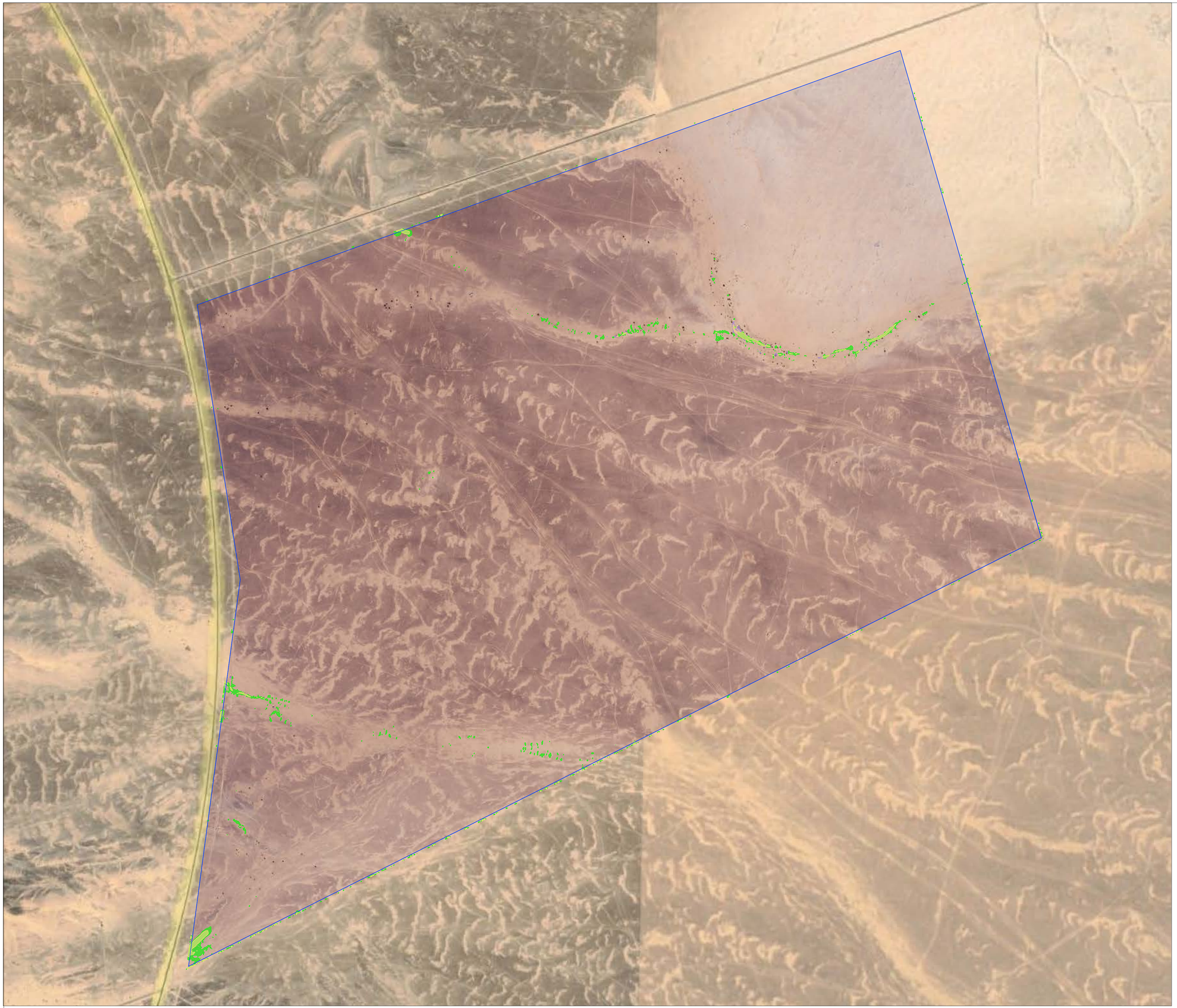

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AFIF 1 PV PLANT

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FLOOD HAZARD

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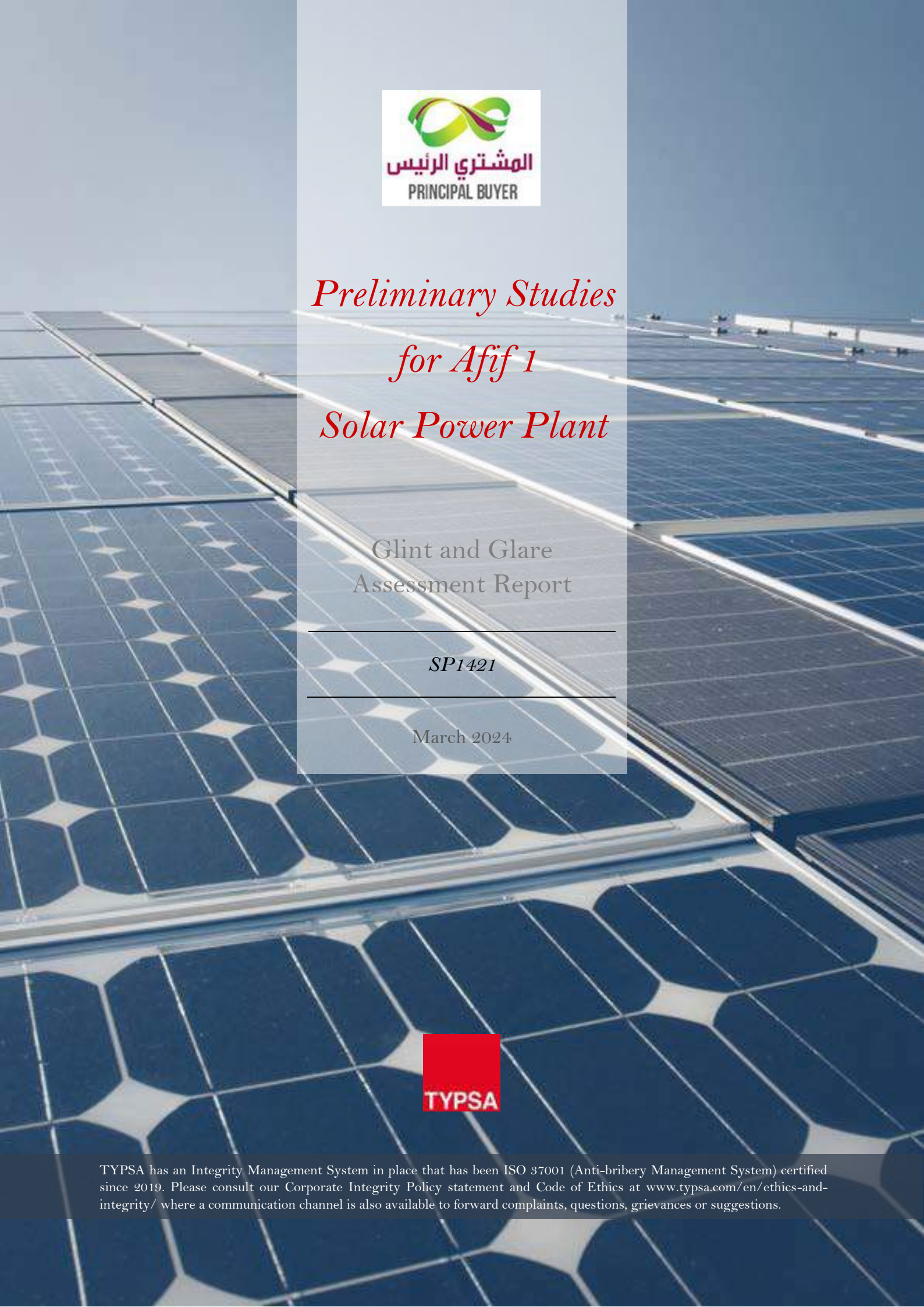
8.3.4. Annex nº 3.4 Glint and Glare Assessment



المشتري الرئيس
PRINCIPAL BUYER

Preliminary Studies for Afif 1 Solar Power Plant

Glint and Glare Assessment Report

SP1421

March 2024

TYPSA

TYPSA has an Integrity Management System in place that has been ISO 37001 (Anti-bribery Management System) certified since 2019. Please consult our Corporate Integrity Policy statement and Code of Ethics at www.typsa.com/en/ethics-and-integrity/ where a communication channel is also available to forward complaints, questions, grievances or suggestions.

Quality control sheet

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Table of contents

Executive Summary 8

Glint and Glare 9

Assessment Report 9

1. Introduction 9
2. Scope and purpose of the document 10
3. Site details 10
4. Applicable standards and procedures 12
5. Glint and Glare fundamentals 13
   - 5.1. Definition 13
   - 5.2. Ocular Impact 13
   - 5.3. Reducing reflection 14
   - 5.1. Glare Reduction Methods 15
6. Methodology 17
   - 6.1. Site visit based approaches: Helicopter flyover approach 17
   - 6.2. Computer-based approaches 17
     - 6.2.1. Solar Glare Hazard Analysis Tool (SGHAT) 17
     - 6.2.2. ForgeSolar 18
     - 6.2.3. Report Interpretation 21
7. Receptors 23
   - 7.1. Almardamah Road and Haraniga Road 23
   - 7.2. Dawadmi Domestic Airport 24
     - 7.2.1. Background 24
     - 7.2.2. Runway and Flight Paths 25
     - 7.2.3. Airport Traffic Control Tower (ATCT) 25
8. Simulation & Analysis of results 26
   - 8.1. Inputs & Setup 26
   - 8.2. Results 27
   - 8.3. Vegetation Barrier Results 28
9. Conclusions 29
10. References 30

Annexes 31

Annex A. ForgeSolar General Glare Analysis Report 31

Annex B. ForgeSolar Glare Analysis Report with Vegetation Barrier 32

List of figures

Figure 1. General Project Location 9
Figure 2. Afif 1 Site 10
Figure 3. Afif 1 Site and Dawadmi Domestic Airport 11
Figure 4. Afif 1 Site and route 30 11
Figure 5. Sample glare hazard plot defining ocular impact as a function of 14
Figure 6. Solar PV Glare observed at Manchester Boston Regional Airport. 15
Figure 7. Example of expected glare per month. Source: ForgeSolar 19
Figure 8. Reflectance profiles of typical PV module materials (Source: Yellowhair, 2015). 19
Figure 9. Module surface reflectivity as a function of incidence angle. Source: ForgeSolar 20
Figure 10. Almardamah Road and Haraniga Road 23
Figure 11. Location of airports in Saudi Arabia (GACA) 24
Figure 12. Runway 25
Figure 13. ATCT 25
Figure 14. PV Array description in ForgeSolar Report. 26
Figure 15. Results 27
Figure 16. Annual Predicted Glare Example 27
Figure 17. Vegetation Barrier Example 28
Figure 18. Results (vegetation barrier) 28

List of tables

Table 1. General Site Data Table 10
Table 2. Site Coordinates 10

Executive Summary

Saudi Power Procurement Company (Principal Buyer) is developing a new photovoltaic power plant, named Afif 1 Solar Power Plant with an area of 39.87 km^2 located about 23 km southeast to the city of Afif in the Riyadh Province, Saudi Arabia. Positioned at an altitude of 978 meters above sea level.

As part of the pre-development studies, an analysis of the potential glint or glare occurrence on the existing nearby airports and roads by means of the ForgeSolar photovoltaic simulation planning software is required.

No glare caused by the future Afif 1 Solar Power Plant is expected at any of the Flight Paths studied and the ATCT of the Dawadmi Domestic Airport, the closest Saudi airport according to GACA's public information.

The simulation only reveals minor glint and glare during few hours of the day on both main roads that run parallel to Afif 1 Solar Power Plant. This level of glare is not a relevant and mainly occurs during short periods at sunrise and sunset of some months.

This issue can be easily solved by placing a vegetation barrier around the PV plant .

The presented conclusions should only be used as an initial approach to the Glint and Glare issue. For a more precise estimate, a ForgeSolar glare analysis should be later on updated once final plant configuration is performed by IPP developer on final project stage for definitive information. However, results are not expected to differ to much from the current assessment since the site location, technology and land occupation are not expected to change, only internal PV plant arrangement.

Glint and Glare Assessment Report

1. Introduction

The National Renewable Energy Program (NREP) is a strategic initiative under Vision 2030 and the Kingdom Renewable Energy Initiative. The program aims to maximize the potential of renewable energy in Saudi Arabia.

The program sets out an organized and specific road map to diversify local energy sources, stimulate economic development and provide sustainable economic stability to the Kingdom considering the goals set for Vision 2030, which include establishing the renewable energy industry and supporting the advancement of this promising sector while working to fulfill the Kingdom's commitments to reducing carbon dioxide emissions.

The Ministry of Energy works to execute the NREP through its development branch Saudi Power Procurement Company (SPPC), as it is responsible for the Pre-Development phase and Tendering phase for renewable energy projects across the kingdom.

The park area within the Afif 1 Solar Power Plant is strategically positioned to complement the project's solar infrastructure, ensuring a practical blend of functionality and land use.

The park area has been meticulously planned and defined during the early stages of the development phases. The land is secured, and the boundaries of this area are clearly demarcated within the site plan documentation, to eliminate any potential ambiguity.

Figure 1. General Project Location

2. Scope and purpose of the document

This report is prepared to fulfill some requirements during the predevelopment of this power plant:

- As required by GACA after the Stakeholder Meeting for SPPC PV plant development held on 14th February 2024.
- As part of the *ESIA* report and completes other works and surveys of the pre-development activities for this solar project.

The potential reflection from the solar PV arrays over the control towers and airplanes is a major concern for airport authorities. Furthermore, FAA regulation must be applied, and the airport must certify that the there is no risk of an optical impact on the airport traffic control tower cab based on a glint and glare detailed study.

Additionally, the potential reflection from the solar PV arrays might also impact on the driver of the nearest road. No formal regulation is applicable for this. However, the good practices must plan to avoid any adverse effect as much as possible.

The following paragraphs assesses the potential glint or glare occurrence on the existing road and the airport by using the ForgeSolar photovoltaic simulation planning software.

3. Site details

The table below summarizes the main features of the site:

Solar Power plant	Available surface (km^2)	X (WGS84/UTM Z 38N)	Y (WGS84/UTM Z 38N)	Elevation (m.a.s.l.)
Afif 1	39.87	311,794.12	2,632,476.74	978

Table 1. General Site Data Table

The coordinates (WGS 84 / UTM zone 38N) of the corners of the boundary are the following:

Point	X	Y
1	308,575.91	2,631,499.10
2	308,090.69	2,627,874.90
3	316,083.49	2,631,891.10
4	314,761.60	2,636,457.17
5	308,172.56	2,634,073.88

Table 2. Site Coordinates

Figure 2. Afif 1 Site

The figure below shows the location of the project with respect to the Dawadmi Domestic Airport:

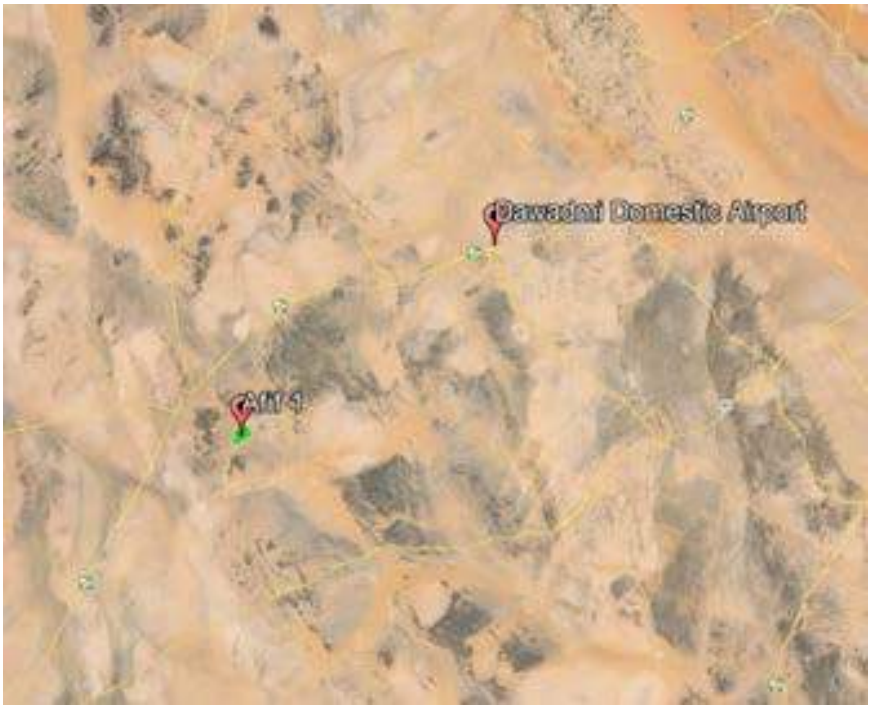


Figure 3. Afif 1 Site and Dawadmi Domestic Airport

Dawadmi Domestic Airport is located approximately about 120 km away from the PV plan as later depicted on Figure 11.

The last figure shows the location of the project and the different roads that run parallel to the site. (Almardamah Road is about 60 m away from the PV Solar Plant and Haraniga Road is about 150 m away):

Figure 4. Afif 1 Site and route 30

4. Applicable standards and procedures

Depending on the PV location and its orientation, glare can last for several hours. As a result, glare is expected to occur frequently throughout the year. The pilot's visibility is affected when reflected sunshine enters his or her eyes. This visual impairment leads to faulty airplane landings. When the risk of this hazard is qualified as unacceptable, some counter measurements should be applied to reduce it accordingly to acceptable levels. After construction, if any glare effects are found, the airport must implement the necessary measures to mitigate them.

The Federal Aviation Administration published a paper titled "*Technical Guidance for the Evaluation of Selected Solar Technologies on Airports*" in 2010 and an update titled "*Interim Policy, FAA Review of Federally Obligated Airports Solar System Projects*" in 2013. The final version of this document, titled "*Final Policy, Review of Solar Energy System Projects on Federally Obligated Airports. Document Number 2021-09862*", " was just published in 2021.

This document specifies that the current Airport Traffic Control Tower must be devoid of any glare potential. Moreover, the final approach path of aircraft should exhibit only a minimal potential for afterimages, indicated by the color green on the Glare Hazard Plot. Furthermore, as per FAA regulations, glare exceeding an angle of 50 degrees from the pilot's line of sight can be disregarded as it does not present a safety threat.

At first, the FAA (Federal Aviation Administration) considered that solar energy systems in the vicinity of airports may give pilots on the final approach a disruptive glint and glare impact. The FAA has since concluded that, in the majority of cases, the glint and glare that solar energy systems cause to pilots during the final approach is comparable to the glint and glare that pilots frequently encounter from water features, glass-façade structures, parking facilities, and similar features.

Nevertheless, ongoing reports of potential glint and glare emanating from on-airport solar energy installations impacting personnel within ATCT cabs have continued. Consequently, the FAA has determined that the agency policy should prioritize examining the impact of on-airport solar energy systems on federally obligated towered airports, particularly on the ATCT cab at these airports.

As mentioned before, there is no specific regulation on roads regarding the glint and glare issue; nevertheless, the main objective will be to avoid or limit the potential hazard or distraction for drivers as much as possible.

5. Glint and Glare fundamentals

5.1. Definition

Glint is commonly defined as a brief flash of brilliant light created by a moving source's reflection. A transient solar reflection from a moving car is an example of glint.

A constant source of bright light is known as glare. Glare is usually linked with stationary objects that reflect sunlight for a longer period of time due to the slow relative movement of the sun. The duration is the difference between glint and glare. Industry-standard glare analysis techniques measure glare on a minute-by-minute basis; consequently, solar risks are commonly referred to as 'glare.'

According to the Federal Aviation Administration of the United States, momentary blindness, commonly known as flash blindness, occurs when 7-11 W/m2 of irradiance hits the eye for 4-12 seconds. This is merely a 1-2 percent reflection of typical solar irradiance (incoming sunshine) for a specific area, which typically ranges between 800-1000 W/m2.

A surface's reflected light might also be 'Specular' or 'Diffuse.' Specular reflection occurs when a smooth and polished surface, such as glass or water, reflects light in a concentrated beam. A rough surface, such as vegetation or pavement, causes diffuse reflection, which results in a less concentrated beam of light. For individuals in the receiving angle field, specular reflection can cause 'Glint' or 'Glare'. The percentage of specular reflection from solar PV panels is still a point of contention.

5.2. Ocular Impact

The ocular impact of solar glare is quantified into three categories (Ho, 2011):

- **Green** - low potential to cause after-image (flash blindness).
- **Yellow** - potential to cause temporary afterimage.
- **Red** - potential to cause retinal burn (permanent eye damage).

The metric proposed by Ho et al. appears to be the most practical among the existing glare evaluation metrics, as suggested by Danks et al. (2016). Glare impact is delineated by the potential for irreversible eye injury, the likelihood of after-image occurrence, and the low probability of after-images based on retinal irradiance and subtended source angle, as outlined by Ho and Sims (2012). To visualize the impact of glare, a Glare Hazard Plot, which is a function of subtended source angle and retinal irradiance, is employed.

Each minute of glare is represented by a small circle in the appropriate hazard zone on the chart. There are three sections in this graph: low potential for after-image, potential for after-image, and retinal burn. After-image potential is represented by the plot region below the retinal burn line (red color). When a large amount of solar insolation penetrates the retina, permanent eye damage (also known as retinal burn) occurs. Solar PV array reflections are not focused enough to cause retinal injury. A reference point is provided for convenience, illustrating the risk of viewing the sun without filtration, i.e. looking at the sun.

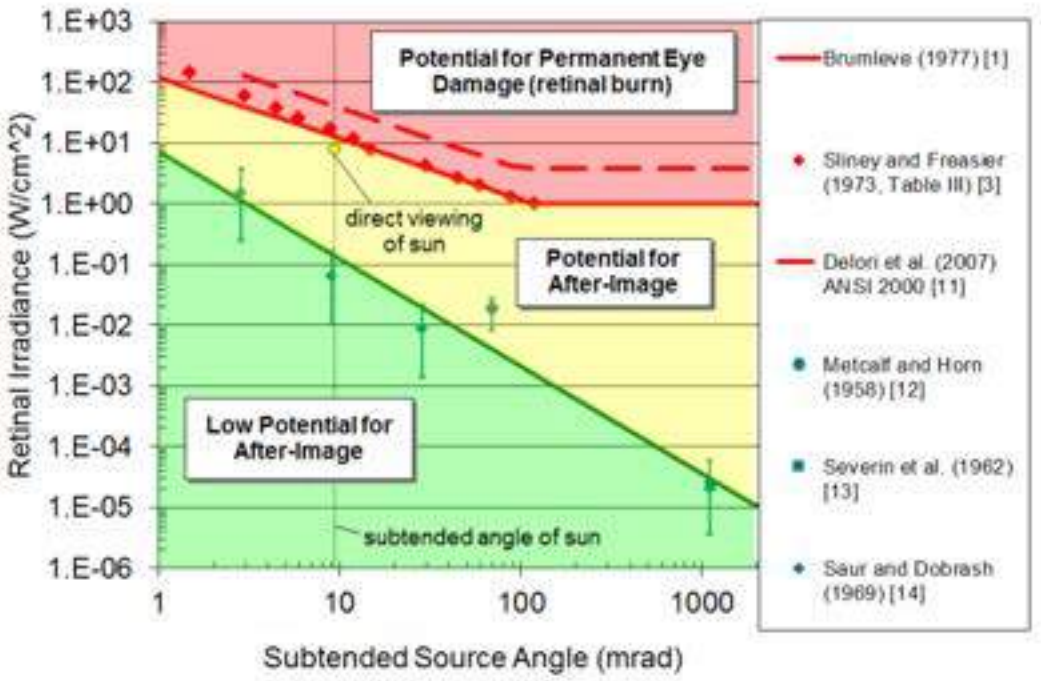


Figure 5. Sample glare hazard plot defining ocular impact as a function of retinal irradiance and subtended source angle (Ho, 2011)

Glint/Glare can be a concern for aviation safety when the solar farm is close to a runway, especially when the plane is descending to land. The aircraft will most likely be at a higher altitude than the sun reflection, therefore enroute activities will not be a concern. The other more frequent ocular impact of solar glare may occur to the personnel at the Air Traffic Control Tower (ATCT).

5.3. Reducing reflection

The surface reflection of bare silicon is more than 30%. Texturing and applying anti-reflection coatings (ARC) to the surface helps diminishing reflection. Solar cells have anti-reflection coatings similar to those seen on other optical devices like camera lenses. They are made up of a thin layer of dielectric material with a specific thickness that causes the wave reflected from the ARC top surface to be out of phase with the wave reflected from the semiconductor surface. This causes a destructive interference of the out-of-phase reflected waves, resulting in zero net reflected energy.

While the reflection can be reduced to zero for a particular thickness, index of refraction, and wavelength, the index of refraction is wavelength dependent, therefore zero reflection happens only at a single wavelength. The refractive index and thickness for photovoltaic applications are selected to minimize reflection for a wavelength of 0.6 m. This wavelength was chosen because it is near to the solar spectrum's peak output. However, because solar PV modules operate across a spectrum, ARC cannot be designed to cover the whole range. Instead, ARC coatings are designed to reduce total reflectance losses rather than glancing angle reflectivity or specific polarizations.

The use of rough surfaces and anti-reflection materials to reduce reflection has been extensively studied. Surface-topography based ARC such as porous, photonic nanostructures, textured glass, and anti-reflection

grating were developed in response to the demand for omnidirectional AR (ARG). The usage of these PV materials improves conversion efficiency while reducing reflective energy losses (Tallberg et al., 2019).

The solar PV module's front glass cover can be altered optically to reduce glare and increase light absorption. Texturing the PV's module, which is predicated on light trapping and increasing internal reflections, is another way to reduce reflection. The pyramid, inverted pyramid, and honeycomb are examples of texturing structures that could be placed on the top surface. To get the desired level of texture, the spacing between structures and their depth are modified (lightly to deeply).

To avoid Glint and Glare, most solar PV module manufacturers now use anti-reflective coating (ARC). The coating is crucial because it reduces the reflection of the bare solar cell from 30% to 3-4%. The AR coating's lifespan is limited due to natural corrosion and module cleaning.

Figure 6. Solar PV Glare observed at Manchester Boston Regional Airport.

Dust/haze clouds or high humidity in the atmosphere disperse sunlight. Because this component of sunlight (known as dispersed or diffuse irradiance) has no directionality, it has only a minor impact on the occurrence of glare.

5.1. Glare Reduction Methods

Reducing glare is achieved through many possible approaches, usually acting simultaneously, below we present a compilation of the relevant methods, including those already detailed above:

- **Selection of PV modules with special Anti-Reflective (AR) coating:** Manufacturers generally reduce reflection by utilizing low-iron high-transmission glass followed by anti-reflective treatment. An extra layer of anti-reflective substance on the exterior surface of the glass is used in newer generations of panels to further reduce sunlight reflection. This also aids in increasing solar absorption.
    - Solar panels in several international airports have been chosen for their low reflectance factor (much lower than most objects found at airports such as parked cars). Antiglare modules, for example, are sold by some PV manufacturers specifically for solar applications in highways, airports, and railways where glare is an issue.
- **PV glass surface texturing:** Roughening the protective glass surface is another contemporary design innovation that reduces reflection. A roughened surface minimizes specular reflection, which produces sharper and more concentrated light beams. Because it provides a diffuse reflection, a

textured glass layer can reduce reflectivity. It should be noted that textured glass tends to accumulate more dust and particles, requiring more frequent cleaning.

- **Variation in PV module orientation:** Adjusting the tilt and orientation angle of PV modules is another powerful approach that can be used for effective mitigation of glare. These modifications have the potential to affect the direction of solar reflection, and hence the level of glare impact. ForgeSolar may be used to evaluate the glare potential of new PV system design specifications. A fall in the expected yield is a concern and could be because these changes can influence PV power production.
    - By analyzing the Annual Glare Occurrence Plot, a very good approximation can be obtained of the time intervals that PV panel orientation should be modified, which will likely involve an alteration of the backtracking algorithm during some limited period of time.
    - Minor changes in orientation in these specific time intervals will presumably allow ATCT locations closer to the ideal position to observe no glare throughout the year and pass all FAA guidelines.
- **Shading from the Glare:** The Air Traffic Control Tower can be outfitted with blinds or protective films. The FAA and U.S. military require in most ATCTs the installation of specific window shades to reduce glare while preserving the full view out.
    - Traditional window coverings like vertical blinds and drapes only work to reduce glare when these are drawn, which naturally blocks the view of the outside. This would pose a serious threat to airport control tower safety. Factory tinted/metalized glass or window film is also dangerous since it prevents visibility in cloudy or dark situations and cannot be raised quickly enough in an emergency to enable the tower to flash the light gun.
- **Develop an Emergency Glint Response Plan:** Improved safety can be achieved by developing an emergency reaction strategy that includes methods for swiftly reducing potential glare effects on pilots and air traffic controllers. If glare hazards persist, mitigation techniques such as barriers and screens, pilot notice, and stow procedures can be used.

6. Methodology

This section discusses various **methods** for determining the intensity and influence of solar glare. The glare consultant classifies these options based on the need for a site visit.

6.1. Site visit based approaches: Helicopter flyover approach

Ho et al. (2011) used a helicopter flyover to analyze glare from a heliostat at the National Solar Thermal Test Facility in the United States. According to this estimate, a bright glare may be seen from the heliostat's mirrors from nearly 1700 meters. This helicopter approach can be used to assess glare for existing solar PV plants. The glare impact of a planned solar PV system can also be evaluated. The solar PV module is deployed at random throughout the chosen site. The tilt and angle of the PV module can be adjusted from zero to maximum.

The reflection on receptors such as air traffic controllers and pilots is measured from a helicopter for each arrangement. This type of field test, once the solar PV modules are at the planned location, is typically done in collaboration with authorized (airport) employees. This method is insufficient since the field test takes place just once a year, but the sun's position in the sky fluctuates throughout the year. The disadvantage is that the occurrence of glare throughout the year cannot be determined using this method. A single test may miss glare hazards that occur throughout the year. For these reasons, it is not a recommended approach to glare analysis, since it is outperformed by the computer-based approaches.

6.2. Computer-based approaches

The ability to predict glare is critical for the safe installation of solar PV systems in airport locations. The main steps of a desirable glare assessment approach are:

- Identification of the solar reflections that might reach the observer's eye.
- Computation of the Intensities (& duration) of these reflections
- Comparison of the obtained value with threshold limit to find whether it exceeds the safe value of glare.

The SGHAT and ForgeSolar are the most reputed programs for calculating Glint and Glare that use the Ho et al. technique. The user provides the input parameters (selection of solar PV plant and receptor locations) via interactive Google maps and the software uses complex algorithms to assess the effects of a PV installation on glare.

Factors such as inter-module distance, barriers between observers and PV array, fluctuations in PV module optical characteristics, and atmospheric conditions are not taken into account in this method. This method is only applicable to flat surfaces, such as solar PV arrays.

6.2.1. Solar Glare Hazard Analysis Tool (SGHAT)

Sandia National Laboratories, working for the US Department of Energy, produced this program, which complies with FAA (Federal Aviation Administration) glare assessment requirements (as per document 78 FR 63276).

Using the Ho et al. technique, the impact of solar PV glare on sensitive sensors is calculated. It has very quick annual simulations and leverages interactive Google maps for site selection. During the simulation, the user

can select from five various types of PV module top layer materials, including smooth glass without ARC, smooth glass with ARC and Light-textured glass without ARC, Light-textured glass with ARC, and deeply textured glass.

Because the FAA has approved the use of SGHAT software for glare assessment of solar installations in US airports, it demonstrates confidence in the software's conclusions. The user can only enter one set of observer view angles (downward and azimuthal). The user must then repeat the simulation for a different set of viewing angles.

6.2.2. ForgeSolar

ForgeSolar is the **commercially licensed version of the Solar Glare Hazard Analysis Tool, which performs** glare assessments and optimizations based on the SGHAT algorithms. Sims Industries received a license for the commercial development of the tool from the Sandia National Laboratories in December 2016.

It provides two estimation tools to the user, namely Glare gauge and GlaReduce.

- Glare Gauge is capable of predicting the impact of glare from solar PV arrays on selected receptors.
- GlaReduce can be used to optimize solar PV design (tilt angle and orientation angle) for mitigating the glare hazard.

ForgeSolar's glare assessment approach was further developed from the SGHAT version. The glare-check algorithm, the sun-scatter factor in the path and the glare impact calculations have all been improved. The slope error is connected to the selected PV module material by default, and the maximum rotation angle (default) for single axis tracked solar PV systems is set to 60 degrees.

The sun's position and vector calculation are calculated using latitude, longitude, and elevation, which are automatically retrieved. The user must sketch out the intended solar energy system, as well as the receptor sites (ATC Tower Cab) and the final approach path.

Provides a quantified assessment of:

- When and where glare will occur throughout the year for a prescribed solar installation.
- Potential effects on the human eye at locations where glare occurs.

If glare is detected, the tool estimates the retinal irradiance and subtended angle (size/distance) of the glare source to estimate ocular risks ranging from a transient after-image to retinal burn.

Although they have similar limitations, ForgeSolar offers an improved technical capability and user interface, and frequent updates allow for regular bug fixes and the introduction of new prediction tools. Therefore, **ForgeSolar will be the software of choice for this Glint and Glare analysis**.

The location of the sun will be determined at each time step. Regulatory agencies often require a one-minute time step. The PV Array Results tab includes comprehensive information and glare visualizations. The data is separated into PV arrays and components. The first section offers a description of glare expectations, which describes the total non-overlapping glare that each PV array is predicted to emit for all receptors. Below the analysis summary table is a table of distinct glare, computed by month.

Distinct glare per month

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-under-thr (green)	0	90	503	508	389	390	387	484	495	247	0	0
pv-under-thr (yellow)	0	264	901	664	551	436	513	630	690	493	0	0

Figure 7. Example of expected glare per month. Source: ForgeSolar

ForgeSolar does not accurately represent the specific geometry of a system; details like module gaps, PV array height variations, and support structures may have an impact on actual glare results. The PV array is modeled as a footprint filled with infinitesimally small panels that reflect sunlight along the tilt and orientation's trajectory.

Sandia National Laboratories analyzed over twenty PV module samples to create five general material reflectance profiles. These profiles are available in ForgeSolar and can be used to customize the PV array's material specifications during analysis.

When not directly facing the sun, a panel that absorbs 90% of direct sunlight may reflect up to 60%. This is a regular occurrence for low-tilt panels at sunset and sunrise (Yellowhair, 2015). The commonly cited assertion that PV panels reflect less than 5% of sunlight is only accurate when the panels are facing the sun directly. This claim only applies to fixed-mount panels for a few minutes of the day at most. The reflectance of each material profile is shown in the graph below as a function of incidence angle, with 0° indicating that the panels are directly facing the sun.

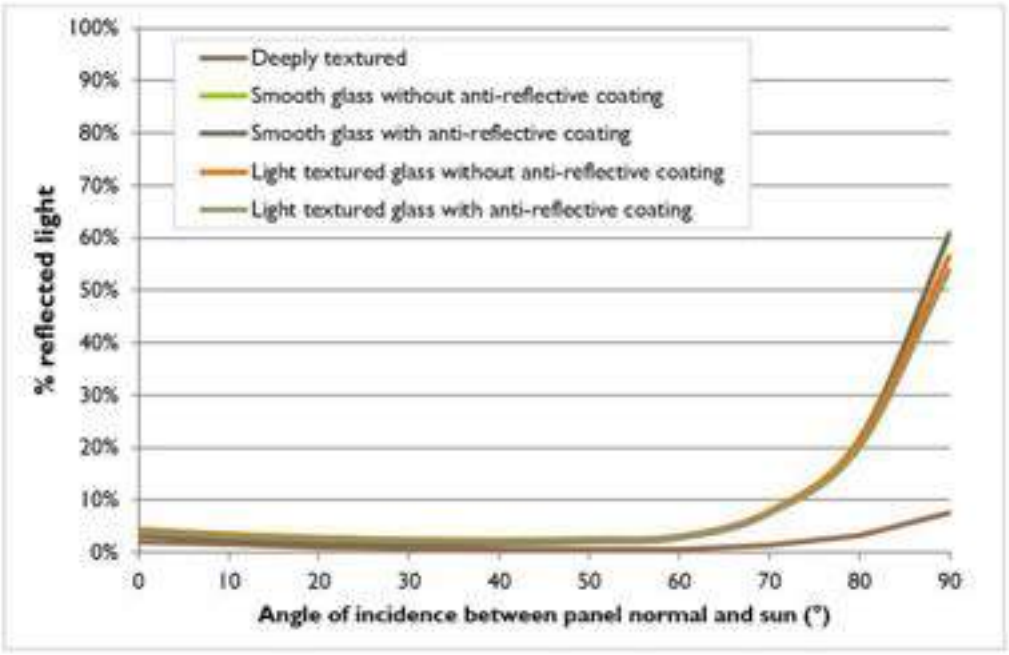


Figure 8. Reflectance profiles of typical PV module materials (Source: Yellowhair, 2015).

Angle (deg)	Smooth glass without anti-reflective coating	Smooth glass with anti-reflective coating	Light textured glass without anti-reflective coating	Light textured glass with anti-reflective coating	Deeply textured glass
0	0.0441	0.0324	0.0431	0.0390	0.0210
10	0.0357	0.0242	0.0333	0.0301	0.0152
20	0.0297	0.0190	0.0266	0.0240	0.0107
30	0.0262	0.0167	0.0229	0.0208	0.0076
40	0.0250	0.0174	0.0223	0.0204	0.0059
50	0.0262	0.0210	0.0247	0.0229	0.0056
60	0.0298	0.0275	0.0302	0.0281	0.0066
70	0.0789	0.0744	0.0776	0.0738	0.0143
80	0.2185	0.2128	0.2097	0.1994	0.0330
90	0.6052	0.6086	0.5666	0.5389	0.0760

Figure 9. Module surface reflectivity as a function of incidence angle. Source: ForgeSolar

It is worth mentioning that backtracking algorithms will significantly alter the expected glare since, in order to limit the shadows on the nearby modules during the rising and setting of the sun, the PV modules will show a higher angle of incidence between the panel normal and the sun. These solar moving algorithms will be implemented in the selected tracking system and are also included in the ForgeSolar software, so the backtracking effects will be considered in the final analysis.

ForgeSolar software presents certain limitations that hinder the precision or interpretation of the results if not accounted for appropriately. The main assumptions and limitations that concern this current report are:

- DNI (Direct Normal Irradiance) is obtained from a clear day irradiance profile, being lower in the mornings and evenings (following sun-position algorithms, considering longitude and latitude). It doesn't contemplate cloud cover, atmospheric attenuation, or other environmental factors. Because of this assumption, the results obtained will likely present a stronger glare than the resulting reflection observed in practice.
    - Throughout the year, the position of the Sun in the sky at the PV plant location is a function of daytime. It is calculated in relation to the reflecting surface and observer. As a conservative estimate, the maximum intensity of sunlight (DNI) will be 1000 W/m^2 (at noon on a sunny cloudless day).
- Man-made or natural obstacles between the solar installation and the observation points are not taken into account by the algorithm. This limitation will increase the observed glare in the simulation results.
- The algorithm places all the PV panels in a plane determined by the total heights of the array's vertices, which reduces considerably the accuracy of the simulation if the PV array has an extensive surface with uneven ground. A correct adjustment of this macro-PV array becomes necessary to obtain more exact results. For this purpose, each PV array has been divided into smaller sub-arrays that extend

over lesser surfaces. All the sub-arrays and their relative impact on the observation points can be found in the annexed ForgeSolar report.

- The yearly hazard analysis algorithm's steps all use random number computations. As a result, predicted minutes of glare may differ between runs. The evaluations of Observation Point receptors, like ATCTs, are predominantly affected by this constraint.

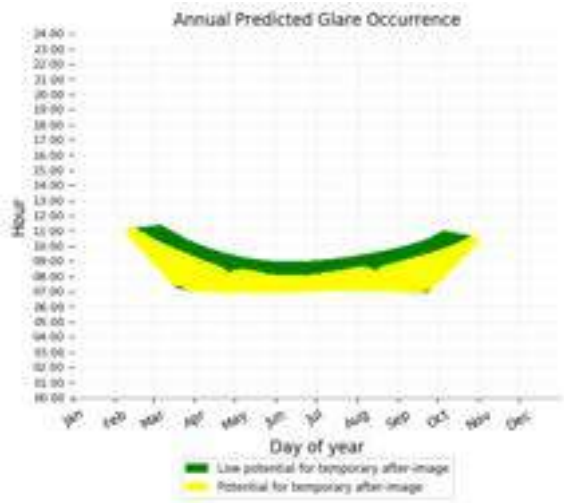
The rest of the assumptions and limitations concerning ForgeSolar software are listed at the end of every ForgeSolar report.

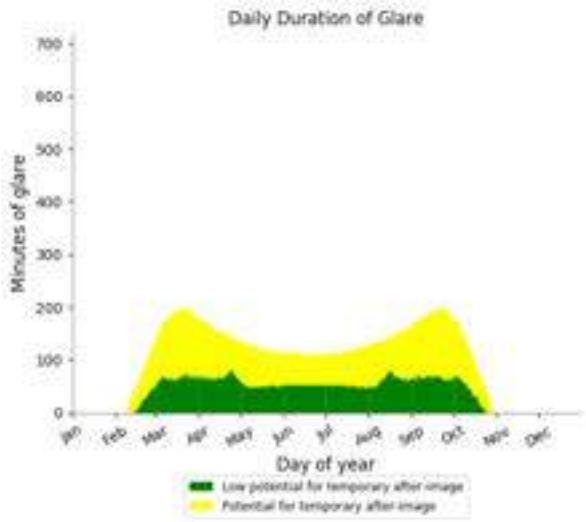
6.2.3. Report Interpretation

The report generated by the ForgeSolar software includes considerable information regarding each subarray and its impact on the specified receptors. To understand completely the information provided by the annexed report we present here an explanation for the interpretation of the different types of plots used:

<u>Annual Glare Occurrence Plot</u>

The annual glare occurrence plot shows when glare is likely to occur for the specified receptor at various times of the day and year. The x-axis represents the months, while the y-axis represents the hours of the day. The estimated ocular impact is used to color-code the occurrences.



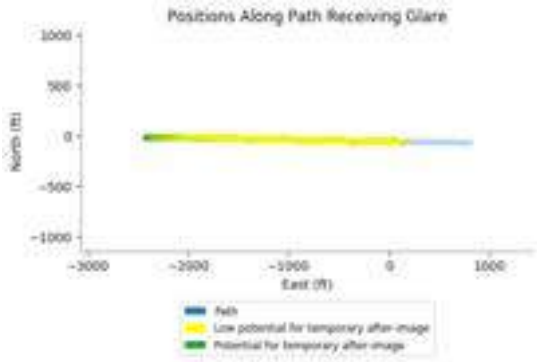


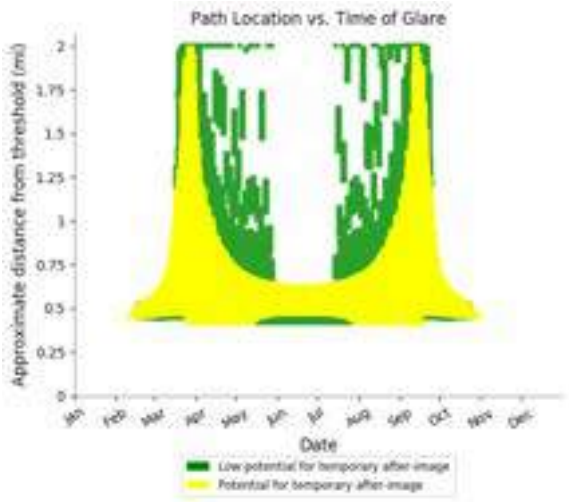
<u>Daily Glare Duration Plot</u>

The daily glare duration plot adds together expected glare minutes on a daily basis to give an estimate of the total number of minutes glare will be seen each day over the course of an entire year.

Plot of Path Positions Receiving Glare

This diagram depicts the approximate spots along the route where glare will be visible. In other words, this image highlights the route receptor's estimated affected parts.



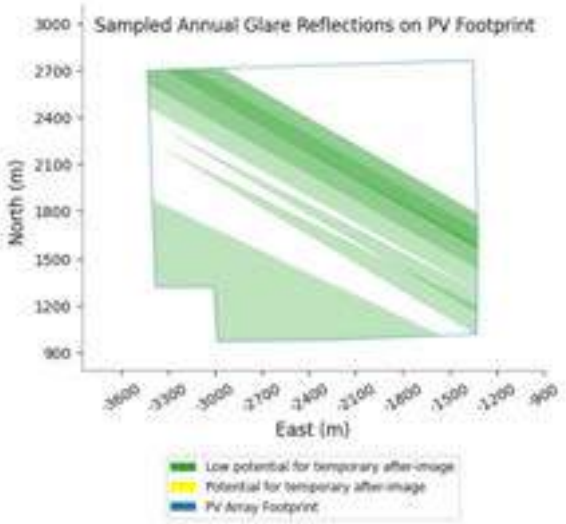


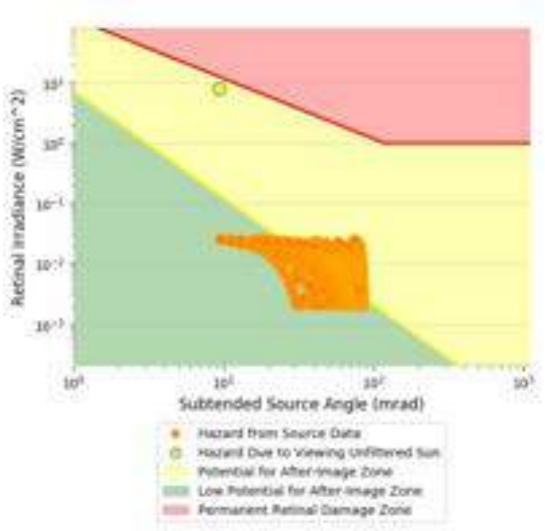
Plot of Path location and Time of Glare

The Path Location vs. Time of Glare plot depicts the estimated distances along the 2-mile approach path where glare will be visible, as a function of the time of year.

PV Footprint Glare - Spot Heatmap Plot

On a yearly basis, the PV Footprint Heatmap plot shows the approximate aggregate locations within the sketched PV footprint where glare-spots are projected to appear from the receptor's perspective. The color-coding of the plotted polygonal areas is dependent on the expected glare hazard.





Glare Hazard Plot

The glare hazard graphic shows how each minute of predicted glare will affect your eyes. The x-axis reflects the subtended source angle. The retinal irradiance affecting the observer is represented on the y-axis.

The three hazard zones, denoted by the hues green, yellow, and red, are based on research and represent the predicted impact. The retinal damage zone's border lies close to the yellow circle (with a blue outline), which depicts the danger of staring at the naked sun. The glare hazard plot aids in identifying the type of glare and its effects.

7. Receptors

7.1. Almardamah Road and Haraniga Road

Almardamah Road is a 100 km length two-way road that runs to the west limit of the Project site, adjacent to the plot and connects Routes 50 and 80. On the other hand, Haraniga Road runs to the north limit of the project site and connects Almardamah Road with Haraniga village.

Figure 10. Almardamah Road and Haraniga Road

7.2. Dawadmi Domestic Airport

7.2.1. Background

According to GACA's public information (https://gaca.gov.sa/web/en-gb/page/home), the closest Saudi airport to our project is Dawadmi Domestic Airport.

Dawadmi Domestic Airport also known as King Salman Domestic Airport, is an airport serving Dawadmi, a city in the Riyadh province in Saudi Arabia. This airport has a passenger handling capacity of 900,000 passengers and a total built-up area of 0.0084 km^2.

Figure 11. Location of airports in Saudi Arabia (GACA)

7.2.2. Runway and Flight Paths

The airport counts with one runway, shown in red in the following picture:

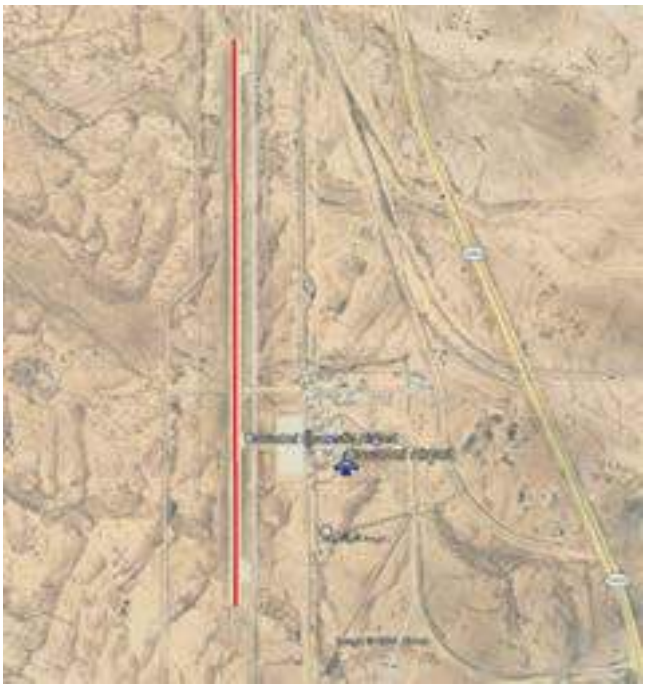


Figure 12. Runway

7.2.3. Airport Traffic Control Tower (ATCT)

The location of the ATCT is shown here:

Figure 13. ATCT

8. Simulation & Analysis of results

8.1. Inputs & Setup

For the location of the glare receptors and subsequent extraction of the results presented in the annexed report, TYPSA has implemented:

- First, the airport and all its receptors: ATCT and flight paths.
- Secondly, roads that cross next to the site.
- Finally, TYPSA has carried out a simulation considering the implementation of a 5-meter vegetation barrier surrounding the photovoltaic plant.

Relevant inputs concerning the simulation can be found in detail in the annexed report, an example is shown below:

Name: Afif 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.2803
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	23.806478	43.117032	990.46	1.50	991.96
2	23.783282	43.121324	987.12	1.50	988.62
3	23.750506	43.117035	991.62	1.50	993.12
4	23.787700	43.194927	969.09	1.50	970.59
5	23.828770	43.181384	981.63	1.50	983.13

Figure 14. PV Array description in ForgeSolar Report.

As shown in the image, information regarding the backtracking algorithm, tracking axis orientation, GCR or even panel material can be found for the PV array. Worth mentioning is the use of AR coating, which will reduce the expected glare, although as mentioned previously, these coating techniques are most useful with low incidence angles.

A function of the module surface material and the incidence angle between the panel normal and the sun position will be used to compute the reflectivity of the modules at each time step.

Other parameters like the pupil diameter or the ocular transmission coefficient were left in the default values, which are specified at the beginning of the report since they are estimations based on research and no relevant reason to modify them was found.

8.2. Results

The report generated by the ForgeSolar software provides a complete analysis of the glare received by each receiver, finding no glare affecting any of the Flight Paths or ATCT of the Dawadmi Domestic Airport.

Simulation results show that small amounts of yellow and green glare during the year will appear on the roads. Specifically, the following results are obtained:

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Road 1	29	0.5	229	3.8
Road 2	403	6.7	446	7.4
Aldwadmi Airport - 1	0	0.0	0	0.0
Aldwadmi Airport - 2	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Figure 15. Results

The table above illustrates the total annual glare received by each receptor. The expected glare is only observed during the early and late hours of the day when the irradiation is less intense. At central hours, there is no risk to the drivers.

Also, depending on the side of the road where they are located, the glint and glare is caused at different times of the day (sunrise or sunset):

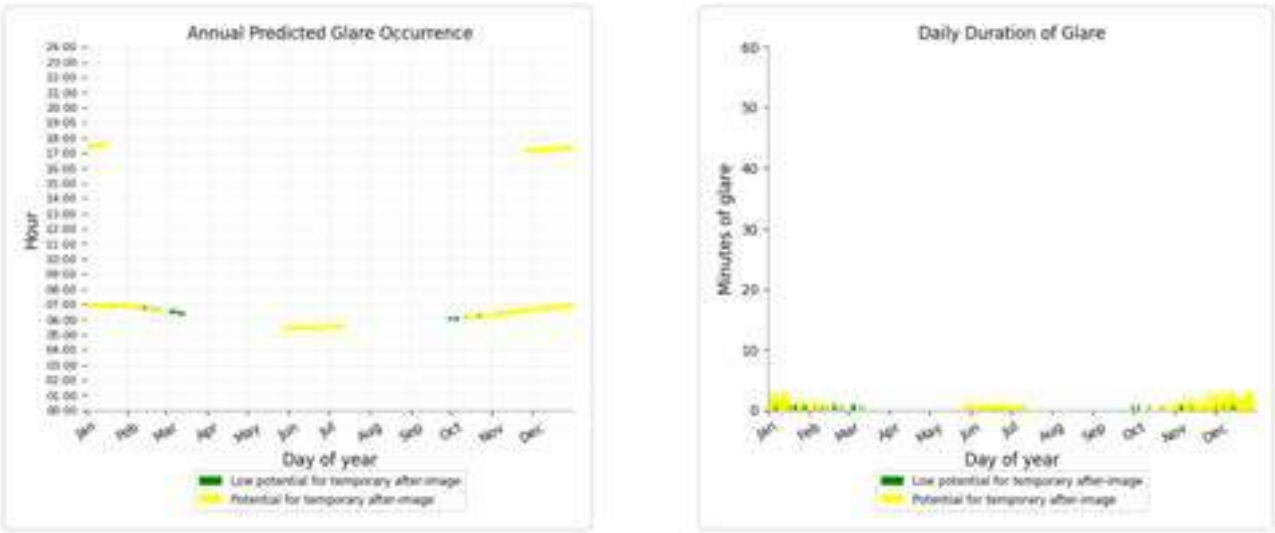


Figure 16. Annual Predicted Glare Example

8.3. Vegetation Barrier Results

In order to find solutions to avoid the small minutes of yellow glare on the roads, a simulation including a 5-meter vegetation barrier surrounding the PV plant has been considered and carried out.

A vegetation barrier in a PV project is a physical structure or measure implemented to reduce the visual impact of the project to the environment. Vegetation barriers can take various forms, such as physical fences, hedges, or the use of herbicides or vegetation management practices. The specific type and design of the barrier depend on factors like project location, local regulations, environmental considerations...

Figure 17. Vegetation Barrier Example

The simulation results show that the amount of yellow glare is almost completely reduced, from 229 minutes to only 4 minutes during the whole year for Almardamah Road (road 1) and completely reduced for Haraniga Road (road 2). Specifically, the following results are obtained:

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Road 1	50	0.8	4	0.1
Road 2	0	0.0	0	0.0
Aldwadmi Airport - 1	0	0.0	0	0.0
Aldwadmi Airport - 2	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Figure 18. Results (vegetation barrier)

9. Conclusions

Saudi Power Procurement Company (Principal Buyer) is developing a new photovoltaic power plant, named Afif 1 Solar Power Plant with an area of 39.87 km2 and located about 23 km southeast to the city of Afif in the Riyadh Province, Saudi Arabia. Positioned at an altitude of 978 meters above sea level. A study has been carried out to assess the glare and glint risk on the nearby airport and roads.

No glare caused by the future Afif 1 Solar Power Plant is expected at any of the Flight Paths studied and the ATCT of the Dawadmi Domestic Airport.

The simulation reveals little glint and glare during a few hours of the day on both roads that run parallel to Afif 1 Solar Power Plant. In no cases the level of glare is significant, and it only occurs during shot periods at sunrise and sunset of some months.

These results are not of concern due to the distance between the roads and the PV plant and the low number of glint and glare hours occurring during the entire year.

However, it is possible to eliminate almost all the glint and glare effects by implementing some mitigation measures presented during this report and presented again at the end of this section.

A simulation was carried out by placing a vegetation barrier. The simulation including a vegetation barrier around the PV plant shows that the amount of yellow glare is almost completely reduced in the roads that run parallel to the site:

- Almardamah Road (road 1): Yellow glare is reduced from 229 minutes to 4 minutes.
- Haraniga Road (road 2): Yellow glare is completely reduced.

If any further deep analysis or test still show any harmful glare in key locations, there are some commentary simple measurements to eliminate or reduce the glare:

- **Using a vegetative barrier.**
- **Selection of PV modules with special Anti-Reflective (AR) coating and surface texturing.**
- **Shading the ATCT from the glare**
- **Variation in PV module orientation:** The information provided by the Annual Glare Occurrence Plot and the PV Footprint Glare - Spot Heatmap Plot with a modification of the backtracking algorithm (or simply a deactivation of the backtracking) during the brief time intervals of the year when glare is a concern would be very effective in eliminating glare.

The presented conclusions should only be used as an initial approach to the Glint and Glare issue. For a better estimate, a ForgeSolar glare analysis should be later performed for road and airport, with some more precise and definitive information.

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Annexes

Annex A. ForgeSolar General Glare Analysis Report

FORGESOLAR GLARE ANALYSIS

Project: **AFIF 1**

The Afif 1 Solar Energy Park represents a pioneering step towards realizing Saudi Arabia's vision of a sustainable and diversified energy future, in alignment with the National Renewable Energy Program (NREP).

Site configuration: **Basic**

Client: SPPC

Created 24 Mar, 2024
Updated 24 Mar, 2024
Time-step 1 minute
Timezone offset UTC3
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category >1 GW
Site ID 115171.19503

Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
Afif 1	SA tracking	SA tracking	432	7.2	675	11.2	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Road 1	29	0.5	229	3.8
Road 2	403	6.7	446	7.4
Aldwadmi Airport - 1	0	0.0	0	0.0
Aldwadmi Airport - 2	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: Afif 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.2803
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

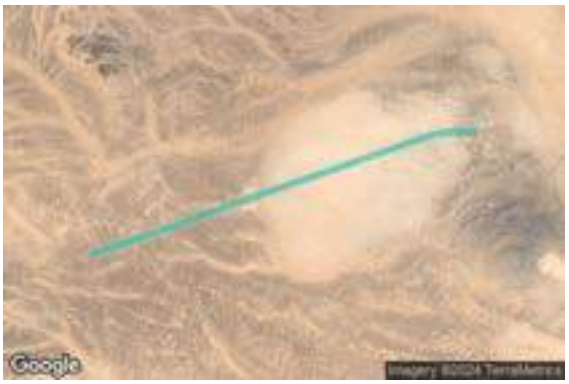
Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	23.806478	43.117032	990.46	1.50	991.96
2	23.783282	43.121324	987.12	1.50	988.62
3	23.750506	43.117035	991.62	1.50	993.12
4	23.787700	43.194927	969.09	1.50	970.59
5	23.828770	43.181384	981.63	1.50	983.13

Route Receptors

Name: Road 1
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	23.838940	43.097646	999.99	0.00	999.99
2	23.830382	43.103825	996.76	0.00	996.76
3	23.821039	43.109233	996.00	0.00	996.00
4	23.808318	43.114468	994.00	0.00	994.00
5	23.800465	43.116614	991.99	0.00	991.99
6	23.789392	43.118674	990.11	0.00	990.11
7	23.779810	43.119189	986.99	0.00	986.99
8	23.770384	43.119018	987.38	0.00	987.38
9	23.759151	43.117301	989.11	0.00	989.11
10	23.748467	43.114554	993.72	0.00	993.72
11	23.730843	43.109061	1007.00	0.00	1007.00
12	23.711512	43.103654	1028.39	0.00	1028.39
13	23.697386	43.099298	1025.84	0.00	1025.84

Name: Road 2
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	23.808515	43.114307	993.92	0.00	993.92
2	23.814012	43.131988	986.36	0.00	986.36
3	23.821236	43.153617	980.79	0.00	980.79
4	23.829323	43.179280	982.64	0.00	982.64
5	23.834721	43.195988	970.17	0.00	970.17
6	23.838725	43.208648	964.55	0.00	964.55
7	23.839117	43.218862	962.00	0.00	962.00

Flight Path Receptors

Name: Aldwadmi Airport - 1
Description:
Threshold height: 15 m
Direction: 333.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	24.437660	44.127712	924.35	15.24	939.59
Two-mile	24.411743	44.141804	930.71	177.57	1108.27

Name: Aldwadmi Airport - 2
Description:
Threshold height: 15 m
Direction: 154.1°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	24.462000	44.114598	916.38	15.24	931.62
Two-mile	24.488004	44.100697	913.77	186.54	1100.30

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	24.441073	44.130830	923.54	10.00

Map image of 1-ATCT

Glare Analysis Results

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
Afif 1	SA tracking	SA tracking	432	7.2	675	11.2	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Road 1	29	0.5	229	3.8
Road 2	403	6.7	446	7.4
Aldwadmi Airport - 1	0	0.0	0	0.0
Aldwadmi Airport - 2	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: Afif 1

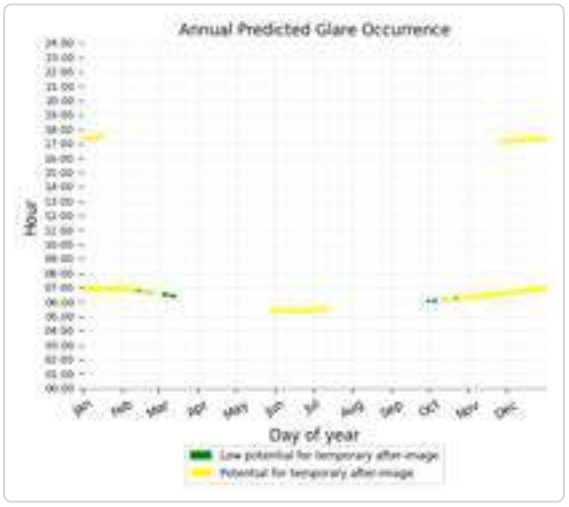
potential temporary after-image

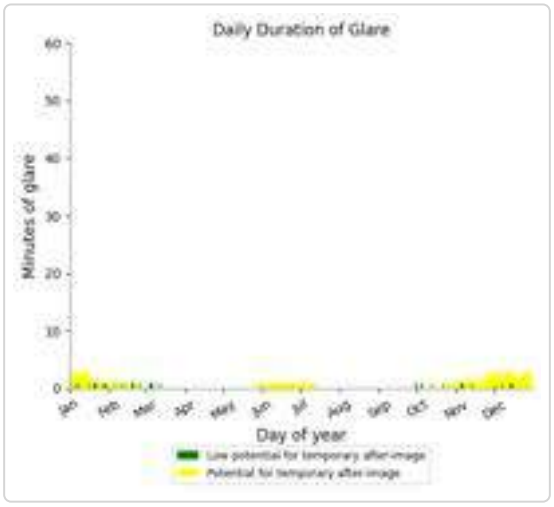
Receptor results ordered by category of glare

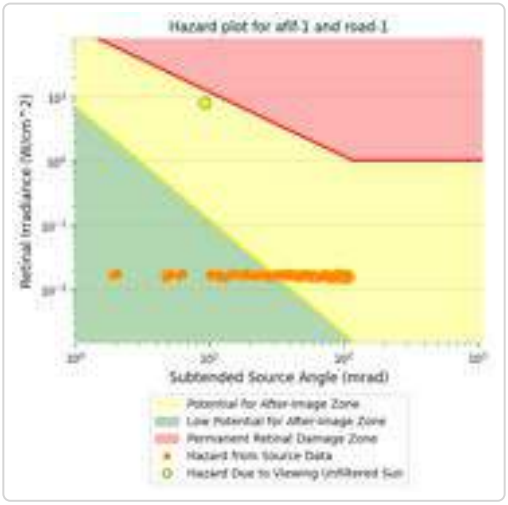
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Road 1	29	0.5	229	3.8
Road 2	403	6.7	446	7.4
Aldwadmi Airport - 1	0	0.0	0	0.0
Aldwadmi Airport - 2	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

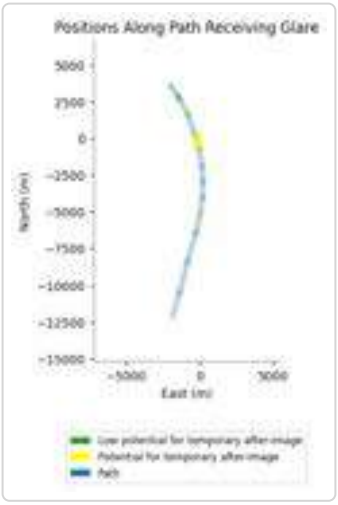
Afif 1 and Route: Road 1

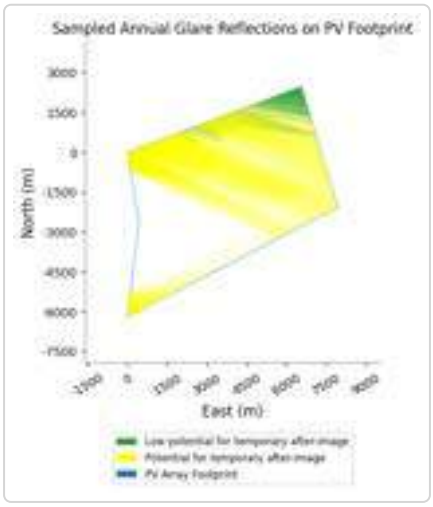
Yellow glare: 229 min.
Green glare: 29 min.





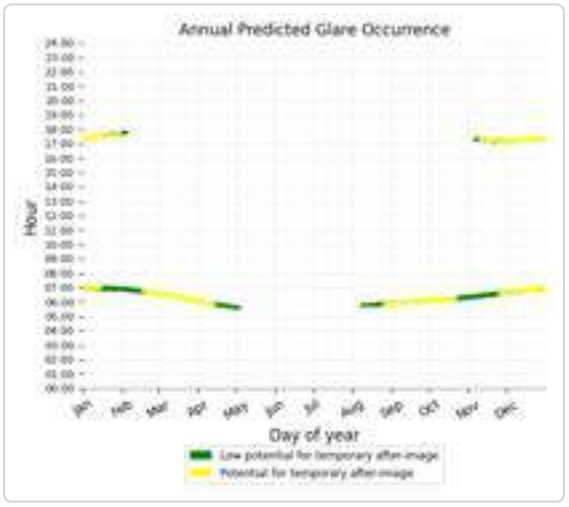


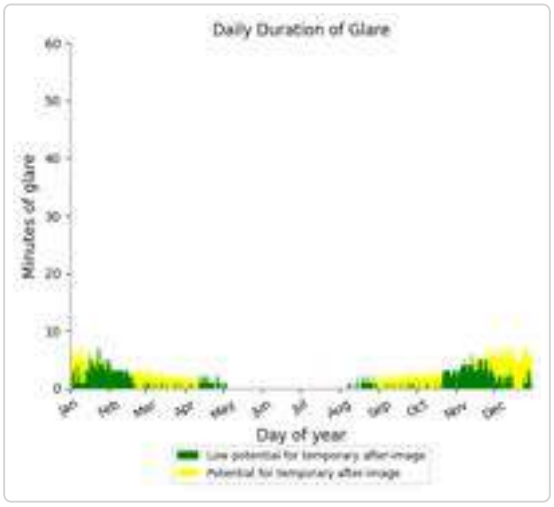


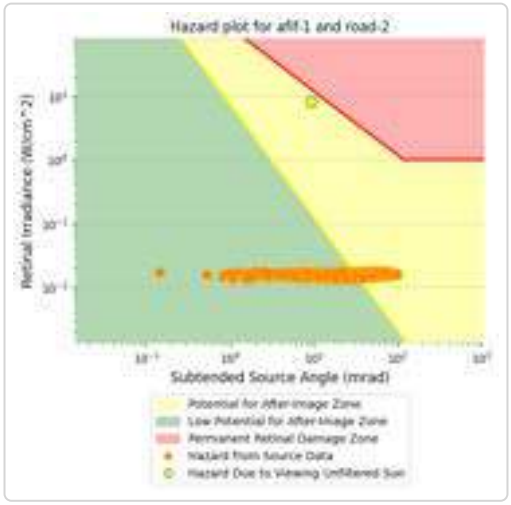


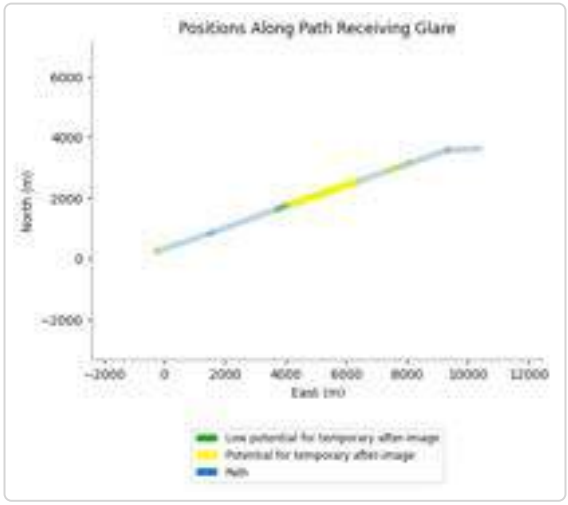
Afif 1 and Route: Road 2

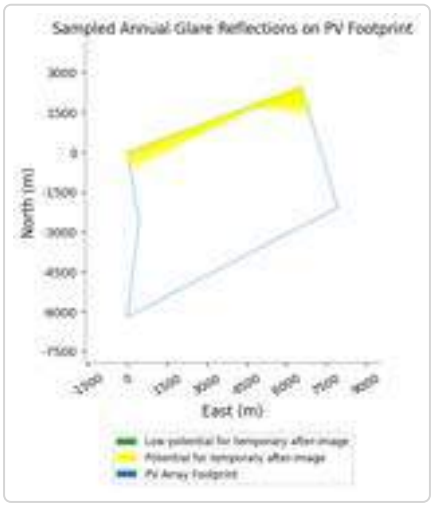
Yellow glare: 446 min.
Green glare: 403 min.











Afif 1 and FP: Aldwadmi Airport - 1

No glare found

Afif 1 and FP: Aldwadmi Airport - 2

No glare found

Afif 1 and 1-ATCT

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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Annex B. ForgeSolar Glare Analysis Report with Vegetation Barrier

FORGESOLAR GLARE ANALYSIS

Project: **AFIF 1**

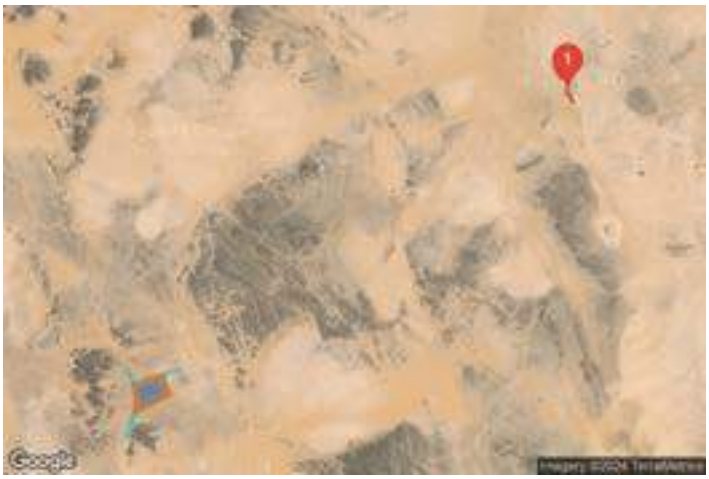
The Afif 1 Solar Energy Park represents a pioneering step towards realizing Saudi Arabia's vision of a sustainable and diversified energy future, in alignment with the National Renewable Energy Program (NREP).

Site configuration: **Vegetation Barrier**

Client: SPPC

Created 21 Mar, 2024
Updated 24 Mar, 2024
Time-step 1 minute
Timezone offset UTC3
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category >1 GW
Site ID 114928.19503

Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2



Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
Afif 1	SA tracking	SA tracking	50	0.8	4	0.1	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Road 1	50	0.8	4	0.1
Road 2	0	0.0	0	0.0
Aldwadmi Airport - 1	0	0.0	0	0.0
Aldwadmi Airport - 2	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: Afif 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.2803
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

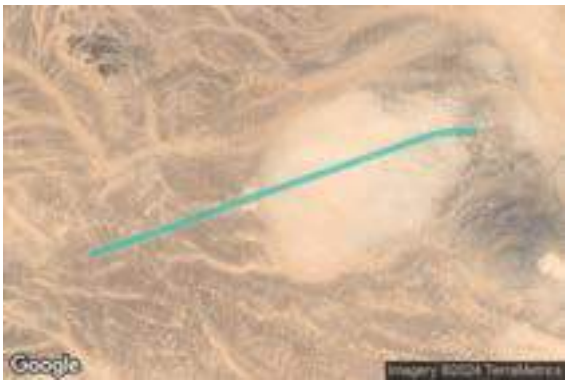
Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	23.806478	43.117032	990.46	1.50	991.96
2	23.783282	43.121324	987.12	1.50	988.62
3	23.750506	43.117035	991.62	1.50	993.12
4	23.787700	43.194927	969.09	1.50	970.59
5	23.828770	43.181384	981.63	1.50	983.13

Route Receptors

Name: Road 1
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	23.838940	43.097646	999.99	0.00	999.99
2	23.830382	43.103825	996.76	0.00	996.76
3	23.821039	43.109233	996.00	0.00	996.00
4	23.808318	43.114468	994.00	0.00	994.00
5	23.800465	43.116614	991.99	0.00	991.99
6	23.789392	43.118674	990.11	0.00	990.11
7	23.779810	43.119189	986.99	0.00	986.99
8	23.770384	43.119018	987.38	0.00	987.38
9	23.759151	43.117301	989.11	0.00	989.11
10	23.748467	43.114554	993.72	0.00	993.72
11	23.730843	43.109061	1007.00	0.00	1007.00
12	23.711512	43.103654	1028.39	0.00	1028.39
13	23.697386	43.099298	1025.84	0.00	1025.84

Name: Road 2
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	23.808515	43.114307	993.92	0.00	993.92
2	23.814012	43.131988	986.36	0.00	986.36
3	23.821236	43.153617	980.79	0.00	980.79
4	23.829323	43.179280	982.64	0.00	982.64
5	23.834721	43.195988	970.17	0.00	970.17
6	23.838725	43.208648	964.55	0.00	964.55
7	23.839117	43.218862	962.00	0.00	962.00

Flight Path Receptors

Name: Aldwadmi Airport - 1
Description:
Threshold height: 15 m
Direction: 333.7°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	24.437660	44.127712	924.35	15.24	939.59
Two-mile	24.411743	44.141804	930.71	177.57	1108.27

Name: Aldwadmi Airport - 2
Description:
Threshold height: 15 m
Direction: 154.1°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	24.462000	44.114598	916.38	15.24	931.62
Two-mile	24.488004	44.100697	913.77	186.54	1100.30

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	24.441073	44.130830	923.54	10.00

Map image of 1-ATCT

Obstruction Components

Name: Vegetation Barrier
Top height: 5.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	23.806480	43.117031	990.46
2	23.783282	43.121324	987.12
3	23.750510	43.117035	991.62
4	23.787704	43.194928	969.09
5	23.828770	43.181383	981.63
6	23.806480	43.117031	990.46

Glare Analysis Results

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
Afif 1	SA tracking	SA tracking	50	0.8	4	0.1	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Road 1	50	0.8	4	0.1
Road 2	0	0.0	0	0.0
Aldwadmi Airport - 1	0	0.0	0	0.0
Aldwadmi Airport - 2	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

PV: Afif 1

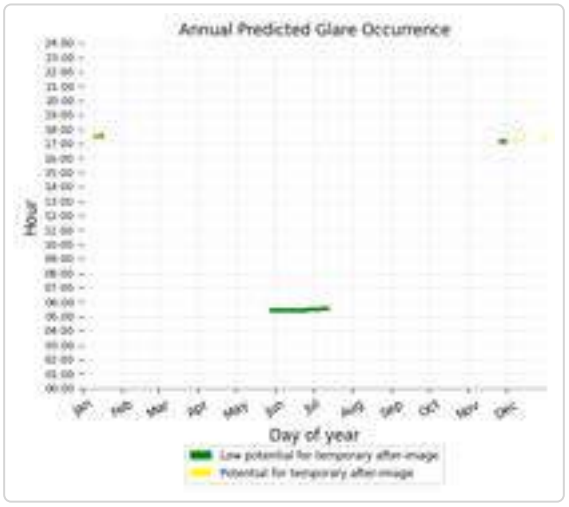
potential temporary after-image

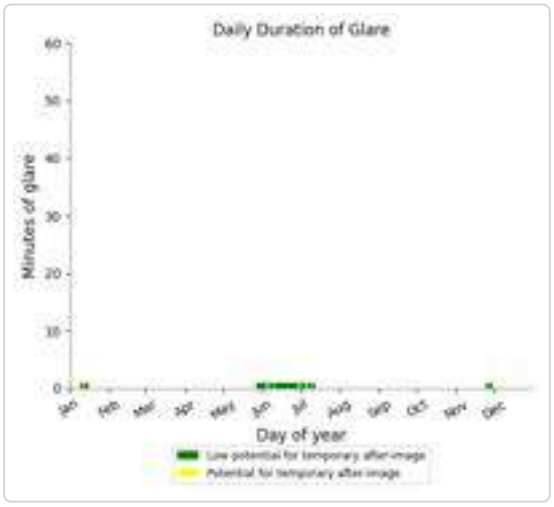
Receptor results ordered by category of glare

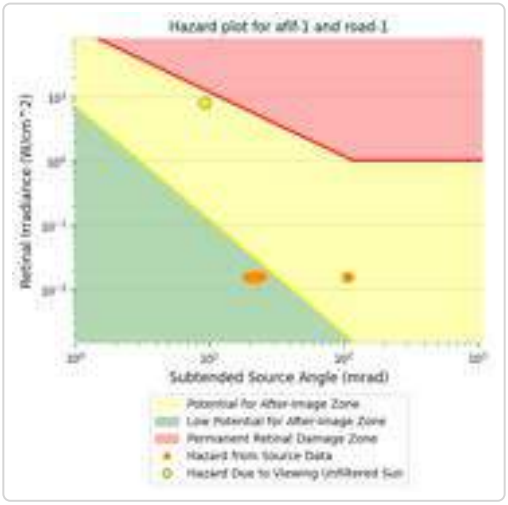
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Road 1	50	0.8	4	0.1
Road 2	0	0.0	0	0.0
Aldwadmi Airport - 1	0	0.0	0	0.0
Aldwadmi Airport - 2	0	0.0	0	0.0
1-ATCT	0	0.0	0	0.0

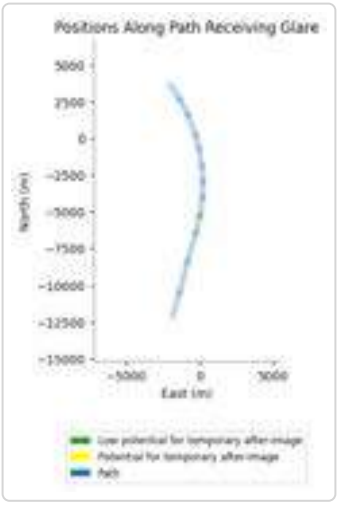
Afif 1 and Route: Road 1

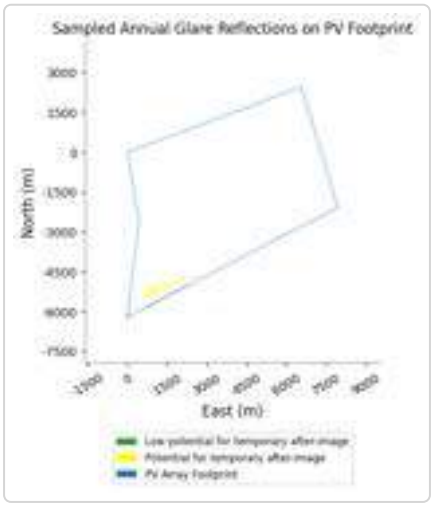
Yellow glare: 4 min.
Green glare: 50 min.











Afif 1 and Route: Road 2

No glare found

Afif 1 and FP: Aldwadmi Airport - 1

No glare found

Afif 1 and FP: Aldwadmi Airport - 2

No glare found

Afif 1 and 1-ATCT

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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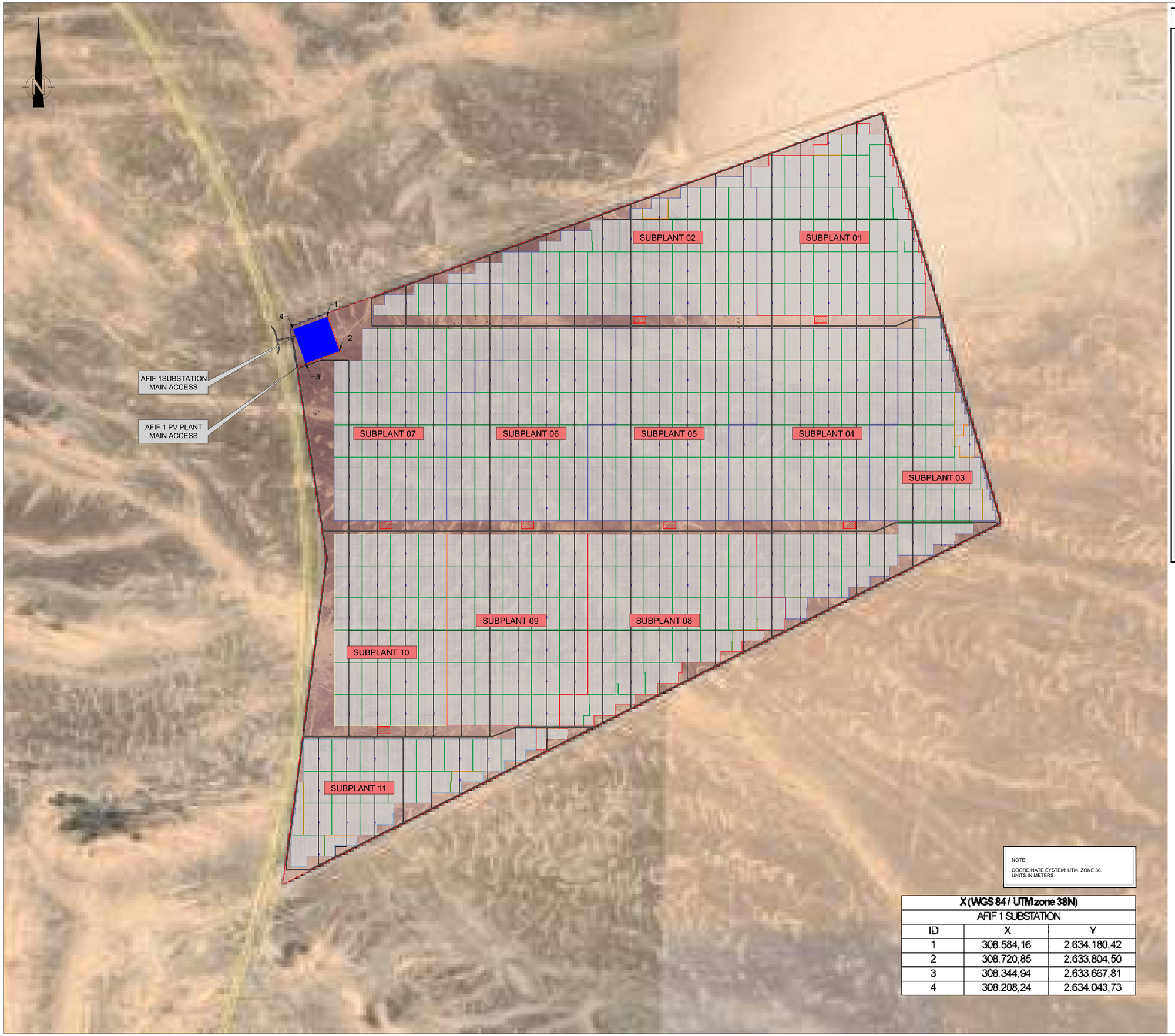
8.4. Annex nº 4. Project Maps



PROJECT DATA

Total Peak Power:	2,645.4243 MWp
Nominal power:	2,137.8140 MW (T=XXºC)
Ratio DC/AC:	1.2374
PV Module:	695W
Cells:	HETEROJUNCTION
Nº of modules:	3,806,366
Nº of strings:	131,254
Nº of modules per string:	29
Structure:	Tracker
Number of structures:	43,540(1P87)+317(1P58)
Orientation:	0º Azimuth
Pitch:	6.50 m
Number of Blocks:	305 (B1) + 12 (B2)
Blocks:	
	B1
Peak Power:	8.5054 MWp
Nominal Power:	6.874 MWac
Nº of modules:	12,237
Nº of strings:	422
	B2
Peak Power:	4.2723 MWp
Nominal Power:	3.437 MWac
Nº of modules:	6,148
Nº of strings:	212
Int. Substations 33/132 kV:	07
Subplants:	11
Subplant:	*02,03,04,05,06,07*
Peak Power:	255.1620 MWp
Nominal Power:	206.2200 MWac
Subplant:	*01,08,09*
Peak Power:	250.9289 MWp
Nominal Power:	202.7830 MWac
Subplant:	*10*
Peak Power:	204.1296 MWp
Nominal Power:	164.9760 MWac
Subplant:	*11*
Peak Power:	157.3695 MWp
Nominal Power:	127.1690 MWac
Fence length:	27.045 km
Fenced area:	39.619 km^2

LEGEND

- SITE
- PV PLANT FENCE
- TRACKER 1P87
- TRACKER 1P58
- POWER STATION
- INTERNAL ROAD (4m/10m)
- INTERNAL 33/132 kV SUBSTATION
- PV BLOCK B1 (305)
- PV BLOCK B2 (12)
- PV SUBPLANT TYPE 1
- PV SUBPLANT TYPE 2
- PV SUBPLANT TYPE 3
- PV SUBPLANT TYPE 4
- SUBSTATION

NOTE:

COORDINATE SYSTEM: UTM. ZONE 38.
UNITS IN METERS.

X (WGS 84 / UTM zone 38N)		
AFIF 1 SUBSTATION		
ID	X	Y
1	308.584,16	2.634.180,42
2	308.720,85	2.633.804,50
3	308.344,94	2.633.667,81
4	308.208,24	2.634.043,73

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8.5. Annex nº 5. Material Safety Data Sheet (MSDS)

Not applicable

Afif 1 PV
Kingdom of Saudi Arabia

ESIA Addendum

April 2025

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1	Financial Capital
2	Social Capital
3	Natural Capital
4	Manufactured Capital
5	Human Capital

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CONTENTS

1 INTRODUCTION 1
1.1 Project Description 2
1.2 Project Location 2
1.3 Project Timeline 2
1.4 Construction Phase 4
1.5 Operation Phase 4
2 LAND USE AND SOCIAL IMPACTS 5
2.1 Standards and Regulations 5
2.2 Baseline 5
2.3 Potential Project Impacts 10
2.4 Mitigation Measures 12
2.5 Monitoring 14
3 HUMAN RIGHTS IMPACTS ASSESSMENT 15
3.1 Overview 15
3.2 Standards and Regulations 15
3.3 Project Affected People 19
3.4 Potential Project Impacts on Human Rights 20
3.5 Mitigation Measures 24
3.6 Monitoring 33
4 CLIMATE CHANGE IMPACT ASSESSMENT 35
4.1 Overview 35
4.2 Standards and Regulations 36
4.3 Baseline Data 37
4.4 Project Vulnerability 45
4.5 Project Effects 47
4.6 Mitigation Measures 51
5 CUMULATIVE IMPACTS ASSESSMENT 53
5.1 Objectives of the Cumulative Impact Assessment 53
5.2 Identification of Concurrent Developments and Environmental Drivers 54
5.3 Identification of Valued Environmental Components 54
5.4 Assessment of Cumulative Impacts on VECs 55

6 REFERENCES I
APPENDIX A – STAKEHOLDER ENGAGEMENT GUIDELINE IV
APPENDIX B – QUESTIONNAIRE RESPONSES VIII
APPENDIX C – CLIMATE CHANGE RISK SCREENING XII

FIGURES

Figure 1-1 Project Location - National Context 3

Figure 1-2 Project Location - Local Context 3

Figure 2-1 Typical Landscape at the Project Site 6

Figure 2-2 Structures on the Project Site 7

Figure 2-3 Identified Herder Locations 8

Figure 2-4 Identified Herders 8

Figure 4-1 Köppen Geiger climate classification for Saudi Arabia 39

Figure 4-2 Observed Monthly Average Temperatures (Maximum – red; mean – orange, minimum – yellow), and rainfall (blue) in Saudi Arabia 1991-2020 40

Figure 4-3 Projected Average Maximum Surface Air Temperature, Saudi Arabia 41

Figure 4-4 Annual Average Precipitation in KSA 2010 – 2021 41

Figure 4-5 Project Precipitation in KSA 42

Figure 4-6 Number of People Affected by Key Natural Hazards in KSA 1980 – 2020 43

Figure 4-7 Projected Cumulative Waste from Solar Photovoltaic Projects 50

TABLES

Table 1-1 Tentative Project Schedule 2

Table 2-1 Herders' Livestock Numbers 9

Table 2-2 Land Use and Social Impacts Mitigation Measures 12

Table 2-3 Land Use and Social Monitoring Requirements – Construction and Operation 14

Table 3-1 Human Rights Mitigation & Management Measures – Construction 24

Table 3-2 Human Rights Mitigation & Management Measures – Operation 29

Table 3-3 Key Monitoring Indicators during Construction and Operation 33

Table 4-1 Generators-GHG Emissions During Construction of the Project 48

Table 4-2 Generator-GHG Emissions During Operation of the Project – Per Generator 49

Table 4-3 Modelled results of cumulative waste volumes of end-of-life PV panels for KSA, in tonnes (IRENA & IEA, 2016) 50

Table 5-1 Activities and Developments Included in CIA 54

Table 5-2 Assessment of Cumulative Impacts on VECs 56

LIST OF ABBREVIATIONS

ABBREVIATION	MEANING
5 Capitals	5 Capitals Environmental and Management Company
AoI	Area of Influence
CCPI	Climate Change Performance Index
CCRA	Climate Change Risk Assessment
CIA	Cumulative Impacts Assessment
$CO_{2\text{-eq}}$	Carbon Dioxide Equivalent
CRI	Climate Risk Index
E&S	Environmental & Social
EPC	Engineering, Procurement, and Construction
EPFI	Equator Principles Financial Institutions
EPs	Equator Principles
ESIA	Environmental and Social Impact Assessment
ESMS	Environmental and Social Management Systems
GBVH	Gender Based Violence and Harassment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GRM	Grievance Redress Mechanism
HR	Human Resource
HRGPs	Guiding Principles on Business and Human Rights
HSE	Health, Safety, and Environment
IFC	International Finance Corporation
ILO	International Labour Organization
IRENA	International Renewable Energy Agency
KSA	Kingdom of Saudi Arabia
KWh	Kilowatt Hours
MEWA	Ministry of Environment, Water and Agriculture
MoL	Ministry of Labour
Mt	Megatonnes
NGSA	National Grid SA
ODS	Ozone Depleting Substances
OHS	Occupational Health and Safety
OHTL	Overhead Transmission Line
PPE	Personal Protective Equipment
PS	Performance Standard
PV	Photovoltaic
REPDO	Renewable Energy Project Development Office
SEA	Sexual Exploitation and Abuse

Abbreviation	Meaning
SEC	Saudi Electricity Company
SEP	Stakeholder Engagement Plan
SGI	Saudi Green Initiative
SH	Sexual Harassment
SPPC	Saudi Power Procurement Company
SSP	Shared Socioeconomic Pathways
TCFD	Task Force on Climate-related Financial Disclosures
UAE	United Arab Emirates
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VEC	Vulnerable Environmental Components
VOC	Volatile Organic Compound
WHO	World Health Organization

1 INTRODUCTION

The Kingdom of Saudi Arabia (KSA) has a distinct geographical and climatic location that makes utilizing renewable energy sources economically attractive, supporting KSA's efforts to diversify the domestic energy mix under the strategic initiative "the National Renewable Energy Program (NREP)", launched at the direction of His Majesty the King as part of Vision 2030, which aims to increase the Kingdom's share of renewable energy production, achieve a balance in the mix of local energy sources, and fulfil the Kingdom's obligations towards reducing greenhouse gas emissions. The Afif 1 Photovoltaic (PV) Project (the Project) is one of the solar PV projects that are being developed by ACWA Power and the Public Investment Fund (PIF) in the Kingdom as part of PIF's commitment to develop 70% of Saudi Arabia's renewable energy by 2030.

An Environmental and Social Impact Assessment (ESIA) Report for the "Afif 1 Solar Power Plant" was completed in October 2024 by TYPSA. The Project has been permitted by the national regulator, the National Centre for Environmental Compliance (NCEC). ACWA Power is preparing an ESIA Addendum to fulfil identified gaps in the original ESIA.

As a result, 5 Capitals Environmental and Management Consultancy (5 Capitals) has been engaged by ACWA Power to prepare this ESIA Addendum with a focus on the following areas:

- Land Use, Social Impacts, and Ecosystem Services;
- Human Rights;
- Climate Change; and
- Cumulative Impacts.

To address the scope of the ESIA Addendum, this Report is structured in the following format:

- **Chapter 1 Introduction** (this chapter): provides a brief introduction of the Project, its location, and the purpose of the Report;
- **Chapter 2 Land Use and Social Impacts**: assesses the impact on land use and social aspects, including ecosystem services;
- **Chapter 3 Human Rights Impacts Assessment**: provides the human rights risk assessment for the Project;
- **Chapter 4 Climate Change Risk Assessment**: provides the climate change impact and vulnerability assessment;
- **Chapter 5 Cumulative Impacts Assessment**: outlines the potential cumulative impacts of the Project; and
- **Chapter 6 References**: Provides the list of references used to inform and prepare this report.

1.1 Project Description

Note: *the description below is intentionally brief and for the purpose of context in this ESIA Addendum.*

The Project, developed by Saudi Power Procurement Company (SPPC) (Principal Buyer), will comprise the installation of solar PV panels and on-site energy storage facilities together with grid connection infrastructure. The Project utilises bifacial PV modules with trackers. The operational duration of the Project will be 25 years as per Power Procurement Agreement (PPA) with Saudi Power Procurement Company (SPPC). The Project Company who has the overall responsibility for developing the Project is Afif One Renewable Energy Company with the Commercial Registration No. 1009170066. The company responsible for operation and maintenance (O&M) of the Project will be NOMAC.

1.1.1 Associated Facilities

The Project will be connected to a 380 kV substation owned by the National Grid SA (NGSA) which will have an overhead transmission line (OHTL) connection to the grid. The development and operation of this substation and OHTL are not within the scope of this Project, or financed under this Project, therefore are considered as Associated Facilities.

1.2 Project Location

The Afif 1 Project is located approximately 23 km southeast of the city of Afif in the Riyadh Province of KSA as indicated in the following figures. The area available for the project is approximately 40.0 km^2. The site is located at 978 meter above sea level.

1.3 Project Timeline

The key development timeline for the Project as per the schedule estimate at the time of preparing this report is as follows:

Table 1-1 Tentative Project Schedule

MILESTONE	SCHEDULE
Financial Close	31 August 2025
Notice to Proceed (NTP)	1 Sep 2025
Initial Commercial Operation Date (ICOD) 1	NTP + 18 Months
ICOD 2	NTP + 19 Months
PCOD	NTP + 26 Months

Figure 1-1 Project Location - National Context

Figure 1-2 Project Location - Local Context

1.4 Construction Phase

It is estimated that approximately 2,317 workers, which will include both skilled and unskilled workers, will be required on-site at the peak of construction. This will include the EPC contractor and subcontractors.

During construction, the Project workforce will be accommodated in Afif town, about 23 km from the Project site.

1.5 Operation Phase

As outlined earlier, the Project will be operational for a duration of 25 years. Considering the fully atomised systems that will be installed at the plant, such as the robotic panel cleaning, limited number of workers (approximately 14 to 16 workers) will be required during operation phase. Operational staff will be mainly responsible for the routine O&M activities, to undertake overall plant monitoring, ensure safe operation, maintenance and repairs abiding by PV industry's best practices in order to maximize the performance, availability and reliability of the PV Plant.

2 LAND USE AND SOCIAL IMPACTS

2.1 Standards and Regulations

2.1.1 National Context and Regulations

There are no statutory requirements in KSA's legal system for land acquisition and resettlement related to informal land users. Processes are in place for legal title holders only.

2.1.2 Lenders Requirements

IFC PERFORMANCE STANDARD 5-LAND ACQUISITION AND INVOLUNTARY RESETTLEMENT

This standard recognises that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets or access to assets that leads to loss of income sources or other means of livelihood) because of project-related land acquisition and/or restrictions on land use. Where involuntary resettlement is unavoidable, it should be minimised, and appropriate measures to mitigate adverse impacts on displaced persons and host communities should be carefully planned and implemented.

2.2 Baseline

2.2.1 Land Ownership

The land is owned by the Government and is Head Leased to Saudi Power Procurement Company (SPPC) who will lease the land to the Project Company, therefore no land acquisition is required for the Project.

2.2.2 Land Use at and near the Project Site

Afif 1 Solar Energy Park is located about 23 km southeast of the city of Afif, in Riyadh Province. There are two small communities near the Project site, one 3.5 km northeast to the Project site (around 40 buildings) and another one 1.5 km southwest to the Project site (around 20 buildings). In addition, there is small town called Almardamah, situated about 8 km to the south. The capital city of Riyadh is approximately 370 km east of the Project site.

There is an existing dual carriage way road (Almardamah road) that connects Route 50 and Route 80 highways with the western boundary of the Project site. Project area will be permanently fenced. It is expected that all project activities will be within the limits of this area, so it is expected that the project's footprint will be limited to these limits.

As per the ESIA prepared by TYPSA, the Project site is used for camel, sheep, and goat grazing. Livestock enclosures and mobile homes were observed on the Project site. Observations made during recent site visit are discussed in the following section.

2.2.3 Site Visit Observations

During a joint site visit on January 28th, 2025, conducted by 5 Capitals and ACWA Power, the site was observed for signs of any settlements, herders, and any other land use.

Settlements and animal enclosures were observed on the Project site. The land is predominantly a barren, sandy landscape with small areas of gravel, and areas of sparse vegetation and very few trees. The typical landscape of the Project site can be seen in the figure below.

Figure 2-1 Typical Landscape at the Project Site

Areas of temporary structures, tents, and portable accommodation were observed, most of which had camel or sheep fenced or roaming near the structures. All the sheep were observed to be feeding and drinking from metal troughs of animal feed and water and were typically fenced in metal enclosures. Camels were observed grazing near groups of structures. Trucks and cars were also observed near the structures, and paths were formed by clear vehicle tracks. Water tanks were found near structures; the well shown in Figure 2-2 was dry and not in use. No other facilities were observed such as toilet facilities, water connection, or electrical connections.

Figure 2-2 Structures on the Project Site

2.2.4 Site Visit Consultations

During 5 Capitals' and ACWA Power's site visit on January 28th, 2025, consultations were held with a herder from each area of livestock and structures observed on or close to the site. Prior to the site visit, 5 Capitals prepared a consultation questionnaire in line with the stakeholder engagement guidelines (See Appendix A) for ACWA Power and 5 Capitals to engage with people on or adjacent to the Project site, should any be observed. It was important to consider the complex cultural context in Saudi Arabia when preparing the questionnaire, and hence the extent and type of questions was tailored to suit this.

The primary purpose of the questionnaire-based consultation was to gain an overview of the baseline situation of such people at the site and to understand their land uses, livelihoods, and access to ecosystem services, hence, to consequently determine what potential effects the Project might have, if any. The responses to the questionnaires are presented in Appendix B.

Two herders living with their family members were identified at the site and were interviewed. Their locations are indicated in the following figure.

Figure 2-3 Identified Herder Locations

Figure 2-4 Identified Herders

Herder H-1 owns 6 tents, animal enclosures, and a water tank, while herder H-2 owns a caravan, animal enclosures, and a water tank. Based on the consultations it was noted that both herders use the Project site for camel grazing. Herder H-1 also owns goats and sheep that are fed predominantly using animal feed due to the lack of grazable vegetation on the site. The number of livestock animals owned by the herders is shown in the following table.

Table 2-1 Herders' Livestock Numbers

HERDER ID	SHEEP	GOATS	CAMELS
H-1	~ 100	20	20
H-2	0	0	15

Both herders were owners of the livestock themselves. They both stated that herding was their main source of income. Herder H-1 has an informal agreement with one employee who works for him, while herder H-2 does not have any employees. It is noted that the livestock owners do not have land use rights or other agreements, and the herders are aware that the land is owned by the government. Both herders use the site all year round; Herder H-1 has resided on the site for 32 years and herder H-2 for 4 years.

Both herders stated that they were notified about the project 10 days prior to the site visit from government officials at a local committee. So far, the herders have not received any support to relocate from the Project site. Herder H-1 stated that he was unwilling and unable to move, and that he did not know alternative land to move to. Herder H-2 said he was able to relocate and had access to alternative land.

Following the interview, ACWA Power exchanged telephone numbers with the herders to facilitate communication.

During the consultation with the herders, ACWA Power presented the Project boundary, showing them around the perimeter for their understanding. It was also established that the herders have not identified suitable land for relocation, though the process has begun for herder H-2. In addition, consultations will continue with both herders to ensure that a suitable relocation site is identified before any displacement occurs, and additional support will be provided as needed. The herders confirmed their understanding that the land would no longer be accessible throughout the construction and operational phases.

Throughout KSA, herders are allowed to graze undeveloped land with livestock without formal contracts, however this comes with an understanding that should the land be required for development purposes, they must move off the land. It is typical that these herders can easily relocate due to the vast expanse of very similar landscape and vegetation in proximity.

2.3 Potential Project Impacts

2.3.1 Land Use Change

At the time of the site visit in January 2025, two herders with their family members were observed on the site. Due to the Project development, the site will be fenced and Project structures (i.e., the solar field) will be constructed. Consequently, the site will no longer be accessible.

The area being used for grazing within the Project site is understood to be limited as most of the Project site was observed to be an open sand and gravel habitat with little vegetation, which is the reason the animals are fed animal feed due to the lack of grazable vegetation on the site.

Given the abundance of open, available land outside of the site within proximity, and expected grazing areas for camels available for use by herders, the loss of land due to the Project for grazing activities is expected to be very minimal.

2.3.2 Relocation

The Project area will be fenced, and therefore access to that area will no longer be possible. As such, any people, structures, and livestock on the Project site will require to be relocated outside of the Project's footprint.

Although the structures are mobile, both herders use the land for grazing all year round. Both the herders H-1 and H-2 will require relocation since their structures and livestock are currently located within the Project boundary. It is noted that herder H-2 has already started the process of identifying suitable alternative land for their relocation, and has stated that relocation will not impact his livelihood in any way.

It is noted that consultations are on-going with herder H-1 to ensure that he could identify suitable land and appropriate support is provided if required (i.e., in moving the animal feed etc.) Additionally, the herder will not be displaced from site until an alternative relocation site is identified. ACWA Power responded that the site is not yet handed over to the Project Company and is still under SPPC/Ministry of Energy ownership, and that they have raised the issue about herder H-1 with SPPC, the off taker of the Project. SPPC has confirmed as part of the bid clarification that they are responsible for the relocation of herders.

2.3.3 Livelihood

Herding was stated to be the main source of income for both of the herders consulted. However, it was evident from the site visit and consultations that the animals are fed using metal troughs due to lack of grazing area. The livestock and herders will move to new pastures, and the livestock rearing will continue as normal. Herder H-2 confirmed that his livelihood will not be impacted by relocation. Discussion with herder H-1 is ongoing to ensure his and his employee's livelihood will

not be affected after assisted relocation. If herding continues as per normal, their incomes will not be impacted by the Project.

2.3.4 Access

During the consultations, it was established that the site is not used as a transportation or migration route. However, wheel tracks from cars and trucks, left by the herders, were observed on the Project site. Once the herders have been relocated, there will be no longer any need to access the site. The Project will not impact the roads near the Project site, therefore any vehicles that use the roads as access route can continue to do so during and after the Project is constructed.

2.3.5 Ecosystem Services

Ecosystem services are the benefits that people, including businesses derive from ecosystems. A decline or loss of any of these services and their benefits can result in socio-economic impacts that extend beyond environmental damages (World Resources Institute, 2013). These are organised into: (i) provisioning services which are products people obtain from the ecosystem (ii) regulating services which are benefits people obtain from regulation of ecosystem services (iii) cultural services which are non-material benefits from the ecosystem (iv) supporting services which are natural processes that maintain other services (IFC PS6). These are discussed below in the context of the Project site and its area of influence.

Provisioning Services - The direct area of influence of the Project is not considered to be host to natural resources that may be considered ecosystem services. For example, the site does not provide food, fuel or other raw materials to the local or the wider population.

Regulating Services – The Project site consists of sparse vegetation and therefore does not support any considerable regulating services such as erosion control, temperature regulation or carbon sequestration.

Cultural services – The desert environment at the Project site does not provide any non-material benefits from the ecosystems, such as contributing to cultural identity, spiritual enrichment or tourism.

Supporting services – There are certain supporting services such as nutrient cycling, primary production and soil formation that are applicable for the Project site, however these foundational processes are expected to continue to function effectively despite potential disturbances from Project activities.

Considering the construction and operational aspects of the Project, any impacts that will result in major impacts to ecosystem services have not been identified. As such, the Project is not expected to result in any notable changes to ecosystem services dependencies that requires a detailed analyses.

IFC PS6 outlines that ecosystem services valued by humans are often underpinned by biodiversity and hence impacts to biodiversity can adversely affect the delivery of ecosystem services.

The ecosystem services available to (and in use by) humans at the Project site are limited, primarily due to the lack of land users, lack of valuable vegetation, or other ecological features that are commonly used to derive benefits. The consultation questionnaire (ref. Appendix A) included a question (#2) that was targeted towards identifying provision and benefits of ecosystem services to people on or close to the site. The responses provided by all herders specified that there are not specific derived benefits from the site to these herders.

Based on the site observations and details provided in sections above, the habitat is of low grazing importance due to the lack of substantial suitable vegetation.

As seen in Figure 2-1, there were limited observed trees on site that would produce substantial firewood provisions. In areas of thicker vegetation, shrubs were most predominant, which give little to no firewood provision. The habitat is representative of typical large regional arid ecosystems within KSA, and the loss in ecosystem services are envisaged to be minimal.

Based on the baseline sections, the Project site will not impact any significant ecosystem services.

2.4 Mitigation Measures

To reduce potential land use and social impacts, appropriate measures should be implemented. The table below presents the relevant mitigation measures.

Table 2-2 Land Use and Social Impacts Mitigation Measures

IMPACT	MITIGATION
Land Use Change	• Given the abundance of open, available, similar land outside of the site within proximity, the loss of land due to the Project for grazing activities is expected to be very minimal. For H-1, further consultation will be carried out by SPPC who currently owns the Project site and is responsible for the relocation of the herders. During the consultation, the Project Company has offered its full support, as needed to assist the herders in case of any issues. The contact details of the Project Company have been provided to the herders in case of any assistance that may be required.
Relocation	• The owner of structures and livestock within the site will be provided with support and sufficient time (at least two months from conclusion of interview) to identify suitable relocation sites for their livestock. Relocation of herders will be facilitated by SPPC before handing the land over to the Project Company. • Consultations will continue with this owner to ensure that they have identified suitable alternative land and determine whether they require support from the Project in relocating their livestock, structures, and animal feed.

IMPACT	MITIGATION
	• Additionally, consultations will also continue to ensure that the owner of the livestock and their herders are kept up to date with the Project construction timeline (in case of any changes). • The herders/workers will not be displaced until a suitable relocation site has been identified and relocation has occurred. • Construction safety buffers will be established if the construction phase of the Project commences before the herders are able to identify a suitable relocation land. This will ensure that there is no disruption to their livelihood. • Should any issues arise with construction disrupting herders near the Project site, the concerned work will pause until a resolution is found. • Monitoring will be undertaken to ensure that the herders have been able to successfully re-establish their activities at the new relocation site.
Livelihoods (owners of livestock and their herders/workers)	• All the livestock owners and their workers will have access to the grievance mechanism (see section below on details of the grievance mechanism).
Access	• The Project will not obstruct any access routes outside of the Project boundaries.
Ecosystem Services	• The Project activities will be restricted within its boundaries to ensure that there is no impact on areas outside its Area of Influence (AoI).

2.4.1 Access to the Grievance Mechanism

The livestock owners and their herders/workers will continue to have access to the Grievance Redress Mechanism (GRM) throughout the Project's lifespan in line with the Project Stakeholder Engagement Plan (SEP). This will allow them to raise any concerns or issues they have in relation to the Project. The details of the Project GRM will be posted in strategic locations in both Arabic and English, where it is visible to external stakeholders including herders.

The GRM established for the Project will allow for:

- Verbal complaints/concerns received in person or through phone calls; and
- Written complaints/concerns received through emails or grievance boxes located:
  - At the main gate;
  - At the gate of the temporary site facilities; and
  - Around the site.

The grievance mechanism will allow parties to raise concerns or complaints against the Project without cost, retribution, or fear of negative consequences.

2.5 Monitoring

Table 2-3 Land Use and Social Monitoring Requirements – Construction and Operation

MONITORING	PARAMETER	MONITORING LOCATION / MEANS OF VERIFICATION	FREQUENCY & DURATIONS
Herder Grievances	Grievances concerning relocation and support	Grievance Log	On-going
Relocation	Ensure that the herder is relocated to a suitable site before the start of construction within their areas of use. Provide relocation support if requested by herder H-1. Ensure that post relocation, the herders have been able to successfully re-establish their activities at the new site.	Herder's relocation site Notes of on-going consultation with the herders, particularly during the relocation process. Type of support provided to the owner (if any)	On-going
Other Grievances	Grievances from the local communities and other stakeholders	Grievance Log	On-going

3 HUMAN RIGHTS IMPACTS ASSESSMENT

3.1 Overview

With new requirements under EP IV, an increased attention is being given to the accountability of businesses for their impact on human rights and it necessitates the inclusion of a 'Human Rights Impact Assessment' as part of the ESIA for projects financed by Equator Principles Financial Institutions (EPFIs). Accordingly, a Human Rights Impact Assessment has been conducted to evaluate:

- The rights of the local community and herders who live and work in the surrounding area to a healthy, safe, and secure environment;
- The rights of the labourers to adequate healthy and safe living conditions; and
- The rights of the labourers to healthy, safe, and fair working environments and conditions.

3.2 Standards and Regulations

3.2.1 National Context and Regulations

Saudi labour law is governed by Royal Decree No. M/51 (23 Sha'ban 1426 / 27th September 2005). The labour law includes terms and conditions of employment in Saudi Arabia required by employers and includes details of worker rights.

The Ministry of Labour (MOL) approved amendments to the Labour Law on 5th April 2015 (Resolution No. 258) which was first published in the official gazette on 24th April 2015.

The Ministry of Labour and Social Development was later merged with Ministry of Civil Service to establish the Ministry of Human Resources and Social Development in 2019, which is the governing Ministry in Saudi Arabia responsible for providing development, support, and protection for the community.

Section 26 of the Basic Law of Governance states the Government is responsible for protecting human rights in accordance with the Shari'a Law that governs the country. Human Rights treaties ratified by the Kingdom include (Treaty Body Database, 2020):

- Convention against Torture and Other Cruel Inhuman or Degrading Treatment or Punishment (23 September 1997);
- Convention on the Elimination of All Forms of Discrimination against Women (7 September 2000);

- International Convention on the Elimination of All Forms of Racial Discrimination (23 September 1997);
- Convention on the Rights of the Child (26 January 1996);
  - Optional Protocol to the Convention on the Rights of the Child on the involvement of children in armed conflict (10 June 2011):
  - Optional Protocol to the Convention on the Rights of the Child on the sale of children child prostitution and child pornography (18 August 2010);
- Convention on the Rights of Persons with Disabilities (24 June 2008);
- The Arab Charter of Human Rights; and
- Geneva Convention (18 May 1963).

In addition, Saudi Arabia is an International Labour Organisation (ILO) member state and has ratified 16 ILO Conventions out of which 6 are part of the IFC Performance Standard 2 – Labour and Working Conditions.

3.2.2 Lender Requirements

IFC PERFORMANCE STANDARD 4-COMMUNITY HEALTH, SAFETY AND SECURITY

This standard establishes requirements for the safeguard of the local community from potential risks associated with the project including impacts associated with the introduction of communicable disease, loss of ecosystem function, site access and operation, material use etc. It requires the Client (and Project) to avoid or minimise the risks and impacts to community health, safety, and security that may arise from Project related activities, with particular attention to vulnerable groups.

IFC PERFORMANCE STANDARD 2-LABOUR AND WORKING CONDITIONS

IFC PS2 recognises that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers. This includes rights for direct, contracted, and supply chain workers (as applicable for key primary supply chains).

PS2 is in part guided by several ILO conventions, as follows:

- ILO Convention 87 on Freedom of Association and Protection of the Right to Organize;
- ILO Convention 98 on the Right to Organize and Collective Bargaining;
- ILO Convention 29 on Forced Labour (ratified by KSA);
- ILO Convention 100 on Equal Remuneration (ratified by KSA);
- ILO Convention 105 on the Abolition of Forced Labour (ratified by KSA);
- ILO Convention 111 on Discrimination (Employment and Occupation) (ratified by KSA);
- ILO Convention 138 on Minimum Age (of Employment) (ratified by KSA);

- ILO Convention 182 on the Worst Forms of Child Labour (ratified by KSA);
- UN Convention on the Rights of the Child, Article 32.1; and
- UN Convention on the Protection of the Rights of all Migrant Workers and Members of their Families.

In addition to this, PS2 outlines certain requirements for projects linked to Human Resource (HR) policies, management, working conditions, and terms of employment (other elements not linked to the ILO conventions above) as well as key processes for occupational health and safety (OHS) management, and grievance redress.

UNITED NATIONS HUMAN RIGHTS GUIDING PRINCIPLES (HRGPS)

- HRGP II on "The corporate responsibility to respect human rights" recognises that it is the responsibility of businesses and corporations to respect human rights. It is a global standard of expected conduct for all business enterprises wherever they operate. It exists independently of a States' ability and/or willingness to fulfil their human rights obligations and does not diminish those obligations. The Foundational principles to take into consideration are:
- Principle 11: Business enterprises should avoid infringing on the human rights of others and should address adverse human rights impacts with which they are involved;
- Principle 12: The responsibility of business enterprises to respect human rights refers to internationally recognized human rights – understood, at a minimum, as those expressed in the International Bill of Human Rights and the principles concerning fundamental rights set out in the International Labour Organization's Declaration on Fundamental Principles and Rights at Work;
- Principle 13: The responsibility to respect human rights requires that business enterprises avoid causing or contributing to adverse human rights impacts through their activities and address such impacts when they occur;
- Principle 14: The responsibility of business enterprises to respect human rights applies to all enterprises regardless of their size, sector, operational context, ownership, and structure. Nevertheless, the scale and complexity of the means through which enterprises meet that responsibility may vary according to these factors and with the severity of the enterprise's adverse human rights impacts;
- Principle 15: Business enterprises should have policies and processes appropriate to their size and circumstances in place.
- Principle 16: Policy commitment
- Principle 17 to 21: Human rights due diligence
- Principle 22: Remediation

IFC GUIDANCE ON GENDER BASED VIOLENCE AND HARASSMENT (GBVH) IN THE CONSTRUCTION SECTOR

The assessment, prevention, monitoring, and response measures with regards to GBVH should be underpinned by the following principles:

- Survivor Centred: The rights of GBVH survivors need to be consistently prioritised and used as the starting point for all decisions on efforts to assess, prevent, monitor, and respond to GBVH.
- Safe: Survivors, witnesses, and those who report and seek to address GBVH can be at risk of retaliation, including threatening and violent behaviour, often from those who do not like their position of power being challenged. Companies should prioritise the safety of those who have experienced, witnessed, and reported GBVH.
- Context specific: All measures need to be rooted in a thorough understanding of the local context. Investors and companies should understand the legal and social context, and identify the support mechanisms that are in place.
- Collaborative: Companies should seek inputs from a range of internal and external stakeholders to increase the likelihood of broader buy-in and make GBVH prevention more effective.
- Inclusive: Companies should recognise the heightened risks of GBVH faced by certain groups who are subject to discrimination and marginalisation. High risk groups often include people with disabilities, single parents, migrants and ethnic minorities, and sexual and gender minorities. The system should also account for illiterate or non-literate people who may not be able to access written information on GBVH reporting mechanisms.
- Integrated: Processes and efforts to assess, prevent, monitor, and respond to GBVH need to be integrated as much as possible into existing processes and management systems, such as occupational health safety, security management systems, environmental and social management systems (ESMS), and HR policies and procedures.
- Non-discriminatory: All survivors need to be listened to and treated equally whilst promoting diversity in the workplace.
- Well-informed: Companies should draw on relevant expertise when developing prevention and response measures. The grievance mechanism and investigation procedures should be set up to ensure they are appropriate, relevant, and safe in the local context.

According to the guidance, the benefits of addressing GBVH include:

- Improves workers' physical and emotional wellbeing and strengthens occupational health and safety.
- Avoids reputational damage, financial risks, and legal liabilities for companies, investors, and construction contractors.
- Builds relationships and social license to operate in communities. This can result from regular dialogue to understand and track project GBVH risks as well as the effective use of measures to prevent and respond to GBVH.
- Broadens the pool of potential workers that companies can draw upon, including women workers from nearby communities because of lower perceived risk of GBVH.

3.3 Project Affected People

3.3.1 Local Communities and Herders

As outlined earlier, the Project is located about 23 km southeast of the city of Afif, in the Riyadh Province. Urban centers found near the Project site include Almardamah (about 8 km south) and Riyadh (about 370 km east).

There is an existing road (Almardamah road) that connects routes 50 and 80 to the Project site. The entire Project area will be fenced.

The Project activities can potentially result in direct or indirect impacts to users of the adjacent road, and the closest community known as Almardamah which is about 8km away.

During the site visit on 28th January 2025 conducted by 5 Capitals and ACWA Power the site was observed for signs of settlements, herders, and any other land use. No permanent structures were noted on the Project site.

Two herders with families were identified, one of which (H-1) stated their structures and livestock had been on the site for thirty-two years. Other than the herders, no activities were observed on the Project site itself.

Note: *Refer to the Land Use and Social Impacts chapter above for further information.*

3.3.2 Project Workers

There are estimated to be up to 2,317 workers on-site at the peak of construction. The Project will equate to approximately 22,254 worker-months. It is expected that about 50% of the workers and staff will be expatriates, likely to be predominantly from India and China.

The workforce will be accommodated in Afif, 23 km to the Southeast of the Project site. During the operational phase, it is expected that there will be 14-16 workers, which will include Saudi nationals.

Certain parties may also engage contract staff (e.g., from agencies) where additional manpower is required. There will also be suppliers and/or service providers for deliveries, waste management etc., who will have access to the site and will be exposed to certain risks.

Accordingly, Project related activities, management processes, living conditions, and work environments can result in potential adverse impacts to employees and workers listed above.

3.4 Potential Project Impacts on Human Rights

3.4.1 Construction Phase

COMMUNITY SAFETY AND SECURITY

All construction projects have potential risks to public safety due to the use of high-powered equipment, heavy construction equipment, excavation activities, transportation, fire incidents, and pollution releases. Additionally, unauthorised access to the construction site, including the public presents a safety and security concern. There is a small residential community of approximately 20 buildings about 1.5km away which is the closest receptor to the Project site. However, the overall risk is inherently low, as the nature of a PV project's construction phase is not typically hazardous.

Public risks during the construction phase of a project have the potential to result in isolated incidents, which could be highly dangerous to a person or group of people, however, this rarely occurs. Such impacts are very unlikely during this Project due to the distance from receptors, and lack of receptors.

It is noted that a Grievance Mechanism will be established for the Project to allow third parties to raise concerns or complaints against the Project without cost, retribution, or fear of negative consequences.

The Project will ensure that the right of local communities to a clean and safe environment is safeguarded through the implementation of mitigation and management measures detailed in the ESIA and this ESIA Addendum.

OCCUPATIONAL HEALTH AND SAFETY

Common activities undertaken during construction such as civil works, the movement of heavy machinery, excavation, welding, handling of chemicals, and works undertaken at height, in confined space or with electrical hazards etc. can introduce risk to the health and safety for the workforce. Risks are more likely to be apparent for those who are not familiar, applicably qualified, or otherwise well trained with the type of works undertaken and/or the associated hazards.

The type of hazards attributable to a construction site will vary significantly depending on the construction methods employed and the degree of control implemented by the contractor. Health, Safety, and Environment (HSE) personnel will be on site during the project construction. These personnel will be dedicated HSE professionals to ensure the Engineering, Procurement and Construction (EPC) workers and affiliated sub-contractors demonstrate consideration of health and safety risks as part of their chosen construction methods and that these risks are appropriately mitigated during the construction phase.

COMMUNICABLE DISEASES

Impacts on Workforce

The risk associated with the spread of communicable diseases within workforces is prominent in construction working environments that require the sharing of equipment, accommodation, sanitary facilities, canteens, and means of transportation between workers. A high number of workers working in such proximity or confined spaces such as for this Project also increases the risk of infection.

Impacts on Surrounding Community

The location of employees' accommodation which will be in Afif, may also have a possible impact on community health where integration with local communities takes place, should either party become infected with a communicable disease.

WORKING CONDITIONS, WELFARE & ACCOMMODATION

Unfair wages, education, and opportunities among the workforce can result in opportunistic immoral practices with labourers and site staff who consequently suffer.

The quality of living accommodation, living areas, the number of workers per room, facilities and amenities available to workers, maintenance accommodation areas, and provisions of associated services (e.g., catering, waste management, etc.) can significantly impact the lives and wellbeing of Project workers. This may include the lack of welfare provisions on-site such as clean drinking water, hygienic and ample toilet facilities, hand basins (with soaps/hand wash), temperate rest areas, food, and other amenities necessary to the works and the environment.

WORKER AND WORKFORCE EXPLOITATION

The Project will have several parties contributing as part of the construction phase, of which there will likely be varying internal processes and procedures for each concerning HR, labour/workforce employment, and other related elements.

However, labour exploitation on construction sites has been common for decades, especially in environments where the workers may not be part of a syndicate of a cooperative. Examples from other projects within the region have shown that there can be instances of forced labour, labour with poor contracting conditions, or lacking processes in place to manage such elements. Therefore, potential risks exist regarding the above and are expected to be more prevalent at lower ends of the Project hierarchy, particularly for sub-contractors and agency/contracted manpower that may need to be engaged.

GENDER INEQUALITY & DISCRIMINATION

Saudi Arabia has eliminated restrictions on women's employment in industrial sectors including construction, however, the construction industry remains lacking in gender diversity, being

dominated by men. Women are generally more likely to face discrimination in terms of employment or wages, even when they engage in the same tasks as men.

In addition, income earning opportunities for women through direct employment during the construction phase or through indirect employment has the potential to increase household tensions and expose women to cultural pressure, or harassment and violence in their homes or communities, considering them 'home makers' who should not be engaged in construction work.

The Project should guarantee the right of all Project workers including women to just and favourable work conditions, free of discrimination.

GENDER BASED VIOLENCE AND HARASSMENT, SEXUAL EXPLOITATION & ABUSE, AND SEXUAL HARASSMENT

Members of the workforce, their family members, or the neighbouring communities can potentially face harassment in the workplace or at home in forms of GBVH, Sexual Exploitation & Abuse (SEA), and Sexual Harassment (SH). The influx of workers from outside of the Project region may increase the likelihood of GBVH. The constructions workers are likely to be predominantly young males coming from other regions and outside of the country. These workers will be away from their families and removed from their normal social spheres. This could potentially result in peer pressure and involvement in unlawful behaviour. Such behaviour can lead to unwanted aggressive advances and harassment.

During the construction phase, workers will also be vulnerable to various forms of harassment, exploitation, and abuse, which could be aggravated by the traditional male working environment.

3.4.2 Operational Phase

COMMUNITY SAFETY AND SECURITY

Although they are expected to be minimal for a Solar PV project, the Project will carry certain risks that could result in impacts to public or external party safety where such impacts are transferred or received outside of the Project boundaries. Such impacts are unlikely to occur, but may relate to fire, Volatile Organic Compound (VOC) fumes, explosions, spills of back-up generator fuels, and un-warranted or accidental releases of sanitary wastewater. The extent of such impacts may range outside of the boundaries of the Project and require the involvement of external agencies to help manage and abate such impacts (e.g., Civil Defence, Police, and Army).

As outlined earlier, there are two small communities near the Project site, located about 3.5 km and 1.5 km away from the site.

Potential risks can arise from unauthorised parties (including the public) accessing the Project, such as electrocution. Several measures are considered to reduce those risks including fencing the site, installing monitored gates, and hiring security guards either through a 3rd party or direct

employees of the company to prevent the public from trespassing to the site and any malicious intrusion during operation.

OCCUPATIONAL HEALTH AND SAFETY

The risks generally associated with the operational phase of the Project are anticipated to be less than during the construction phase due to reduced site activity and requirements for heavy vehicles, equipment, and machinery. During the operational phase there will be a limited workforce, their work will be predominantly office based, and the cleaning of the solar panels is going to be largely automated. However, there will remain occupational health and safety risks attributable to the operational phase associated with maintenance and inspection requirements.

The severity and likelihood of risks during the operational phase will also depend on the frequency and requirements for planned and unplanned maintenance. The O&M team should develop and implement a robust plan to appropriately manage these risks.

A grievance mechanism has been established for the Project and will be implemented to allow employees to express their concerns or complaints without cost, retribution, or fear of negative consequences.

COMMUNICABLE DISEASES

Even though the required number of workers is limited during operation, there is potential for the spread of diseases among workers, or within the local community and vice-versa to the workforce.

WORKING CONDITIONS

The number of staff required during operation is limited at approximately 14 to 16, however, a lack of welfare provisions on-site such as clean drinking water, hygienic and ample toilet facilities, hand basins (with soaps/hand wash), temperate rest areas, food, and other amenities necessary to the works and the environment can impact the lives of Project workers.

GENDER BASED VIOLENCE AND HARASSMENT

Much of the staff will be direct employees of the Project Company, therefore the potential risks associated with violence and harassment are anticipated to be limited due to consistent processes in place as part of the respective HR management systems, assuming they are appropriately designed and resourced.

3.5 Mitigation Measures

3.5.1 Construction Phase

To reduce potential impacts on health and safety of the community and site personnel, and to ensure the provision of the required human rights during the construction phase, appropriate measures should be implemented. The table below presents the relevant mitigation measures.

Table 3-1 Human Rights Mitigation & Management Measures – Construction

Potential Impact	Mitigation and Management Measures
Public/Community Safety	• Risks to public safety will be appropriately addressed and prepared for in an 'Emergency Preparedness and Response Plan'. - The plan will include the appropriate procedure to respond to any such incidents, as well as site-specific contact details and details of external agencies who may be required. • Site personnel should be trained in emergency procedures and plans, and the potentially affected receptors should be notified of procedures to follow via relevant communication channels. • Employees shall undergo a Code of Conduct (COC) training to ensure smooth coordination with the neighbouring community. • Project induction training will include a section on COC when engaging with local community members. This will include an overview of culturally appropriate measures and etiquette to bear in mind. • All high-risk areas including fuel storage areas will be secured with internal fencing and will be patrolled by security throughout the day. • Appropriate mechanisms for emergency control (e.g., firefighting equipment) will be placed at suitable positions around the site. • The implementation of a robust grievance mechanism will be ensured.
Public/Community Security	• The EPC Contractor shall prepare a Security Plan consistent with its Security Risk Assessment. • The Project will employ its security staff to provide 24/7 security control across the Project site and dedicated security staff at gatehouses. • All vehicles entering the site will require pre-approved clearance and will need to be registered. • The Project site will be guarded during the enabling work's stage and security will manage visitors as per the Security Management Plan. • Project security will record all instances of incoming vehicles. • CCTV will be installed at key locations around the site and gatehouses. • Appropriate lighting will be provided at gatehouses for security personnel to prevent unauthorised access. • Project personnel will only be provided access to the construction site with valid ID cards and permits to work in line with HSE requirements. • People trying to gain unauthorised access to the site without appropriate permits and PPE will not be permitted or will be removed from site if identified, an investigation shall be carried out on how they were able to access the site, and corrective action taken. • The security personnel will be regularly trained on GBVH COC including how to handle grievances related to GBVH from the community.
Occupational Health and Safety	• The EPC Contractor will provide all workers with a safe and healthy work environment, considering inherent risks and specific classes of hazards associated with the Project.

Potential Impact	Mitigation and Management Measures
	• The EPC Contractor shall implement and maintain an OHS management system considering specific risks associated with the Project, legal requirements, and duty of care. • The EPC Contractor shall be responsible for ensuring that all affiliated sub-contractors comply with the OHS management system. The OHS management system shall be in-line with recognised international best practice and as a minimum, this plan shall include: - Means of identifying and minimising, so far as reasonably practicable, the causes of potential H&S hazards to workers. - Provision of preventive and protective measures, including modification, substitution, or elimination of hazardous conditions or substances. - Provision of appropriate protective equipment to minimise risks, and the requirement and enforcement of its use. - Training of workers, and the provision of appropriate incentives for them to use and comply with OHS procedures and protective equipment. - Documentation and reporting of occupational accidents, diseases, and incidents. - Emergency prevention, preparedness, and response arrangements.
Staff/Community Exposure to Communicable Diseases	• Staff and workers shall have access to medical insurance, health professionals, and suitable medical facilities, which will aim to prevent the spread of diseases internally and externally. • Any reportable disease shall be diagnosed by the authorised medical centre doctors. Diagnosis includes identifying any new symptoms or any significant worsening of existing symptoms. • The potential for exposure to water-borne, water-based, vector-borne diseases and communicable diseases as a result of Project activities will be prevented, avoided, and minimised to the extent possible through following good hygienic practices. • Any external and internal spreading of diseases shall be diagnosed and the precautions as per the instructions from the national or local medical authority shall be implemented. • The Health and Safety Team on site should provide advice during training or inductions on exposure to diseases, including national and project requirements for any infectious disease that may be present. • Provide a 24hr emergency hotline. • Isolate/care for sick and potentially infected staff and workers. • Identify any vulnerable groups (i.e., those with pre-existing conditions) working in the Project site (for the EPC and sub-contractors) and take precautionary measures in accordance with the national and World Health Organization (WHO) guidelines. • Provide testing for staff as required at no cost to them. • Promote personal hygiene among the workers and provide training and posters to remind workers to wash their hands regularly, clean their work areas and equipment, sanitize properly, etc. • Ensure suitable distancing, proper ventilation, and hygiene within workers accommodation. • Coordinate and regulate transportation of workers and access to the site i.e., through reduced bus occupancy, and temperature and PPE checks etc.

Potential Impact	Mitigation and Management Measures
	• Provide a flexible working regime for employees who may prefer to work from home due to health issues, childcare, home schooling, etc. without fear of victimisation.
Worker's Welfare On-Site	• Ensure that welfare provisions are available on-site, including but not limited to: - Hygienic and regularly cleaned toilets (commensurate to applicable requirements or good practices for the quantity required on-site, or in areas of the site); - Basins and running clean water, with hand-wash/soap for hand cleaning; - Rest areas (with air conditioning, chairs, and tables); and - Clean drinking water available in working areas (at a suitable temperature). • If applicable, suitable and hygienic areas for eating and storing food (including refrigerators, heating devices [ovens/microwaves] etc.)
Workers' Accommodation	• Provide accommodation that complies with the IFC & EBRD Workers Accommodation: Processes and Standards (2009).
Workers' Terms of Employment, Non-Discrimination and Equal Opportunities, Working Relationships	• Project parties will establish HR Policies and processes to ensure working conditions and terms of employment are compliant with the requirements of National Labour Law, IFC PS 2, and associated ILO conventions. • Project employment relationships shall be on the principle of equal opportunity and fair treatment and will not discriminate concerning any aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, promotion, termination of employment, retirement, and discipline. • Project parties will not make employment decisions based on personal characteristics, such as gender, race, nationality, ethnic origin, religion or belief, disability, age, or sexual orientation, unrelated to inherent job requirements. • Project parties will document and communicate to all workers their working conditions and terms of employment including their entitlement to wages, hours of work, overtime arrangements and overtime compensation, and any benefits (such as leave for illness, maternity/paternity, or holiday). *Special measures of protection or assistance to promote local employment opportunities or selection for a particular job based on the inherent requirements of the job, which are per national law, will not be deemed discrimination.*
Workers' Forced Labour	• Project parties will not employ forced labour, which consists of any work or service not voluntarily performed that is exacted from an individual under threat of force or penalty. This covers any kind of involuntary or compulsory labour, such as indentured labour, bonded labour, or similar labour-contracting arrangements. • Such requirements are also applicable in the hiring of agency/other contracted manpower, for which processes should be in place by the Project party to undertake due diligence on the agency providing the manpower. Where potential risks of forced labour are identified other suppliers with reputable processes and controls should be sought. • HR policies and procedures will be adapted appropriately to the size of the workforce required for the Project. Policies and procedures must be

Potential Impact	Mitigation and Management Measures
	prepared to demonstrate consistency with the requirements of national legislation and IFC PS 2.
Child Labour	• Project parties will comply with all relevant national laws and provisions related to the employment of minors. • In any event, Project parties will not employ children in a manner that is economically exploitative or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. • Young people below the age of 18 years will not be employed in hazardous work and all work of persons under the age of 18 shall be subject to an appropriate risk assessment. • Such requirements are also applicable in the hiring of agency/other contracted manpower, for which processes should be in place by the Project party to undertake due diligence on the agency providing the manpower. Where potential risks of child labour are identified other suppliers with reputable processes and controls should be sought.
Workers' Wages, Benefits, Conditions of Work and Retrenchment	• HR policies and procedures will be adapted appropriately to the size of the workforce required for the Project. Policies and procedures must be prepared to demonstrate consistency with the requirements of national legislation and IFC PS 2 and include a COC on GBVH. • Wages, benefits, and conditions of work offered should be overall comparable to those offered by equivalent employers in the relevant region of that country/region and sector concerned. • If Project parties anticipate collective dismissals associated with the proposed Project, the parties shall develop a plan to mitigate the adverse impacts of retrenchment in line with national law and good industry practice and based on the principles of non-discrimination and consultation. Without prejudice to more stringent provisions in national law, such consultation will involve reasonable notice of employment changes to the workers' representatives and, where appropriate, relevant public authorities so that the retrenchment plan may be examined jointly to mitigate adverse effects of job losses on the workers concerned. The outcome of the consultations will be reflected in the final retrenchment plan.
Workers Conditions-Key Supply Chain (i.e., PV Module Suppliers)	• Project parties shall devise and implement applicable controls to ensure the measures herein are implemented by any sub-contractors and the requirements for workers conditions are included in the pre-qualifications criteria for selection of key contractors and suppliers. • Project parties will take reasonable steps to inquire about the use of child labour and forced labour in their supply chains and try to exert influence where possible or identify other suppliers.
Grievance Mechanism	• A grievance mechanism for workers will be provided to raise reasonable workplace concerns. • Workers will be informed of the grievance mechanism at the time of hiring and make it easily accessible to them. • The mechanism will involve an appropriate level of management and address concerns promptly, using an understandable and transparent process that provides feedback to those concerned, without any retribution. • The mechanism will not impede access to other judicial or administrative remedies that might be available under law or through existing

Potential Impact	Mitigation and Management Measures
	arbitration procedures, or a substitute for grievance mechanisms provided through collective agreements. • The grievance mechanism should be used to monitor worker morale, understand how workers are affected and what their concerns are in relation to communicable diseases, and address pressing matters promptly. • The grievance mechanism shall be provided for confidential reporting and a support system for any workers reporting issues relating to GBVH. It will also allow for reporting through word of mouth for those who cannot write. • A grievance mechanism for community members will be provided to raise concerns or complaints. • Community members will be informed of the grievance mechanism through stakeholders' engagement, and it will be made easily accessible to them. • Complaints will be acknowledged, addressed, and closed out in a timely manner.
Violence and Harassment	• The Project parties will conduct a GBVH risk assessment in consultation with relevant stakeholders including women leaders and those working with young adolescent girls and boys. This will also include the identification of potential interventions and risk mitigation measures. • Awareness training will be mandatory for all Project workers regarding the GBVH risks and the workers responsibilities and the legal consequences of being a perpetrator. • Information will be provided on how to report any cases of violence or harassment and the services that will be made available to offer support to any of the survivors. • Approach towards GBVH prevention, mitigation and response will be survivor centred and ensure confidentiality, dignity, and respect to them. • The Project staff will be trained on how to preserve the safety of the women, girls, and boys when interviewing them and collecting information about their experiences on GBVH. • The Project will provide essential services for survivors such as access to counselling services, support groups, legal support etc. at no cost to them. • All determined cases of GBVH will be referred to relevant legal entities in the Project area for further investigation and prosecution. • The Project grievance mechanism will be made available to project workers and community members and will ensure that survivors' information is confidential and kept anonymous. • All cases relating to GBVH shall be documented and closed.

3.5.2 Operational Phase

To reduce the impacts on health and safety of the community and site personnel, and to ensure the provision of the required human rights during the operation phase, appropriate measures should be implemented. The following table presents the relevant mitigation measures.

Table 3-2 Human Rights Mitigation & Management Measures – Operation

POTENTIAL IMPACT	MITIGATION AND MANAGEMENT MEASURES
Public/Community Safety	• Risks to public safety will be appropriately addressed and prepared for in the operational phase 'Emergency Preparedness and Response Plan' and training. • The plan will include the appropriate procedure to respond to any such incidents, as well as site-specific contact details and details of external agencies who may be required. • All high-risk areas including fuel storage areas (such as at the Emergency Generator) will be secured. • Appropriate mechanisms for emergency control (e.g., firefighting equipment) will be placed at suitable positions around the site. • The employees during the operational phase shall undergo a COC training to ensure smooth coordination with any neighbouring community. • Grievance Redress Mechanism shall be made accessible to the community to ensure that community members raise grievances to the Project leadership.
Public/Community Security	• The Project will employ its security staff who will provide 24/7 security control across the Project site and dedicated security staff at gatehouses. • The security personnel will be regularly trained on GBVH COC including how to handle grievances related to GBVH from the community. • All vehicles entering the site will require pre-approved clearance and will need to be registered. Project security will record all instances of incoming vehicles. • CCTV will be installed at key locations around the site and gatehouses. • Appropriate lighting will be provided at gatehouses for security personnel to prevent unauthorised access. • Project personnel will only be provided access to the construction site with valid ID cards and permits to work in line with HSE requirements. • Security arrangements will be in line with the KSA National Standards. In addition to this, security personnel will receive internal training aligned to the UN requirements on the control of force by law enforcement officials. Additional training will be provided to access gate staff regarding grievances, reporting such grievances and dialogue with any members of the local community.
Occupational Health and Safety	• The Project Company will provide the workers with a safe and healthy work environment, considering inherent risks and specific classes of hazards associated with the Project. • The Project Company shall implement and maintain an OHS management system considering specific risks associated with the Project, legal requirements, and duty of care. • The Project Company shall be responsible for ensuring that all affiliated sub-contractors comply with the OHS management system. The OHS management system shall be in-line with recognised international best practice and as a minimum, this plan shall include: - Means of identifying and minimising, so far as reasonably practicable, the causes of potential H&S hazards to workers. - Provision of preventive and protective measures, including modification, substitution, or elimination of hazardous conditions or substances.

Potential Impact	Mitigation and Management Measures
	- Provision of appropriate equipment to minimise risks, and requirement and enforcement of its use. - Training of workers, and the provision of appropriate incentives for them to use and comply with H&S procedures and protective equipment. - Documentation and reporting of occupational accidents, diseases, and incidents. - Emergency prevention, preparedness, and response arrangements
Staff/Community Exposure to Communicable Diseases and Associated Risks	• Staff and workers shall have access to medical insurance, health professionals, and suitable medical facilities, which will aim to prevent the spread of diseases internally and externally. • Any reportable disease shall be diagnosed by the authorised medical centre doctors. Diagnosis includes identifying any new symptoms or any significant worsening of existing symptoms. • The potential for exposure to water-borne, water-based, vector-borne diseases, and communicable diseases as a result of project activities will be avoided or minimised. • Any external and internal spreading diseases shall be diagnosed and the precautions as per the instructions from the national/local medical authority shall be implemented. • Provide a 24hr emergency hotline. • Isolate and/or care for sick and potentially infected staff and workers. • Identify any vulnerable groups (i.e., those with pre-existing conditions) working in the Project site and take precautionary measures in accordance with the national and WHO guidelines. • Provide testing for staff at no extra cost to them. • Promote personal hygiene among the workers and provide training, posters to remind workers to wash their hands regularly, clean their work areas and equipment, and sanitize properly etc. • The transportation of workers and access to the site shall be coordinated and regulated i.e., through reduced bus occupancy, temperature, and PPE checks etc. • Provide a flexible working regime for those workers who may prefer and are able to work from home due to health issues, childcare, home schooling etc. without fear of victimisation. • Address mental health issues during induction and provide information on how to seek help from local experts.
Worker Welfare (on site)	• Project parties will ensure that welfare provisions are available on-site, including but not limited to: - Hygienic and regularly cleaned toilets (commensurate to applicable requirements or good practices for the quantity required on-site, or in areas of the site), - Basins and running clean water, with hand, wash for hand cleaning, - Rest areas (with air conditioning, chairs, and tables), - Clean drinking water available in working areas (at a suitable temperature) - If applicable suitable and hygienic areas for eating and storing food (including refrigerators, heating devices [ovens/microwaves] etc).

Potential Impact	Mitigation and Management Measures
Workers' Terms of Employment, Non-Discrimination and Equal Opportunities, Working Relationships	• Project parties will establish HR Policies and processes consistent with the requirements of National Labour Law, IFC PS 2, and associated ILO conventions. • Project parties will provide a plan detailing how working conditions and terms of employment are compliant with national labour, social security, and occupational health and safety laws. • Employment relationships shall be on the principle of equal opportunity and fair treatment, and will not discriminate concerning any aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, promotion, termination of employment or retirement, and discipline. • Project parties will not make employment decisions based on personal characteristics, such as gender, race, nationality, ethnic origin, religion or belief, disability, age, or sexual orientation, unrelated to inherent job requirements. • Project parties will document and communicate to all workers their working conditions and terms of employment including their entitlement to wages, hours of work, overtime arrangements and overtime compensation, and any benefits (such as leave for illness, maternity/paternity, or holiday). *Special measures of protection or assistance to promote local employment opportunities or selection for a particular job based on the inherent requirements of the job, which are following national law, will not be deemed discrimination.*
Workers' Forced Labour	• Project parties will not employ forced labour, which consists of any work or service not voluntarily performed that is exacted from an individual under threat of force or penalty. This covers any kind of involuntary or compulsory labour, such as indentured labour, bonded labour, or similar labour-contracting arrangements. • HR policies and procedures will be adapted appropriately to the size of the workforce required for the Project. Policies and procedures must be prepared to demonstrate consistency with the requirements of national legislation and IFC PS 2 and include a COC on GBVH. • Such requirements are also applicable in the hiring of agency/other contracted manpower, for which processes should be in place by the Project party to undertake due diligence on the agency providing the manpower. Where potential risks of forced labour are identified other suppliers with reputable processes and controls should be sought.
Child Labour	• Project parties will comply with all relevant national laws and provisions related to the employment of minors. • In any event, Project parties will not employ children in a manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. • Young people below the age of 18 years will not be employed in hazardous work and all work of persons under the age of 18 shall be subject to an appropriate risk assessment. • Such requirements are also applicable in the hiring of agency/other contracted manpower, for which processes should be in place by the Project party to undertake due diligence on the agency providing the manpower. Where potential risks of child labour are identified other suppliers with reputable processes and controls should be sought.

Potential Impact	Mitigation and Management Measures
Workers' Wages, Benefits, Conditions of Work and Retrenchment	• Wages, benefits, and conditions of work offered should, overall, be comparable to those offered by equivalent employers in the relevant region of that country/region and sector concerned. • If Project parties anticipate collective dismissals associated with the proposed Project, the parties shall develop a plan to mitigate the adverse impacts of retrenchment in line with national law and good industry practice, and based on the principles of non-discrimination and consultation. Without prejudice to more stringent provisions in national law, such consultation will involve reasonable notice of employment changes to the workers' representatives and, where appropriate, relevant public authorities so that the retrenchment plan may be examined jointly to mitigate adverse effects of job losses on the workers concerned. The outcome of the consultations will be reflected in the final retrenchment plan. • The workers/representatives shall be involved on any labour reduction measures.
Key Supply Chain (if any)	• Project Company shall devise and implement applicable controls to ensure the measures herein are implemented by any sub-contractors and are internally checked/audited. • Project Company shall take reasonable steps to inquire about the use of child labour and forced labour in their supply chains and try to exert influence where possible or identify other suppliers.
Grievance Mechanism	• A grievance mechanism for workers will be provided to raise reasonable workplace concerns. • Workers will be informed of the grievance mechanism at the time of hiring and make it easily accessible to them. • The mechanism will involve an appropriate level of management and address concerns promptly, using an understandable and transparent process that provides feedback to those concerned, without any retribution. • The mechanism will not impede access to other judicial or administrative remedies that might be available under law or through existing arbitration procedures, or a substitute for grievance mechanisms provided through collective agreements. • A grievance mechanism for community members will be provided to raise concerns or complaints. • Community members will be informed of the grievance mechanism through stakeholders' engagement and make it easily accessible to them. • All complaints will be acknowledged, addressed, and closed out in a timely manner.
Violence and Harassment	• The Project parties will conduct a GBVH risk assessment in consultation with relevant stakeholders including women leaders and those working with young adolescent girls and boys. This will also include the identification of potential interventions and risk mitigation measures. • Awareness training will be mandatory for all Project workers regarding the GBVH risks and the workers responsibilities and the legal consequences of being a perpetrator. • Information will be provided on how to report any cases of violence or harassment and the services that will be made available to offer support to any of the survivors.

Potential Impact	Mitigation and Management Measures
	• Approach towards GBVH prevention, mitigation and response will be survivor centred and ensure confidentiality, dignity, and respect to them. • The Project staff will be trained on how to preserve the safety of the women, girls, boys when interviewing them and collecting information about their experiences on GBVH. • The Project will provide essential services for survivors such as access to counselling services, support groups, legal support etc. at no cost to them. • All determined cases of GBVH will be referred to relevant legal entities in the Project area for further investigation and prosecution. • The Project grievance mechanism will be made available to project workers and community members and will ensure that survivors' information is confidential and kept anonymous. • All cases relating to GBVH shall be documented and closed.

3.6 Monitoring

The protection of human rights is an on-going process, and this should be reflected in the Project's internal management policies.

The EPC Contractor during construction, and the O&M Company during operations are expected to be the primary parties for ensuring that mitigation measures are internally audited, and processes are in place to protect labourers, subcontractors, suppliers, as well as the surrounding community. Monitoring required is provided in the table below.

Table 3-3 Key Monitoring Indicators during Construction and Operation

Monitoring	Parameter	Frequency & Duration	Monitoring Locations
Worker Contracts & HR	Records of contracts, payments, receipt of benefits, leave entitlements, retrenchment etc.	On-going	For all Project workers (direct staff) and oversight of sub-contractor staff dedicated to the project
Women employed in the Project	Number of women employed in the Project including their rank and renumeration compared to men occupying the same positions.	On-going	For all female Project personnel including those employed by the sub-contractors.
Worker Welfare	Quality, appropriate numbers and suitable locations of Sanitation Facilities, Office Spaces, Welfare and Rest Areas	On-going	At all such facilities on-site
Quality of Accommodation	Inspection/internal audit of worker	Monthly	All accommodation facilities provided to

Monitoring	Parameter	Frequency & Duration	Monitoring Locations
	accommodation facilities vs. IFC & EBRD standards		direct and full time sub-contracted labour.
OHS Near Misses (involving external parties)	Any classified near miss	On-going	n/a
OHS Emergency Situations and Incidents	Any classified emergency situation or incident	On-going	n/a
Grievances and disputes including those relating to gender-based violence and harassment, sexual exploitation & abuse, and sexual harassment	Grievances received	On-going	Project site and any other grievances received from communities in reference to Project workforce including suppliers.
Health of the workers	Records of the illnesses the workers are suffering from and an analysis of top diseases.	On-going	Project site clinic or first aid facility
Human rights complaints/violations as reported by Project workers including workers hired through third-parties or in the supply chain	Grievances received	On-going	As defined in the Stakeholder Engagement Plan (SEP)
Emergency Situations and Incidents	Any classified emergency situation or incident	On-going	n/a

4 CLIMATE CHANGE IMPACT ASSESSMENT

4.1 Overview

ACWA Power is seeking finance for the Project from international lenders who are understood to be signatories of the Equator Principles, hence are EPFIs, which necessitates compliance with the Equator Principles (EPs). This chapter has been prepared in compliance with the Equator Principles volume IV which requires the inclusion of a 'Climate Change Risk Assessment' (CCRA) as part of the ESIA studies for projects financed by EPFIs.

4.1.1 Objectives of the CCRA

The objectives of the CCRA are to:

- Review and outline the KSA national regulations and standards, and lenders requirements;
- Review the climate change context and trends of KSA, highlighting the main issues;
- Identify and describe the potential vulnerabilities of the Project to climatic risks;
- Identify and describe the potential impacts of the Project or its activities on the climate;
- Propose project alternatives for potential lesser climatic impacts; and
- Propose actionable recommendations and mitigations to reduce the risks of adverse impacts.

4.1.2 Scope of the CCRA

The CCRA focuses on the climatic risks and impacts to the Project, associated facilities, and workforce during the Construction and Operational phases of the Project.

It considers potential impacts of the Project on the climate also.

4.1.3 Methodology

To address the scope of the CCRA, the following methodology was followed:

- Data collection & baseline development;
  - Desktop background research of national regulations and standards
  - Collation of lenders' requirements for CCRA's
  - Desktop background research of climate risks in KSA, current climatic situations, and future trends
- Scoping of climate risks identified in lenders' requirements for relevance against national desktop background research information to identify potential hazards;
- Analysis of the Project specific level of risk of each identified national hazard;

- Outline of the potential Project alternatives; and
- Proposal of mitigation measures to limit the effects of these potential climatic hazards on the Project and methods of monitoring.

4.2 Standards and Regulations

4.2.1 National Context and Regulations

The Paris Agreement came into force on 4th November 2016. The KSA signed and ratified the Agreement on 3rd November 2016 (UNTC, 2023). To date, the Kingdom of Saudi Arabia has not released a national climate action plan, however, the country has established several initiatives to address climate change issues, including:

- Establishing a Renewable Energy Project Development Office (REPDO) by the Ministry of Energy in 2017 which outlined plans for the kingdom to develop 58.7GW of renewable energy capacity by 2030, in line with Saudi's Vision 2030. In 2019 they also increased the 2023 clean energy target almost threefold to 27.3GW, from the previous target of 9.5GW (MEED, 2019);
- Launched the Saudi Green Initiative (SGI) in 2021 which "*aims to combat climate change, improve quality of life and protect the planet for future generations*", overseen by The Energy and Climate Change Committee and The Environment Committee (Saudi and Middle East Green Initiatives, 2022);
- Establishing a National Committee for the Clean Development Mechanism and Designated National Authority in 2009, which oversees the development process of Clean Development Mechanism projects;
- Establishing a Saudi Energy Efficiency Program launched by Saudi Energy Efficiency Centre, which aims at designing and implanting energy efficiency initiatives for the country; and
- Oil and Gas Climate Initiative lead by Saudi Aramco to help member companies support the Paris Agreement and its aims
  - (https://oilandgasclimateinitiative.com/about-us/#guidingprinciples).

4.2.2 Lenders Requirements

Equator Principles volume IV establishes that impacts on the climate should be avoided where possible, and in support of the 2015 Paris Agreement recognises that EPFIs have a role to play in improving the availability of climate-related information, such as the recommendation by the Task Force on Climate-related Financial Disclosures (TCFD).

More specifically, Principle 1 states that factors such as climate change are required for the project categorisation based on the International Finance Corporation's (IFC) environmental and social categorisation process.

Principle 2 outlines the need for a climate change risk assessment, stating a requirement to "*include assessments of potential adverse […] climate change risks as part of the ESIA or other Assessment*". It further states that "*The Climate Change Risk Assessment should be aligned with the Climate Physical Risk and Climate Transition Risk categories of the TCFD*". These are (TCFD, 2017):

- ***Physical Risk***: Risks related to the physical impacts of climate change; and
  - Acute Physical Risk: those that are event-driven, including increased severity of extreme weather events, such as cyclones, hurricanes, or floods etc; and
  - Chronic Physical Risk: longer-term shifts in climate patterns (e.g., sustained higher temperatures) that may cause sea level rise or chronic heat waves.
- ***Transition Risk***: Risks related with a transition to a lower-carbon economy.

EP 2 delineates emissions into two scopes:

- ***Scope 1 Emissions***: direct emissions from the project owned facilities, or facilities controlled within the physical project boundary; and
- ***Scope 2 Emissions***: indirect emissions associated with the off-site production of energy used by the project, such as connection to the grid.

For projects with combined scope 1 & 2 GHG emissions of over 100,000 tonnes $CO_{2\text{-eq}}$ per annum, Principle 2 states requirements for analysis of alternatives which evaluates low GHG intense alternatives, and Principle 10 states that projects should report their GHG emissions annually.

IFC's PSs underpin EP 2. PS 1 states that the clients "*risks and impacts identification process will consider the emissions of greenhouse gases, the relevant risks associated with a changing climate and the adaptation opportunities, and potential transboundary effects*."

PS 3 continues that clients should "*consider alternatives and implement technically and financially feasible and cost-effective options to reduce Project-related GHG emissions during the design and operation of the Project*". For projects producing in excess of 25,000 tonnes $CO_{2\text{-eq}}$ per annum, PS3 states a requirement for the client to quantify scope 1 and 2 emissions.

4.3 Baseline Data

4.3.1 National Climate Change Context

The mean global temperature has increased by an estimated 1.09 °C since the pre-industrial era. Climate observation and analysis in recent decades indicate that the globe is warming up at an average rate of 0.2°C per year (IPCC, 2021). Regarding long-term projections, the IPCC estimates a global mean surface temperature increase of 3.3 to 5.7°C in the period 2080-2100. The warming effect of progressive GHG emissions on the global climate has caused an upturn in the frequency and intensity of extreme weather events. Indirectly, these effects have also induced the

occurrence of climate-sensitive natural disasters and hazards such as droughts, floods, sea-level rise, and landslides.

By the end of 2021, KSA was reported to have a population of 35.46 million people and Gross Domestic Product (GDP) totalling 833.5 billion US Dollars. While the oil and gas industry accounts for 50% of the country's GDP, the country's economy is also significantly reliant on climate sensitive sectors such as agriculture (OPEC, 2023).

For 2023, KSA scored a Climate Change Performance Index (CCPI) score of 22.41%, rating them as 'very low' and ranking 62nd of 63 countries evaluated (Germanwatch, 2023). KSA also scored a Climate Risk Index (CRI) index of 73, ranking 57th in terms of average fatalities, and 51st in terms of economic losses in relation to extreme weather events (Germanwatch, 2022).

With a growing urban population, increasing temperatures, dwindling groundwater resources, rising sea levels, and recurrent flood events, KSA is faced with growing biophysical and socioeconomic vulnerabilities to climate change. In response to the climate emergency, the country launched a coordinated move towards decarbonisation with its entry into the Paris Climate Accords in 2015, and they have also been part of the United Nations (UN) Framework Convention on Climate Change (UNFCCC) since 1994.

In a movement towards a greener environment, KSA launched the SGI in 2021 which "*aims to combat climate change, improve quality of life and protect the planet for future generations*". To date, it is reported (Arab News, 2023) that this initiative has led to:

- 150,000 homes powered by renewable energy;
- 18 million trees planted in 2022 in KSA;
- 62 sites approved for tree planting;
- 60,000 hectares of land rehabilitated in 2022;
- 250,000 cultivated shrubs in AlUla nurseries;

4.3.2 National Climate

Standing amongst the world's hottest and most arid countries, Saudi Arabia is characterised by a desert climate. In terms of climatic zones defined by the Köppen climate classification system, most of the country falls within the hot, arid desert zone. There are remote patches of cold, arid steepe, and hot, arid steppe, and also areas of cold, arid desert climates, much of which represent mountainous pockets in the country's western reaches.

Figure 4-1 Köppen Geiger climate classification for Saudi Arabia
Source: Beck, H.E. et al. (2018)

The climate mostly consists of high daytime temperatures, inversely low night-time temperatures, and little, irregular precipitation. With climatological influences from both tropical and extra-tropical weather systems, the country experiences the four seasons of winter (December-February), spring (March-May), summer (June-August) and fall (September-November) (Odnoletkova and Patztek, 2021), with a wet season in March and April.

4.3.3 Natural Hazards

Climatic hazards can be divided into natural climatic hazards, and induced climatic hazards.

- **Natural Climatic Hazards** are those hazards that are directly related to the changing climate, such as temperature or rainfall. The climatic changes that are causing the hazards to occur are being directly caused by climate change.
- **Induced Climatic Hazards** are those that can be indirectly related to the changing climate, such as floods and forest fires. The hazards are being caused by other climatic changes, such as sea level rise being induced by increasing temperatures that are the result of climate change.

CLIMATIC NATURAL HAZARDS

Temperature

Baseline and Historic Trends

Summers in the central region are extremely hot and dry, ranging from 27°C to 43°C in the inland areas and 27°C to 38°C in coastal areas. In winter, the temperature ranges between 8°C to 20°C

in the interior parts while higher temperatures of 19°C - 29°C have been recorded in the coastal areas of Red Sea (Climate Change Knowledge Portal, 2021). A graph illustrating the variation in mean annual temperature levels in the period 1991 to 2020 is shown below.

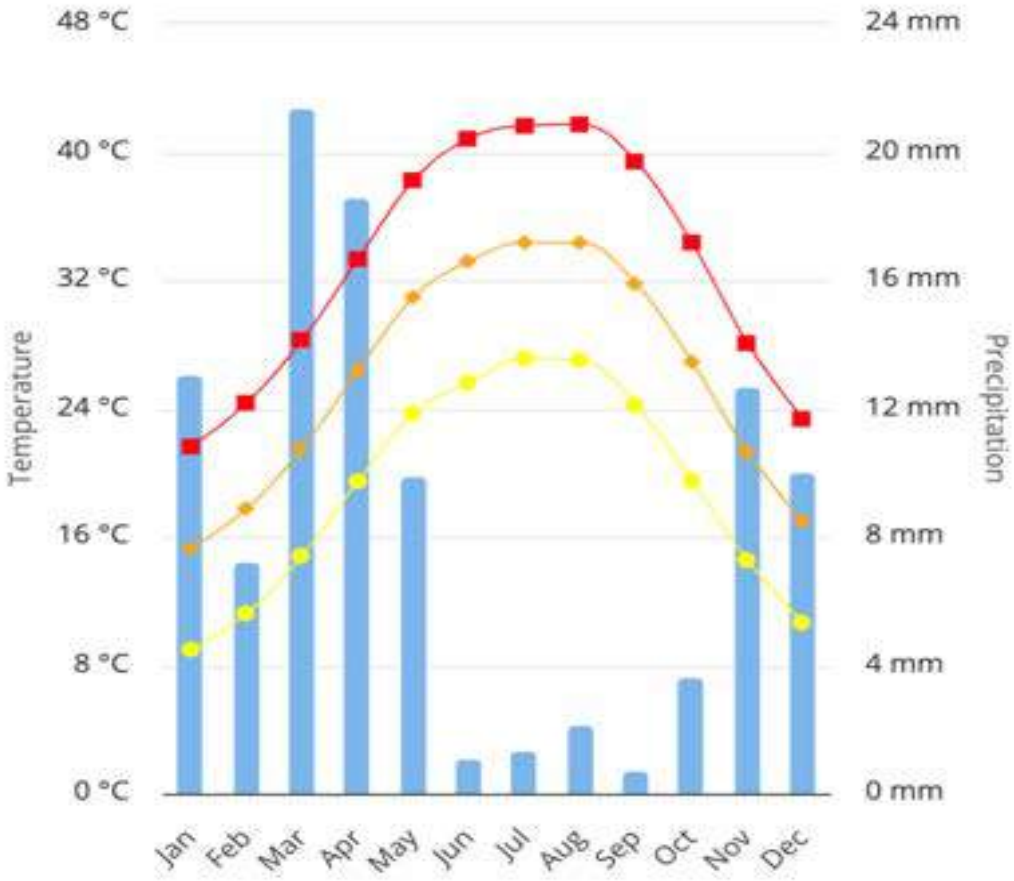

Figure 4-2 Observed Monthly Average Temperatures (Maximum – red; mean – orange, minimum – yellow), and rainfall (blue) in Saudi Arabia 1991-2020

Source: Climate Change Knowledge Portal (2021)

Projections

Below are projected temperatures for KSA using a range of Shared Socioeconomic Pathways (SSPs), future climate change scenarios based on broad socioeconomic trends that could shape future society. Modelling for the most severe SSP5-8.5 scenario predicts that maximum surface temperatures will rise by 16.8% from 2023 – 2100 to an average of 38.66 °C, and to at least 33.88 °C under SSP1-2.6

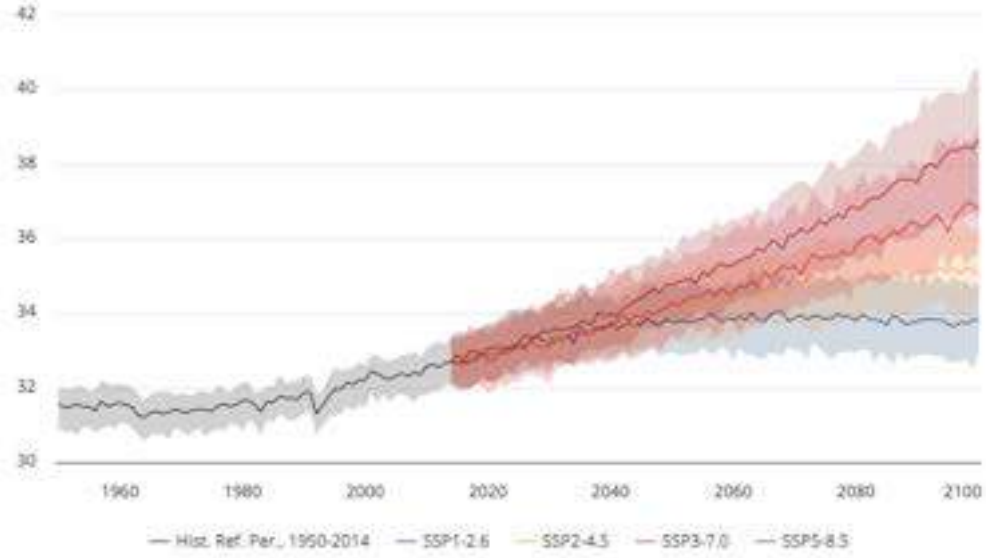

Figure 4-3 Projected Average Maximum Surface Air Temperature, Saudi Arabia

Source: Climate Change Knowledge Portal (2021)

Precipitation

Baseline and Historic Trends

KSA has a rainy season of March and April, as seen in Figure 4-2. The average annual rainfall in most parts of the country is below 150 mm throughout the year, except in the southwest part where the rainfall occurs between 400 – 600 mm annually (Climate Change Knowledge Portal, 2021). The annual average precipitation for 2010 – 2021 can be seen below, as well as monthly variations above in Figure 4-2.

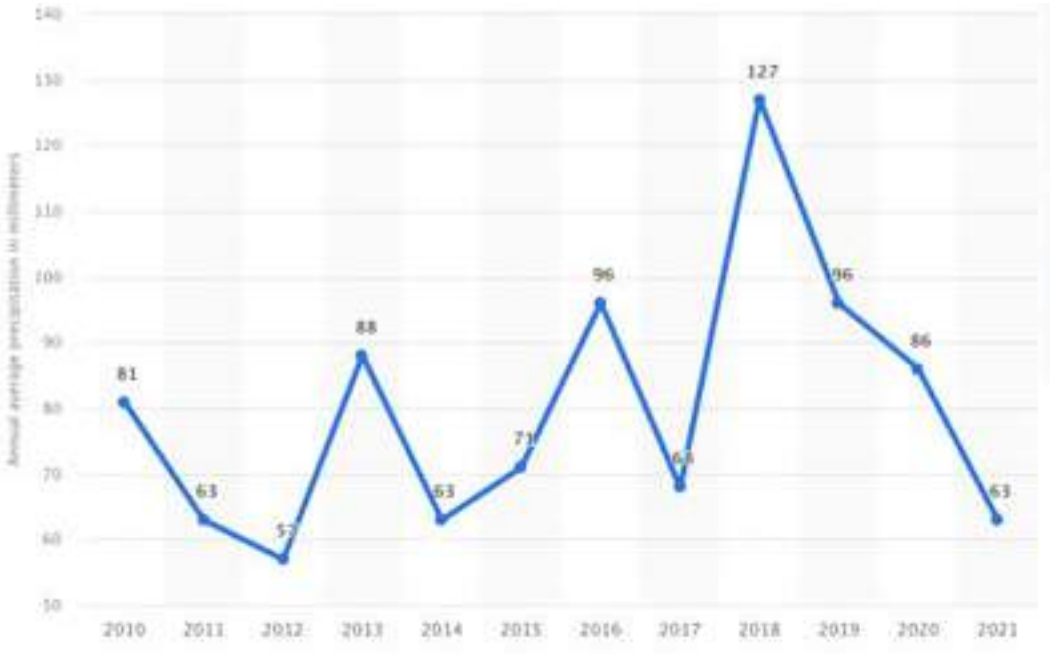

Figure 4-4 Annual Average Precipitation in KSA 2010 – 2021

Source: Statistica (2023)

Projections

Using the SSP5-8.5 model, precipitation is estimated to rise by approximately 12 mm per annum, although there appears to be much variation in these estimations, as seen in the figure below.

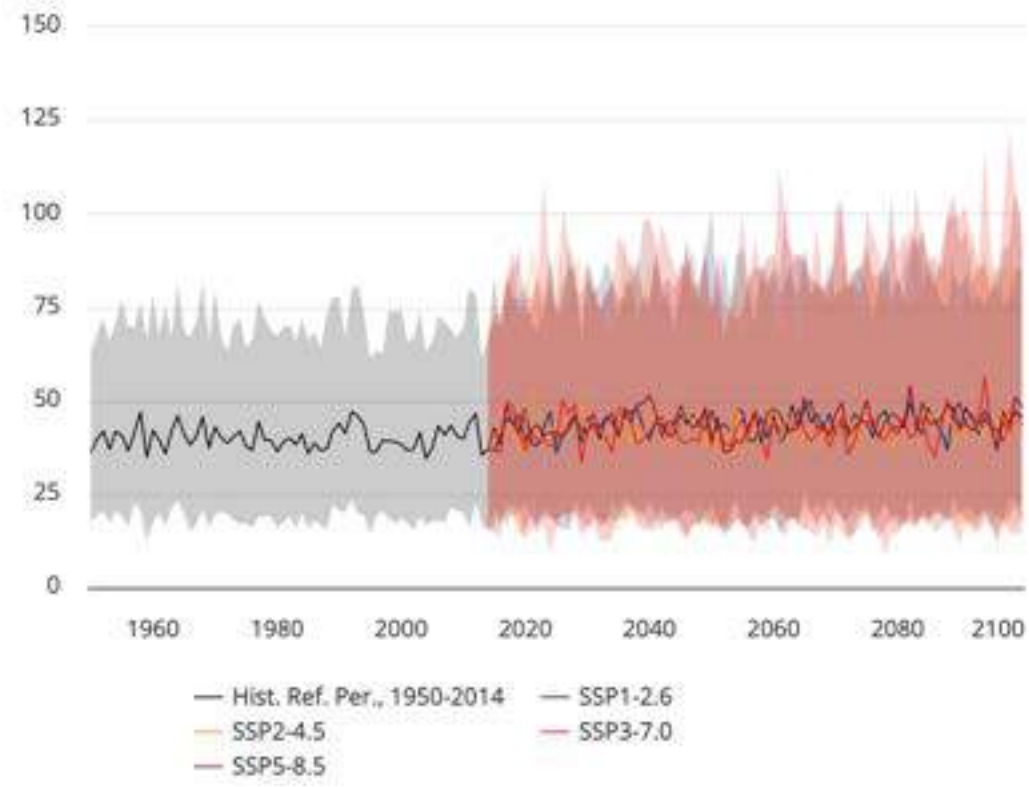

Figure 4-5 Project Precipitation in KSA

Source: Climate Change Knowledge Portal (2023)

The frequency of intense rainfall events is increasing for the majority of Saudi Arabia, while the frequency of weak events is decreasing. The contribution of extreme events (daily rainfall of ≥ 26 mm) to the total rainfall amount varies, but in one case was found to be up to 56%, and this is expected to increase, causing more large scale, intense rainfall events (Almazroui, 2020).

CLIMATE-INDUCED HAZARDS

Flooding

Flash floods are caused by slow-moving weather patterns (convective systems) that generate intense rainfall over a poorly drained area in a short space of time (less than six hours). As outlined above, KSA is observing a trend of more intense rainfall which leads to more extreme flooding.

Severe flash flooding events have been observed in Saudi Arabia in the recent years, especially in Western parts of the country. In August of 2023, the Mecca neighbourhood of Al-Kakiyyah recorded 45 millimetres of rain within 24 hours, causing large scale flooding (Al Jazeera, 2023). A total of 11 extensive flash floods have occurred in KSA since 1985.

Floods are observed to be the most significant key natural hazard for the period of 1980 – 2020 in KSA.

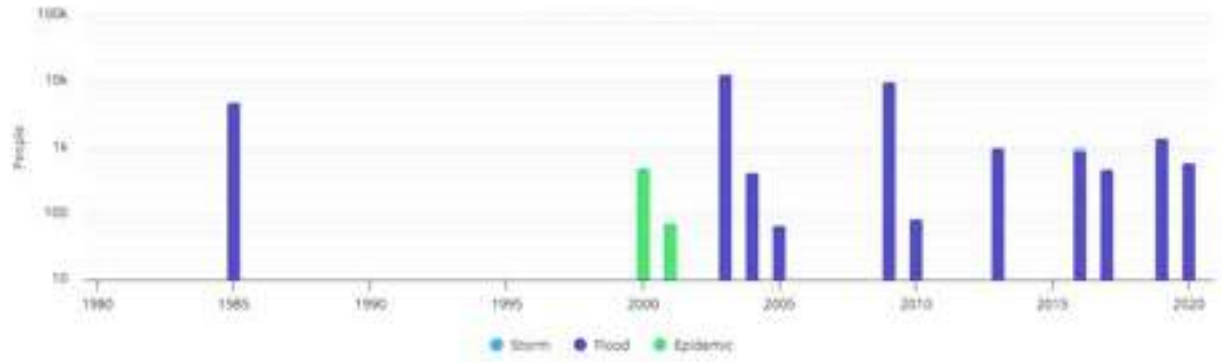

Figure 4-6 Number of People Affected by Key Natural Hazards in KSA 1980 – 2020

Source: Climate Change Knowledge Portal (2023).

Sea Level Rise

Sea level rise is a great national problem; however the Project site is more than 400 km from the nearest coastline and will be located at 978 m above sea level, therefore will not be affected by sea level rise.

Landslide

Think Hazard (2023) have classified the risk of landslides in KSA as 'Medium'. KSA's rainy season of March and April increases the risks of landslides throughout the country. Landslides are one of the biggest environmental risks to the northwest of KSA (Kahal et al., 2021), and are common in the west and southwest (Youssef et al., 2022).

Heat Waves and Drought

Over the past four decades, the mean annual temperature in Saudi Arabia has risen at a rate that is 50% higher than that of the remaining landmass of the Northern Hemisphere. KSA's mean temperature increased by 2.18°C between 1979 and 2019, which is threefold the global average. This trend has been paralleled by an increase in humidity.

The total duration of heat waves in a year (prolonged periods of maximum temperature records) is growing exponentially in most of the big cities in Saudi Arabia (Odnoletkova & Patzek, 2021). Such heatwaves are the most significant weather-related cause of mortality in the world (Gronlund et al., 2018).

The increase in temperatures will also cause an increase in distribution of vector organisms such as malarial mosquitoes, and therefore the transmission of numerous vector-borne diseases like malaria and dengue fever (McMichael et al. 2003).

Alongside heat waves, the rising temperatures are inducing more drought periods. KSA lies in a region of great water stress, and "*is highly vulnerable to recurring droughts*" (Syed et al., 2022).

Eight drought years (1990, 2003, 2007, 2008, 2009, 2011, 2012 and 2017) are identified by Syed et al. (2022), the most extreme being 2007, and the longest period being from 2007 to 2012 when approximately 70% of KSA land area was under drought conditions (ibid.)

It is predicted that in KSA climate change will cause decreased regular national rainfall patterns and increased evaporation rates. More extensive dry periods are expected that will result in further depletion of groundwater reserves, and the worsening of water scarcity.

Water Scarcity

Water scarcity is a key challenge in KSA which depends heavily on desalinated water. According to the US - Saudi Business Council (2021), KSA is the largest country in the world without running surface water, but if has the third-highest per capita freshwater consumption in the world (2022), at over 8 million m^3/day, forecast to reach 12.3 million m^3/day by 2040.

As per the World Future Energy Summit, the Ministry of Environment, Water and Agriculture (MEWA) announced the launch of the Qatrah program in 2019 to rationalise water consumption and address the overuse and waste of water resources (WaterWorld, 2019). The mission of the program is to reduce 24% of the country's daily per capita consumption rate by 2022 and 43% by 2030.

Dust Storms

Dust storms refer to extensive dust dispersion events caused by strong winds that raise dust and sand from deserts and surrounding areas and carry it over large distances. KSA is situated on the Arabian Peninsula, the world's largest source of dust. Together with North Africa, these two regions account for 70% of global dust emissions (Ginoux et al., 2012). Most dust storms are found in the east of KSA, which experiences between 10 and 60 per annum (Albugami et al., 2019).

The increasing temperatures and prolonged dry periods can increase the severity or frequency of dusty days and hence the risk of dust storms. This may include increased wind velocity over current speeds.

Forest Fires

With warmer temperatures and drier climates, the risk of forest fires is increasing throughout KSA, particularly in the southern regions with more vegetation, where the risk is rated as 'high' by Think Hazard (2023).

Erosion and Desertification

It is believed that between 70 and 90 percent of the Arabian Peninsula is under threat of desertification. This desertification is leading to greater levels of erosion in KSA due to the dry, windy conditions, resulting in reduced land productivity and increased unwanted sedimentation.

4.4 Project Vulnerability

In line with EP 2 and IFC PS 2, this CCRA will assess the potentially adverse impacts of climate change risks to the Project, specifically. The potential impacts have been categorised according to the 'Climate Physical Risk and Climate Transition Risk' categories of the TCFD, as required by IFC PS 2.

The acute and chronic climate-related hazards are defined following the major hazard groups as defined in EU Taxonomy[1]. The Equator Principles Guidance Note on Climate Change Risk Assessment[2] states that these hazards should "*be taken into account as a minimum in the climate risk and vulnerability assessment*". These hazards have been scoped for national risk (See Appendix C) based to the desktop review of baseline data in Section 4.3, but not explicitly for the Project itself. The risks that are found to be relevant to KSA are assessed for Project relevance and vulnerability are discussed below. Additional risks to those from the EU Taxonomy have been added to the Project vulnerability assessment below based on the findings of the national baseline study.

4.4.1 Climate Physical Risk

ACUTE PHYSICAL RISK

Extreme Heat Events

The Project province of Riyadh is rated as high risk of extreme heat events (Think Hazard, 2023). If these events occur, Project workers' health and safety may be at risk, particularly if safety measures are not integrated for their protection when working outdoor in heat. The Project site is open, with no natural shade, so extreme heat events could have severe effects.

It is reported that solar panel efficiency is reduced during high heats by 0.3% to 0.5% for every degree above 25 °C (Ecoflow, 2023), so extreme heat events will impair the electricity generation capacity of the Project.

Extreme Precipitation Events

The Project is located inland in an area of the country that experiences relatively stable weather patterns. The province of Riyadh which the Project is located in receives moderate levels of rainfall at 120 mm average per annum between 1991 and 2020, and the most rainfall during March, with an average of 29.77 mm (Climate Change Knowledge Portal, 2025). Extreme precipitation events are not expected to affect the Project.

[1] https://finance.ec.europa.eu/system/files/2020-03/200309-sustainable-finance-teg-final-report-taxonomy-annexes_en.pdf
[2] https://equator-principles.com/app/uploads/Guidance-CCRA_May-2023.pdf

Drought and Water Scarcity

No water sources are available on site, hence all water will be provided from water source such as water trucks by local suppliers.

During construction, water will be used for construction activity purposes as well as for consumption. During operation, water will be mainly required for consumption. Water will not be required for cleaning of the solar panels. Considering the above combined with the number of construction and operational workers, and from 5 Capitals' experience of working in KSA, drought and water scarcity impacts are not anticipated to pose a significant risk to the Project.

Flooding

The Project is located inland in an area of the country that experiences relatively stable weather patterns. The province of Riyadh which the Project is located in receives moderate levels of rainfall. There are no permanent surface water bodies or signs of water accumulation within the area.

ACWA Power confirmed that a complete site study will be conducted by the EPC Contractor before the engineering phase and prior to construction to identify the requirements associated with the site conditions (i.e. wind speed, corrosion category, and flooding) as depicted in the Construction Schedule – Preliminary Works.

Over the timescale of the Project, the changing climatic patterns will not significantly change the level of the risk to flooding, therefore the current low risks are accepted throughout the Project.

Extreme Mass Movement

Although landslides and other mass movements have occurred within KSA, the Project site is flat and stable. Therefore, there is believed to be no overall risk of mass movement events at the Project site.

Dust and Sandstorms

In the event of warmer temperatures and any prolonged dry periods (i.e., during the summer), this could potentially result in the increase in the severity or frequency of dusty days, and dust or sandstorms. Severe dust or sandstorms can affect the workers' health if mitigation measures are not put into place. Furthermore, the PV panels may require more regular cleaning.

CHRONIC PHYSICAL RISK

Mean Temperature Change

Temperature rise is a national issue for KSA, suggesting that average temperatures could rise by as much as another 16% by 2100. The Project is expected to have 2,317 workers at the peak construction period, the majority of which are expected will have to work outdoors. During the

operation phase, it is expected there will be about 14 to 16 workers, some of which will also be working outdoors. Working outdoors in high temperatures for extended periods is dangerous to the health and wellbeing of the workers. It is expected that the number of these staff working outdoors will be limited where possible and the Project will incorporate resting periods during peak seasons.

The increase in temperature due to climate change will not be observed during the timescale of the Project, therefore the current risks are accepted throughout the Project.

Sea Level Rise

Sea level rise is a great national problem; however, the Project site is more than 400 km from the nearest coastline and at about 978 m above sea level, therefore will not be affected by sea level rise.

Erosion

The Project is in a predominantly flat, dry, sandy area. Although extreme wind events are not expected, it is expected that every day winds will frequently move material around, off, or on to the Project site. Winds may remove other material in sections, potentially exposing sub material, or it may gather up against the PV installation footings.

4.4.2 Climate Transitional Risk

As the Project is a Solar PV project and is aligned with wider strategies for a transition to a lower carbon economy (such as those in line with Saudi Vision 2030), there are not expected to be any climate transitional risks related to future low carbon economies (policy, regulations etc.), or future public perceptions of the Project that are considered risks at this stage.

4.5 Project Effects

4.5.1 Construction Phase

SCOPE 1 GHG EMISSION

The stationary combustion sources used during the construction phase of the Project will primarily relate to temporary diesel generators, which will be located around the site in the EPC Contractor and sub-contractors administration and office areas.

Additionally, the construction phase of the Project will necessitate an amount of mobile equipment, vehicles, and machinery to facilitate works. Equipment such as excavators, rollers, cranes, pneumatic compressors, and other vehicles will be abundant on the site, and are expected to be used in most construction processes. Such equipment will be fuelled mostly by diesel.

It is estimated that approximately 1,798KL of diesel will be required for the entire construction duration which equates to about 69,150 L of diesel per month.

Using the GHG Protocol calculation tool for GHG Emissions from Stationary Combustion (World Resources Institute, 2015), the GHG emissions during construction were calculated in carbon dioxide equivalent (CO_{2-eq}) and are summarised in the table below.

Table 4-1 Generators-GHG Emissions During Construction of the Project

Fuel Type	Volume of Fuel (L/ Month)	GHG Emissions (tonnes/month)			Total GHG (tonnes CO2-eq /Month) *
		CO_2	CH_4	N_2O	
Liquid Fossil (Diesel)	69,150	185.079	7.4932e-3	1.499e-3	185.686
Total GHG emissions from fossil fuels (tonnes CO_{2-eq}) per year					**2,228.23**
*If/when the generators are operational					

4.5.2 Operational Phase

GHG Abatement

As a renewable energy project, there is essentially a neutral operational impact on GHGs when the Project is generating, as the Project will not combust fossil fuels, other than for the potential running of generators for required operational functionality tests. A key benefit of the Project is the resulting lowering of the carbon intensity of the grid produced electricity in KSA.

It is possible to make a comparison of GHGs mitigated against a grid factor for GHG emissions in KSA. This is based on the KSA default grid factor of 569 gCO_2/KWh (Climate Scorecard, 2023).

It is expected that the Project will generate an average of 6,419,272 MWh per year for the entire 25-year operating period, generating an estimated relative net emissions saving of 3,652,565.7 tonnes of CO_2 equivalent per year (tCO_{2-eq} /year). Over this 25-year operating period this will result in an estimated total net saving of approximately 91.3 million tCO_{2-eq} when compared to conventional grid energy source.

GHG Emission - Grid Electricity Usage

Although being a renewable energy project, the generation of solar power is intermittent and restricted to daylight hours only. As such the Project will draw power from the grid during the night to provide electricity for lighting, security purposes, (e.g., security systems, CCTV etc.) and any site office, workshop or other requirements being undertaken at night.

Given that it is only expected that security staff will be present at night and there are no operational processes that will require large quantities of power to be drawn from the KSA grid, the amount of power usage is expected to be 15,888 KWh/month.

According to Climate Scorecard, the energy sector in KSA generates 569 gCO_2/kWh. Based on an estimated 15,888 KWh monthly electricity consumption, a total of 108.5 tons of $CO_{2\text{-eq}}$ are expected to be generated annually.

SCOPE 1 GHG EMISSIONS

The Project has emergency diesel generators that will be located on-site. These generators are not expected to be used except during grid blackout conditions where the generator would provide an amount of power load to enable the safe operation of the plant in such circumstances.

It is estimated that approximately 2,500 L of diesel fuel will be required annually (which includes regular functionality testing) per generator. Using the Greenhouse Gas Protocol calculation tool for GHG Emissions from Stationary Combustion (Greenhouse Gas Protocol, 2015), the GHG emissions during operation were calculated and are summarised in the table below.

Table 4-2 Generator-GHG Emissions During Operation of the Project – Per Generator

FUEL TYPE	VOLUME OF FUEL (L/YEAR/GENERATOR)	GHG EMISSIONS (TONNES/YEAR)			TOTAL GHG (TONNES $CO_{2\text{-EQ}}$ /YEAR/GENERATOR)
		CO_2	CH_4	N_2O	
Liquid Fossil (Diesel)	2,500	6.691	2.709e-4	5.418e-5	**6.713**

USE OF OZONE DEPLETING SUBSTANCES (ODS)

Sulphur hexafluoride (SF_6) is to be used in high voltage electrical equipment as the insulating gas, as part of the gas insulated switchgear, and associated facility of the main PV project. There may be some leakage from the gas insulated switchgear, or where mishandled. SF_6 switchgear is widely used in the electrical network and under normal operational conditions leakage should not occur. Management of ODS shall comply with the industry international good practices.

REFRIGERANTS

Trace amounts of refrigerants will be used in chiller packages where needed on-site for air conditioning, refrigerators etc. Where applicable, the requirements of the Montreal Protocol are applicable concerning the use and application of ODS. Any leakage of refrigerants would be negligible.

4.5.3 Decommissioning Phase

WASTE

End-of-life management requirements for PV panels still largely falls under the general waste classification rather than dedicated to PV. Resource Media (2023) have estimated that solar panel waste is set to increase by more than 4,000 per cent in the next decade. The International

Renewable Energy Agency (IRENA) (2022) have further estimated that cumulative waste from PV plant decommissioning will increase from 0.2 Mt (megatonnes[3]) in 2021 to 4 Mt by 2030, 50 Mt by 2040, and more than 200 Mt by 2050 (See figure below).

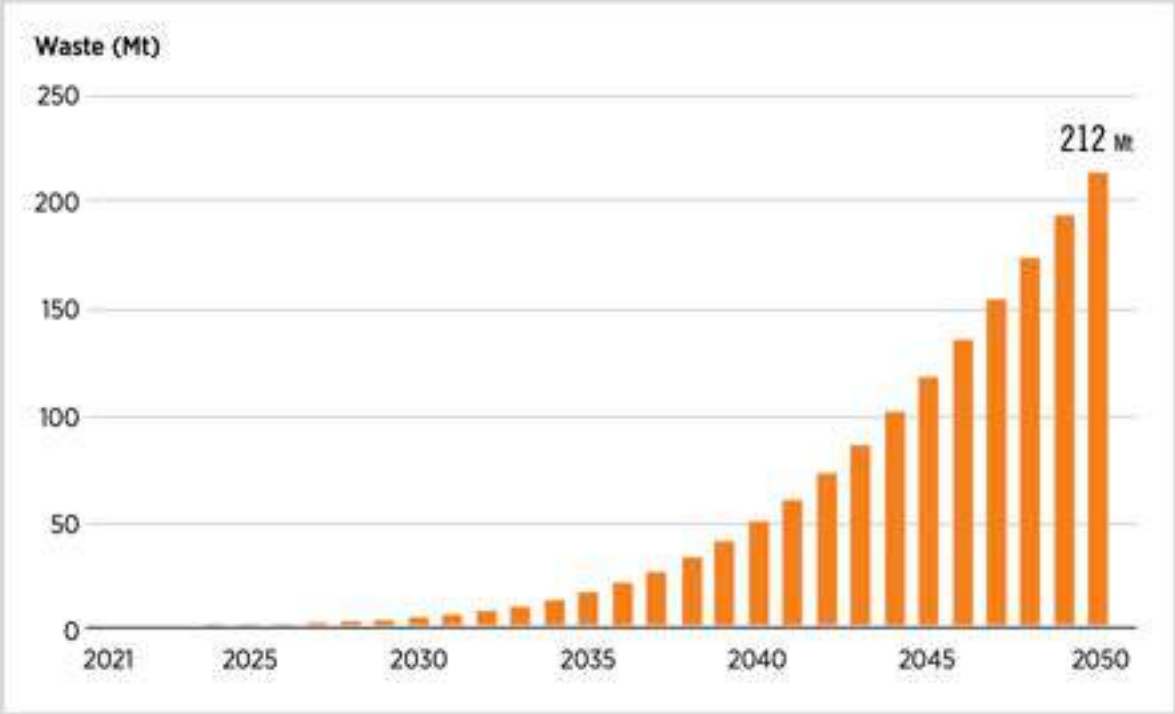

Figure 4-7 Projected Cumulative Waste from Solar Photovoltaic Projects

Source: IRENA (2022).

A country specific breakdown was presented by IRENA and IEA (2016), which specifies that even without 'early loss' waste, Saudi Arabia could have 450,000 tonnes of solar PV waste by 2050, a 149,900% increase.

Table 4-3 Modelled results of cumulative waste volumes of end-of-life PV panels for KSA, in tonnes (IRENA & IEA, 2016)

YEAR	2020	2030	2040	2050
End-of-life waste PV panels in tonnes (no early losses)	300	3,500	70,000	450,000

IRENA (2022) believes that by unlocking the full potential of a circular economy, solar PV panel waste can be restored, reused, and recycled, saving more than 17.7 Mt of raw materials from waste by 2050, generating a value of 8.8 billion US dollars.

The Project will be using monocrystalline solar panels. Generally, a solar panel needs only three years to produce the energy needed to offset its production emission. Given the much longer operational life, the emissions saving outweighs the production emissions (Solaris Renewables).

[3] Millions of tonnes

Following decommissioning the materials will need to be removed. These materials, if not restored, reused, or recycled, will add to the cumulative waste issue, and not aid in deterring the generation of more solar PV panels, which is energy intensive and adds to the effects of global warming.

4.6 Mitigation Measures

4.6.1 Resource Efficiency

The following measures can be implemented in subsequent stages of project planning to minimise GHG emissions over the course of the Project's lifetime:

The Project should implement comprehensive resource efficiency measures to reduce scope 1 and scope 2 GHG emissions during the Project's construction and operational phases. These measures generally include, but are not limited to the following:

- The procurement of equipment for the Project's construction and operational phases that give priority consideration to power efficiency, durability, and water conservation;
- During construction and operation, energy conservation measures for electricity-powered equipment should be promoted, and power consumption should be monitored. Economical use of fuel-powered equipment should be encouraged and monitored on the same basis; and
- During construction, resource efficiency in relation to construction materials should be promoted and monitored in the same manner.

4.6.2 Extreme Heat

The following mitigation measures shall be implemented to mitigate against heat-related medical conditions, for operational labour:

- Workers assigned to operations outside of the buildings and shaded areas will be provided with appropriate Personal Protective Equipment (PPE) (e.g., sun hats and cooling vests).
- Shaded resting areas (ideally with air conditioning) and adequate access to potable water will be provided for workers stationed outside of the Plant's buildings (e.g., guard houses).
- Work locations (and duration, to the extent possible) will be restricted during periods of extreme heat to lessen the risk of heat-related health effects. Maintenance work within high-temperature units will be avoided during days with inordinately high temperatures.
- Staff rooms on the plant's premises will be equipped with HVAC or fans to enable operations at workstations during periods of extreme heat.

4.6.3 Dust

To effectively manage dust-related issues in the context of climate change, it's recommended to maintain diligent visual and secondary monitoring (i.e., weather station reports or other publicly available sources) of dust levels, and ensure outdoor staff are not exposed to hazardous dust levels.

4.6.4 Water Availability

Although not identified as a significant risk to this Project, to reduce impacts on water resources, a water management plan/programme could be implemented to include the following:

- Installing smart water management systems (faucets with sensors, water meters, leakage detection systems etc.);
- Monitoring water consumption;
- Conducting regular maintenance of faucets, plumbing, water tanks etc.; and
- Raising awareness on water conservation among workers.

5 CUMULATIVE IMPACTS ASSESSMENT

Cumulative impacts are defined as those that result from the successive, incremental, and/or combined effects of an action, project, or activity when added to other existing, planned, and/or reasonably anticipated future ones. For any given project, a Cumulative Impact Assessment (CIA) serves to identify resultant environmental and social impacts that can synergize with equivalent impacts of proximate developments, and with natural stressors, such as climate change.

As such, the CIA process primarily consists of the following two aspects:

- Identification and characterisation of potential impacts that can be expected to ensue from the project activities, other developments, and environmental drivers within the temporal and special boundaries of the project in focus; and
- Development of actionable measures for effective prevention, mitigation, and alleviation of negative cumulative impacts and risks, and enhancement initiatives for any positive cumulative impacts.

5.1 Objectives of the Cumulative Impact Assessment

The objectives and outcomes of the CIA study for the Project are as follows:

- Identification of Project components, coincident developments, and natural/ unplanned dynamics that bare mutual Environmental & Social (E&S) impacts, which may arise and/or intensify within the Project's lifetime and influence areas;
- Identification of Vulnerable Environmental Components (VECs) that are subject to E&S impacts brought on by the Project in synergy with external drivers;
- Overview of the current state of the VECs identified, with a focus on baseline attributes of particular relevance to the Project;
- A description and assessment of cumulative E&S impacts foreseen to affect established VECs, relative to baseline conditions, legal requirements, and internationally recognised benchmarks;
- Recommendation of effective mitigation measures to prevent, abate, and/or alleviate negative E&S impacts, alongside enhancement actions to reinforce anticipated Project benefits; and
- Development of a management and monitoring plan with a specific focus on the Project's E&S impacts, which should set out the timing, monitoring indicators, and responsible implementing parties for consistent impact management and performance evaluation in relation to established indicators and targets.

5.2 Identification of Concurrent Developments and Environmental Drivers

Coincident developments that might have E&S impacts are listed below, it is understood the construction phases of this Project and the below activities are concurrent.

Table 5-1 Activities and Developments Included in CIA

PROJECTS/ ENVIRONMENTAL STRESSORS	DESCRIPTION	STATUS
SEC Sub-station (Associated Facilities)	The Project will be connected to adjacent SEC substation.	Design Phase
Overhead transmission line (OHTL) (Associated Facilities)	Overhead transmission line from the SEC sub-station.	Design Phase

5.3 Identification of Valued Environmental Components

The impacts on the main VECs that have been considered for the purpose of this CIA during construction and operation are:

- **Air Quality** – due to the arid nature of the site and surrounding areas there are potential cumulative air quality impacts (particularly with regards to particulate matter) should the construction phases of the projects overlap;
- **Noise** – concurrent construction activities have the potential to result in elevated noise levels across the wider area. Noise levels will be elevated because of construction activities and construction vehicles;
- **Ecology** – Cumulative land take for PV projects resulting in habitat loss and fragmentation. Further, the erection and presence of numerous transmission lines has the potential to result in cumulative impacts to ecology, primarily avifauna, who are at risk of electrocution and collision with transmission lines;
- **Grazing Land** - Cumulative land take for PV projects resulting in loss of grazing land;
- **Landscape/Visual Amenity** – Largescale cumulative impacts on landscape character from the PV projects;
- **Waste Utilities** – Additional pressure on available waste services and utilities due to the large-scale construction projects;
- **Socio-economics** – Employment and other business benefits and opportunities; and
- **Traffic and Road Infrastructure** – Cumulative impacts during construction of multiple projects in the same area.

5.4 Assessment of Cumulative Impacts on VECs

Project activities set for the construction and operational phases were overlaid with respect to the biophysical and socioeconomic context within the Project area to identify interfaces and potential impacts that could grow in magnitude as a result of commonalities amongst the Project components and other local developments (identified above). Potential cumulative impacts derived from this analysis are itemised in correspondence to their respective VECs for the Project's construction and operation phases, in the following table.

Table 5-2 Assessment of Cumulative Impacts on VECs

Valued Environmental Components	Impact-Generating Projects	Cumulative Impacts	
		Construction Phase	Operation Phase
Air Quality	1. Afif 1 PV Project (the Project – planned) 2. SEC Substation (planned) 3. OHTL connection (planned)	• As a worst-case scenario it has been assumed that the construction periods of all the developments will coincide to an extent. • Local ambient air quality will be potentially affected by increased dust during site clearance and earthworks, as well as by gaseous emissions from the exhaust of construction vehicles, equipment, and temporary power generators. • With the adoption of typical and common management practices (mitigation measures) outlined in the ESIA Report, the cumulative impacts are anticipated to have only minor significance. This is mainly attributed to the remote location of the site, which has limited external sensitive receptors.	None expected.
Noise	1. Afif 1 PV Project (the Project – planned) 2. SEC Substation (planned) 3. OHTL connection (planned)	• As a worst-case scenario it has been assumed that the construction periods of all the developments will coincide to an extent. • Construction activities will result in temporary and short duration increases in the noise and vibration levels emanating from construction site noise and construction vehicle noise. With coinciding construction activities there is the potential for cumulative noise impacts. • With the adoption of typical and common management practices (mitigation	None expected.

Valued Environmental Components	Impact-Generating Projects	Cumulative Impacts	
		Construction Phase	Operation Phase
		measures) outlined in the ESIA Report, the cumulative impacts are anticipated to have only minor significance. This is mainly attributed to the remote location of the site, which has limited external sensitive receptors.	
Ecology	1. Afif 1 PV Project (the Project – planned) 2. SEC Substation (planned) 3. OHTL connection (planned)	• Project land take will reduce the available land in the Project area. • Areas of gravel plain and sand that comprise much of the site would be largely unaffected as limited construction works will be required that affect the morphology and topography of such habitats.	• The erection and presence of transmission lines has the potential to result in cumulative impacts to ecology, primarily to avifauna which are at risk of collision and electrocution impacts.
Grazing Land	1. Afif 1 PV Project (the Project – planned) 2. SEC Substation (planned)	• Project land take will reduce the available land in the Project area. • The quality of grazing vegetation within the Project site and locally is limited, and when the local herders were questioned, they stated that they almost exclusively feed their livestock with animal feed due to the lack of volume, species, and quality. Overall, the availability of land is ample, and the consultations with the local herders identified they have areas suitable that they can relocate to.	
Landscape/Visual Amenity	1. Afif 1 PV Project (the Project – planned) 2. SEC Substation (planned) 3. OHTL connection (planned)	• Through construction, and sustained during operations, the land in the Project area will change from typical KSA desert landscape to one of a more industrialized character. In particular, the extensive installation of dark coloured PV modules for the Project will make a significant change to the visual amenity, particularly when viewed from above. • There are certain identified local receptors such as the two nearby communities and nearby local road users that could be affected by visual amenity. This is because the views across the largely flat land will be reduced due to the installation of fences, and tracker foundations, PV modules, and other structures. • Lighting from the projects, although expected to be limited to certain areas (e.g., security entrances and control buildings) will likely be evident at distance, although this is not expected to result in light spill outside of the project areas.	

Valued Environmental Components	Impact-Generating Projects	Cumulative Impacts	
		Construction Phase	Operation Phase
		• The new OHTL also presents a vertical intrusion to a landscape that did not include this previously.	
Waste Utilities	1. Afif 1 PV Project (the Project – planned) 2. SEC Substation (planned) 3. OHTL connection (planned)	• The construction phase of the project will likely overlap with the construction of the OHTL connection and SEC substation, which is located adjacent to the Project site. The generation of liquid, solid, and hazardous waste by the projects could potentially impose additional demands on the existing waste management facilities in the region.	None expected.
Socioeconomics	1. Afif 1 PV Project (the Project – planned) 2. SEC Substation (planned) 3. OHTL connection (planned)	• The outset and progress of construction on the Afif 1 PV Project will create an influx of workers as all the construction phase workers are expected to be foreign workers, likely from India and China. • In the absence of proper management, the influx of workers for the Afif 1 project may potentially result in adverse impacts. These impacts are associated with the risk of social conflict due to different cultures, increased demand and pressure on public infrastructures, facilities and recourses, increased risk of communicable diseases or local inflation of prices.	• The main socio-economic advantage of the Project (including the substation and OHTL) is the benefit of grid stability for economic purposes. • The Projects will also create some (but limited) new employment opportunities in the operations phase.
Traffic and Road Infrastructure	1. Afif 1 PV Project (the Project – planned) 2. SEC Substation (planned) 3. OHTL connection (planned)	• It is anticipated that there will be a period when construction activities for the projects will overlap, and shared routes may be used for transporting construction personnel, materials, and equipment. Given the collective magnitude of these construction operations, an increase in transportation	None expected.

Valued Environmental Components	Impact-Generating Projects	Cumulative Impacts	
		Construction Phase	Operation Phase
		activity can be expected. During periods of significant construction-related traffic, there is the potential for road congestion in specific areas or placing physical stress on the existing road infrastructure.	

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APPENDIX A – STAKEHOLDER ENGAGEMENT GUIDELINE

PV IPPS, KSA

STAKEHOLDER ENGAGEMENT

GUIDELINE FOR PROJECT COMPANY HSSE TEAM

STAKEHOLDER ENGAGEMENT - OVERVIEW

Stakeholder engagement can be described as the systematic method to understand and involve stakeholders and their concerns in project activities and decision-making processes. It identifies the appropriate approach to be used for consultation and information disclosure. Stakeholders include persons or groups that may be directly or indirectly affected by the project, as well as those that may have interest in the project and/or those that may influence the projects outcome either positively or negatively.

OVERARCHING REQUIREMENTS

In order to meet Equator Principles IV (Principle 5 & 6) and IFC Performance Standard (PS 1) requirements, the Project is required to conduct stakeholder engagement.

GUIDELINES

The table below provides a guideline on how the consultation process should be undertaken by the PV IPP Project Company – HSSE Team.

It is recommended that bi-lateral meetings are arranged and held with identified stakeholders. This will avoid open public events/gatherings. It can be explained that the key purpose of the consultations are:

- To share an overview of project information,
- To seek feedback on the project itself.
- To gather specific information on targeted issues.
- To seek advice on any issues in the area (or at the land) that may be of concern or that may have been overlooked.
- To advise on the availability of a third-party grievance mechanism (and how to access it).

ELEMENT	GUIDELINE
Meeting/Consultation Agenda	
Project information	Advise the stakeholder on the following: • Overarching requirement and context of the project – (i.e. in line with REPDOs targets under Vision 2030, Saudi Green Initiative, other strategy etc). • The project parties (including ACWA Power, the PC, EPC, O&M, Sub-Contractors, other relevant 3rd parties). • Project location (include maps showing the geographic location of the site, total area and project boundaries) • Summary of project components/facilities • Details and location of associated facilities (where available), such as access roads, sub-stations and locations of these. Also advise who is responsible for these works.
General overview of the project Construction	• Nature and scale of construction works, any phasing that is planned. • Expected numbers of workforce during construction and operational phases. • Location of project construction facilities such as temporary construction laydown areas, accommodation facilities etc. Timeline and schedule of construction works. • Any expectation on traffic/vehicle flows. • Any specific facilities that may only be necessary for construction (e.g. temporary access roads, batching plants etc.)
General overview of the project Operation	• General overview of day-to-day operations (such as SCADA operations, typical maintenance, cleaning etc.) • Number of O&M staff
Project Impacts	<u>Positive Impacts</u> • Example of positive impacts include employment opportunities, diversification of existing skill base, contribution to KSA renewable energy targets, and reduction on reliance on fossil fuels, benefits towards KSA international targets and commitments linked to the Paris Climate Agreement. etc. <u>Negative Impacts</u> • Example of negative impacts include i.e., dust, noise & traffic during construction, landscape change, community health & safety risks etc. • To include a summary of key mitigation and management measures the project will put in place in order to minimise the negative impacts i.e., ***Note:*** *the positive & negative impacts should match those identified in the ESIA and ESIA Addendum.*
Discussions	During the consultations, stakeholders will be given time to ask for clarifications, additional project information or raise their concerns, or give their general feedback. Where available any requested information should be provided immediately, or where not possible the PC shall revert to them at a later agreed time.
Targeted Questions and Information Gathering	
Guidance Note: *For this important part of the consultation process, please refer to the specific questions in the Annex.*	
Grievance Mechanism	

<table>
<tr><th>Element</th><th>Guideline</th></tr>
<tr><td>Implementation of the Grievance Mechanism</td><td>An important part of the engagement process is to advise that there is a third-party grievance mechanism in place and how it can be accessed.
The Project specific Stakeholder Engagement Plan (SEP) should include details of the grievance mechanism for the Project.
In order to implement it, please ensure that the SEP is completed by including the following details:
<table>
<tr><th>Company</th><th>Details</th></tr>
<tr><td>ACWA Power or Project Company
Name of contact person</td><td>Email: XX
Work: XX
Mob: XX</td></tr>
<tr><td>EPC Contractor
Name of contact person</td><td>Email: XX
Work: XX
Mob: XX</td></tr>
</table>
The grievance mechanism will need to be publicised and available at the project entrance, Project website (if any) & during the consultation meetings.
It is suggested that a handout on this is provided to the stakeholders so there is firmer evidence that this has been communicated.</td></tr>
<tr><td>Grievance Mechanism</td><td>Advise the stakeholders that the purpose of the grievance mechanism is to evaluate and address stakeholders' problems and concerns regarding project activities and impacts. During the stakeholder consultation process, the participants will be made aware of the following:
That the grievance mechanism is available to all third parties (with a separate process for all staff to also raise grievances).
How to access the grievance mechanism (i.e., name of project personnel in charge, contact details including email, phone, office location (if applicable)
Where stakeholders can file their complaints in person or anonymously (through a suggestion box outside the project entrance)
What type of response the complainants can expect to receive.
Duration of time it will take to receive a response (this should be aligned with the SEP).</td></tr>
<tr><td colspan="2">Record of Meetings/Consultations</td></tr>
<tr><td>Minutes of Meetings</td><td>Please document the proceedings of all meetings held with the different stakeholders and provide a list of participants including a signed attendance sheet where it is possible.
All feedback, queries (and the responses provided to these) must be documented.
Consultations through the phone, telecommunication channels such as Zoom, Microsoft Teams or messaging apps should also be documented.
A summary of informal consultations and general /side discussions should also be documented (in the event that formal meetings cannot be arranged).</td></tr>
<tr><td>Photographs</td><td>If permitted by the stakeholder, timestamped photographs of the meeting should be taken – as evidence of the consultation undertaken.</td></tr>
</table>

TARGETED CONSULTATION QUESTIONS

ID	QUESTION
Targeted Stakeholder Group	**Herders and community leaders**
1.	Have you used the land at the Project site in the past and what purpose did you use the land for? (Grazing, camping, transportation route, watermelon cultivation etc.)
2.	Do you obtain any services from the Project site (such as firewood, water, crops, or any cultural or spiritual benefits?)
3.	How long did you/the community use the project site?
4.	Was the land at the project site used seasonal or all year round? If it was seasonal, which months was the land used?
5.	Did you have any formal or informal agreement/contract to access or use the project site? If so, who was this agreement with?
6.	If the land was grazed, what type of herds and approximately how many livestock did you graze on the project site? - Camels - Goats - Sheep - Other etc
7.	Do you own the livestock or are you employed to graze them? If owned, do you employ any workers to assist you and are they on a formal working contracts?
8.	If the person is employed to graze the herds, please specify - Who owns the livestock you graze? - How much do you receive for grazing cattle? - Do you have an agreement with your employer?
9.	How and when were you notified about the project development and that you could no longer use the site?
10.	Who informed you?
11.	Do you have access to alternative land for grazing in the area close to your communities?
12.	Did you own any camps/structures on the project site? If yes, were you able to relocate them to a new site?
13.	Who owns this land and what are the terms of use (formal or informal agreements)?
14.	Were you provided with any support to move from the project site? If yes, what type of support was provided?
15.	What is your main source of income?
16.	What has the impact been on your livelihood as a result of relocating from the project site?
17.	What are your perceived impacts of the project?

APPENDIX B – QUESTIONNAIRE RESPONSES

QUESTIONNAIRE RESPONSE H-1

ID	QUESTION
Targeted Stakeholder Group	**Herders and community leaders**
1.	Have you used the land at the Project site in the past and what purpose did you use the land for? (Grazing, camping, transportation route, watermelon cultivation etc.) **Yes, I live in the land, and I used it for grazing as well.**
2.	Do you obtain any services from the Project site (such as firewood, water, crops, or any cultural or spiritual benefits?) **Grazing.**
3.	How long did you/the community use the project site? **32 years**
4.	Was the land at the project site used seasonal or all year round? If it was seasonal, which months was the land used? **All Year.**
5.	Did you have any formal or informal agreement/contract to access or use the project site? If so, who was this agreement with? **No formal or informal agreements of any sort**
6.	If the land was grazed, what type of herds and approximately how many livestock did you graze on the project site? - **Camels** - **Goats** - **Sheep** - Other etc **20 Camels, 20 Goats, 100 Sheeps**
7.	Do you own the livestock or are you employed to graze them? If owned, do you employ any workers to assist you and are they on a formal working contracts? **I own the livestock and have one employee working for me, but there is no formal contract**
8.	If the person is employed to graze the herds, please specify - Who owns the livestock you graze? - - How much do you receive for grazing cattle? - - Do you have an agreement with your employer?

	N/A
9.	How and when were you notified about the project development? **I Was notified by government officials 10 days ago.**
10.	Who informed you? **A local committee**
11.	Do you have access to alternative land for grazing in the area close to your communities? **No.**
12.	Did you own any camps/structures on the project site? If yes, were you able to relocate them to a new site? **Yes, Tents, fences, water tanks.**
13.	Who owns this land and what are the terms of use (formal or informal agreements)? **The government.**
14.	Were you provided with any support to move from the project site? If yes, what type of support was provided? **No.**
15.	What is your main source of income? **Livestock**
16.	What has the impact been on your livelihood as a result of relocating from the project site? **Still searching for a spot**
17.	What are your perceived impacts of the project? **Didn't provide an answer.**

QUESTIONNAIRE RESPONSE H-2

ID	QUESTION
Targeted Stakeholder Group	**Herders and community leaders**
1.	Have you used the land at the Project site in the past and what purpose did you use the land for? (Grazing, camping, transportation route, watermelon cultivation etc.) **Yes, I used the land for grazing.**
2.	Do you obtain any services from the Project site (such as firewood, water, crops, or any cultural or spiritual benefits?) **Only for grazing.**
3.	How long did you/the community use the project site? **4 years**
4.	Was the land at the project site used seasonal or all year round? If it was seasonal, which months was the land used? **All Year.**
5.	Did you have any formal or informal agreement/contract to access or use the project site? If so, who was this agreement with? **No formal or informal agreements of any sort**
6.	If the land was grazed, what type of herds and approximately how many livestock did you graze on the project site? - **Camels** - Goats - Sheep - Other etc **15 Camels**
7.	Do you own the livestock or are you employed to graze them? If owned, do you employ any workers to assist you and are they on a formal working contracts? **I own the livestock and manage everything myself, without any employees**
8.	If the person is employed to graze the herds, please specify - Who owns the livestock you graze? - - How much do you receive for grazing cattle? - - Do you have an agreement with your employer? **N/A**

9.	How and when were you notified about the project development? **I Was notified by government officials 10 days ago.**
10.	Who informed you? **A local committee**
11.	Do you have access to alternative land for grazing in the area close to your communities? **Yes, and I am still searching for a spot.**
12.	Did you own any camps/structures on the project site? If yes, were you able to relocate them to a new site? **Yes, I have an RV with a water tank and a fence.**
13.	Who owns this land and what are the terms of use (formal or informal agreements)? **The government.**
14.	Were you provided with any support to move from the project site? If yes, what type of support was provided? **No.**
15.	What is your main source of income? **Livestock**
16.	What has the impact been on your livelihood as a result of relocating from the project site? **No impact**
17.	What are your perceived impacts of the project? **Didn't provide an answer.**

APPENDIX C – CLIMATE CHANGE RISK SCREENING

CATEGORY		HAZARD	APPLICABILITY TO THE PROJECT	REASONS
Acute	Temperature Related	Extreme Heat Event	**Applicable**	• Extreme heat events found to be common in KSA. • ThinkHazard (2023) classes KSA at high risk of extreme heat.
	Water Related	Extreme Precipitation Events	**Not Applicable**	• Extreme precipitation events are not common within KSA. • Future projections vary in the possibilities of the worsening or bettering of these events, but changes are seen to be limited.
		Drought	**Applicable**	• Droughts are very common within KSA. • Droughts are causing greater water scarcity in KSA, which could affect the project and its workers.
		Flood	**Applicable**	• Floods are seen to be very common within KSA from the baseline study. • Coastal flooding is classed as high risk by Think Hazard (2023).
	Wind Related	Extreme Wind Events	**Not Applicable**	• The baseline study found no evidence of extreme wind events that occur regularly, or any evidence of future trends to suggest this might occur.
	Solid Mass Related	Extreme Mass Movement	**Applicable**	• Landslides have occurred within KSA. • ThinkHazard (2023) classes KSA at moderate risk of landslides.
	Wildfires	Change In Fire Condition	**Applicable**	• Saudi Arabia has launched a project aimed at preventing forest fires in the kingdom's southern and southwestern regions. • ThinkHazard (2023) classes KSA at high risk of wildfires.
Chronic	Temperature Related	Mean Temperature Change	**Applicable**	• Temperatures are currently very high throughout KSA, and the projections suggest this could rise by as much as another 16% by 2100.
	Water Related	Mean Precipitation Change	**Not Applicable**	• Projections for KSA show no signs of the changes in precipitation levels.
		Sea Level Rise	**Applicable**	• Think Hazard (2023) classifies KSA as at high risk to coastal flooding. • Baseline desk study suggests that areas in KSA are at risk of sea level rise.

Category		Hazard	Applicability to the Project	Reasons
	Wind Related	Mean Wind Change	**Not Applicable**	• Not significant trends in wind speed changes were found during the baseline study.
	Solid Mass Related	Erosion	**Applicable**	• Coastal erosion was found to be an issue in KSA during the baseline study. • Desertification is also leading to greater inland erosion.