MASDAR

Project Name: Banka 315 MWac Solar PV Project Azerbaijan

Climate Change Risk Assessment Report

Document Information

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Abbreviations & Acronyms

Acronym	Definition
ADB	Asian Development Bank
AEP	Annual Exceedance Probability
AIIB	Asian Infrastructure Investment Bank
CCKP	Climate Change Knowledge Portal
CCRA	Climate Change Risk Assessment
CMIP6	Coupled Model Inter-comparison Projects 6
COD	Commercial Operation Date
DFIs	Development Finance Institutions
DRM	direct rainfall method
E&S	Environmental and Social
EBRD	European Bank for Reconstruction and Development
EP	Equator Principles
EPAP	Equator Principle Action Plan
EPFIs	Equator Principles Financial Institutions
ESF	Environmental and Social Framework
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
ESP	Environmental and Social Policy
GHG	Greenhouse Gas
GW	Gigawatts
H&S	health and safety
IFC	International Finance Corporation
IFI	International Financial Institution
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
LV	Low Voltage
Masdar	Abu Dhabi Future Energy Company
MENR	Ministry of Ecology and Natural Resources
MSL	mean sea level
MV	Medium Voltage
MW	Megawatt
NAMA	Nationally Appropriate Mitigation Actions
NAP	National Adaptation Plan
NDC	Nationally Determined Contributions
O&M	Operation and Maintenance
PMC	Project Management Company

Acronym	Definition
PPA	Power Purchase Agreements
PPE	Personal Protective Equipment
PRs	Performance Requirements
PSs	Performance Standards
PV	Photovoltaic
SCADA	Supervisory Control and Data Acquisition
SCS	Soil Conversation Service
SOCAR	State Oil Company of the Republic of Azerbaijan
SPEI	standardized precipitation evaporation index
SSPs	Shared Socioeconomic Pathways
TCFD	Task Force on Climate-Related Financial Disclosure
UNFCCC	United Nations Framework Convention on Climate Change
WBG	World Bank Group

Key Terms & Definitions

Developer (Masdar)	Is the developer of the Project before the establishment of the Project Company and is a shareholder in the Project Company. It oversees Environmental and Social (E&S) performance and compliance.
The Project Company	Is incorporated for the development of the Project and is the owner of the Project and is the key entity that signed the loan agreement with the Lenders. Project Companies for this are Abu Dhabi Future Energy Company (Masdar) and State Oil Company of the Republic of Azerbaijan (SOCAR)
Project Management Company (PMC)	PMC is appointed by the Project Company and is involved for the first two years of operation to ensure that the Operation and Maintenance (O&M) Contractor is adhering to the technical, environmental, and social project specifications required.
Operation and Maintenance (O&M) Contractor	Is responsible for undertaking operation and maintenance activities of the whole Project components and area during the operation phase of the Project. Main scope includes: 1. Protection of investment and assets of the Project and optimizing its performance within established cost parameters by undertaking the operation activities as well as the maintenance works including preventive scheduled maintenance, and corrective unscheduled maintenance; 2. Optimizing labor efficiency; 3. Enhancing asset performance; 4. Promoting awareness and accountability; 5. Reducing downtime and failures; and 6. Improving safety.
Subcontractors	Subcontractors are identified as any entity (international or local) appointed directly by the O&M Contractor through contractual arrangements to undertake operation and maintenance activities within the project area or provide a specific service for the project. This could include but not be limited to the following: civil checks and repairs, electrical and mechanical checks and repairs, replacing broken and damaged PV panels, water supply, waste collection, security services, etc. The subcontractors appointed include the following: •

E&S Compliance Obligations	The E&S compliance obligations for this Project include: 1. The national laws, regulations and standards 2. At this stage, it is understood that Masdar is seeking an amount of project finance from financial Institutions (together "lenders"), potentially including commercial banks that are Equator Principles Financial Institutions (EPFIs) and Development Finance Institutions (DFIs). The lenders have their own internal environmental & social investment policies/standards by which the Project must align. These include: • Asian Development Bank (ADB) • Asian Infrastructure Investment Bank (AIIB) • European Bank for Reconstruction and Development (EBRD) • International Finance Corporation (IFC)
Project country	The Project is located in Banka village in the Neftchala District of Azerbaijan
Project Language	Includes Azerbaijani and English.
Environmental Statutory Authority	Is any central or local government department or statutory agency, body, authority or organization (including the Environment Agency) which has regulatory or enforcement powers in relation to Environmental Law. In relation to this Project, the environmental statutory authority is Ministry of Ecology and Natural Resources (MENR)
Environmental Permit	Any and all permits, licenses, approvals, registrations, notifications, exemptions and other authorizations required under any Environmental Law which is required before any operation activities can commence onsite in relation to the Project. The environmental permit is referred to as permission for operation issued by MENR, Ministry of Health, and Ministry of Emergency Cases.
Local communities	Are the local communities, households, groups, and community leaders (including the village elders) that may be directly or indirectly affected by the Project and its activities. This includes people affected by social and/or environmental impacts attributable to the Project. For this project, local communities include the Banka Village (400 m), Yenikend Village (800 m) and Neftchala City (1 km). The Azerbaijan Fish Farm Facility, and adjacent cafeteria (the Yenikend Fish House), are located immediately south of the Project. It is less than 100 m from the Project boundary to the nearest point of the Fish Farm facility, with the Fish House over 400 m from the Project's southern boundary.

1 Introduction

1.1 Project Background

Masdar signed implementation agreements with Azerbaijan's Ministry of Energy in June 2022 to develop a renewable energy program on a bilateral basis, with a total capacity of 10 gigawatts (GW) across multiple technologies.

Subsequently, Masdar signed joint development agreements with the State Oil Company of the Republic of Azerbaijan (SOCAR) for onshore wind and solar projects, and integrated offshore wind and green hydrogen projects, with a total combined capacity of 4 GW.

The Ministry of Energy of the Republic of Azerbaijan and Masdar signed an Implementation Agreement relating to the assessment, development, and implementation of a 4 GW_{ac} pipeline of solar photovoltaic (PV) and onshore wind projects in the Republic of Azerbaijan starting with 2 GW_{ac} as the first phase.

In June 2023, Masdar signed an agreement with the Ministry of Energy to design, finance, build and operate a 315 megawatt (MW) utility-scale solar farm project (the project). The Banka Solar PV Plant (the Project) is one of three projects making up the first phase and it is the focus of this report.

The project is located to the south of Baku, in the Neftchala District of the Neftchala Region, Azerbaijan. With a capacity of *315* MW. Once completed, the solar farm will displace *262,000* tons of carbon dioxide per year.

The Project will support Azerbaijan to:

- Reduce energy dependence on carbon-based fuels.
- Meet renewable energy targets.
- Reduce greenhouse gas emission rates.

Masdar has appointed 5 Capitals Environmental and Management Consulting (5 Capitals) to perform an Environmental and Social Impact Assessment (ESIA) for the Project. The ESIA will be developed following the requirements of the International Finance Corporation (IFC) Performance Standards (PSs) and with reference to EBRD Environmental and Social Policy 2019 (ESP 2019) Performance Requirements (PRs), Asian Development Bank (ADB) Safeguards, Asian Infrastructure Investment Bank (AIIB) Environmental and Social Framework, and the Equator Principles.

This document is the Climate Change Risk Assessment (CCRA) and has been prepared on behalf of Masdar. The purpose of this document is to present a climate change risk analysis following the requirements of the Equator Principles 4 2021 (EP4) for the Project. In line with that guidance, the scope of work is to include consideration of climate-related 'Physical Risks' as defined by the Task Force on Climate-Related Financial Disclosure (TCFD)2. This document will be submitted as part of Banka 315 MWac Solar PV Project ESIA package.

1.2 Objectives

This CCRA aims to identify the likelihood of future climate hazards and their potential impacts on the operation of the Project, Project workers and neighbouring communities. This is fundamental for informing the prioritization of climate action and adaption and resilience management requirements for the Project.

The CCRA aligns with the Lenders' requirements including Equator Principles Guidance Note on Climate Change Risk Assessment published in May 2023. The CCRA has been undertaken for the Project to calculate the Greenhouse Gas (GHG) emissions and assess of the physical and transition risks during the Project operation phase.

2 Project Description

The Project site location is shown in the figures below, approximately 120 km south from the Baku city and approximately 2 km from the coastline of the Caspian Sea and 500 m north of the Kura River.

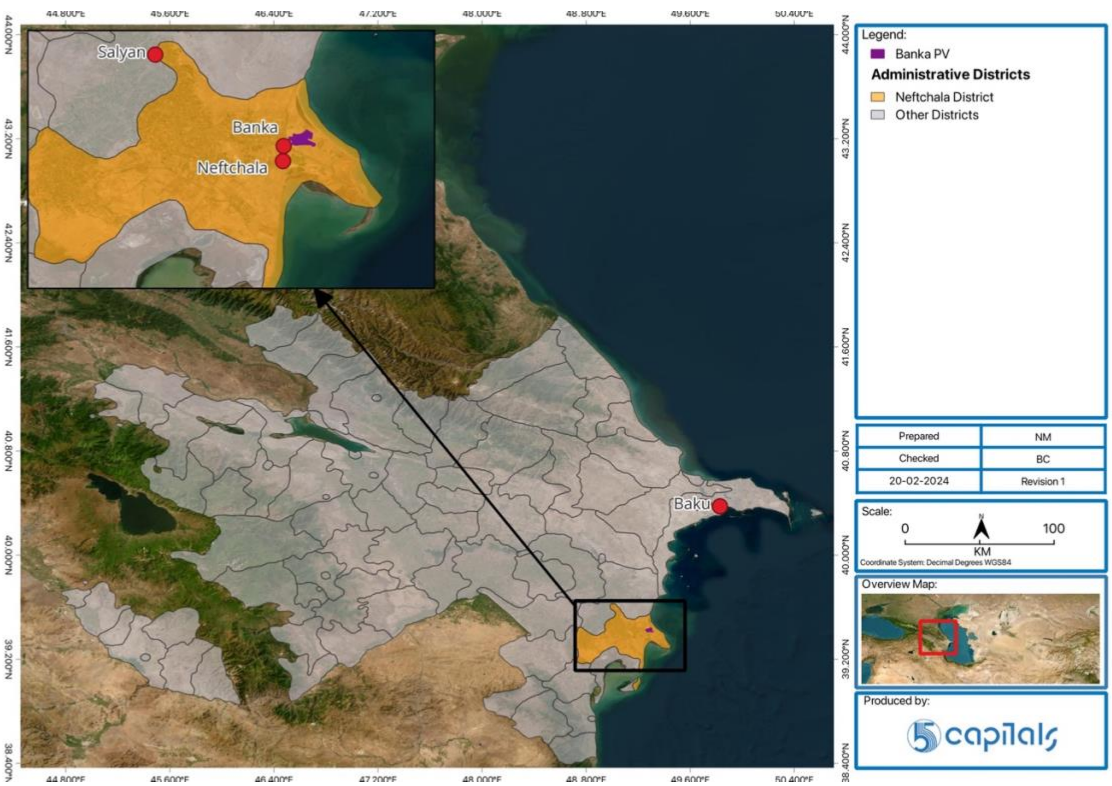

Figure 1 National Project Context

The closest urban areas are within Banka Village (400 m), Yenikend Village (800 m) and Neftchala City (1 km). The Azerbaijan Fish Farm Facility, and adjacent cafeteria (the Yenikend Fish House), are located immediately south of the Project. It is less than 100 m from the Project boundary to the nearest point of the Fish Farm facility, with the Fish House over 400 m from the Project's southern boundary. The following figure depicts the Project relative to its surrounding features.

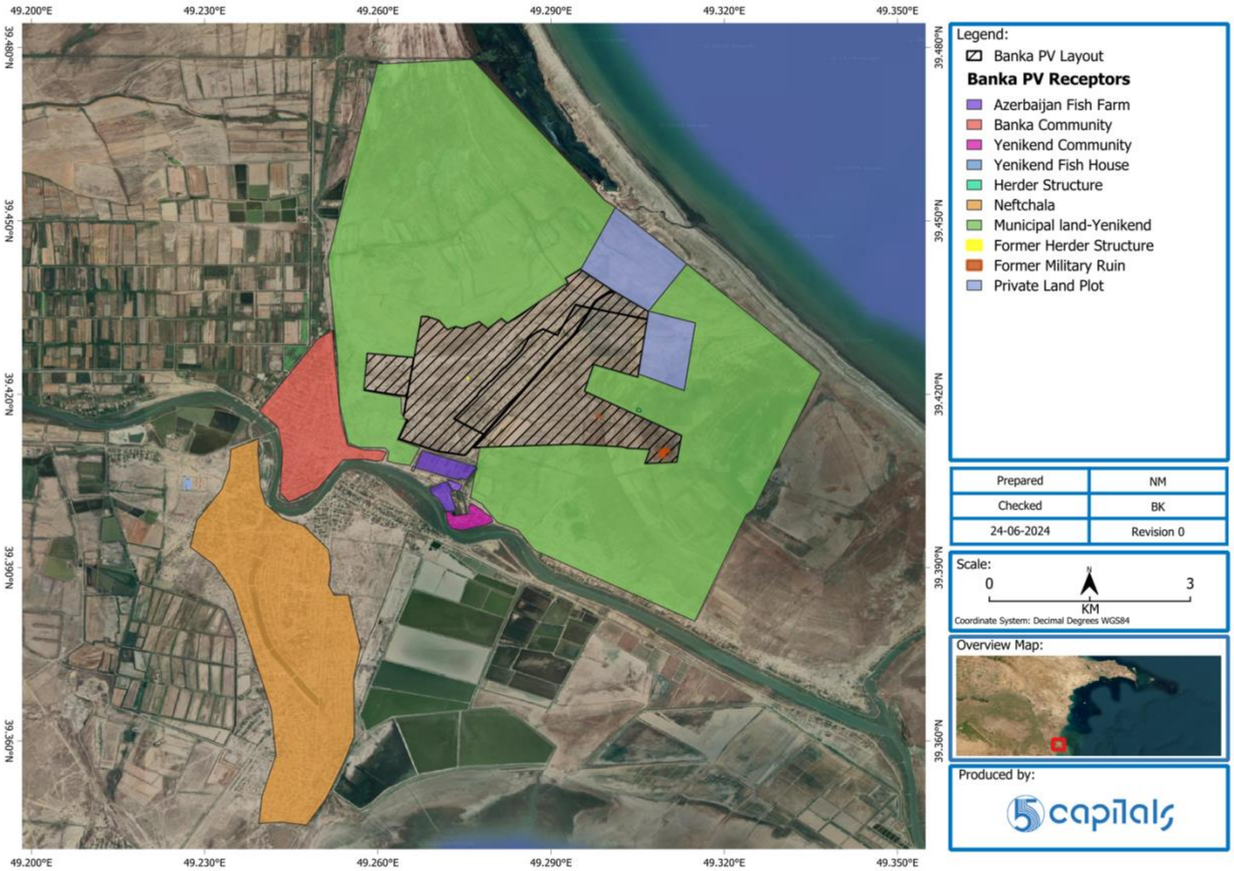

Figure 2 Receptors Relative to the Project

The project will entail the development of a 315 MWac solar power project, within a fenced perimeter area of 973 ha, associated sub-station and access road. The project will not have a dedicated power line but will be integrated into the grid through a new substation in the Navahi settlement. The substation is essential for the prospective development of the network and is planned for construction irrespective of the Projects and is not solely tied to their integration. The development of the grid network within Azerbaijan is part of a Strategic Development Plan. Therefore, the development of the transmission line is not within the Project scope, nor does it fall under the definition of an associated facility

Once developed, the project will be operational for a 25-year period.

The key project components include:

- PV Modules; the PV module considered for the plant will be bifacial monocrystalline modules.

- Inverters; the Project will have both central or string inverters options in the design and the inverter solution will be finalised during the detailed design phase of the Project.
- Mounting Structures; the Project will implement, single axis, E-W tracking, with a tracking range of -55° to +55° or better.
- Low Voltage (LV)/Medium Voltage (MV) Transformers; the Project is foreseen to set up the LV AC from Inverter up to 35 kV MV level.
- PV Plant substation including Power Transformer and Switchgears; the PV plant substation will be built within the PV plant and 35 kV will be stepped up to 300 kV through a power transformer.
- Civil Infrastructure (Roads, Fences, drainage as required, etc.)
- Other balance of plant such as cables, protection, Supervisory Control and Data Acquisition (SCADA) system etc.

2.1 Overview of Project Phases

This section presents the likely activities to take place during the Project development which will include three distinct phases: (i) construction, (ii) operation and (iii) decommissioning each of which is summarized below.

2.1.1 Construction

Construction Activities:

- Site preparation including fencing, clearing, levelling and grading;
- Establishment of access roads to the site;
- Installation of mechanical and electrical infrastructure for PV trackers, modules, and related equipment;
- Construction or compaction of internal roads on-site and other infrastructure including walkways & parking areas;
- Construction of storage facilities for equipment and materials, and construction of laydown area;
- Construction of general buildings, such as administrative building, sanitary rooms, workshops, electrical buildings, auxiliary buildings, and structures, etc.;
- Erection of security fencing;
- Excavation of cable trenches; and
- Construction of mechanical & electrical buildings including the SCADA building.
- Temporary construction facilities including temporary laydown areas, offices, workers accommodation and other facilities.

Construction Workforce

As an initial estimation, and based on experience on similar projects, the typical workforce during the peak construction period is estimated to be 700 – 1,500 workers for a solar PV plant of this size. The workforce will comprise a mix of highly qualified specialists, technicians and low-skilled personnel. Ideally, the low-skilled staff workforce will be encouraged to be sourced locally. Qualified specialists will be sourced both nationally and internationally, depending on the skills availability.

Equipment and Machinery

The following equipment and machinery are likely to be used to construct the Project:

- Excavators
- Graders
- Vibratory rollers
- Loaders
- Hydraulic driving machines
- Cranes and telescoping handlers; and
- Heavy goods vehicles and light good vehicles.

Utilities

Water: The anticipated maximum work force is around 1,000 at its peak and, with an average of 130 litres per person per day. At its peak workforce during construction there would be 130,000 litres/day required to cover the needs of the workforce (or 130 m^3 per day).

Power: Power during the construction phase will be provided by diesel generators.

Concrete and Cement: Based on Masdar's Area 60 Solar PV project, which is located approximately 60 km north of the Project, it is expected that two potential cement manufacturers will be utilised during the construction phase, NORM Cement and Holcim Cement. Concrete producers may include SPARK Beton, Azkontakt Beton and Azital. All of these companies are capable of producing traditional and special types of the concretes required by large scale projects in the country.

Waste and Wastewater

Waste will be generated throughout the construction period. Waste streams will include excavation wastes, packaging wastes, domestic waste from construction workforce etc. Wastes will be segregated and stored onsite before being collected when required by a licensed waste management contractor to a licensed waste management facility.

Wastewater will be collected in septic tanks at site and removed periodically, when required, by a licensed wastewater contractor to a licensed wastewater management facility.

2.1.2 Operation and Maintenance

As per the Power Purchase Agreements (PPA), the plant is to be operational for 25 years. During the operational phase, maintenance will be conducted to ensure efficiency in energy production. Maintenance activities will include cleaning of panels, maintenance of electrical components and control equipment. The routine cleaning of the PV modules is to be conducted automatically by a dry-cleaning robot (i.e., brushes installed on tracks along the rows of the modules) without the use of water in order to make the cleaning process more resource efficient (i.e., avoiding water use) and economically sound.

Operation Workforce

The number of people that are to be employed during operation is expected to be up to 50. A significant percentage is expected to be comprised of Azeris.

Utilities

Water: Water tanker trucks will transport water from outside the solar PV field to water storage tanks within the Project boundary to cover the water demand of the Project, as well as raw water for domestic use, firefighting water demand, and other non-potable water uses if required. Water will not be used for panel cleaning.

Power: Power during the operation phase will be supplied by connection to the national grid and use of Project-generated electricity.

Fuel: The Project will include an emergency diesel generator for use during black-out situations.

2.1.3 Decommissioning

Following the 25 operational years, the Ministry can decide whether to continue, upgrade or decommission; this is outside the scope of this study and to be decided at that time.
Upgrading the PV power plant will entail either replacing old PV modules with new ones, augmenting the total peak power of the plant, or enhancing the plant's power by incorporating new elements.
In the event of decommissioning, the site will be restored close to its original condition, with a Decommissioning and Site Restoration Plan devised prior to this phase.
The components of a PV plant possess inherent value for either reuse or recycling, which will offset the costs of decommissioning the plant and restoring the site. Hazardous wastes will be disposed of in compliance with the environmental guidelines mandated by the country, while non-hazardous materials such as waste metals or plastics will be transported to designated recycling facilities, if available.

2.2 Project GHG Calculations

The project will be utilizing solar energy to produce electricity, which is a key positive impact regarding resource efficiency. The Project will have an installed capacity of 315 MW that will contribute to the national grid. This capacity will help meet the country's increasing electricity demand, as opposed to meeting such demands through conventional electricity production from thermal power plants.

Carbon emissions are categorized into three scopes, each representing different sources of emissions and levels of control:

- Scope 1: scope 1 emissions refer to direct emissions generated from sources owned or controlled by the entity.
- Scope 2: scope 2 emissions include indirect emissions associated with generation of purchased electricity, heat, or heat consumed by the entity. These emissions result from activities

The Project is expected to provide around 641-million kWhr of electricity annually. The Project will likely displace 262,000million tons of CO_2 annually.

The construction phase of the Project will generate GHG emissions from on-site construction activities, including but not limited to transportation of materials, civil works and installation activities, processing of materials, fossil fuels burned in transporting and assembling the system, etc. The International Financial Institution (IFI), under the Framework for a Harmonized Approach to Greenhouse Gas (GHG) Accounting, published the "GHG Accounting for Grid Connected Renewable Energy Projects" (IFI, 2019). The document states that construction emissions for renewable energy projects may be excluded, where forms of renewable energy are generally acknowledged to have low construction/lifecycle emissions.

The operation phase figure covers all activities, including maintenance, cleaning of modules, replacing parts, etc. The power required during operation will be provided by the Project and therefore GHG emissions from power consumption are not anticipated.

Considering the above, and based on the amount of GHG emissions displaced during operation as calculated above, GHG emissions from the Project are considered negligible.

3 Legal & Institutional Framework

This section presents the overall regulatory and policy framework applicable to the Project.

3.1 National Laws & Regulations

The Paris Agreement came into force on 4th November 2016. The Republic of Azerbaijan ratified the Paris Agreement on 9 January 2017.
The United Nations Development Programme in Azerbaijan and MENR signed a project on the Fourth National Communication and the Second Biennial Reporting under the United Nations Framework Convention on Climate Change (UNFCCC). The aim of the project is to support the Government of Azerbaijan through the MENR to continue reporting under the Convention.
Climate change is reflected in the government's strategies as follows:

- Republic of Azerbaijan's Fourth National Communication to the UNFCCC (2021);
- Azerbaijan 2020: Look into the Future Development Concept (2014);
- Comprehensive Action Plan to improve environmental situation in the Republic of Azerbaijan in 2006 (2010);
- Action Plan on Improvement of the Ecological Situation and Efficient Use of Natural Resources in the Republic of Azerbaijan (2015–2020); and
- National Adaptation Plan (NAP).

Azerbaijan ratified the UNFCCC on January 10, 1995, and the Kyoto Protocol on July 18, 2000.

3.1.1 Intended Nationally Determined Contribution

The Intended Nationally Determined Contribution (INDC) represents a non-binding national strategy outlining climate change mitigation efforts in a country. It includes specific goals to reduce pollution[1]. INDCs connects a country's own rules with global efforts agreed upon in the Paris agreement. This aims to create a future that's better for the environment. These contributions are vital fighting climate change because they outline how much a country plans to cut down on pollution and emissions, following the guidelines of the United Framework Convention on Climate Change (UNFCCC).

The Republic of Azerbaijan actively participates in the implementation of the UNFCCC, the Kyoto Protocol and the Paris Agreement. In accordance with Article 4 of the Paris Agreement, the Republic of Azerbaijan has introduced its Nationally Determined Contributions (NDC) to the UNFCCC Secretariat in October 2015 and as a contribution to initiatives for preventing global climate change (mitigation initiatives) compared to 1990 (base year) aims to reduce greenhouse gas emissions by 35% by 2030. Azerbaijan's NDCs by 2050 were renewed in 2023. The new version of Azerbaijan's Nationally Determined Contributions by 2050 include the following[2]:

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1 *What is an INDC? | World Resources Institute*. (2015). Wri.org. https://www.wri.org/indc-definition
2 *The Republic of Azerbaijan Updated document on Nationally Determined Contributions (NDC). (2023). https://unfccc.int/sites/default/files/NDC/2023-10/Second%20NDC_Azerbaijan_ENG_Final%20%281%29.pdf*

1- **GHG emissions**: The Republic of Azerbaijan updated its NDC document in accordance with the Paris Agreement with a target of reducing its GHG emissions by 40% compared to 1990 levels by 2050, taking into account the maximum possible absorption capacity of forests and ecosystems.
2- **Energy Sector**: The Republic of Azerbaijan is accelerating renewable energy adoption through flexible tariff regulations, technical skill development, consumer awareness, and private sector involvement.
3- **Heat Supply:** The strategic roadmap for public utilities in Azerbaijan outlines specific indicators for installing modern, energy-efficient, and environmentally friendly boiler and heating systems in new and upgraded facilities. To enhance efficiency in the public utilities sector, several regulations have been approved. These measures aim to improve preventive actions and regulate relationships among manufacturers, suppliers, and consumers.
4- **Transport:** Over the past decade, Azerbaijan has significantly developed its transportation system to become a key transit and trade hub, focusing on the restoration and construction of road and railway infrastructure along north-south and east-west corridors.
5- **Industrial Processes and Product Use**: Greenhouse gas emissions in Azerbaijan's industrial sector, notably from mining, chemical industry, metallurgy, and other manufacturing industries, increased by 2.5 times from 1990 to 2016, reaching 5.12% due to industrial growth, increased clinker production for cement since 2011, and methanol production starting in 2013. To mitigate these emissions, measures should be implemented to promote modern technologies, enhance energy efficiency, increase the use of alternative energy sources, and develop recycling initiatives in both public and private sectors.
6- Agriculture, Land Use, Land Use Change: The agricultural sector, the second-largest source of greenhouse gas emissions in Azerbaijan after the energy sector. The Strategic Roadmap for agricultural production and processing outlines preventive and adaptation policies to address climate change across four priority areas: developing mechanisms and adaptation plans to mitigate climate impacts, creating performance indicators for environmentally compliant agricultural production, assessing environmental impacts of land-use changes, and fostering environmentally friendly agricultural products.
7- Forestry: Azerbaijan prioritizes forest development due to their crucial role in greenhouse gas absorption. Forests, which are not typically used for industrial purposes, protect soil, regulate water, conserve biodiversity, shape microclimates, and absorb carbon. The State Program for Poverty Reduction and Sustainable Development aims to expand forested and protected areas, doubling greenhouse gas absorption to 7.2 million tons of CO2 equivalent by 2016 from 1990 levels. These efforts will enhance forest coverage and greenhouse gas absorption, supporting the country's updated Nationally Determined Contributions.
8- Waste Sector: Greenhouse gas emissions in Azerbaijan's waste sector have increased by 72% from 1990 to 2016, accounting for 2.2% of total emissions in 2016. Effective management of this sector is crucial for reducing emissions. The National Strategy for

Improving Solid Waste Management outlines measures to enhance waste collection, promote recycling, reduce state subsidies, and boost the recycling market. Implementing this strategy aims to create favorable conditions for entrepreneurs and investors, establish new enterprises, increase employment, and incorporate international experience and modern technologies.

3.1.2 National Adaptation Plan

National Adaptation Plans (NAPs) were introduced at the UNFCCC COP16 in 2010 to help countries plan for climate adaptation. The NAP process is flexible building on existing adaptation efforts to integrate climate change considerations into national decision-making. With support from the United Nations countries globally are guided to create NAPs to identify medium- and long-term adaptations needs based on current climate science. The overarching aim of NAPs is to systematic reduce climate-related damage, enhance adaptive capacity, and promote sustainable economic development by 2050.

As per the World Bank Group (WBG) and the Asian Development Bank (ADB) Climate Risk Country Profile published in 2021, Azerbaijan has committed to the Paris Climate Agreement, outlining its climate change mitigation strategies in the NDC submitted in 2017 and renewed in 2023. These strategies span several sectors, including energy, oil and gas, residential and commercial buildings, transport, agriculture, and waste management[3]. The country plans to align its climate change policies with EU standards, developing sector-specific guidelines for implementing the Paris Agreement, particularly in agriculture and energy. These initiatives mainly involve technological upgrades to minimize environmental impacts, alongside regulatory adjustments and public awareness campaigns[3].

The National Adaptation Plan for Azarbaijan is not in place yet. In its Third National Communication to the UNFCCC in 2015, Azerbaijan identified adaptation measures in agriculture, water supply, forestry, coastal areas, human health, and tourism. The nation is in the process of developing a NAP, anticipated to be finalized by 2024. The NAP is expected to concentrate on water, agriculture, and coastal areas, as designated by the Ministry of Ecology[3].

Additionally, Azerbaijan has created and executed Nationally Appropriate Mitigation Actions (NAMA) focusing on enhancing energy efficiency in buildings, modernizing the transport fleet with hybrid vehicles and promoting eco-driving, and capturing and utilizing associated gas in the oil industry. The initial NAMA projects, piloted with SOCAR (the State Oil Company), are being considered for broader implementation across the country[3].

3 WBG & ADB. (2021). Climate Risk Country Profile: Azerbaijan (2021): The World Bank Group and Asian Development Bank. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-06/15835-Azerbaijan%20Country%20Profile-WEB.pdf

3.2 Requirements for Project Financing

3.1.3 Equator Principles (Eps)

The Equator Principles is a voluntary set of principles institutions, called Equator Principles Financial Institutions (EPFIs), sign on to, in order to show their commitment to assess and manage the environmental and social risks of their projects. Equator Principles 4 (EP4) also sets out obligations for climate change risk analysis (CCRA) in line with the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD). Following the EP4 guidance note on CCRA,7 a CCRA is required in the following instances:

- For Category A and, as appropriate, Category B projects. For these projects the CCRA is to include consideration of relevant climate-related 'Physical Risks' as defined by the Task Force on Climate-Related Financial Disclosure (TCFD).
- For all projects, in all locations, when combined Scope 1 (direct) and Scope 2 (indirect electricity) emissions are expected to be more than 100,000 (tCO2e) per year. For these projects the CCRA is to include consideration of climate-related 'Transition Risks' (as defined by the TCFD).

Applicable and considered Equator Principles for the CCRA are listed in the table below:

Table 1 Summary of Equator Principles

No.	Principle	Discussions
1	Review & Categorization	Identifies categorization for projects as either Category A, B, or C. This is determined by an E&S review and due diligence undertaken by the financial institution or their advisor. Based on the project review, the project is assigned a category.
2	Environmental & Social Assessment	This requires that for Category A and B projects, an Environmental and Social Impact Assessment (ESIA) is done. The Principle provides guidance and an illustrative list of issues the ESIA study should address. In addition, the Principle requires an assessment of potential adverse **human rights impacts** and **climate change risks**.
3	Applicable Environmental and Social Standards	The Equator Principle 3 requires that an assessment process comply with relevant host country laws. In addition, for projects located in Non-Designated Countries (such as Azerbaijan), compliance with IFC Performance Standards on Environmental and Social Sustainability (Performance Standards) is required.
4	E&S Management System and EP Action Plan	The financing institution will require the client to develop or maintain an Environmental and Social Management System (ESMS) for all category A and B projects. In addition, the Client must prepare an Environmental and Social Management Plan (ESMP).
7	Independent Review	An independent E&S review will be undertaken for Category A and B projects on the EIA, ESMP, ESMS, SEP, and others as applicable, and an Equator Principle Action Plan (EPAP) will be prepared.
8	Covenants	The Principle requires that the Client covenant and comply with ESMP and EPAP requirements and provide periodic reports to document compliance with ESMP and EPAP and local E&S regulations.
9	Independent Monitoring and Reporting	After the financial close, for category A and B projects, the financing institution will require independent monitoring and reporting to assess project compliance with Equator Principles.
10	Reporting and Transparency	Identifies E&S reporting requirements for the client for category A and B projects.

3.1.4 International Finance Corporation (IFC)

According to the IFC's Performance Standard 1, the client must "*establish and maintain a process for identifying the environmental and social risks and impacts of a project*." As part of this process, *"the risks and impacts identification process will consider the emissions of greenhouse gases (GHGs), the relevant risks associated with a changing climate and the adaptation opportunities, and potential transboundary effects, such as pollution of air, or use or pollution of international waterways*". For projects expected to generate more than 25,000 tonnes of CO2 equivalent (tCO2e) per year of GHG emissions, quantifying the direct and indirect emissions within the Project boundaries shall also be carried out in line with an internationally recognized methodology.

Applicable and considered IFC Performance Standard Requirements for the CCRA are listed in the table below:

Table 2 IFC Performance Standard Requirements

IFC PS	Key Points	(Direct/Indirect) related to CCRA
PS1: Assessment and Management of Environmental and Social Risks and Impacts	PS1 underscores the importance of managing social and environmental performance throughout the life of a project by using a dynamic social and environmental management system. Specific objectives of this Performance Standard are: ▪ To identify and assess social and environmental impacts, both adverse and beneficial, in the project's area of influence; ▪ To avoid, or where avoidance is not possible, minimize, mitigate, or compensate for adverse impacts on workers, affected communities, and the environment; ▪ To ensure that affected communities are appropriately engaged on issues that could potentially affect them; and ▪ To promote improved social and environmental performance of companies through the effective use of management systems.	**Directly related to CCRA**
PS 3: Resource Efficiency and Pollution Prevention	This Performance Standard outlines a project approach to pollution prevention and abatement in line with internationally available technologies and practices. It promotes the private sector's ability to integrate such technologies and practices as far as their use is technically and financially feasible and cost-effective in the context of a project that relies on commercially available skills and resources. Specific objectives of this Performance Standard are: ▪ To avoid or minimize adverse impacts on human health and the environment by preventing or minimizing pollution from project activities and ▪ To promote the reduction of emissions that contribute to climate change.	**Directly related to CCRA**
PS4: Community Health, Safety and Security	This PS recognizes that project activities, equipment, and infrastructure often benefit communities, including employment, services, and opportunities for economic development. However, projects can also increase risks arising from accidents, releases of hazardous materials, exposure to diseases, and the use of security personnel. While	**Indirectly related to CCRA**

IFC PS	Key Points	(Direct/Indirect) related to CCRA
	acknowledging the public authorities' role in promoting the health, safety, and security of the public, this PS addresses the project sponsor's responsibility regarding community health, safety, and security.	
PS5: Land Acquisition and Involuntary Resettlement	Involuntary resettlement refers to physical and economic displacement due to project-related land acquisition. Where involuntary resettlement is unavoidable, appropriate measures to mitigate adverse impacts on displaced persons and host communities should be carefully planned and implemented.	**Indirectly related to CCRA**
PS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	This Performance Standard reflects the Convention on Biological Diversity's objectives to conserve biological diversity and promote the use of renewable natural resources sustainably. This Performance Standard addresses how project sponsors can avoid or mitigate threats to biodiversity arising from their operations and sustainably manage renewable natural resources. Specific objectives of this Performance Standard are: ▪ To protect and conserve biodiversity and ▪ To promote the sustainable management and use of natural resources through the adoption of practices that integrate conservation needs and development priorities.	**Indirectly related to CCRA**

3.1.5 European Bank for Reconstruction and Development (EBRD)

The EBRD has established a thorough set of Performance Requirements (PRs) covering essential aspects of environmental and social sustainability, which projects must adhere to. Key to these requirements is the implementation of the mitigation hierarchy and adherence to international best practices[4].

Applicable and considered EBRD Performance Requirements for the CCRA are listed in the table below:

Table 3 EBRD Performance Requirements

EBRD PRs	**Key Points**
PR 1: Assessment and Management of Environmental and Social Risks and Impacts	The objectives of this Performance Requirement are: • "To identify and assess environmental and social impacts and issues, both adverse and beneficial, associated with the project." • "To adopt measures to avoid, or where avoidance is not possible, minimize, mitigate, or offset/compensate for adverse impacts on workers, affected communities, and the environment." • "To identify and, where feasible, adopt opportunities to improve environmental and social performance." • "To promote improved environmental and social performance through a dynamic process of performance monitoring and evaluation."[5]
PR 3: Resource Efficiency and	The objectives of this Performance Requirement are:

4 Environmental and Social Policy. (2019). In European Bank for Reconstruction and Development (EBRD). Environmental and Social Policy (ebrd.com)
5 ESP_PR01_Eng.pdf (ebrd.com)

EBRD PRs	Key Points
Pollution Prevention and Control	• "To identify and assess environmental and social impacts and issues, both adverse and beneficial, associated with the project." • "To adopt measures to avoid, or where avoidance is not possible, minimize, mitigate, or offset/compensate for adverse impacts on workers, affected communities, and the environment." • "To identify and, where feasible, adopt opportunities to improve environmental and social performance." • "To promote improved environmental and social performance through a dynamic process of performance monitoring and evaluation."[6]

3.1.6 ADB

The Asian Development Bank (ADB) Safeguard Policy Statement[7] adopted in 2009 is aligned and consistent with the IFC policies, integrating previous ADB policies and Safeguard Requirements on environment, involuntary resettlement and Indigenous Peoples under it. The objectives of the environmental safegaurds is to ensure the environmental soundness and sustainability of projects and to support the integration of environmental considerations into the project decision-making process. ADB requires comprehensive environmental assessments for its projects to identify potential environmental impacts, including detailed analysis of climate change risks and vulnerabilities.

3.1.7 AIIB

The Asian Infrastructure Investment Bank (AIIB) has a comprehensive Environmental and Social Framework (ESF)[8] that integrates climate change considerations into its policies and operations. The ESF aims to ensure that the projects financed by AIIB are environmentally and socially sustainable, and it reflects the Bank's commitment to addressing climate change.

- The Environmental and Social Policy requires projects to undergo a climate risk and vulnerability assessment to identify potential climate-related risks and ensure resilience. This includes evaluating the impact of climate change on project performance and longevity. The policy requires the estimation and reporting of GHG emissions for relevant projects. It encourages the implementation of measures to reduce emissions and enhance carbon sequestration.
- The Environmental and Social Standards also requires the assessment of climate change risks and the integration of appropriate mitigation and adaptation measures into project design and implementation. In addition, it focuses on resource efficiency, including energy use, and the reduction of pollution, including GHG emissions. It promotes the use of clean and renewable energy sources.

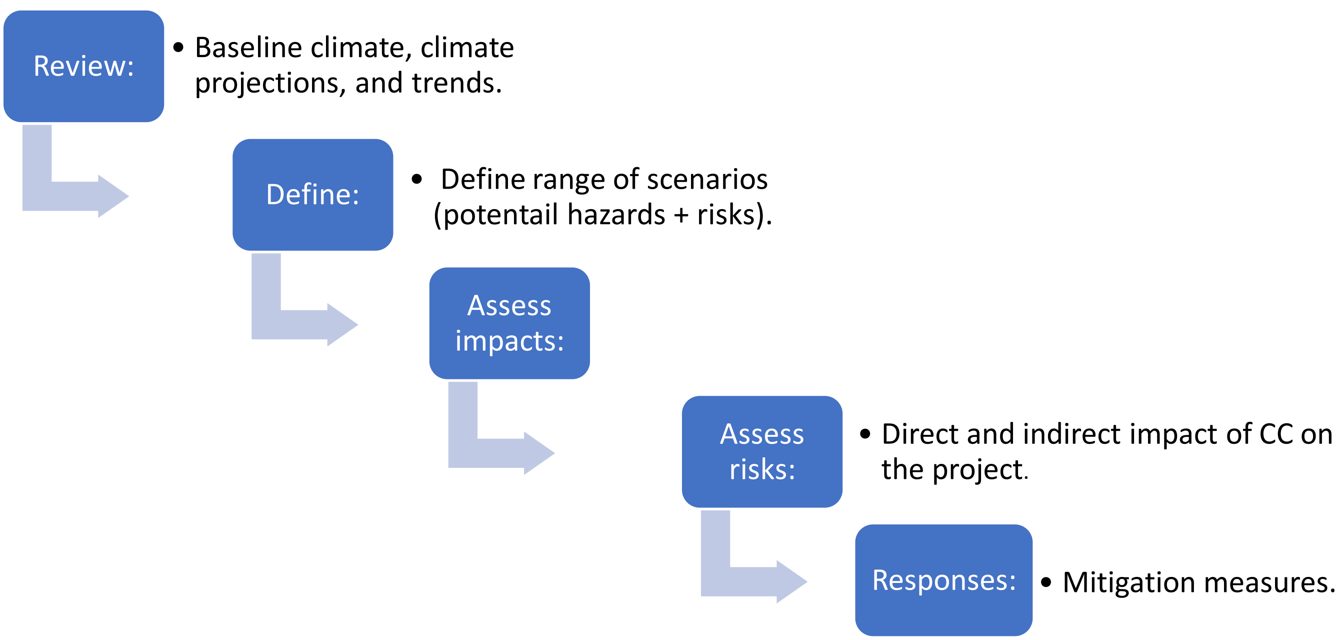
6 ESP_PR03_Eng.pdf (ebrd.com)
7 ADB Safeguard Policy Statement. (2009) https://www.adb.org/sites/default/files/institutional-document/32056/safeguard-policy-statement-june2009.pdf
8 Environmental and Social Framework, Approved February 2016 (Amended February 2019, May 2021 and November 2022). https://www.aiib.org/en/policies-strategies/_download/environment-framework/AIIB-Environmental-and-Social-Framework_ESF-November-2022-final.pdf

4 Climate Change Risk Assessment

This section evaluates previous climatic events and trends through the analysis of historical data to understand the change of the climate conditions over time. Examining these historical patterns forms a basis for improving the understanding of future projections and predicting potential climate scenarios. Based on the available historical and projected data, the future climate risks are evaluated and strategies to mitigate and adapt to expected climatic changes are determined.

4.1 Approach & Methodology

The figure below outlines the main steps to complete a qualitative assessment for physical risks aligned with the TCFD process for applying scenario analysis of climate related.



4.2 Baseline Climate Overview

Azerbaijan boasts a highly diverse climate, featuring nine of the eleven global climate zones. These range from semi-arid regions in the central and eastern parts, including Baku, to temperate zones in the north, continental climates in the west, and cold and tundra regions. Consequently, there's a wide range of annual temperatures and precipitation levels across the country. Generally, the mountainous regions experience more precipitation and cooler temperatures, while the central lowlands and Caspian Sea coast have a drier, hotter climate.

Summers are particularly hot in the lowland areas, and winters are moderate (WBG & ADB, 2021)[9].

In the hottest months of July and August, average temperatures in Baku and other eastern and southeastern regions typically reach around 27ºC, while in the mountainous north and west, temperatures range between 15ºC and 20ºC during the same period. During winter (December to February), Baku experiences average temperatures of about 3ºC to 4ºC, whereas temperatures in the western and northern areas plummet to between −5ºC and −10ºC. Rainfall in Azerbaijan displays a bimodal distribution throughout the year, with average levels surpassing 40 millimetres (mm) per month from April to June and again in October. The peak precipitation occurs in May and June in the northern and western parts of Azerbaijan, where it can exceed 100 mm per month (CCKP, 2024).

The following figure presents the average monthly temperature and precipitation from 1991 till 2020 in the Project area. The highest average maximum temperature of 33°C and the lowest average minimum temperature of 0.84°C were recorded in July and January respectively. The annual mean temperature in the Project area was recorded at 15.39°C in 1991, increasing to 16.59°C in 2022. The highest precipitation levels of 51.75mm are recorded in October compared to the lowest levels of 17.43mm in July (CCKP, 2024).

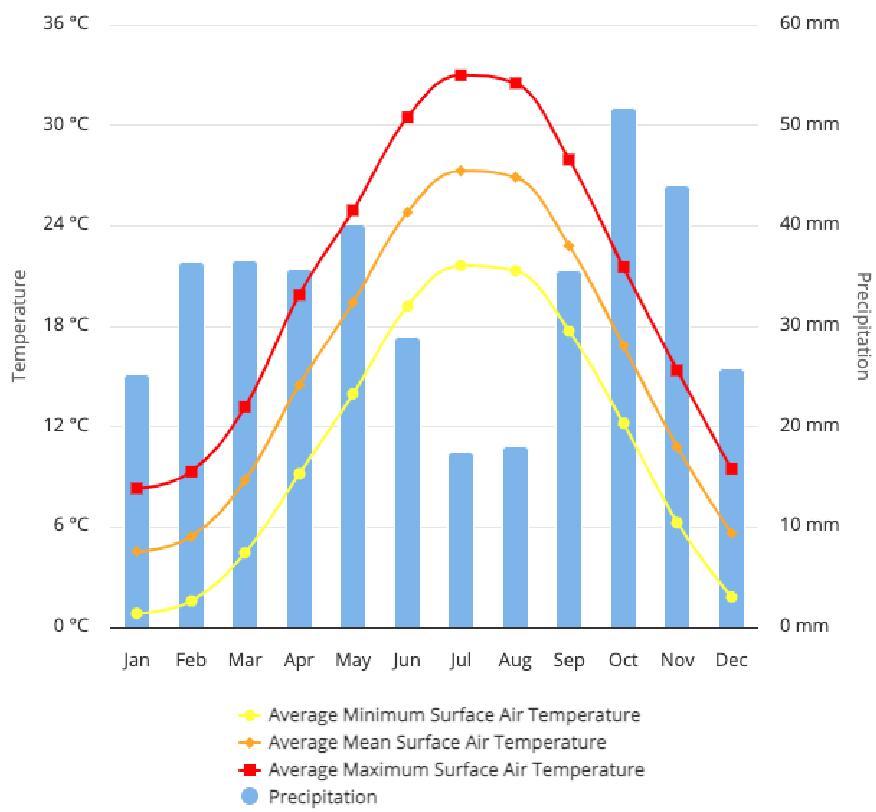


Figure 3 Average Monthly Climate Conditions in the Project Area for 1991-2022 (CCKP, 2024)

9 WBG & ADB. (2021). Climate Risk Country Profile: Azerbaijan (2021): The World Bank Group and Asian Development Bank. https://www.adb.org/sites/default/files/publication/707466/climate-risk-country-profile-azerbaijan.pdf

Table 4 Average Monthly Mean Air Temperature and Precipitation in the Project Area (CCKP, 2024)

Parameter	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature (°C)	4.6	5.4	8.8	14.5	19.4	24.8	27.3	26.9	22.8	16.9	10.8	5.6
Precipitation (mm)	25.2	36.3	36.6	35.6	40.2	28.9	17.4	18	25.6	51.6	40.1	25.8

4.3 Projected Climate Future and Physical Risks

The primary data source for the World Bank Group's Climate Change Knowledge Portal (CCKP), which has been used as the primary source for identifying projections in this section, is the Coupled Model Inter-comparison Project Phase 5 (CMIP5) models, which are utilized within the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), providing estimates of future temperature and precipitation.

In that portal, the future climate projections have been developed the formulation of societal development narratives under the Shared Socioeconomic Pathways (SSPs). The SSPs consider societal factors such as demographics, human development, economic growth, inequality, governance, technological change and policy orientations. These variables were chosen based on their common use as inputs to emissions or impact models and their relationships to each other. Several SSP scenarios, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 are presented on the portal.
The SSP2-4.5and SSP5-8.5will be used for this assessment to determine future trends and apply these to the Project:

- **SSP2-4.5** is approximately in line with the upper end of aggregate Nationally Determined Contribution emission levels by 2030. It represents assessed temperature projections for NDCs to be between 2.7 and 3.4°C by 2100, corresponding to the upper half of projected warming under SSP2-4.5. New or updated NDCs by the end of 2020 did not significantly change the emissions projections up to 2030, although more countries adopted 2050 net zero targets in line with SSP1-1.9 or SSP1-2.6. The SSP2-4.5 scenario deviates mildly from a 'no-additional- climate-policy' reference scenario, resulting in a best-estimate warming around 2.7°C by the end of the 21st century relative to 1850-1900.

- **SSP5-8.5** is a high reference scenario with no additional climate policy. Emission levels as high as SSP5-8.5 are not obtained by Integrated Assessment Models (IAMs) under any of the SSPs other than the fossil fueled SSP5 socioeconomic development pathway.

The Project commercial operation date (COD) is expected in January 2027, therefore, the potential climate change scenarios under the Coupled Model Inter-comparison Projects 6 (CMIP6) during the Project's lifetime till 2052 were obtained from CCKP. The applicable parameters are discussed in detail in the sections below.

4.3.1 Temperature

4.3.1.1 Future Scenarios

1- *Mean temperature*

Under scenario SSP2-4.5, for the time period 2020-2039, the average mean surface air temperature in the Project area is projected to be the highest in July where the 10-90th percentile range is 29.40°C to 30.90°C (median 30.13°C). The lowest temperature is expected in January where the 10-90th percentile range is expected at 4.31°C to 6.01°C (median 4.86°C). The 50th percentile for the projected annual average mean surface air temperature anomaly for 2020-2039 for the Project area (Ref. Period: 1995-2014), is highest in July at 1.47°C increase.

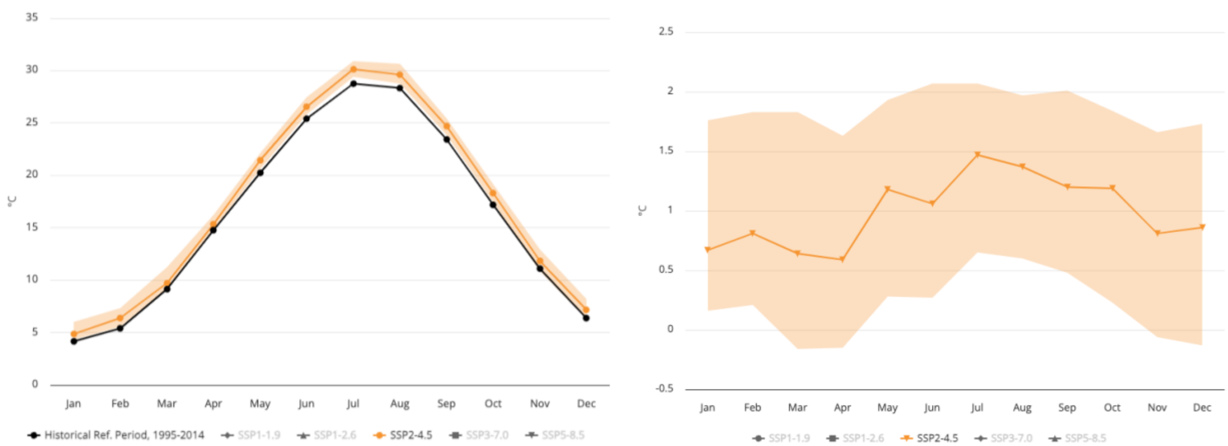


Figure 4 Projected Climatology (Left) and Anomaly (Right) of Average Mean Surface Air Temperature for 2020-2039 (Annual) for the Project Region; (Ref. Period: 1995-2014), SSP2-4.5, Multi-Model Ensemble

Under scenario SSP2-4.5, for the time period 2040-2059, the average mean surface air temperature in the Project area is projected to be the highest in July where the 10-90th percentile ranges between 30.27°C to 31.82°C (median 31.13°C). The lowest temperature is expected in January where the 10-90th percentile range is 4.53°C to 6.44°C (median 5.49°C). The 50th percentile for the projected annual average mean surface air temperature anomaly for 2040-2059 for the Project area (Ref. Period: 1995-2014), is highest in July at 2.37°C.

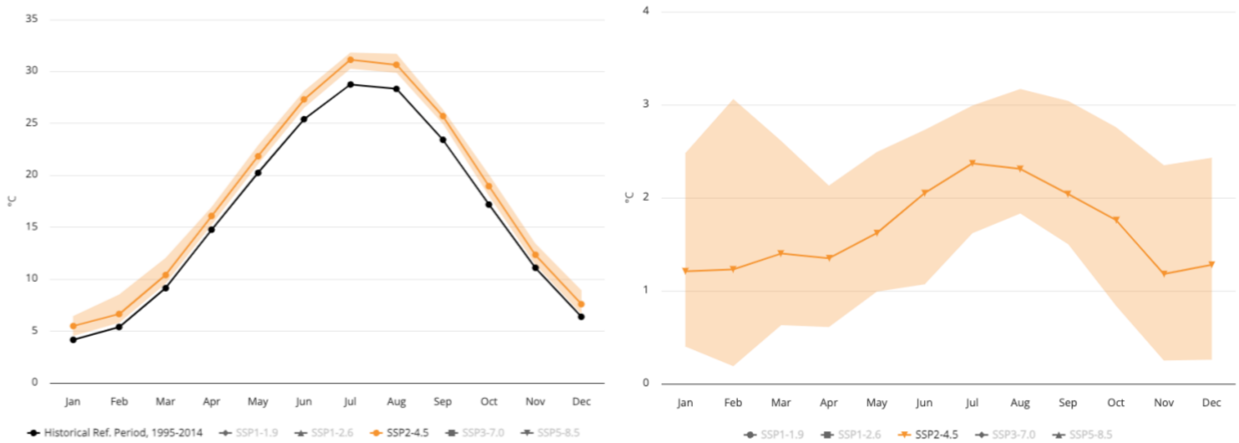


Figure 5 Projected Climatology (Left) and Anomaly (Right) of Average Mean Surface Air Temperature for 2040-2059 (Annual) for the Project Region; (Ref. Period: 1995-2014), SSP2-4.5, Multi-Model Ensemble

As presented in the following figure, under scenario SSP2-4.5, in 2027, the 10-90th percentile range of average mean surface air temperature in the Project area is expected to be 16.53°C to 18.47°C (median 17.13°C). By 2052, the 10-90th percentile range of average mean surface air temperature in the Project area is expected to reach 17.06°C to 19.17°C (median 17.96°C).

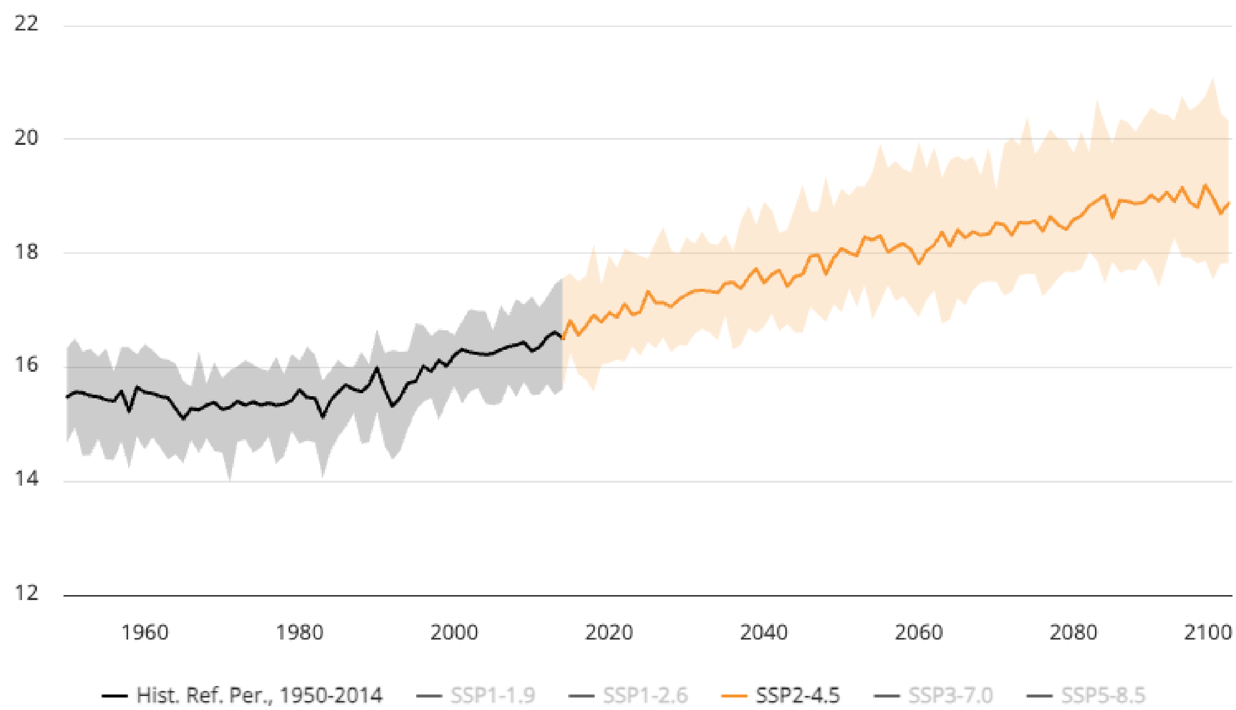


Figure 6 Projected Average Mean Surface Air Temperature for the Project Region; (Ref. Period: 1995-2014), SSP2-4.5, Multi-Model Ensemble

<u>Under scenario SSP5-8.5, for the time period 2020-2039</u>, the average mean surface air temperature in the Project area is expected be highest in July where the 10-90th percentile range is 29.44°C to 31°C (median 30.36°C). The lowest temperature is expected in January

where the 10-90th percentile range is 4.12°C to 6.24°C (median 5.06°C). The 50th percentile for the projected annual average mean surface air temperature anomaly for 2020-2039 for the Project area (Ref. Period: 1995-2014), is highest in August at 1.74°C.

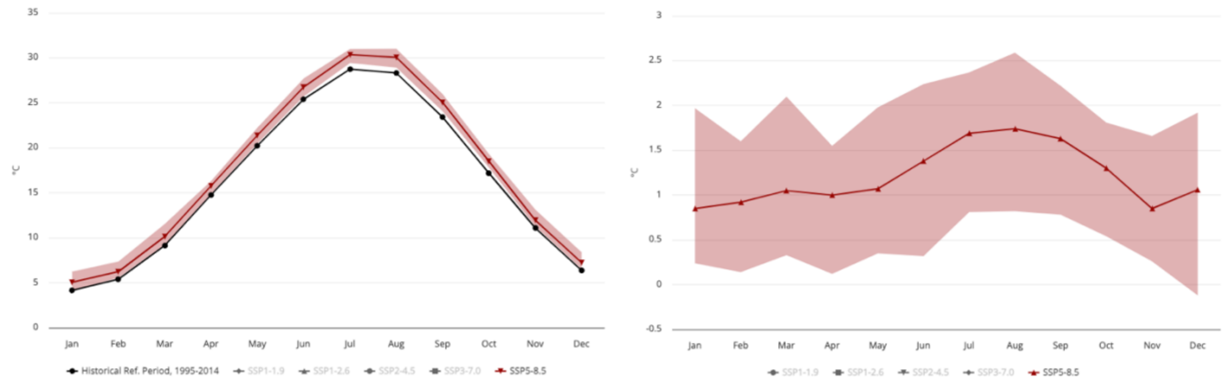


Figure 7 Projected Climatology (Left) and Anomaly (Right) of Average Mean Surface Air Temperature for 2020-2039 (Annual) for the Project Region; (Ref. Period: 1995-2014), SSP5-8.5, Multi-Model Ensemble

<u>Under scenario SSP5-8.5, for the time period 2040-2059</u>, the average mean surface air temperature in the Project area is highest in July where the 10-90th percentile ranges between 30.32°C to 32.84°C (median 31.83°C). The lowest temperature is in January where the 10-90th percentile range is expected at 5.09°C to 7.76°C (median 5.96°C). The 50th percentile for the projected annual average mean surface air temperature anomaly for 2040-2059 for the Project area (Ref. Period: 1995-2014), is highest in August at 3.21°C.

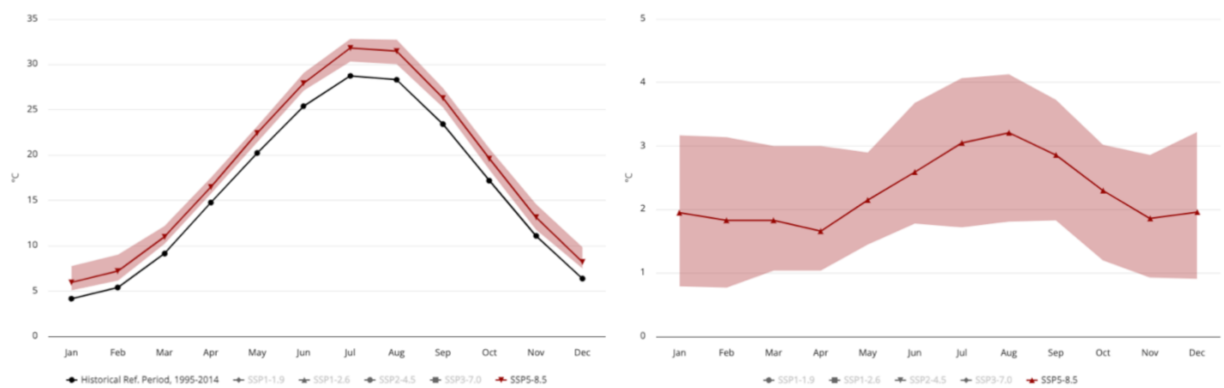


Figure 8 Projected Climatology (Left) and Anomaly (Right) of Average Mean Surface Air Temperature for 2040-2059 (Annual) for the Project Region; (Ref. Period: 1995-2014), SSP5-8.5, Multi-Model Ensemble

As presented in the following figure, under scenario SSP5-8.5, in 2027, the 10-90th percentile range of average mean surface air temperature in the Project area is expected to range between 16.36°C and 18.27°C (median 17.29°C). By 2052, the 10-90th percentile range of average mean surface air temperature in the Project area is expected to reach a range of 17.47°C to 20.12°C (median 18.54°C).

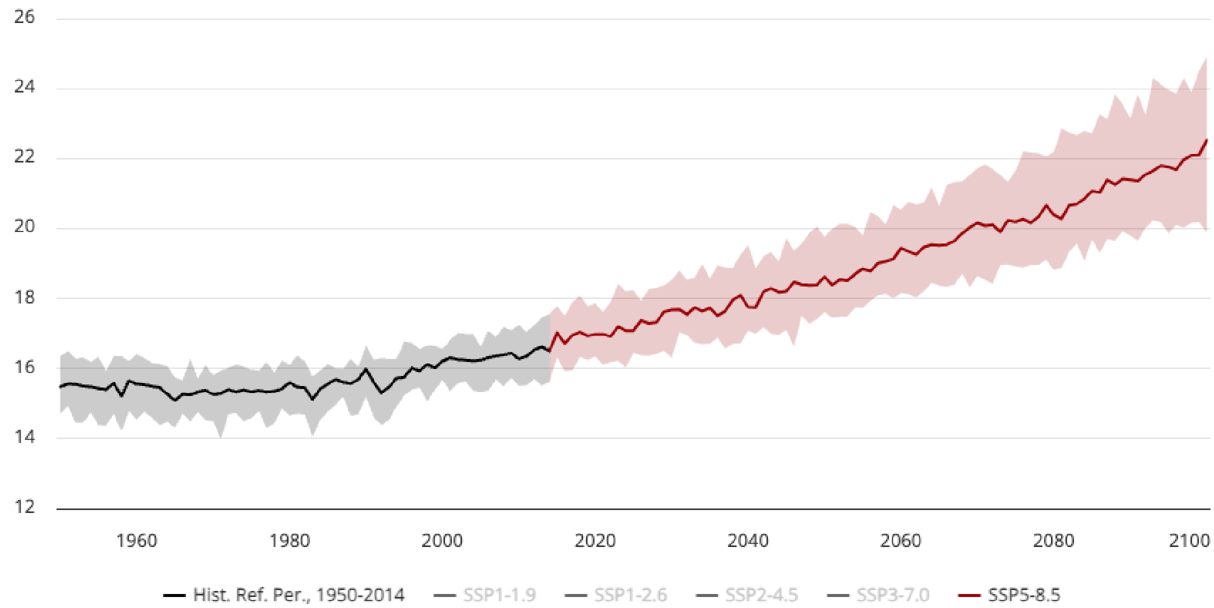


Figure 9 Projected Average Mean Surface Air Temperature for the Project Region; (Ref. Period: 1995-2014), SSP5-8..5, Multi-Model Ensemble

The table below presents the projected anomaly changes in temperature between the Projects COD compared to the end of operation. This encompasses the minimum, maximum and average daily temperature values, offering a comprehensive view of the expected temperature variation.

Table 5 Projected Anomaly Changes in Temperature in the Project Area

Scenario	Average Daily Maximum Temperature (Median & 10th-90th percentile range)		Average Daily Temperature		Average Daily Minimum Temperature Scenario	
Years (Time Period)	2027	2052	2027	2052	2027	2052
RCP4.5	21.89°C (21.34°C - 23.55°C)	22.93°C (21.78°C - 24.00°C)	17.13°C (16.53°C - 18.47°C)	17.96°C (17.06°C - 19.17°C)	12.28°C (11.61°C - 13.42°C)	13.06°C (12.26°C - 14.31°C)
RCP8.5	22.19°C (21.16°C - 23.21°C)	23.56°C (22.32°C - 25.12°C)	17.29°C (16.36°C - 18.27°C)	18.54°C (17.47°C - 20.13°C)	12.43°C (11.49°C - 13.33°C)	13.57°C (12.53°C - 15.37°C)

2- Extreme Weather & Heatwaves

Primarily, increases in heatwave probability simply reflect the general increase in ambient temperatures, which constantly move away from the baseline Period 1995-2014 against which heat wave is measured. Another lens through which to view extreme heat is the annual frequency of days in which temperatures breach 35°C.

Summer temperatures peak with an average July maximum of 31°C in Azerbaijan, reaching maximum temperature of 33°C in the Project area (CCKP, 2024). The historic climatology showing the number of hot days with maximum temperature above 35°C in the Project area

(Ref. Period: 1995-2014) is shown in the graph below. In 1950, the median number of hot days with maximum temperature above 35°C was approximately 25 days annually (10th % of 15.25 days and 90th % of 21.47 days). The median number of hot days with maximum temperature above 35°C has increased in 2014 to a 50th percentile average approximately 42 days per year (10th % of 30.12 days and 90th % of 55.28 days).

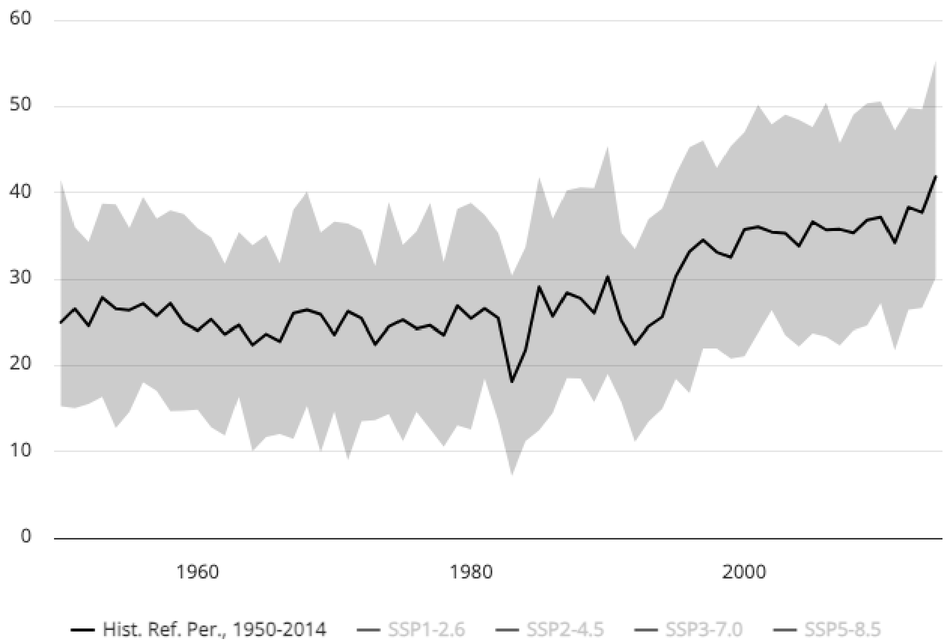


Figure 10 Historical Climatology of Number of Hot Days (Tmax > 35°C) per Year for 1950-2014 in the Project Area, Multi-Model Ensemble

<u>Under scenario SSP2-4.5,</u> the number of hot days with maximum temperature above 35°C in the Project area is highest in July with a median of 15.38 days for the period 1995-2014, projected to increase to 20.92 days for 2020-2039 and to further increase to 23.46 days for 2040-2059. In 2027, the COD of the Project, the projected number of hot days with maximum temperature above 35°C is 49.45 days (median), increasing throughout the Project lifetime to reach 62.41 days (median) in 2052.

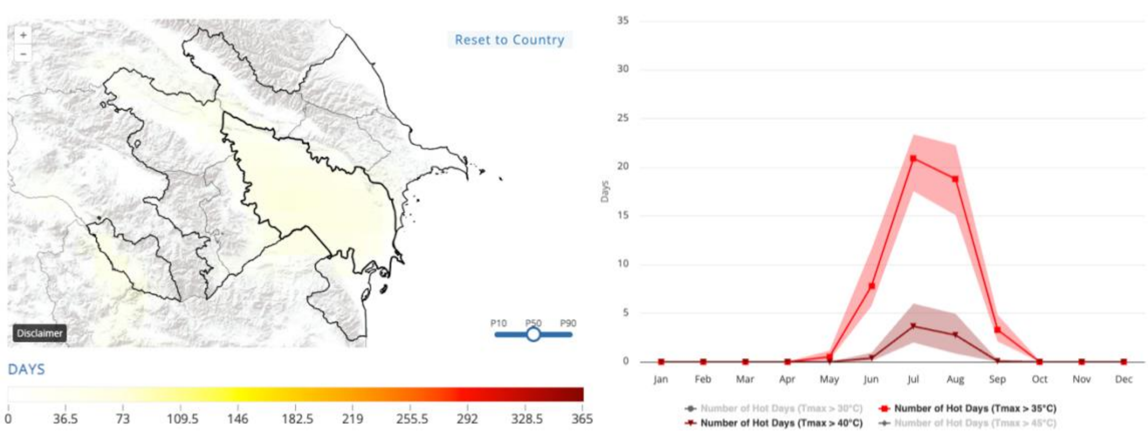


Figure 11 Projected Number of Hot Days (Tmax > 35°C) for the Project Area (2020-2039), SSP2-4.5, 50th Percentile

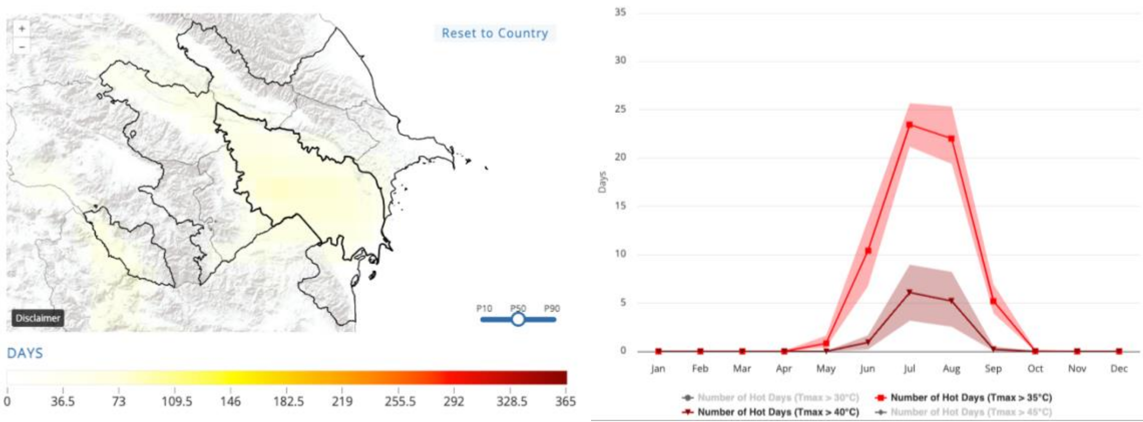


Figure 12 Projected Number of Hot Days (Tmax > 35°C) for the Project Area (2040-2039), SSP2-4.5, 50th Percentile

<u>Under scenario SSP5-8.5,</u> the number of hot days with maximum temperature above 35°C in the Project area is highest in July with a median of 15.38 days for the period 1995-2014, projected to increase to 21.32 days for 2020-2039 reaching 25.4 days in the period of 2040-2059. In 2027, the COD of the Project, the projected number of hot days with maximum temperature above 35°C is 51.13 days (median), increasing throughout the Project lifetime to reach 69.54 days (median) in 2052.

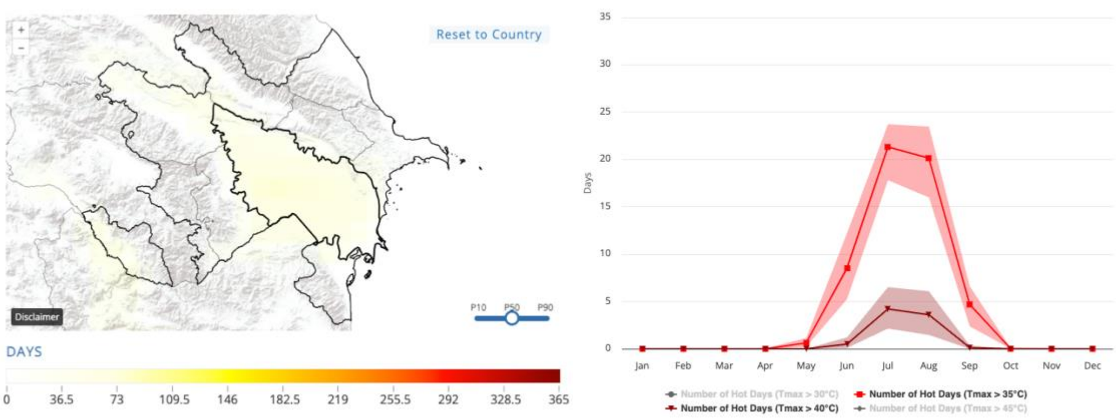


Figure 13 Projected Number of Hot Days (Tmax > 35°C) for the Project Area (2020-2039), SSP5-8.5, 50th Percentile

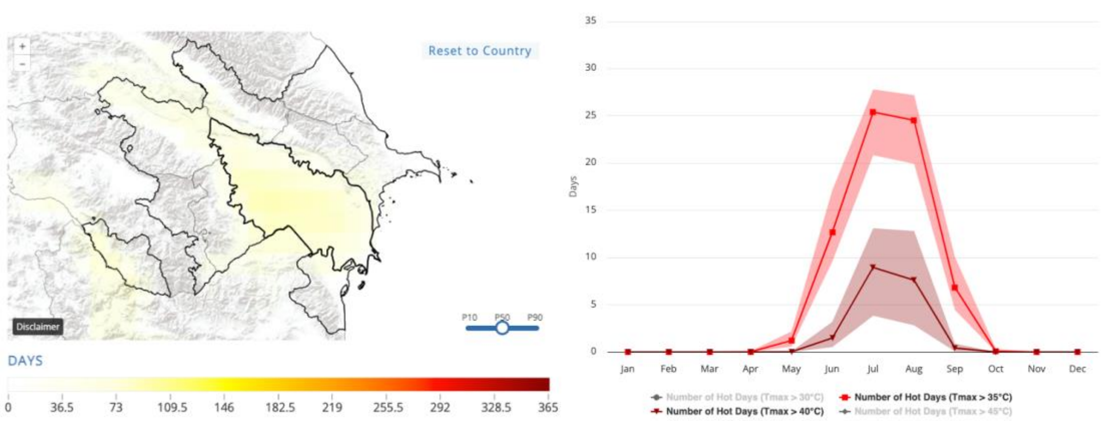


Figure 14 Projected Number of Hot Days (Tmax > 35°C) for the Project Area (2040-2039), SSP5-8.5, 50th Percentile

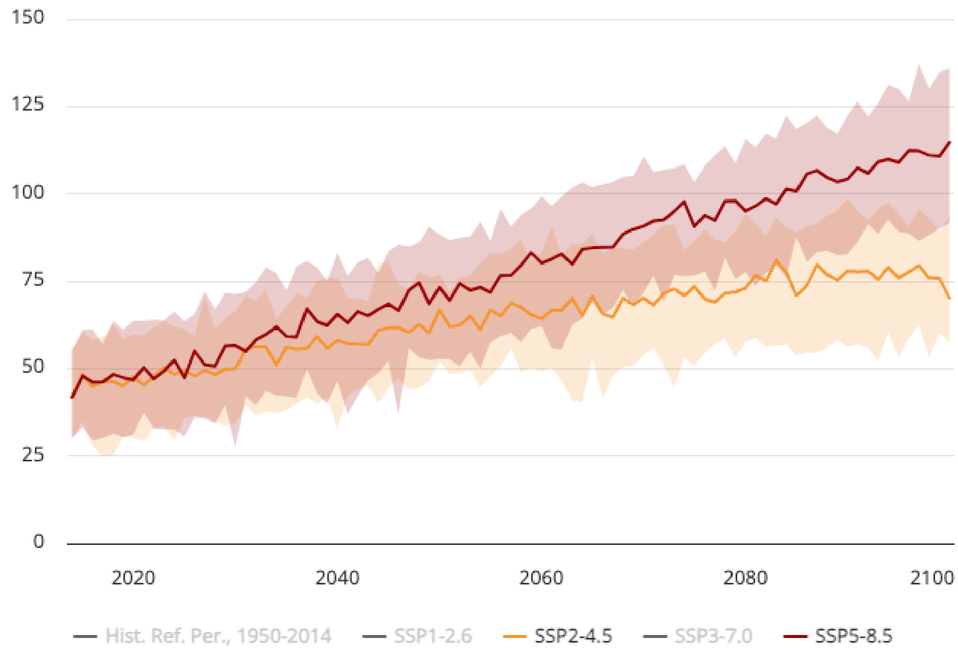


Figure 15 Projected Climatology of Number of Hot Days (Tmax > 35°C) per Year for the Project Area (Ref. Period: 1995-2014), SSP2-4.5 and SSP5-8.5, Multi-Model Ensemble

3- Bushfire Weather

Studies suggest that climate change will have a significant impact on future fire . Suitable weather conditions (hot, dry and windy) must generally exist for fires to spread. Given the combination of factors required for increased bushfire conditions, the potential increase in the future will rely heavily on projected changes in the weather.

There is high confidence that climate change will result in harsher fire weather in the future. This is seen in the mean changes and when examining individual models and scenarios. However, there is low confidence in the magnitude of the change, as this is strongly dependent on the rainfall projection.

According to the ThinkHazard website, the projected climate changes suggest that Azerbaijan is likely to experience more frequent occurrences of fire weather, characterized by higher temperatures and greater variability in rainfall patterns. For regions already susceptible to wildfires, this could mean longer fire seasons with more days conducive to fire spread due to extended dry periods. Climate models also indicate a potential increase in fire severity. Even areas with historically low wildfire risk might see an increase in hazard levels as the wildfire-prone zone expands according to climate projections. In the Project area, the wildfire hazard is classified as high according to the information that is currently available to this tool, indicating more than 50% chance of encountering weather that could support a significant wildfire[10].

10 ThinkHazard. Accessed June 2024. https://thinkhazard.org/en/report/19-azerbaijan/WF

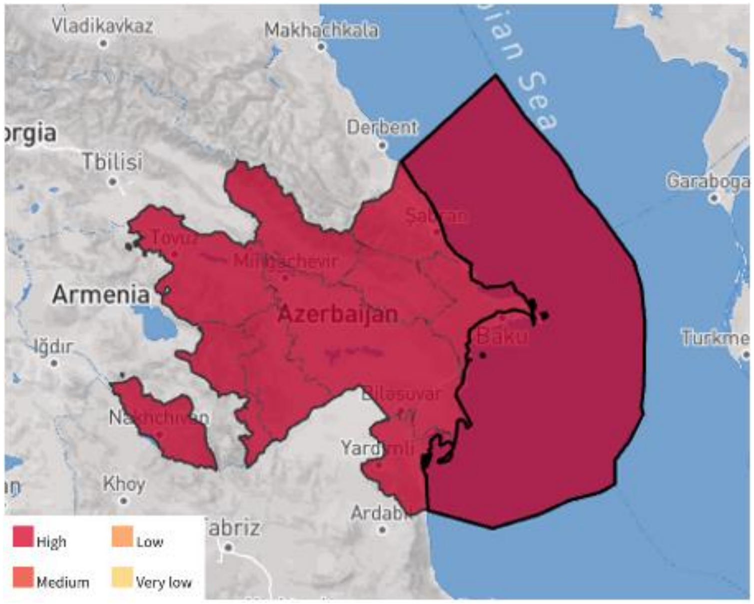


Figure 16 Indication of Projected Wildfire (ThinkHazard, 2024)

In 2014, hot and dry weather conditions during the summer exacerbated drought conditions in Azerbaijan. Record-breaking temperatures were observed across various regions in August, leading to significant environmental impacts. The prolonged drought severely affected forested areas, causing damage to forest cover. As a consequence of these adverse conditions, twelve separate fire incidents were reported that year, resulting in the burning of approximately 58.8 hectares of forest land[11].

The Project site and surrounding area is generally grazed with limited vegetation. Therefore, the risk of bushfire weather direct impacts on the Project is not expected. This has therefore not been assessed any further. The impacts of increased temperature that could lead to fires has been assessed in section 4.3.2 of this report.

4- ***Extreme Cold Weather***

The historic climatology showing the number of ice days with maximum temperature below 0°C in the Project area (Ref. Period: 1995-2014) is shown in the graph below. In 1950, the median number of ice days with maximum temperature below 0°C was approximately 0.39 days annually (10^{th} % of 0.03 days and 90^{th} % of 2.14 days). The median number of ice days with maximum temperature below 0°C has decreased in 2014 to a 50^{th} percentile of 0.19 days per year (10^{th} % of 0.01 days and 90^{th} % of 3.43 days).

11 Ministry of Ecology and Natural Resources Republic of Azerbaijan. (2015). Third National Communication to the United Nations Framework Convention on Climate Change Republic of Azerbaijan. https://unfccc.int/resource/docs/natc/azenc3.pdf

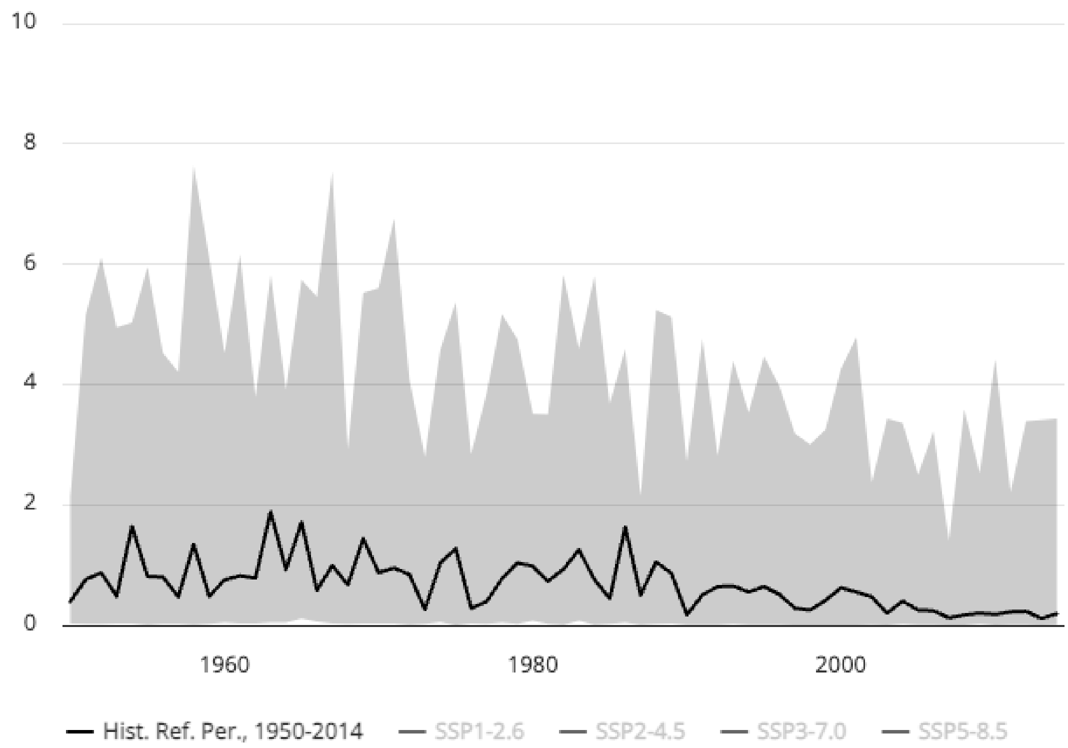


Figure 17 Historical Climatology of Number of Ice Days (Tmax < 0°C) in the Project Area for 1950-2014

<u>Under scenario SSP2-4.5,</u> the number of ice days with maximum temperature below 0°C in the Project area is highest in January with a median of 0.68 days for the period 1995-2014, projected to decrease to 0.26 days for 2020-2039 and increase to 0.29 days for 2040-2059. In 2027, the COD of the Project, the projected number of ice days with maximum temperature below 0°C is 0.09 days (median), slightly fluctuating throughout the Project lifetime, yet remaining below 0.2 days to reach 0.03 days (median) in 2052.

<u>Under scenario SSP5-8.5,</u> the number of ice days with maximum temperature below 0°C in the Project area is highest in January with a median of 0.68 days for the period 1995-2014, projected to decrease to 0.35 days for 2020-2039 reaching 0.15 days for 2040-2059. In 2027, the COD of the Project, the projected number of ice days with maximum temperature below 0°C is 0.07 days (median), slightly fluctuating throughout the Project lifetime, yet remaining below 0.3 days to reach 0.04 days (median) in 2052.

4.3.1.2 Risk Assessment and Mitigation

As per the CCKP, the average daily maximum temperature in 2027 is 22.19°C compared to 23.56°C in 2052. However, during the summer months of July and August over the project's lifetime, the Project area may witness extreme temperatures projected to exceed 35°C, with more than 3°C increase from current temperatures. Hence, if the project components are not chosen and designed to withstand these high temperatures, the anticipated temperature rise could potentially impact the power generation of the PV system, accelerate the aging of its components, and elevate the risk of fire.

As per the CCKP, projected extreme cold temperatures of 0°C are expected for very few days annually during the Project lifetime. Cold weather can have both positive and negative impacts on solar PV Projects. Solar PV panels operate more efficiently at cooler temperatures which can improve overall efficiency especially when cold weather is accompanied with clear, sunny skies or in the presence of snow which can temporarily reflect sunlight onto the panels once it melts or is cleared away. This can enhance energy production during the winter months. However, heavy snow accumulation or ice formation on solar panels could potentially reduce or completely block sunlight from reaching them.

To ensure the efficiency and reliability of the Project components, the Solar panels have been selected with operating temperatures of 45°C. To further mitigate extreme heat events and increased temperature, the detailed design and procurement shall ensure that all equipment and machines allow continuous operation at rated power (or rated current), in the full range of site conditions, without exceeding applicable temperature and temperature rise limits (35°C) or failing upon exceptional electric and electromechanical stresses.

To mitigate fire risks, the Project shall be equipped with a fire protection system that features comprehensive fire detection and response facilities. The Project design shall consider fire-resistant materials for mounting structures, cabling, and other components. Installing advanced monitoring systems to detect issues early, such as reduced output due to smoke or potential damage from heat, allowing for timely interventions may be considered.

To mitigate extreme cold conditions, the Solar PV systems should be designed with features such as tilt angles optimized for snow shedding, or if possible heating elements to prevent snow buildup on panels. Regular maintenance is crucial in cold climates to ensure panels remain clear of snow and ice and that any system components affected by cold temperatures are properly maintained.

Acute physical climate risks relevant to the Project include health and safety incidents amongst operational plant workers during periods of extreme heat. The incidence of substantially high temperatures could potentially impact on the wellbeing of workers, particularly those who will not operate within units with controlled temperatures. Workers stationed in the Plant's exterior, for instance, will be prone to health effects such as dehydration, and heat stress, heat stroke, heat exhaustion, heat cramps, heat rashes and burns from contact with overheated surfaces. To ensure the safety of the workers, the following measures are proposed:

- Induction and refresher health and safety (H&S) trainings will include trainings on prevention of and first response to extreme heat/cold exposure. The trainings will cover risk factors, mitigating Personal Protective Equipment (PPE), first aid measures and nearest health centre for treatment of hyperthermia or hypothermia.
- Ensure all workers receive worker induction and regular ongoing training (e.g., toolbox talks, work briefings) on the health and safety risks of extreme weather conditions.

- Ensure the availability of medical facilities and nurses as well as first aid and transport for medical emergencies.
- Workers assigned to operations in the exterior of the Plant's buildings and shaded areas will be provided with appropriate PPE (e.g., sun hats and cooling vests).
- Shaded resting areas and adequate access to sufficient potable water will be provided for workers and maintenance staff stationed outside of the Plant's buildings.
- Work locations (and duration, to the extent possible) will be restricted during periods of extreme heat or cold to lessen the risk of heat/cold-related health effects. Maintenance work within high/cold-temperature units will be avoided during days with inordinately high/low temperatures.
- Staff rooms on the plant's premises will be equipped with air conditions/fans/heaters to enable operations at workstations during periods of extreme heat/cold.
- Monitor weather forecast and halt outdoor maintenance work in any expected events of extreme weather conditions (rain storm, extreme cold, extreme heat waves, high wind etc.).
- All workers will be entitled to health insurance and sick leaves in accordance with national Labour Law.
- Further information and management plans to address workers welfare will be included in the Project H&S Plan.

4.3.2 Precipitation

4.3.2.1 Future Scenarios

Under scenario SSP2-4.5, for the time period 2020-2039, the average precipitation in the Project area is projected to be the highest in April where the 10-90th percentile range is 43.98mm to 55.49mm (median 50.24mm). The lowest precipitation is expected in July where the 10-90th percentile range is expected at 10.22mm to 17.93mm (median 13.49mm). The 50th percentile for the projected annual precipitation anomaly for 2020-2039 for the Project area (Ref. Period: 1995-2014), is highest in March with 3.49mm increase (10-90th percentile range of -2.39mm to 9.42mm).

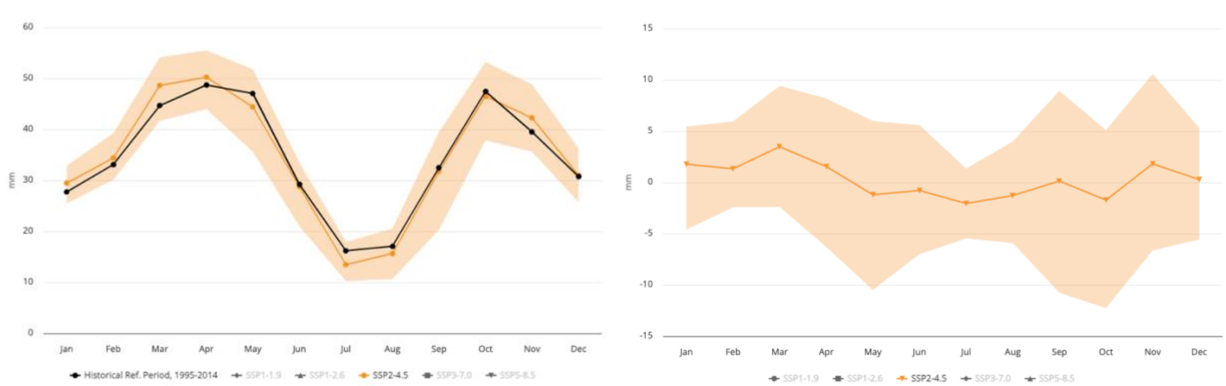


Figure 18 Projected Precipitation Climatology (Left) and Anomaly (Right) for 2020-2039 (Annual) for the Project Region; (Ref. Period: 1995-2014), SSP2-4.5, Multi-Model Ensemble

<u>Under scenario SSP2-4.5, for the time period 2040-2059</u>, the average precipitation in the Project area is projected to be the highest in March where the 10-90th percentile range is 41.61mm to 55.5mm (median 49.62mm). The lowest precipitation is expected in August where the 10-90th percentile range is expected at 7.99mm to 17.70mm (median 13.35mm). The 50th percentile for the projected annual precipitation anomaly for 2020-2039 for the Project area (Ref. Period: 1995-2014), is highest in November with 4.77mm increase (10-90th percentile range of -3.38mm to 13.73mm).

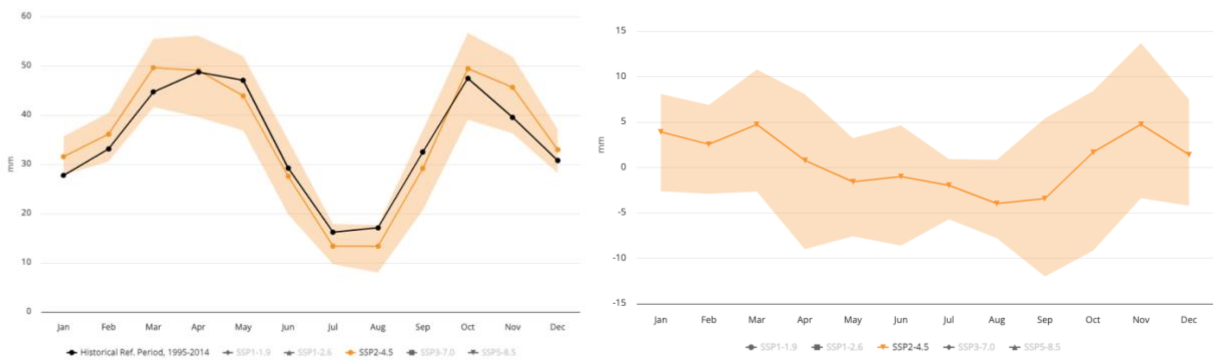


Figure 19 Projected Precipitation Climatology (Left) and Anomaly (Right) for 2040-2059 (Annual) for the Project Region; (Ref. Period: 1995-2014), SSP2-4.5, Multi-Model Ensemble

As presented in the following figure, under scenario SSP2-4.5, in 2027, the 10-90th percentile range of precipitation in the Project area is expected to be 323.04mm to 502.07mm (median 426.49mm). By 2052, the 10-90th percentile precipitation in the Project area is expected to reach a range of 346.73mm to 508.75mm (median 405.40mm).

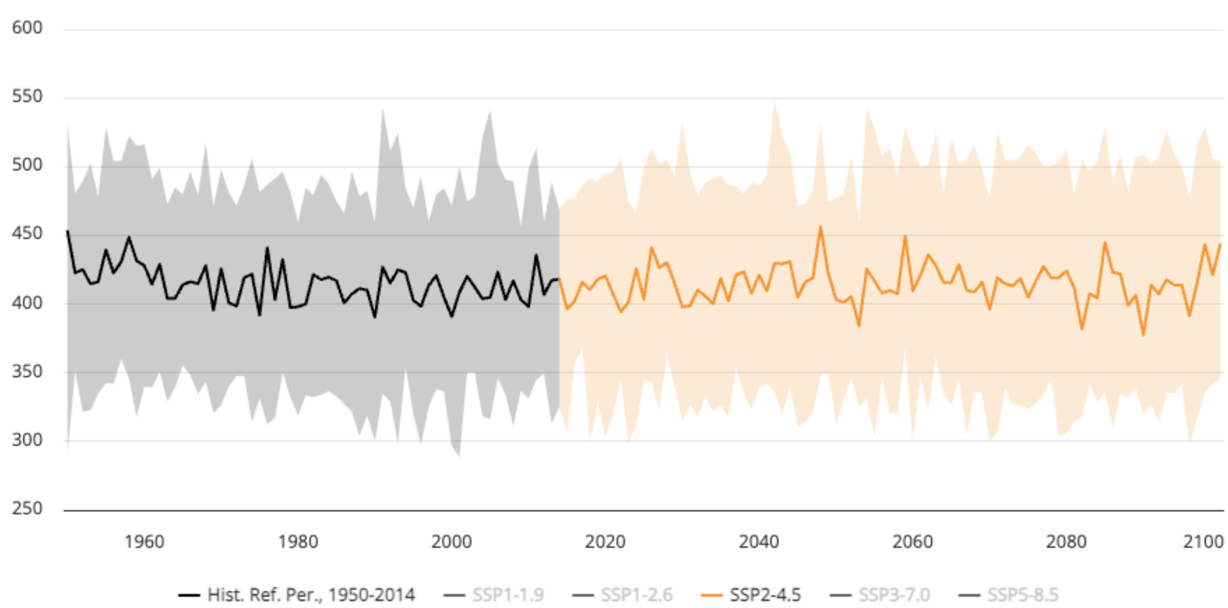


Figure 20 Projected Precipitation for the Project Region; (Ref. Period: 1995-2014), SSP2-4.5, Multi-Model Ensemble

<u>Under scenario SSP5-8.5, for the time period 2020-2039</u>, the average precipitation in the Project area is projected to be the highest in April where the 10-90th percentile range is

43.14mm to 57.78mm (median 48.72mm). The lowest precipitation is expected in July where the 10-90th percentile range is expected at 10.31mm to 18.04mm (median 16.2mm). The 50th percentile for the projected annual precipitation anomaly for 2020-2039 for the Project area (Ref. Period: 1995-2014), is highest in November with 2.74mm increase (10-90th percentile range of -6.10mm to 10.12mm).

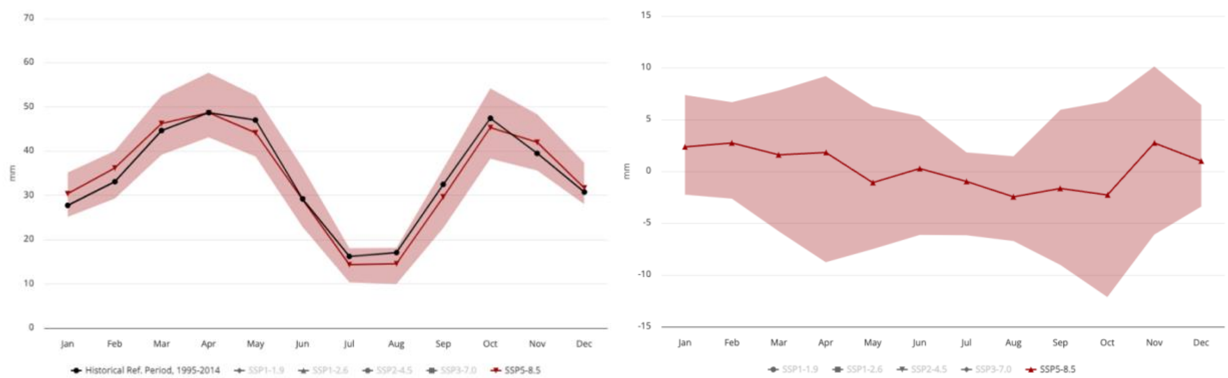


Figure 21 Projected Precipitation Climatology (Left) and Anomaly (Right) for 2020-2039 (Annual) for the Project Region; (Ref. Period: 1995-2014), SSP5-8.5, Multi-Model Ensemble

<u>Under scenario SSP5-8.5, for the time period 2040-2059</u>, the average precipitation in the Project area is projected to be the highest in April where the 10-90th percentile range is 43.14mm to 57.78mm (median 48.72mm). The lowest precipitation is expected in July where the 10-90th percentile range is expected at 10.31mm to 18.04mm (median 16.2mm). The 50th percentile for the projected annual precipitation anomaly for 2020-2039 for the Project area (Ref. Period: 1995-2014), is highest in November with 6.13mm increase (10-90th percentile range of -4.61mm to 12.81mm).

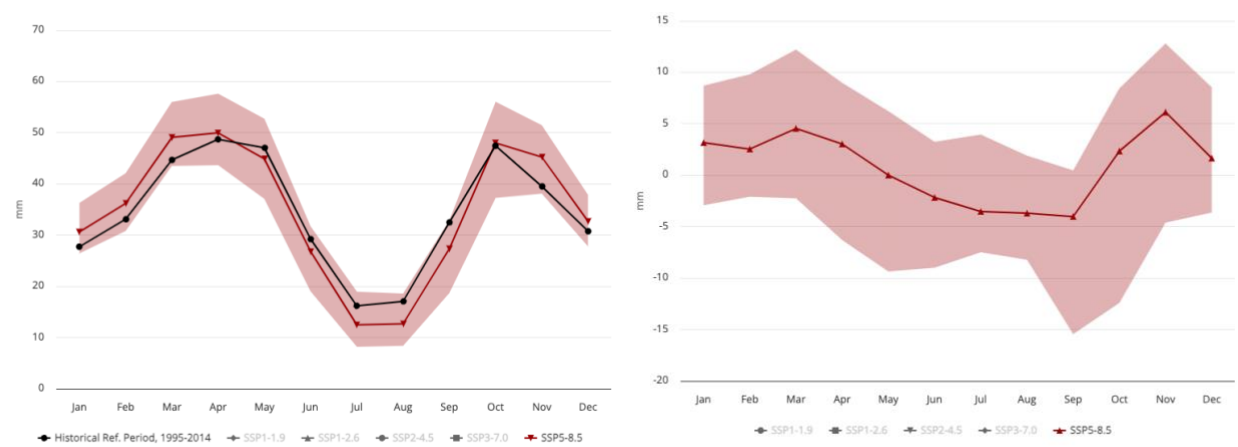


Figure 22 Projected Precipitation Climatology (Left) and Anomaly (Right) for 2040-2059 (Annual) for the Project Region; (Ref. Period: 1995-2014), SSP5-8.5, Multi-Model Ensemble

As presented in the following figure, under scenario SSP5-8.5, in 2027, the 10-90th percentile range of precipitation in the Project area is expected to be 340.17mm to 492.55mm (median 423.89mm). By 2052, the 10-90th percentile precipitation in the Project area is expected to reach a range of 308.05mm to 518.96mm (median 421.96mm).

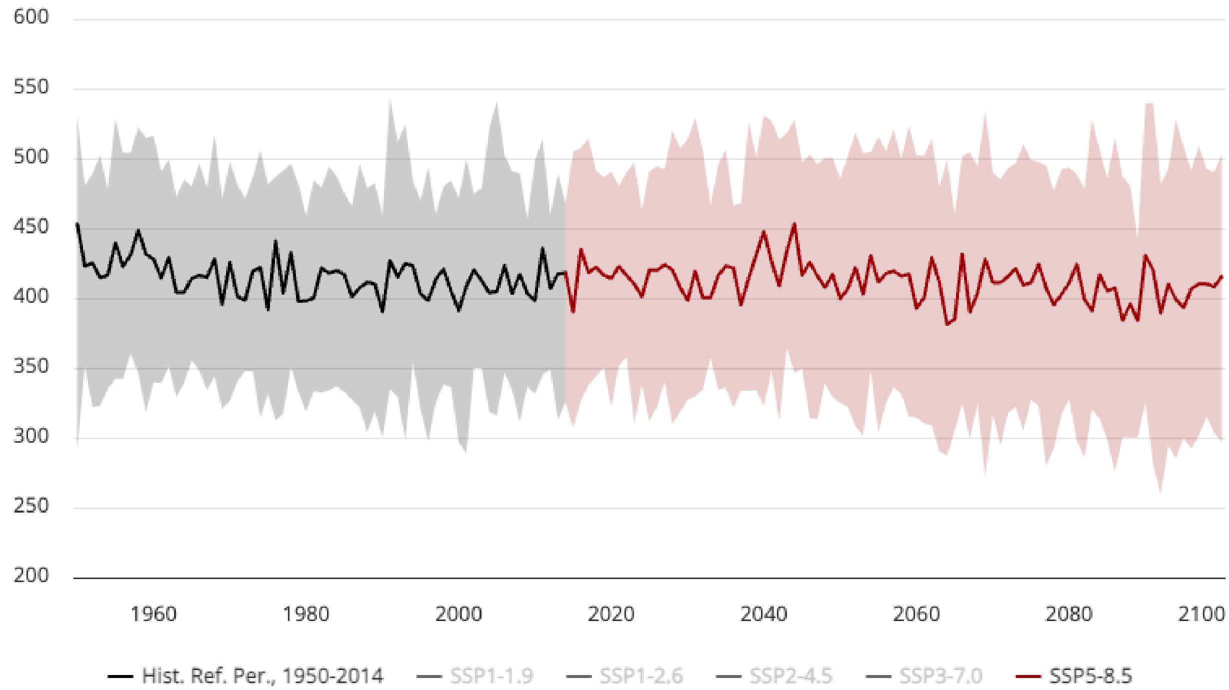


Figure 23 Projected Precipitation in the Project Region; (Ref. Period: 1995-2014), SSP5-8..5, Multi-Model Ensemble

For the Project operational period, across all scenarios, the anticipated median (50th percentile) precipitation is expected to remain comparable to historical patterns, showing fluctuations without significant projected increases in the future. Considering the rainfall projections, significant impacts due to increased precipitation is not expected.

1- Floods

According to the Climate Country Profile Report of WBG & ADB in 2021[12], Azerbaijan experiences frequent flooding which typically occurs in late spring and early summer in higher altitude areas of the country (above 1,500 m in altitude), whereas in lower areas, flooding may occur in spring or autumn. The parts of the country at greatest risk of floods are in the central and south-eastern regions, while some parts of the country, such as the south slope of the Greater Caucasus, experience mudflows caused by flooding.
Severe flooding occurred in Azerbaijan in 1995, affecting 1.5 million people and resulting in approximately $30 million losses. In 2003, severe floods impacted 30,000 people, resulting in over $70 million in damage. Azerbaijan's water resources depend primarily on two key river basins, that of the Kur and Aras rivers. The future hydrology of their basins, including the greater and lesser Caucasus mountain ranges, will likely determine fluvial flooding trends.

To determine the flood risks at the Project site, a Hydrometeorological Study was prepared by JURU in 2024. For flood risk the direct rainfall method (DRM) is employed. DRM involves directly

12 WBG & ADB. (2021). Climate Risk Country Profile: Azerbaijan (2021): The World Bank Group and Asian Development Bank. https://www.adb.org/sites/default/files/publication/707466/climate-risk-country-profile-azerbaijan.pdf

applying rainfall to the hydrodynamic surface-flow model. For soil data, the Global Hydrological Soil Groups (HYSOGs250m) were used. This allows to create an infiltration layer with the Deficit Constant, Soil Conversation Service (SCS) Curve Number, and Green and Broad methods. Historical 3 hours, 12 hours and 24 hours rainfall data from the Neftchala meteorological station for the past 20-30 years was used for the model. Due to the unavailability of observed rainfall data for time intervals smaller than 3 hours, an extrapolation adjustment was made. As a result of this extrapolation adjustment, it was possible to determine the values of precipitation amount up to the amount that can fall in an interval of up to 30 minutes.
The following maps present the four different scenarios of annual exceedance probability (AEP) flood depth and flood flow velocity. The 10% AEP flood depth (10 years return period), indicates that certain parts of the Project area will be subject to 0.1m and 2m with limited areas of 2m to 3m depth. These areas expand in the remaining three scenarios, 5% (20 years return period), 2% (50 years return period) and 1% (100 years return period) with the majority of the site experiencing flood levels 0.1m to 1.5m and larger areas experiencing flood depth reaching 3m. Similarly, the flood velocity under the 10% AEP flood flow velocity (10 years return period), ranges between 0.4m/s and 0.8m/s in the flooded areas with limited places reaching flow velocity of 1.6m/s. The flood flow velocity increases under the remaining three scenarios where larger areas of the site may experience flood flow velocity of 2m/s.

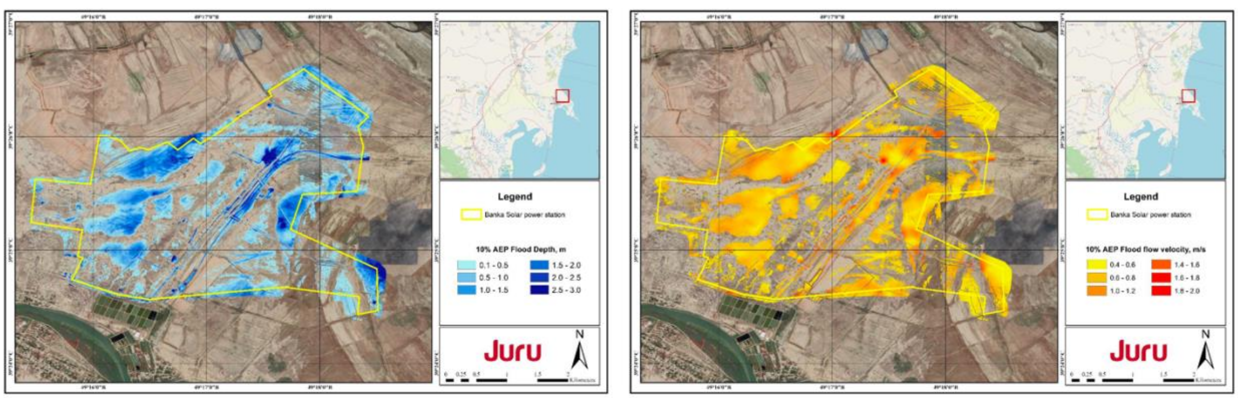


Figure 24 Map Showing the Modelling results 10% AEP Flood Depth (Left) Flood Velocity (Right) (Return period for 10 years)

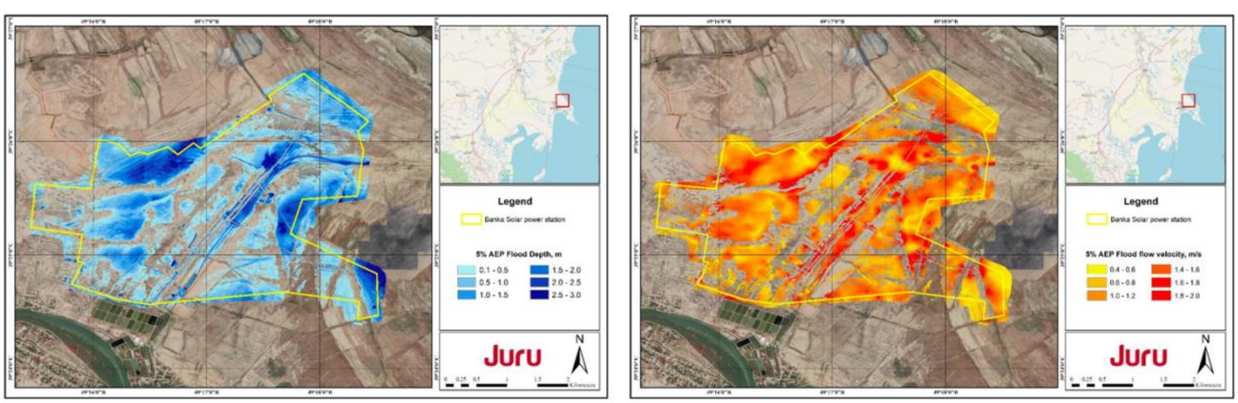


Figure 25 Map Showing the Modelling results 5% AEP Flood Depth (Left) Flood Velocity (Right) (Return period for 20 years)

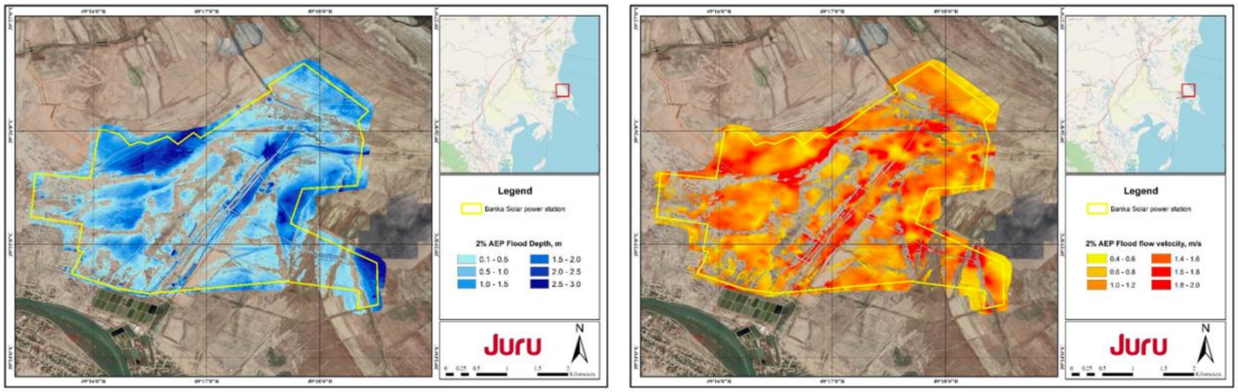


Figure 26 Map Showing the Modelling results 2% AEP Flood Depth (Left) Flood Velocity (Right) (Return period for 50 years)

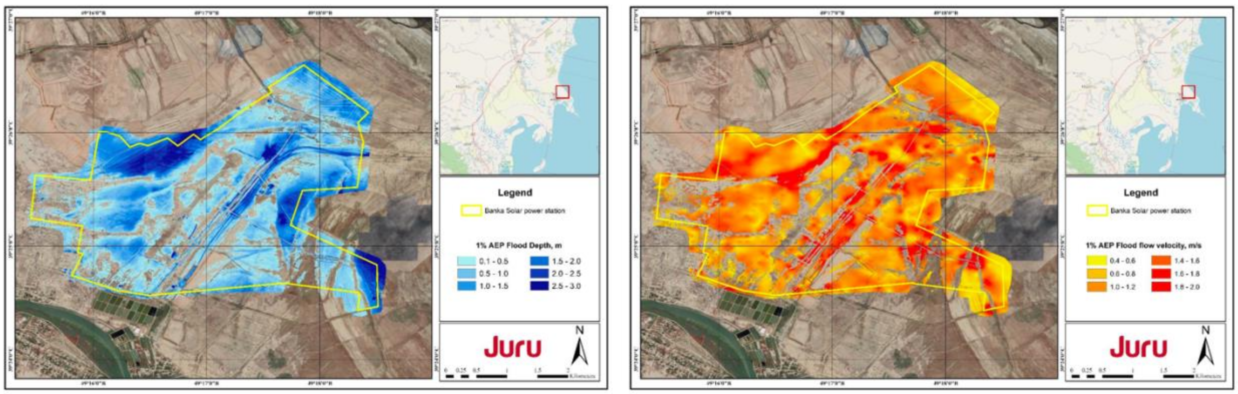


Figure 27 Map Showing the Modelling results 1% AEP Flood Depth (Left) Flood Velocity (Right) (Return period for 100 years)

2- Drought

According to the Climate Country Profile Report of WBG & ADB in 2021[13], Azerbaijan may experience two primary types of drought, meteorological due to the lack of precipitation and hydrological, usually due to a deficit in surface and subsurface water flow, potentially from the region's larger river basins. Currently, Azerbaijan faces an annual median probability of severe meteorological drought of about 2%, defined by a standardized precipitation evaporation index (SPEI) of less than −2.26.

Naumann et al. (2018) referenced in the Climate Country Profile report provides a perspective on changes in drought conditions under different warming scenarios. They predict significant increases in the duration and magnitude of meteorological droughts in West Asia by the end of the 21st century under global warming levels of 1.5°C, 2.0°C, and 3.0°C. Droughts that are currently extremely rare in West Asia (100-year droughts) are projected to become 5 to 10 times more common under these warming scenarios. Similarly, model ensembles forecast a significant rise in the annual probability of severe drought by the 2090s. This rise is particularly notable in higher emissions pathways, with a projected increase in the median probability of severe drought from an observed 2% per year from 1986–2005 to a forecasted 73% or 85% by

13 WBG & ADB. (2021). Climate Risk Country Profile: Azerbaijan (2021): The World Bank Group and Asian Development Bank. https://www.adb.org/sites/default/files/publication/707466/climate-risk-country-profile-azerbaijan.pdf

the end of the century. These projections indicate a shift towards a chronically drought-affected environment in many parts of Azerbaijan, likely contributing to the expansion of arid ecosystems and desertification.

According to the ThinkHazard Platform, in the Project area (Neftchala District) water scarcity is classified as **low** according to the information that is currently available to this tool. This means that there is a 1% chance drought will occur in the coming 10 years[14].

Under scenario SSP2-4.5, for the time period 2020-2039: As shown in the graphs below, the mean (50^{th} percentile) SPEI in the Project region, is relatively similar to the historical trend with SPEI projected range of -0.02 to -0.03 compared to -0.02 to -0.06 in 1995-2014. The 10^{th} percentile however shows a potential increase in drought events with SPEI reaching -0.34 in May. The 90^{th} percentile shows a positive trend with the SPEI reaching 0.2 in May.

Under scenario SSP5-8.5, for the time period 2020-2039: As shown in the graphs below, the mean (50^{th} percentile) SPEI in the Project region, shows a decrease in the drought index with projected climatology SPEI index reaching 0.05 index compared to -0.02 to -0.06 in 1995-2014. The 10^{th} percentile however shows a potential increase in drought events with SPEI reaching -0.3 in April. The 90^{th} percentile shows a positive trend with the SPEI reaching 0.3 in March and December.

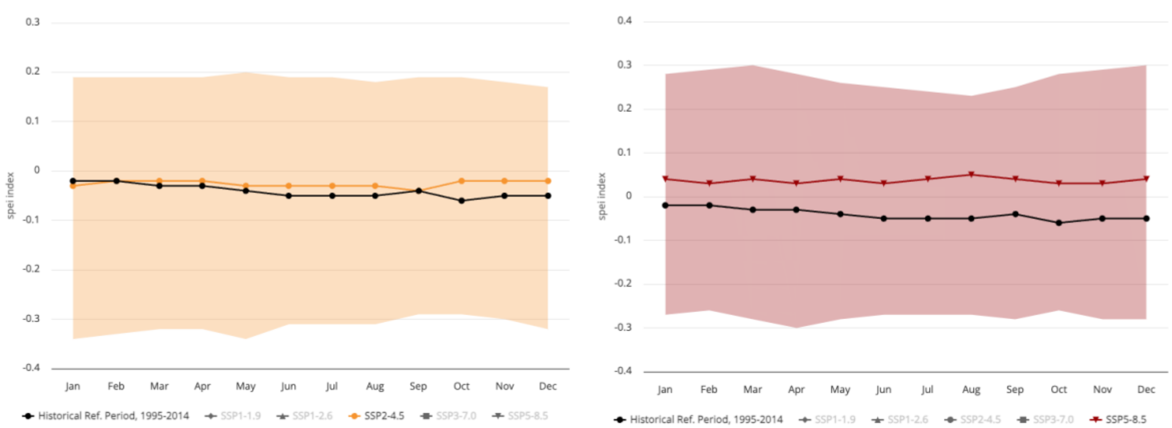


Figure 28 Projected Climatology of Annual SPEI Drought Index for 2020-2039 (Annual) for the Project Region; (Ref. Period: 1995-2014), SSP2-4.5 (Left) SSP5-8.5 (Right), Multi-Model Ensemble

Under scenario SSP2-4.5, for the time period 2040-2059: As shown in the graphs below, the mean (50^{th} percentile) SPEI in the Project region, shows a decrease in the drought index with projected climatology SPEI index reaching 0.04 index compared to -0.02 to -0.06 in 1995-2014. The 10^{th} percentile however shows a potential increase in drought events with SPEI reaching -0.31 in March. The 90^{th} percentile shows a positive trend with the SPEI reaching 0.21 in March.

Under scenario SSP5-8.5, for the time period 2040-2059: As shown in the graphs below, the mean (50^{th} percentile) SPEI in the Project region, shows a decrease in the drought index with projected climatology SPEI index reaching 0.07 index compared to -0.02 to -0.06 in 1995-2014.

14 ThinkHazard. Accessed June 2024. https://thinkhazard.org/en/report/19-azerbaijan

The 10th percentile however shows a potential increase in drought events with SPEI reaching -0.21 in September. The 90th percentile shows a positive trend with the SPEI reaching 0.36 in January.

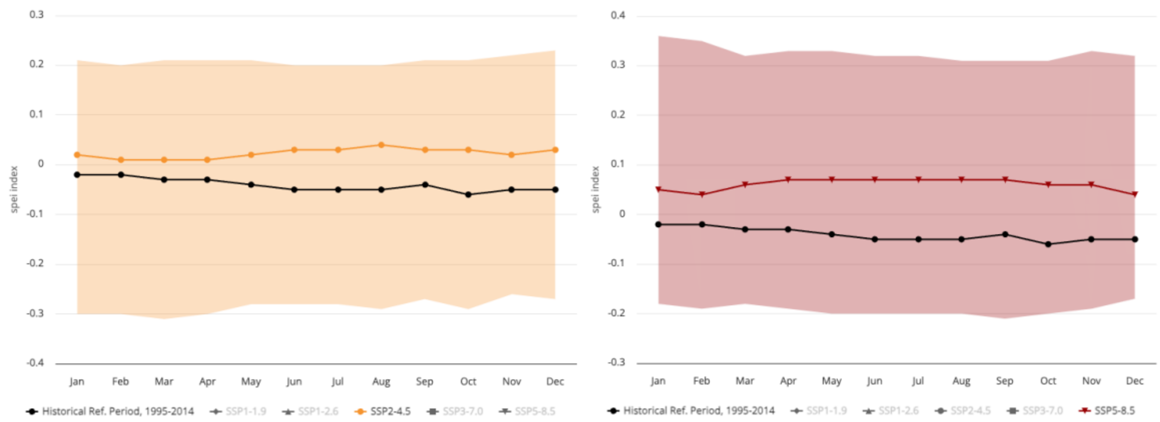


Figure 29 Projected Climatology of Annual SPEI Drought Index for 2040-2059 (Annual) for the Project Region; (Ref. Period: 1995-2014), SSP2-4.5 (Left) SSP5-8.5 (Right), Multi-Model Ensemble

Based on the data presented above, the Project region is at low risk of drought during the operational period where the 50th-90th percentile future trends predict more wet conditions and therefore lower drought risk.

4.3.2.2 Risk Assessment and Mitigation

Climate-induced natural disasters, such as floods, droughts, high-intensity rainfall events may interrupt the PV plant operations through severe damage to the panels, buildings, equipment and materials. Forced power outages resulting from natural hazards can therefore compound the risk of economic losses and stress to communities reliant on the power grid. This can also risk the safety of the Project workforce. Based on the projected rainfall data and flood risk modelling carried out by JURU, the site is at risk of floods and therefore, design mitigation will be required to ensure the safety of the Project, the workers and the surrounding sites. The following mitigation measures are proposed:

- Stormwater drainage systems shall be designed to withstand the maximum discharge in the most extreme foreseeable precipitation events to ensure no loss of operation for a flooding level with a return period of 1 in 100 years.
- Implement the mitigation measures presented in the Hydrometeorological Study prepared by JURU in 2024. These have not been included here to avoid repetition, the measures are presented in Chapter 7 of Appendix A.
- Implement the mitigation measures discussed under section 4.3.1.2 of this report.

Water consumption during operation is expected to be minimal. Even though the drought index did not indicate a high risk of drought events in the Project area, a water management plan should be implemented to reduce the impacts on water resources. The plan should 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.
- Raising awareness on water conservation among workers.

4.3.3 Sea Level Rise / Coastal Flooding

4.3.3.1 Future Scenarios

According to the Climate Country Profile Report of WBG & ADB in 2021[15], as of 2015, between 1996 and 2015, the Caspian Sea level decreased by an average of 6.7 cm per year, primarily due to evaporation. With rising regional temperatures, this trend is expected to continue, potentially decreasing the sea level by 4-5 meters by the end of the century. The natural factors in the decrease of the Caspian Sea level are climate change including global warming, reduced or absence of precipitation and increased evaporation[16]. Additionally, anthropogenic activities result in additional stress to the Caspian Sea level as the neighbouring countries have built dams that contribute to further reduce the sea level[16].

The Project is located along the Caspian Sea. To determine the risks of sea level rise and coastal flood risk, a Hydrometeorological Study was prepared by JURU in 2024. The study refers to the IPCC report for historical and projected sea level rise. Systematic observations of water levels in the Caspian Sea began in 1837. Measurements show that over the first century, until 1930, the sea level remained relatively stable, fluctuating between -25 and -26 meters. However, between 1929 and 1941, there was a sharp decrease of almost two meters, from -25.88 to minus -27.84 meters. Over the next thirty-seven years, the sea level fluctuated but generally declined, reaching its lowest recorded level of -29.01 meters in 1977. From 1930 to 1977, the overall decrease in the sea level was 3.2 meters, with an average decline rate of about 4 cm per year. Starting in 1979, the Caspian Sea level began to rise significantly, increasing by 2.35 meters between 1979 and 1991, with an average rise rate of about 14.3 cm per year. The sea level was projected to continue fluctuating and further decreasing until 2023 reaching levels lower than -28.5m. Despite the continued decline and the natural and the anthropogenic stressors on the Caspian Sea level, the Hydrometeorological study concluded that the Caspian Sea level near the Project area will experience mean sea level (MSL) rise of 0.20m in 2100 (IPCC as reported in JURU, 2024).

15 WBG & ADB. (2021). Climate Risk Country Profile: Azerbaijan (2021): The World Bank Group and Asian Development Bank. https://www.adb.org/sites/default/files/publication/707466/climate-risk-country-profile-azerbaijan.pdf
16 Vali Kaleji. (2023). Decreasing Water Levels in the Caspian Sea: Causes and Implications. https://www.cacianalyst.org/publications/analytical-articles/item/13769-decreasing-water-levels-in-the-caspian-sea-causes-and-implications.html

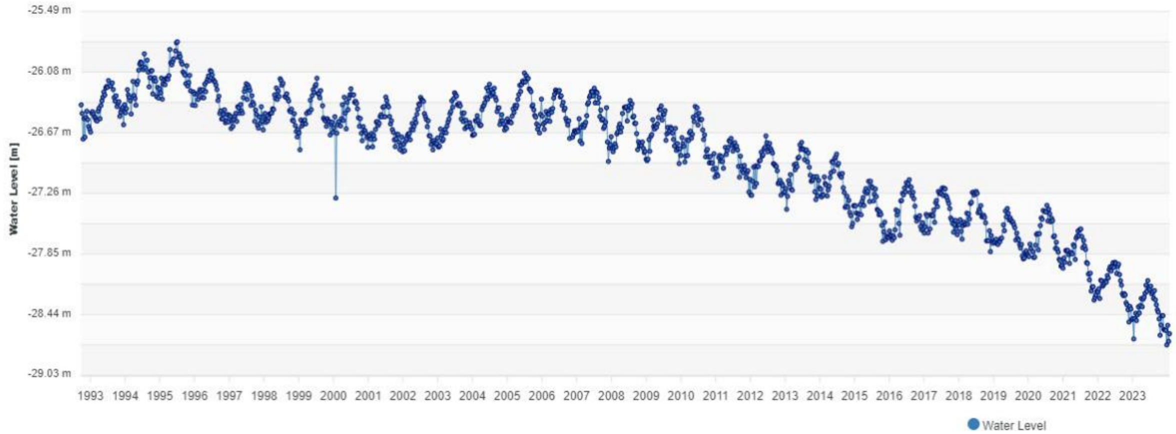
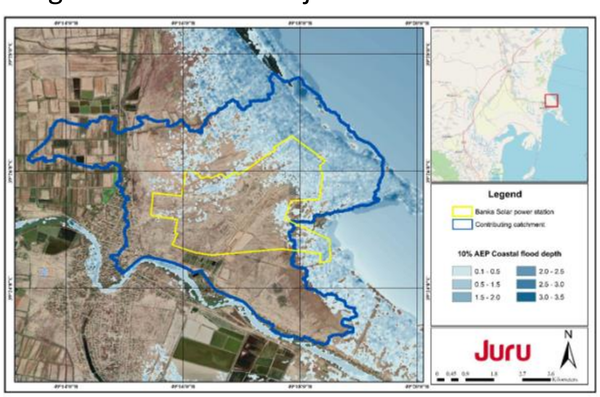
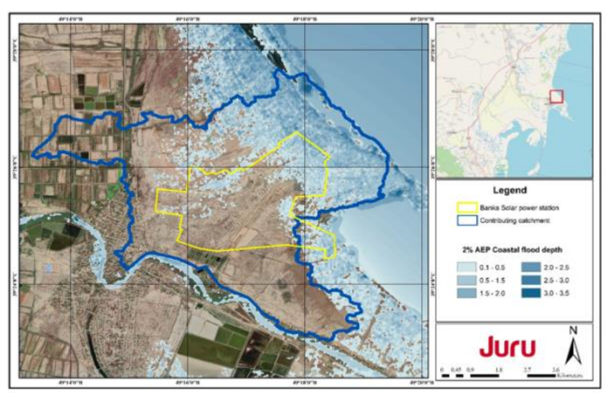


Figure 30 Caspian Sea Water Level Change (IPCC as reported in JURU, 2024)

In this part of the Caspian Sea, the tidal range is relatively small, with spring tides reaching up to 0.4 meters (JURU, 2024). Coastal flood hazards can stem from various sources, including tides, storm surges, waves, seiches, rainfall, river flows, and tsunamis. The likelihood of coastal flooding is lower than a 100-year return period event due to the need for multiple conditions to align, such as the maximum seasonal tide, maximum meteorological tide, and expected sea level rise by 2100. These maximum water levels are safety limits for the design of the solar power plant, with flood risk from Caspian Sea water at -24.4 meters for a 100-year event. Astronomical factors cause the water level in the Caspian Sea to rise and fall approximately every 3 hours (JURU, 2024).

The Hydrometeorological Study prepared by JURU in 2024 indicate that the Project area in general and the Project site are at risk of coastal flood. As shown in the following graphs, the modelled 10% and 2% AEP coastal flood depth ranges between 0.1m and 2m in the northern and eastern part of the site. The coastal flood area increases in the modelled 1% AEP extending to larger areas of the Project site.





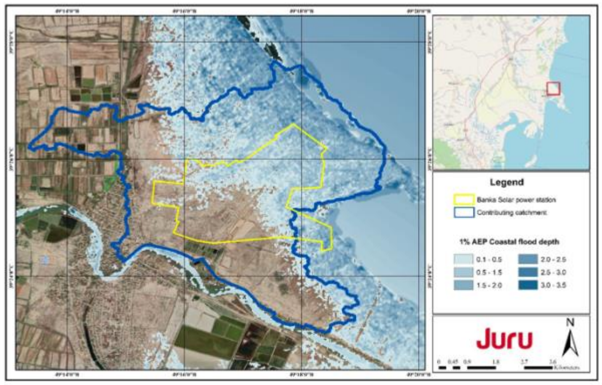


Figure 31 Maps Presenting the 10% AEP (Upper Left), 2% AEP (Upper Right), and 1% AEP (Bottom) Coastal Flood Depth

4.3.3.2 Risk Assessment and Mitigation

Similar to the intense rainfall and flood risk discussed in section 4.3.2.2, coastal floods can interrupt power plant operations and workforce which may result in the risk of economic losses and stress to communities reliant on the power grid. Based on the projected Caspian Sea level and the coastal flood risk modelling carried out by JURU in 2024, the site is at risk of coastal floods and therefore, design mitigation will be required to ensure the safety of the Project, the workers and the surrounding sites. The applicable design mitigations are provided in the Hydrometeorological Study prepared by JURU in 2024. These have not been included here to avoid repetition, the measures are presented in Chapter 8 of Appendix A.

4.4 Transition Risks

Climate transition risks refer to those which may arise from the plans or processes that may be put in place to adjust to a lower-carbon, climate-resilient economy. These can include changes or updates to policy or legislation (e.g. introduction of emission limits), imposition of carbon tax, shifts in demand and supply due to technology and market changes and reputation risks reflecting changing customer or community perceptions (Equator Principles, 2020).

Given the Project is a Solar PV plant that aligns with transition to lower carbon economies, there are not expected to be specific risks related to future low carbon economies (policy, regulations etc.) or future public perceptions of the Project that are considered to be risks at this stage.

5 Appendix A - Hydrometeorological Study Prepared by JURU, 2024

PROJECT:	**COMBINED CAPACITY OF 835MWAC SOLAR PV POWER PLANTS IN AZERBAIJAN-CONSTRUCTION BONKA SOLAR PV**
LOCATION:	**NEFTCHALA REGION, BANKA SITE, AZERBAIJAN**
CLIENT:	**ABU DHABI FUTURE ENERGY COMPANY PJSC - MASDAR**
JURU REFERENCE:	
REVISION:	**E**
JURU ISSUE:	**HYDROMETEOROLOGICAL STUDY REPORT**
ISSUE DATE:	**May 28, 2024**

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Revision History

Rev.	Date	Status	Originated	Checked	Approved
A	21.05.2024	Preliminary Meteorological Report Issued for Client / Comment.	SHY	TD	
B	15.03.2024	Report updated in accordance Comments (Page 61)	SHY	TD	
C	18.05.2024	Report updated in accordance Discussions and comments (Page 59-66)	SHY	TD	
D	21.05.2024	Report updated in accordance Comments (Page 57, 62, 63, 65, 66)	SHY	TD	
E	28.05.2024	Report updated in accordance Comments (Page 60, 61, 63, 65, 70)	SHY	TD	

HOLD Record

Hold Ref.	Description / Reason for HOLD	Ref. Section

CONTENTS

ABBREVIATIONS

ASCE(Eng)	American Society of Civil Engineers
ASHRAE(Eng)	American Society of Heating, Refrigerating and Ambient-Conditioning Engineers
AP	Atmosphere pressure
GEV	Generalized Extreme Value
IDF (Eng)	Intensity duration frequency
MCDB (Eng)	Mean Coincident Dry Bulb Temperatures
MCWB (Eng)	Mean Coincident Wet Bulb Temperatures
DEM	Digital Elevation Model
SP (Russ)	Construction norm
WMO (Eng)	World Meteorological Organization
HEC-RAS	Hydrological Engineering Center's River Analysis System

UNITS

Length	km (m)
Area	km^2 (m^2)
Volume	m^3
Velocity	m/s
Concentration	vol.%, wt.%, ppm (V), ppm
Time	hr, s
Frequency	Hz, %
Mass	kg, ton (t)
Density	kg/m^3, mg/l
Mass flow rate (liquid and gas)	kg/hr
Mass flow rate (steam)	t/hr
Pressure	Pa, kPa, MPa, kg/cm^2, Bar
Energy	kcal, cal, J, kJ
Voltage	V, kV
Temperature	°C

1. INTRODUCTION

1.1. EXECUTIVE SUMMARY

In 2020 Azerbaijan set a target of increasing the share of renewables in its electricity mix to 30% by 2030. As Azerbaijan is relatively sunny, it has excellent solar power potential. According to the Ministry of Energy, technical potential is around 23000 MW. The country's 2400 to 3200 sunshine hours annually compare well internationally, as does its solar intensity, estimated at 1500 to 2 000 kWh/m^2. The best resources are in the central river valleys and the north and northwest.

On 4 Jun'22, the Ministry of Energy of the Republic of Azerbaijan and Masdar signed an Implementation agreement relating to the assessment, development and implementation of a 4 GWac pipeline of solar PV and onshore wind projects in the Republic of Azerbaijan starting with 2GWac as the first phase. The Implementation Agreement granted Masdar exclusive rights to develop Phase 1.

The Projects are being developed as a bilateral agreement between the Abu Dhabi Future Energy Company - Masdar and the Government of Azerbaijan. Masdar (hereinafter referred to "Company") will be responsible to build, own and operate the solar PV plants on Build, Operate & Own (BOO) basis.

The site is in Banka village in the Neftchala Region of Azerbaijan. The total capacity of Banka is 390 MWac. The total area allocated for the project is 1014 hectares.

1.2. BACKGROUND

Engineering hydrometeorological studying on the object **COMBINED CAPACITY OF 835MWAC SOLAR PV POWER PLANTS IN AZERBAIJAN-CONSTRUCTION BONKA SOLAR PV PROJECT IN THE REPUBLIC OF AZERBAIJAN** were carried out by the specialists of **JURU Limited and AT Geotech** on the basis of contract**.**

For the implementation of engineering surveys for construction, **JURU Limited and AT Geotech** have a Certificate of admission to work on the implementation of engineering surveys.

Engineering and hydrometeorological surveys are carried out to study the meteorological conditions of the site where the project is being designed. As a result of the preparatory work, initial data on the hydrological regime of the climatic conditions of the region will be obtained. As a result of the survey, data on climatology necessary for the design of the facility will be obtained.

1.3. PURPOSE AND OBJECTIVES OF RESEARCH

The purpose of engineering and hydrometeorological surveys is a comprehensive study of the hydrometeorological conditions of the territory on which construction sites are located and the forecast of possible changes in these conditions as a result of interaction with the designed objects in order to obtain the necessary and sufficient materials for making informed design decisions.

The objective of this hydrological study is to develop and evaluate the existing drainage patterns and flow rates for the runoff tributary to the Project. The hydrology will be the base used to determine the location of the natural watercourses upstream and within the project area and the amount of runoff that flows in the existing watercourses.

1.4. SITE DESCRIPTION OF THE PROJECT

The Banka solar power plant project area is located in the eastern part of the city of Banka, Neftchala district of the Republic of Azerbaijan.

The Neftchala district borders on the Salyan district in the north and the Kyzylagaj state reserve in the south. It is considered a flat area. The area is located at 22 meters below sea level. Anthropogenic deposits are common. In the area there is the island of Kur Dili, which, due to falling sea levels, sometimes turns into a peninsula.

Geologically, the area under investigation is composed of eolian and eluvial prialival rocks of the Quaternary period. The main rivers were created as a result of the geological work of the Kura River.

In some places, the results of the terragen work of the sea are clearly visible.

From the hydrological point of view, the Kura River flows from the southern part of the territory and flows into the Caspian Sea.

Until 1953, the regime of the Kura River was purely natural. High water levels in the river were observed in April-May and slightly in July, and low levels in August-September. If in October-

November there was a rise in the level again, it was lower in value than in the spring. The area around the river Kura was subject to flooding in the spring (lead).

Since 1953, after the filling of the Mingachevir reservoir, the river flow was regulated and, in connection with this, a new hydrogeological regime was established.

The effect of the Kura on groundwater remained in a narrow zone of the coast. In particular, the southern parts of the studied object may fall into this zone of influence.

Groundwater in the area is close to the surface and relatively saline. In areas close to the surface (1.0-1.5 m) of the groundwater level, the salinity and saline content of the water are several times higher. Groundwater is chemically rich in chlorine and sulfate-chloride salts. This mineralization of groundwater creates a risk of secondary salinization.

1.5. CODES AND STANDARDS

General technical requirements for performing engineering surveys, their composition and types are regulated by the following fundamental documents:

- ✓ ASCE/SEI 24-14. Flood Resistant Design and Construction
- ✓ ASCE 7. Minimum Design Loads for Buildings and Other Structures.
- ✓ AzDTN 2.1-1 "Load and impact"
- ✓ BS 85500:2015 – Flood Resilient Construction
- ✓ BS 8533:2015 – Assessing and managing flood risk in development.
- ✓ MSN 2.04-01-98 Construction climatology
- ✓ TR-55 Urban hydrology for small watersheds, United States Department of Agriculture USDA.
- ✓ EN1991-1-4: General actions - Wind actions
- ✓ SN 63-76 Guidelines for the Analysis of Storm Water Runoff from Small Reservoirs
- ✓ FP 204-078-1. This policy updates and supersedes the Standards for Flood Risk Analysis and Mapping
- ✓ СП 482.1325800.2020 “Engineering and hydrometeorological surveys for construction. Set of rules"

2. CLIMATIC CHARACTERISTICS OF THE TERRITORY

The purpose of hydrometeorological surveys is to obtain the necessary data to assess the climatic conditions of the construction area and identify dangerous hydrometeorological phenomena. Based on climatic conditions, equipment is selected, technological parameters are calculated, loads on building structures are determined, the period of operation of facilities is determined, and the impact of structures on the environment is assessed.

To assess the climatic conditions of the survey area, a network of representative stations was selected, and materials from long-term observations were analyzed. Based on the results of meteorological surveys, a climate profile was compiled.

Climatic parameters include the temperature of the outside air, the speed of its movement, pressure, characteristics of changes in water vapor, the amount of precipitation, solar radiation.

Climatic characteristics for the survey area are given based on the nearest weather station.

The selection of a meteorological station to characterize the climatic conditions of the survey site was carried out in according to WMO No. 100 Guide to Climatological Practices, when data are available, it is recommended to use data from a weather station located at a distance of ≤ 100 km. For construction located in mountainous areas, the selection of representative meteorological stations should be made taking into account the altitude above sea level, the exposure of mountain slopes, and the position relative to the valley bottom.

The study area has not been sufficiently studied meteorologically. The closest representative meteorological station to the survey site is the NEFTCHALA meteorological station (AJ000037925).

Observation of meteorological elements consists of measurements at one-minute intervals. However, according to the requirements of WMO-No. 8 normative document of WMO, data recording is recorded in average amounts for the intervals of 03, 06, 09, 12, 15, 18, 21, 24 hours of Greenwich time.

During the survey, preliminary and field deciphering of available satellite images and cartographic materials was carried out, and data was collected to study the natural conditions of the study area.

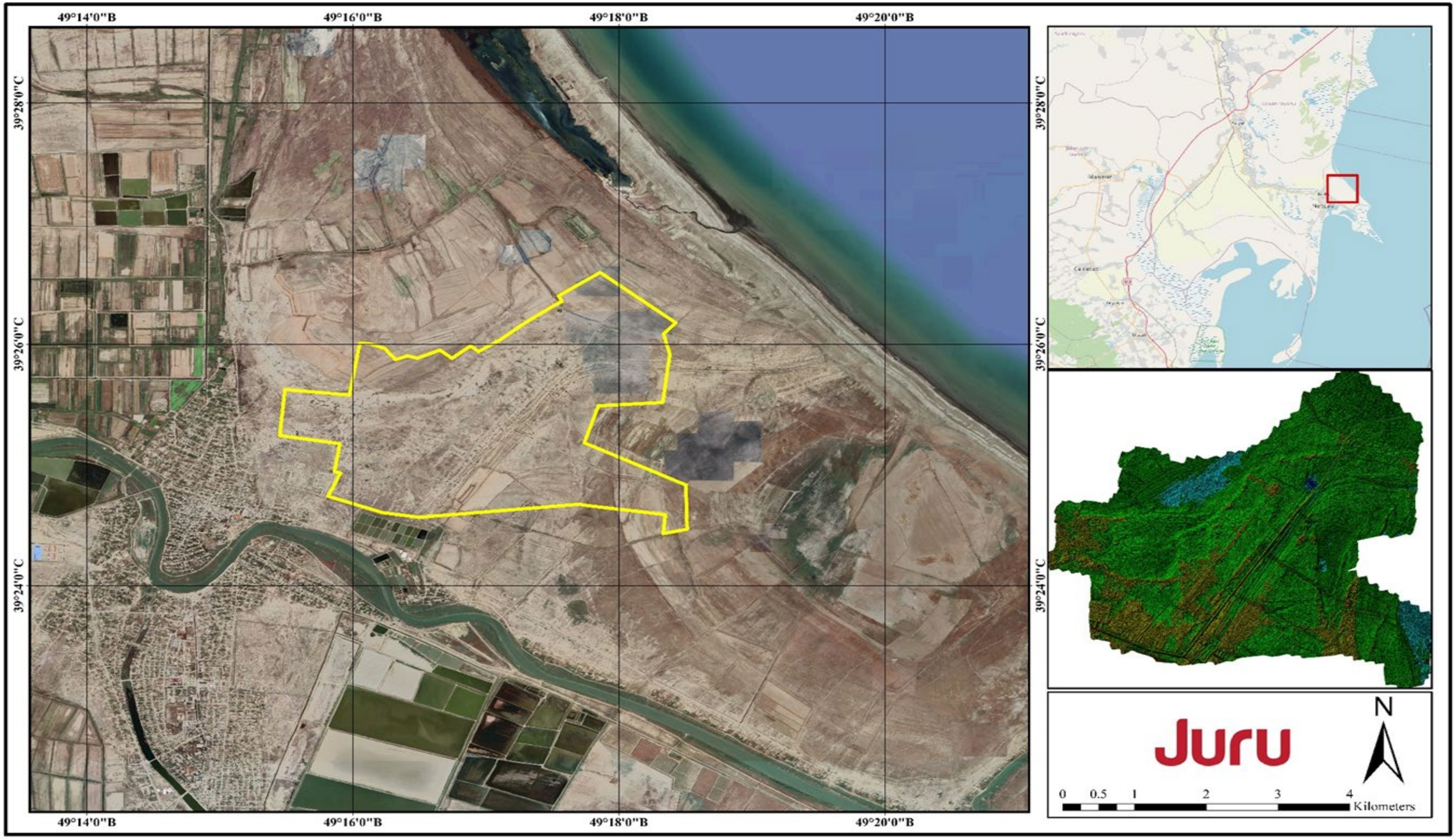


Figure 1.1: Study area Bank solar power station

2.1. FEATURES OF ATMOSPHERIC CIRCULATION IN THE REGION

Atmospheric circulation is one of the main climate-forming factors. Synoptic processes developing over the territory of Azerbaijan (over objects) are currently divided into 8 types.

The zonal transfer of air masses that dominates the territory of Transcaucasia is in some cases disrupted under the influence of interlatitudinal exchange, which causes intense invasions of cold air masses from the north and the removal of warm masses from the south. The Main Caucasus Ridge plays a large role in shaping the characteristics of circulation processes over the territory of Transcaucasia. The mountain ranges of the Caucasus are a natural

Hindering the free spread of northern cold air masses. However, under certain conditions, cold air masses begin to flow around the ridge from the Caspian Sea and penetrate into the territory of Absheron, and therefore into Baku.

The Lesser Caucasus Mountain system also plays a significant role in the development of atmospheric processes in the city, due to which the moisture content and speed of warm air masses moving from the south mainly decrease. Frontal processes also have a certain influence on the climate of this region. Air masses formed on the polar and even Arctic fronts penetrate here.

Uneven heating of land and sea, as well as the presence of a weakly gradient pressure field in the coastal strip and some distance inland, contribute to the emergence of breezes. The unique physical and geographical position of the Territory, the proximity of the Caspian Sea and the complexity of the orographic conditions of the area create a wide variety of forms of local circulation. The synoptic processes developing over Transcaucasia, in particular over Absheron, which determine the climate of Baku, are divided into eight main types, depending on the main routes of penetration of air masses and their transformation.

In the cold half of the year, a characteristic feature of the development of atmospheric processes is the high frequency of meridional movements of cold masses of Arctic air in the rear part of the trough of northern cyclones, oriented through Central Europe to the Balkans, the Black Sea and the Caucasus. This situation contributes to the accumulation of cold air over the European part of the USSR and its breakthrough in a southern direction.

In winter, in most cases (about 20%), the weather is determined by local atmospheric circulation processes. In the presence of an area of high pressure or a blurred pressure field over the Caucasus, a transformation of the arriving air masses of temperate latitudes occurs.

Quite often, such processes lead to the formation of fens, causing warm and dry weather. In 15% of cases, the weather in this area is influenced by an anticyclone located over the south and southeast of the European Union. When the continental anticyclone intensifies and there is an area of low pressure over the Caucasus, continental air from temperate latitudes invades. Sharp weather changes in winter are associated with the invasion of arctic air (about 10%) from Northwestern Siberia, from the Kara, Barents or Norwegian seas. Continental Arctic air in areas of high pressure moves south. At the same time, in the southern regions there is a revival of cyclonic activity and the entry of southern cyclones through Transcaucasia into the Southern Caspian Sea. Such a situation contributes to the intense invasion of Arctic air in the rear of southern cyclones, with a sharp drop in air temperature, increased cloudiness, and precipitation.

In the warm half of the year, the development of atmospheric processes is determined mainly by changes in the intensity of solar radiation. There is a weakening of the meridional circulation, which contributes to an increase in westerly transport. The restructuring of pressure systems in spring leads to the development of the Azores maximum and the weakening of the spur of the Siberian maximum. Intrusions of continental Arctic air almost completely stop.

Air masses moving from the north arrive in the Baku region greatly transformed. The increase in the frequency of local circulation processes (25%) is associated with the development of low-gradient high-pressure areas. There are processes leading to the removal of tropical air (21%), which causes a sharp increase in air temperature.

Features of the summer circulation are manifested in the weakening of advection and the strengthening of the role of radiation and local climate factors. There are no intensive invasions from the Arctic. The weather is largely determined by the activity of the Azores anticyclone, expressed in the spread of its spurs to the east. This process causes stable dry and warm, partly cloudy weather.

In November the pre-winter begins. With further intensification of cyclonic activity and cold intrusions, winter comes.

Periodic disruption of the summer circulation begins at the end of August, when cyclonic activity intensifies and the frequency of northwestern and western cyclones increases. In October, more intense cold intrusions are observed in the rear of cyclones. In autumn, the spurs of the Azores anticyclone are destroyed, and the spurs of the Siberian anticyclone are increasingly spreading from the east. The speed of movement of western cyclones decreases as they approach the spurs of the continental anticyclone; Cloudy weather forms in the transition zone.

2.2. SOLAR RADIATION

The source of energy for physical processes occurring on the earth's surface and in the atmosphere is the radiant energy of the Sun. Its influx onto the earth's surface depends on the angle of inclination of the sun's rays, which at any given time is determined by the latitude of the area, the declination of the sun and the time of day, knowledge of the duration of daylight is required, which in turn is determined by the latitude of the area and the declination of the sun on a given day.

Solar radiation enters the earth's surface in the form of two streams: direct solar radiation S, emanating directly from the solar disk, and diffuse radiation D, emanating from the entire vault of heaven. The sum of these fluxes is called total radiation Q. At meteorological stations, direct solar radiation S arriving at a surface perpendicular to the sun's rays is measured.

The arrival of total radiation depends on the height of the sun, the length of the day, the transparency of the atmosphere, cloudiness and albedo of the underlying surface. The amount of solar radiation reaching the earth's surface depends on the latitude of the place, the height of the sun, cloudiness and transparency of the atmosphere.

In territory, the average duration of sunshine per year is 2244 hours, or 58% of the theoretically possible amount. The minimum duration of sunshine is observed in winter, in December - February (85-88 hours, or 34-35% of the possible).

In Baku, the average annual solar radiation is 5564 MJ/m^2. At the same time, most of the total radiation from April to September is due to direct radiation, and in the period from October to March - to diffuse radiation.

Table 2.1: Monthly and annual amounts of solar radiation under average cloudy conditions (MJ/m^2)

Months	S	S'	D	Q	R
January	201	71	96	168	38
February	205	92	130	222	54
March	335	184	205	390	84
April	458	293	260	553	126
May	675	469	272	742	163
June	788	566	239	804	176
July	750	532	256	788	172
August	729	490	226	716	163
September	528	314	188	503	117
October	323	159	172	331	75
November	205	80	113	193	46
December	176	59	96	155	22
Annual	5373	3309	2253	5565	1236

The radiation balance under cloudy conditions decreases compared to the radiation balance under clear skies, but to a lesser extent than direct and total radiation, since cloudiness also reduces the expenditure part of the radiation balance - effective radiation and reflected radiation.

When the solar disk is open, an increase in cloudiness can lead to a slight increase in the radiation balance compared to a cloudless sky.

Maximum values of the radiation balance can reach 411 MJ/m^2 in June and decrease to 38 MJ/m^2 in December.

2.3. AIR TEMPERATURE REGIME

According to the recommendations of the World Meteorological Organization, the period from 1961 to 1991 was adopted for calculating the basic climate normal, and in recent years from 1991 to 2022. In this regard, it became necessary to revise the norms of the main climatic characteristics and draw up new climatic descriptions of the territory on the basis.

Table 2.2 below shows the ambient temperature indicators observed in the meteorological station of Neftchala in 1992-2022 years.

Table 2.2: Long-term indicators of air temperature in MS Neftchala (for periods 1992-2022), °C

Months	The long-time annual average	Absolute maximum	The long-time annual maximum	Absolute minimum	The long-time annual minimum
January	5.2	24.1	16.3	-8.8	-2.6
February	5.9	25.8	17.6	-7.7	-2.0
March	8.6	35.5	21.6	-1.2	1.6
April	13.1	35.9	25.8	0.4	4.7
May	19.1	35.9	31.9	1.9	10.3
June	24.2	39.9	35.9	2.1	14.2
July	26.7	41.2	36.6	2.6	17.6
August	26.7	42.7	36.9	2.2	15.2
September	22.9	37.0	34.6	2.2	12.6
October	17.5	35.3	28.1	0.0	8.9
November	11.2	27.1	21.5	-2.8	2.3
December	6.8	26.0	17.0	-4.7	-0.5
Annual	15.7	42.7	27.0	-8.8	6.9

The main indicators of the temperature regime are the average monthly maximum and minimum ambient temperatures. According to the data analysis in the table in the territory the average annual air temperature is +15.7 °C, absolute minimum air temperature was -8.8 °C. the absolute maximum was +42.7 °C. The coldest month of the year is January with an average monthly ambient temperature of 5.2 °C. the warmest is July with an average monthly temperature of +26.7 °C.

Distribution parameters of extreme air temperature observed at Neftchala meteorological station are presented in the following table.

Table 2.3: Distribution parameters of the maximum and minimum air temperature observed at the Neftchala meteorological station

Range	Minimum air temperature, °C			Maximum air temperature, °C		
	Years	Temperature	Probability density	Years	Temperature	Probability density
1	1999	-0.7	0.018	1992	35.7	0.018
2	2019	-0.7	0.0501	1995	35.7	0.0501
3	2011	-1.2	0.0823	1996	35.8	0.0823
4	2003	-1.4	0.1144	2001	35.8	0.1144
5	2013	-1.6	0.1465	2003	35.8	0.1465
6	2000	-2.2	0.1787	1993	35.9	0.1787
7	2005	-2.2	0.2108	1994	35.9	0.2108
8	2007	-2.7	0.2429	1997	35.9	0.2429
9	2018	-2.7	0.2751	2004	35.9	0.2751
10	2004	-2.9	0.3072	1999	36.2	0.3072
11	2021	-3	0.3393	2019	36.2	0.3393
12	2022	-3	0.3715	2002	36.5	0.3715
13	2020	-3.2	0.4036	1998	36.6	0.4036
14	2017	-3.4	0.4357	2013	36.6	0.4357
15	2006	-3.6	0.4679	2005	37.0	0.4679
16	2010	-3.6	0.5	2006	37.2	0.5
17	1996	-3.9	0.5321	2009	37.2	0.5321
18	1994	-4	0.5643	2007	37.3	0.5643
19	1998	-4	0.5964	2008	37.8	0.5964

Range	Minimum air temperature, °C			Maximum air temperature, °C		
	Years	Temperature	Probability density	Years	Temperature	Probability density
20	1995	-4.2	0.6285	2010	37.9	0.6285
21	1997	-4.6	0.6607	2014	38.0	0.6607
22	2002	-4.7	0.6928	2016	38.3	0.6928
23	2001	-5	0.7249	2015	38.5	0.7249
24	1992	-5.4	0.7571	2000	38.8	0.7571
25	1993	-5.4	0.7892	2022	39.0	0.7892
26	2016	-5.6	0.8213	2020	39.3	0.8213
27	2012	-5.7	0.8535	2011	39.5	0.8535
28	2015	-6.4	0.8856	2012	39.9	0.8856
29	2014	-7.7	0.9177	2021	40.0	0.9177
30	2009	-8.5	0.9499	2018	41.2	0.9499
31	2008	-8.8	0.982	2017	42.7	0.982

The calculated values of extreme maximum and minimum temperatures of various probability are determined by the distribution for a series of observation from 1992 to 2022 at the Neftchala meteorological station and Table 2.4 is presented.

Table 2.4: Calculated extreme air temperature according to Neftchala meteorological station, °C

Return period, year	AEP, %	-ln(-ln(Pt))	Extreme air temperatures	
			Minimum	Maximum
2	0.5	0.3665	-2.3	38.8
5	0.8	1.4999	-4.3	40.2
10	0.9	2.2504	-5.6	41.1
20	0.95	2.9702	-6.8	42.0
50	0.98	3.9019	-8.4	43.1
100	0.99	4.6001	-9.6	44.0

2.4. REGIME OF RELATIVE HUMIDITY

The air humidity regime in Neftchala throughout the year is determined by the nature of circulation processes, expressed in changes in air masses. In winter, cold and relatively humid air masses come to the city; in summer, on the contrary, they are warm and dry. Humidity and air temperature are in a certain relationship: in areas of the city with high air temperatures, low humidity is observed, and in areas with low temperatures, high humidity is observed.

Table 2.5 below shows the ambient relative humidity indicators observed at the Neftchala meteorological station in 1992-2022 years.

Table 2.5: Air relative humidity indicators observed at the Neftchala meteorological station in period 1992-2022 years, %

Months	The long-time annual average	Absolute maximum	The long-time annual maximum	Absolute minimum	The long-time annual minimum
January	85.8	99.4	92.4	10.4	35.5
February	86.2	99.4	91.1	19.8	36.0
March	82.5	99.4	90.2	13.5	30.1
April	78.2	99.4	98.6	13.5	29.4
May	72.5	99.4	97.1	9.4	28.1
June	59.2	99.4	91.8	9.4	19.3
July	52.9	95.4	87.9	8.3	18.3
August	53.5	99.4	87.2	5.2	17.5
September	69.1	99.4	96.3	11.5	21.6
October	83.0	99.4	98.5	17.7	31.2
November	86.2	99.4	99.4	13.5	37.5
December	85.3	99.4	99.3	14.6	35.4
Year	74.5	99.4	96.2	5.2	28.3

The annual course of relative humidity, which characterizes the degree of ambient saturation with water vapor, is opposite to the annual course of water vapor elasticity and ambient temperature.

From winter to summer, as the ambient temperature rises, the values of relative humidity gradually decrease. The strongest decrease is observed in April - May, which is explained by a significant increase in the influx of solar heat, intensification of transformation processes, and a sharp decrease in precipitation in May.

Table 2.6 below show the indicators of relative air humidity observed by terms at certain times of the day at the Neftchala meteorological station.

Table 2.6: Air relative humidity indicators observed by terms at certain times the Neftchala meteorological station in period 1992-2022 years, %

Months	21:00	00:00	03:00	06:00	09:00	12:00	15:00	18:00
January	85.5	86.6	86.5	83.5	76.5	75.0	82.6	86.1
February	85.8	87.4	87.5	84.0	76.0	74.6	81.8	87.6
March	84.3	87.0	86.6	79.8	72.0	68.9	76.2	85.8
April	81.0	84.9	83.9	73.2	65.7	63.9	71.4	83.4
May	75.9	83.1	82.0	66.3	58.6	55.7	62.7	79.6
June	63.9	74.1	71.4	52.1	45.1	43.7	49.4	69.8
July	54.4	64.7	61.5	43.5	37.2	37.3	42.7	59.9
August	57.3	65.5	63.8	46.8	39.8	39.8	46.6	62.0
September	72.8	78.9	77.7	63.7	54.7	52.5	62.5	76.8
October	84.6	88.2	88.1	80.2	69.6	68.3	78.7	86.9
November	86.5	88.2	87.5	82.4	73.2	73.1	83.5	88.0
December	85.2	86.3	85.3	81.9	73.6	73.2	82.1	86.1
Year	76.4	81.3	80.1	69.8	61.8	60.5	68.3	79.3

The average annual relative air humidity in the region was 74.5%, the maximum average monthly relative air humidity in the region is observed in December-January (86%), the minimum in June-July (52%).

2.5. PRECIPITATION

Monthly and annual precipitation is given in millimeters, which measure the height of the water layer that has fallen to the surface of the earth.

The annual course of precipitation in the site is characterized by its predominance in the winter-spring period, the maximum occurs in March (29.9 mm), the minimum in July - August (1.8-6.9 mm with virtually no precipitation). In the cold half of the year (November-March) there is 2 times more precipitation than in the warm half of the year. (April-October). The average annual precipitation is 278.2 mm.

Table 2.7 below shows the indicators of the amount of precipitation observed at the Neftchala meteorological stations between 1992 and 2022 years.

Table 2.7: Average monthly, absolute maximum, minimum precipitation the Neftchala meteorological station for each month period 1992-2022 years, mm.

Months	The long-time annual average	Absolute maximum	Absolute minimum
January	28.9	79.5	5.9
February	26.0	84.4	2.8
March	29.9	57.0	2.5
April	22.3	82.4	0.0
May	15.8	46.8	0.0
June	7.5	43.9	0.0
July	1.8	6.7	0.0
August	6.9	63.0	0.0
September	28.9	151.3	0.0
October	46.0	200.0	8.1
November	36.2	115.9	2.0
December	32.2	100.2	0.0

2.6. ATMOSPHERE PRESSURE

Atmospheric pressure varies significantly throughout the year depending on the nature of atmospheric circulation and the time of year. Higher pressure is observed in the cold season due to the invasion of cold air from the north and east in the spurs and ridges of the Siberian anticyclone and air compaction as the temperature drops; lower pressure is observed in the warm half of the year due to the general warming of the atmosphere.

The average annual atmospheric pressure normalized to sea level at the Neftchala meteorological station is 1018.5 hPa. It has a minimum in summer and a maximum in winter. With the onset of a cold period, the pressure at the site increases. Its sharpest increase is observed in September and October, when the pressure difference between neighboring months reaches 2.5 hPa.

Table 2.11: Average monthly and observed by terms at certain times atmospheric pressure in Neftchala for each month and for the year and date of appearance for period 1992-2022 years, hPa

Months	The long-time annual average	21:00	00:00	03:00	06:00	09:00	12:00	15:00	18:00
January	1023.3	1024.3	1024.4	1024.2	1024.6	1023.5	1022.3	1023.3	1024.4
February	1022.3	1023.0	1023.2	1023.1	1023.3	1022.3	1021.1	1022.0	1023.2
March	1019.4	1020.0	1020.1	1020.0	1021.4	1019.3	1018.2	1019.9	1020.2
April	1017.9	1018.7	1018.8	1018.5	1018.1	1017.3	1016.4	1016.8	1018.8
May	1016.0	1017.1	1018.9	1018.6	1016.7	1015.9	1015.0	1015.3	1017.5
June	1012.4	1013.2	1014.1	1013.9	1012.9	1012.1	1011.2	1011.3	1013.8
July	1010.8	1011.5	1012.5	1012.4	1012.7	1010.4	1009.4	1009.8	1012.4
August	1012.8	1013.2	1014.0	1014.2	1013.2	1012.2	1011.2	1011.6	1013.7
September	1017.0	1017.8	1018.4	1018.5	1017.9	1018.2	1015.8	1016.4	1018.2
October	1021.8	1025.3	1026.8	1025.2	1025.6	1024.4	1024.7	1025.8	1025.4
November	1024.0	1023.9	1024.0	1025.2	1024.0	1024.1	1024.5	1023.0	1024.0
December	1024.7	1025.3	1026.8	1025.2	1025.6	1024.4	1024.7	1025.8	1025.4
Year	1018.5	1019.4	1020.2	1019.9	1019.7	1018.7	1017.9	1018.4	1019.8

3. HYDROLOGIC AND HYDRAULIC STUDIES

3.1. OBJECTIVES AND WORK FLOW

The objective of this study is to develop and evaluate the existing drainage patterns and flow rates for the runoff tributary to the Project. The hydrology will be the base used to determine the location of the natural watercourses upstream and within the project area and the amount of runoff that flows in the existing watercourses.

Taking account of the goals of the recommended project, the objectives of the hydrological and hydraulic studies are set as follows:

- ✓ The 100-year (1%AEP Annual Exceedance Probability), 50-year (2% AEP), 25-year (4% AEP) and 10-year (10% AEP) inundation limits will also be determined for the major watercourse that crosses the Project. The proposed design of the Project will then take into account the location of the existing drainage courses and the amount of flow, as well as the 25, 50 100-year flow width, depth, and the velocity. This study will also show the change in runoff rates and characteristics and the 25, 50, 100-year inundation limits due to the development of the Project;
- ✓ Flood modelling for different return periods and application of results on survey plan to establish the flood lines for different return periods for the Project site
- ✓ Identification of constraints limiting the use of spaces on banks
- ✓ Considering the need for flood mitigation and development considerations
- ✓ Flood management measures
- ✓ Application of hydraulic data of drainage lines crossing the road and the conceptual culvert design
- ✓ Assessing flood risk for extreme situations and giving recommendations on reducing risks, provide conclusions on mitigation measures;
- ✓ To recommend betterment of drainage system along the proposed alignment, where deterioration of present drainage conditions due to implementation of the project is predicted, if any.

3.2. SCOPE OF WORKS

The overall scope of the study includes a set of works to determine the risk of flooding of the future construction site.

Based on the above, the following tasks were defined as research objectives:

- ✓ A study should be conducted on the following topography data sets: Conduct a topography study using site measure data with spatial resolution of 0.1 to 0.5m, satellite based Digital Elevation Model (DEM and satellite imagery, which will give a better understanding of the terrain surface
- ✓ Have a general overview of the physical and hydraulic characteristics of the Waterways through the site;
- ✓ On-site review of waterways and delimitation of conditions of lows. Inspection of upstream and downstream of the study area. To identify the hydraulic constraints limiting the use of the spaces in the banks;
- ✓ Watershed based Hydrological model. Rainfall analysis shall be based on local standards Collection of relevant rainfall data (hourly, daily, yearly etc.) for the project site. Analyze the rainfall data and estimate maximum rainfall depth for 24 hours and for various short durations including duration of concentration (time of concentration) for 2-, 25-, 50- and 100-year return-period. The rainfall data and analysis shall be included in the report;
- ✓ Collect the details of historical flood data and its study. Analysis of runoff coefficient and manning's coefficient, time of concentration. Estimate the maximum rainfall intensities for various return periods & durations including concentration times and prepare Intensity-Duration-Frequency (IDF) curve. Analysis of rainfall hyetograph. Assessment of all probable source of flooding like flash floods, pluvial flooding, fluvial flooding, groundwater flooding;
- ✓ Study and evaluate whether providing storm water drainage is must or the risk can be mitigated by raising the structure above the HFL expected. In case there is run off intercepting the plant and drainage is required, whether there is embankment or peripheral drain to be provided. The height of embankment or section of peripheral drain to be evaluated along with tentative location on proposed plot plan;

- ✓ A soft copy of drawing showing the Flood level of 100-year (1%AEP), 50-year (2% AEP), 25-year (4% AEP) and 10-year (10% AEP). Generation of micro streams within the project site. Watershed analysis should cover macro watershed-based runoff estimation. Flood risk assessment within the project site. Prepare flood inundation map indicating the flood levels, inundated area, flow direction and velocity in and around the plant area;
- ✓ Flood risk at the access of the plant areas. High flood level impact assessment at the drainage outlet points in project site area. Various types of remedial measures with drainage patterns and discharge points locations described with detailed feasibility for the site flooding;
- ✓ Development pre-project & post project hydraulic study, potential scour and recommendation for the drainage design on the proposed plot plan.

Based on the results of hydrometeorological surveys, this report was compiled. Report as a minimum should consist of the project location, project description, study objective, hydrology design criteria, peak rainfall intensity in mm/hr, maximum daily rainfall, runoff coefficient at drainage area, software used, pre-project water shed characteristics, pre- project hydrology, post project watershed characteristics, post project hydrology, pre-and post-project peak flow summary. It shall also consist of flood hazard meaning thereby the inundation limits, flood depth, flow velocity, post project effect, potential scour and project site mitigation. Pre-project drainage design, post project drainage design, recommendation and summary shall also be included in the report.

3.3. DESIGN PRINCIPLES AND STANDARDS

The adopted governing philosophy was to provide minimal disruption to the natural drainage system on the site while protecting the solar farms from erosion and accommodating the proposed master plan development. The objectives of the design were to:

- ✓ Protect the solar farm panels from submergence by flood waters;
- ✓ Protect the solar farm panels from erosion;
- ✓ Provide basic storm water management infrastructure for the master plan;
- ✓ Reduce flows from the development to pre-development conditions;
- ✓ Minimize intervention to the natural drainage of the site.

The main standard is to qualify the impact of rainwater on the design structure in a building site using ASCE 7 Minimum Design Loads for Buildings and Other Structures, BS 851188-1:2019+A1:2021 Flood resistance products - Building products and other local codes.

3.4. MAXIMUM RAINFALL INTENSITY AND DURATION WITH RETURN PERIODS

The rainfall data observed at the weather station were processed statistically. The Gumbel method Type-1 was used to study the laws of empirical distribution.

In probability theory and statistics, the Generalized Extreme Value Distribution Type-1 is used to model the maximum (or minimum) of a number of units. In probability theory, the Gumbel density function Type-1is used mainly in extreme value and duration analysis (also known as duration analysis or event history modeling). The Gumbel Distribution Type-1 is a special case of the generalized extreme value distribution (also known as the Hera-Tippett distribution). It is also known as the logarithmic distribution and the double exponential distribution (the term sometimes used interchangeably to refer to the Laplace distribution).

The Gumbel distribution function Type-1is mathematically expressed as follows:

$$G(x,\mu,\beta) = \frac{1}{\beta} e^{\frac{x-\mu}{\beta}} e^{-e^{\frac{x-\mu}{\beta}}}$$

where m is the location parameter and b is the scale parameter.

The value of the random variable X_T is associated with a given recurrence period T can be obtained from the following expression:

$$X_T = \bar{X} + K_T * S$$

where X is the mean value of observations (for example, the arithmetic means of the observations) and S is the standard deviation of the observations.

The frequency factor is associated with the recurrence period T, K_T (**Factor Gumbel EV**), is determined by the following expression:

$$K_T = -\frac{\sqrt{6}}{\pi}\left[0.5772 + Ln(Ln(\frac{T}{T-1})\right]$$

This equation is used to calculate the frequency ratios associated with return cycles (2, 5, 10, 25, 50, 100 years).

The empirical distribution showed a trend towards logarithmic growth; the correlation ranged between 0.90 and 0.95. The purpose of the analysis was to study empirical distribution of the amount of the observed precipitation over 3, 6, 12 and 24-hour intervals.

Table 3.1 below shows the amount of rainfall observed at the Neftchala meteorological station in the period 1992-2021 years.

Table 3.1: 3-hour, 12-hour and daily maximum rainfall observed at the Neftchala meteorological station between 1992-2021 years

Range	Year	Maximum 3-hour rainfall, mm	Maximum 12-hour rainfall, mm	Maximum daily rainfall, mm
1	1992	18.6	59.3	69.4
2	1993	16.2	46.7	58.8
3	1994	13.7	54.8	61.8
4	1995	20.1	41.9	58.9
5	1996	28.7	44.3	67.9
6	1997	21.3	57.8	59.2
7	1998	26.7	30.5	64.4
8	1999	28.7	32.8	90.2
9	2000	13.2	25.1	51.5
10	2001	16.8	39.2	50.2
11	2002	18.5	39.6	86.3
12	2003	20.6	44.1	61.9
13	2004	22.8	48.8	104.4
14	2005	47.7	77.3	94.6
15	2006	27.7	58.7	195.2
16	2007	21.4	24.4	72.9
17	2008	13.7	43.0	64.4
18	2009	31.2	35.6	103.2
19	2010	23.4	47.1	72.9
20	2011	60.1	60.1	117.9
21	2012	27.8	58.9	86.3
22	2013	39.7	44.5	101.9
23	2014	23.2	49.2	97.6

Range	Year	Maximum 3-hour rainfall, mm	Maximum 12-hour rainfall, mm	Maximum daily rainfall, mm
24	2015	40.2	45.0	73.4
25	2016	41.2	91.8	107.6
26	2017	12.3	38.4	51.8
27	2018	23.6	46.8	46.8
28	2019	25.8	54.7	81.6
29	2020	24.0	50.9	73.8
30	2021	23.0	44.0	99.4

3.5. DATA COLLECTION

In hydrological modeling, digital relief model of the area, type of land cover, degree of infiltration of geological layers, structure of soil composition, amount of atmospheric precipitation, flow hydrographs of precipitation water were developed.

3.5.1. DIGITAL TERRAIN MODEL AND WATERSHED DEFINITIONS

The ALOS DEM model was used to create the DEM model based on region characteristics. https://www.eorc.jaxa.jp/ALOS/en/aw3d30/index.htm. The Global DEM model has a raster cell of 30*30 m (AW3D30) and has been corrected using ALASKA PALSAR data to improve its accuracy.

To improve accuracy of the DEM model, the area was corrected using topographic data. The 3D DEM model of the region was created using the ALOS Palsar DTM correction method. The resulting DEM model has a size of 12 meters in pixels, the vertical relief is corrected, and the accuracy is high.

The Complex Energy Index (CEI) was used as the basis for the proposed methodology for modeling the river network.

In the study, the analysis of the use of various forms of indices was carried out, on the basis of which the authors propose the general form of the index in the following form:

$$a = \delta * Q^m * \Delta z^n$$

where a is the index, Q is the flow rate, Δz is the local slope, δ, m and n are the parameters. Options for specifying the formula are the above-used areas of the water body A as a flow index:

$$Q_i \propto A_i$$

and also, the E relief energy index known in the literature:

$$E_i \propto A_i^{0.5} * \Delta z_i$$

Formulas in the form of a record used for calculations using the DEM, where i is the number of the raster cell in which the value of the corresponding index is calculated.

The raster coverage obtained as a result of processing the original DEM is used to calculate the derived data necessary for further calculations:

- flow directions;
- total drain;
- slope.

When working with several basins within the large DEM fragment, it is advisable to sequentially process the entire fragment to obtain raster coverages of Fill, Flow Direction, Flow Accumulation and Slope. After that, it is necessary to set closing gates for the simulated basins, select their water-collecting areas, which are then used as a mask (Environment Settings – Raster Analysis - Mask) to optimize the calculations by excluding the calculations of DEM points that lie outside the simulated basins. The river network structure is modeled by setting the CEI threshold value using the Raster Calculator tool of the SpatialAnalyst/MapAlgebra toolset using the Con function. As a result, the raster cells, the CEI values are selected with the limit which is greater than the specified one.

Discontinuities are removed by specifying the resulting raster as the weigh raster using the FlowAccumulation tool of the SpatialAnalyst/Hydrology toolset. In order to avoid the loss of the initial cells of the selected streams, the result obtained is summed up with the previously obtained raster of the river network with discontinuities by simple addition using the RasterCalculator tool of the SpatialAnalyst/MapAlgebra toolset.

The result of the summation is processed by the SetNull tool of the SpatialAnalyst/ Conditional toolset, replacing all cells that are not equal to zero, by one. As a result, we obtain a connected raster of the simulated river network, in which the primary water streams start from the points at which for the first time (along the flow line) the CEI value exceeded the specified one.

The resulting raster represents a linear waters stream network model to which the standard SpatialAnalyst/Hydrology toolset is consistently applied: StreamLink which identifies segments between two series connections, between a connection and a mouth, or between a connection and a source; StreamOrder which defines and assigns an order value to the identified raster segments of the water stream network; StreamtoFeature which converts a raster representing a linear water stream network to vector features.

Construction of watersheds network is implemented by means of a number of techniques that make it possible to implement the principle of their ordinal classification, coupled with the ordinal characteristics of the river network corresponding to them.

The algorithm for creating a raster model can be conditionally divided into two stages:

• obtaining the raster model of the river network, which stores in its attribute table both identifier of the private link of the channel network and identifier of the order;

• selection of raster cells lying on the border of each private water body.

Using the FlowDirection procedure, we process the initial DEM of the basin, and use the resulting raster of flow directions to obtain partial identified water bodies of a given order using the Watershed procedure and the river network raster obtained at the previous stage.

The result is a set of rasters corresponding to the number of the selected stream orders.

Each of them presents a network of boundaries of partial water bodies of the same order, formed by the boundary cells of the raster.

A 1:500 scale topographic map of the area was used to create digital models of the small-scale terrain. To develop a digital model of the terrain in raster format, the topo v raster function of the

ArcGIS 10.6 program was used. The Topo to Raster tool is an interpolation method specifically designed for creating hydrologically correct digital elevation models (DEMs). It is based on the ANUDEM program developed by Michael Hutchinson.

The interpolation procedure was designed to take advantage of input data types that are publicly available and known characteristics of elevation surfaces. The method uses an iterative finite difference interpolation method. It is optimized to have the computational efficiency of local interpolation methods such as inverse distance weighted interpolation (IDW) without the loss of surface continuity of global interpolation methods such as Kriging and Spline. It is essentially a discretized planar spline method in which the roughness factor is modified so that the adjusted DEM can accommodate abrupt changes in the surface (such as gorges, mountain ridges, steep cliffs).

Digital models of detailed terrain were developed with a spatial resolution of 0.1 to 0.5 m.

The figure below shows a digital relief model of the construction object with a spatial resolution of 0.5 m. The territory lies between -21.9 -27.9 meters above sea level.

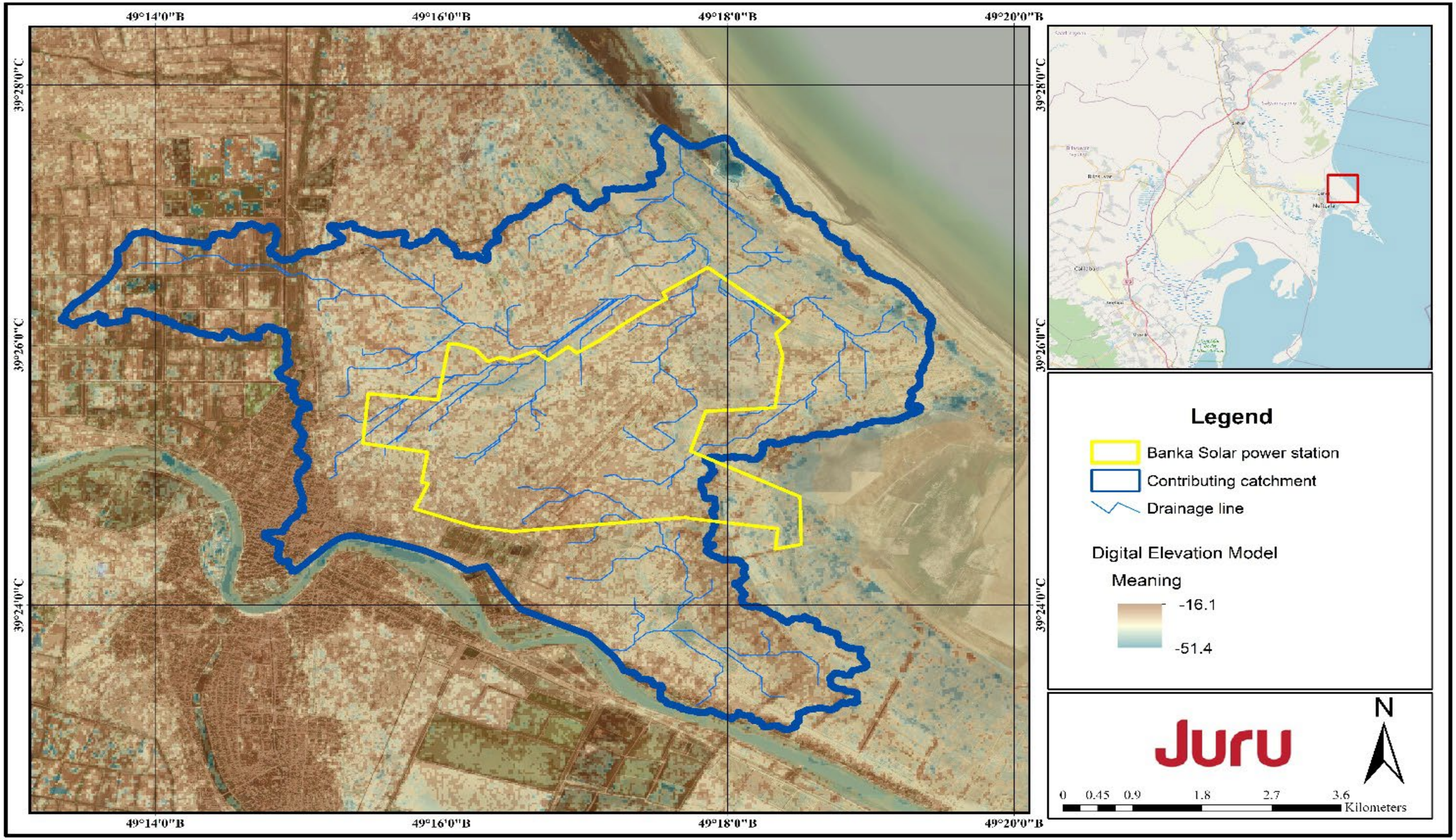


Figure 3.1: Sub basins and drainage network system obtained from 30 m ALOS PALSAR data.

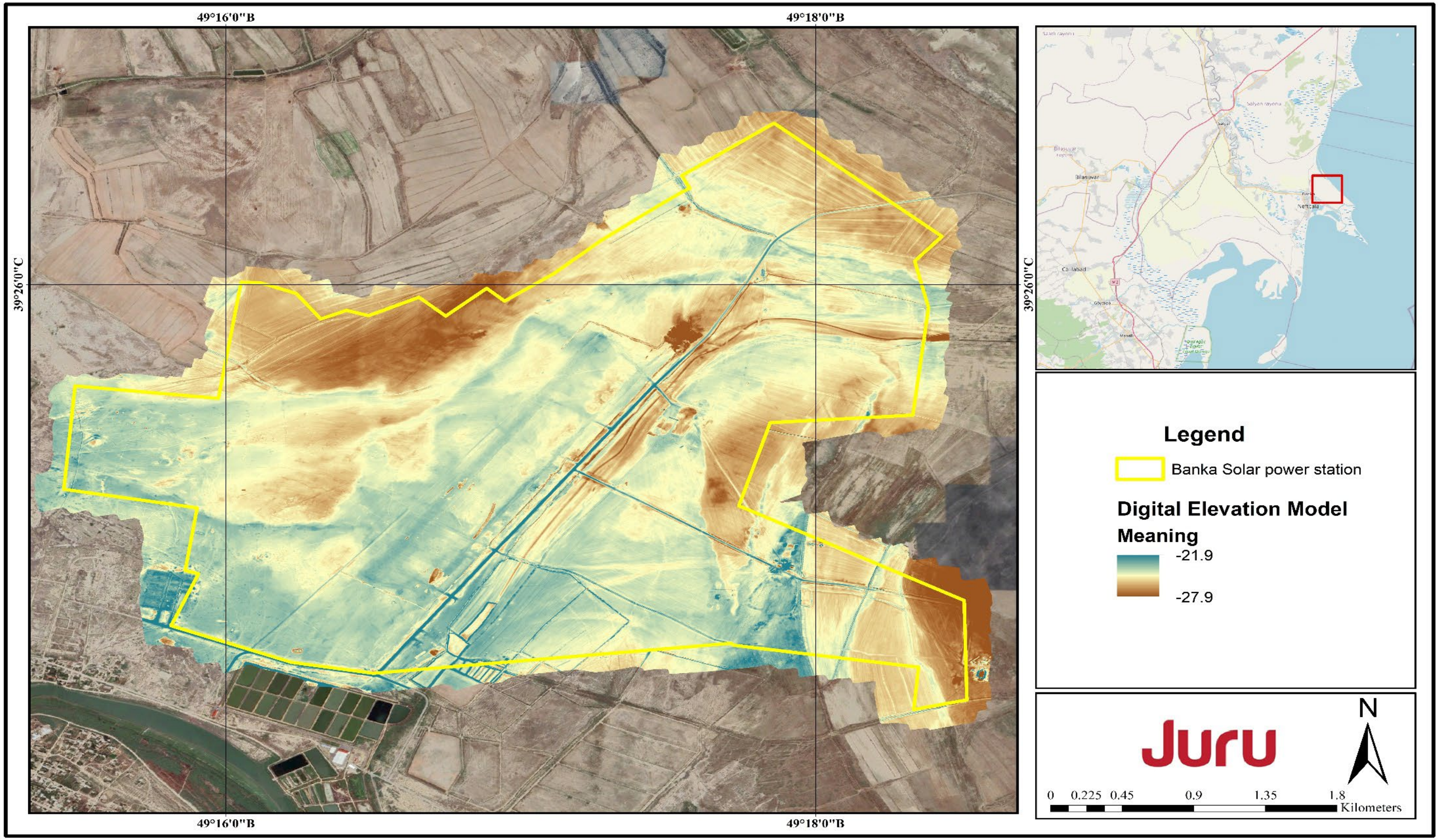


Figure 3.2: Topographic survey DEM for model area

3.5.2. GEOLOGICAL STRUCTURES

From the geological point of view, the region is dominated by a complex consisting of alluvial and pre-alluvial deposits and marine deposits.

The area is covered with marine sedimentary rocks of the latest age.

Figure 3.3 below shows the geological map of Azerbaijan.

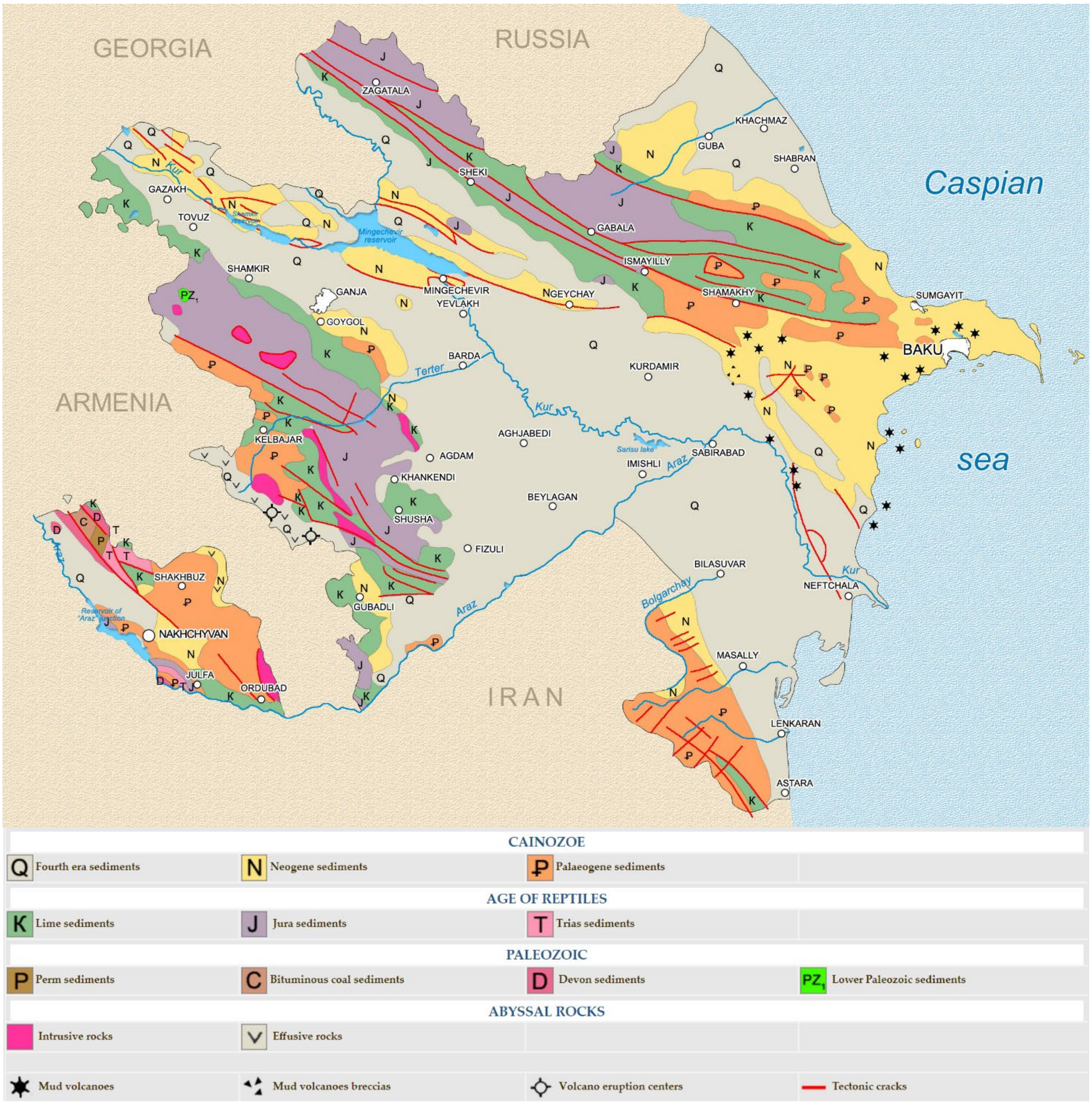


Figure 3.3: Geological map of the territory (source: www.azerbaijan.az)

3.5.3. LAND USE LAND COVER DATA

According to the type of land use, the studied area consists mainly of Grass. In some places, there is a bog landscape formed as a result of bogs.

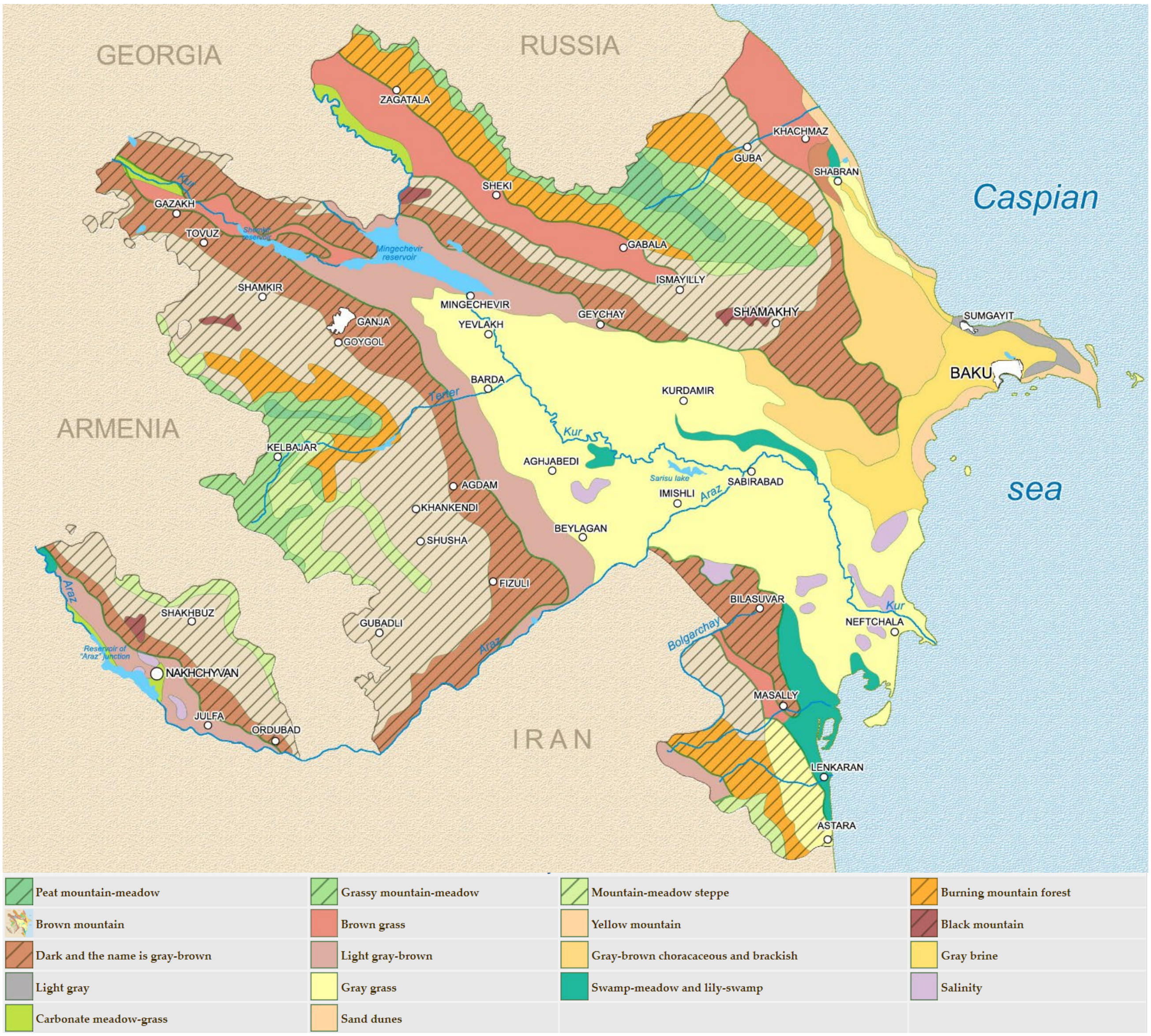


Figure 3.4: Land use and land cover map Azerbaijan (source: www.azerbaijan.az)

Global land-cover datasets have been downloaded from source the Environmental Systems Research Institute (ESRI) Sentinel-2 10m Land Use/Land Cover Time Series data set https://www.arcgis.com/apps/instant/media/index.html?appid=fc92d38533d440078f17678ebc20e8e2.

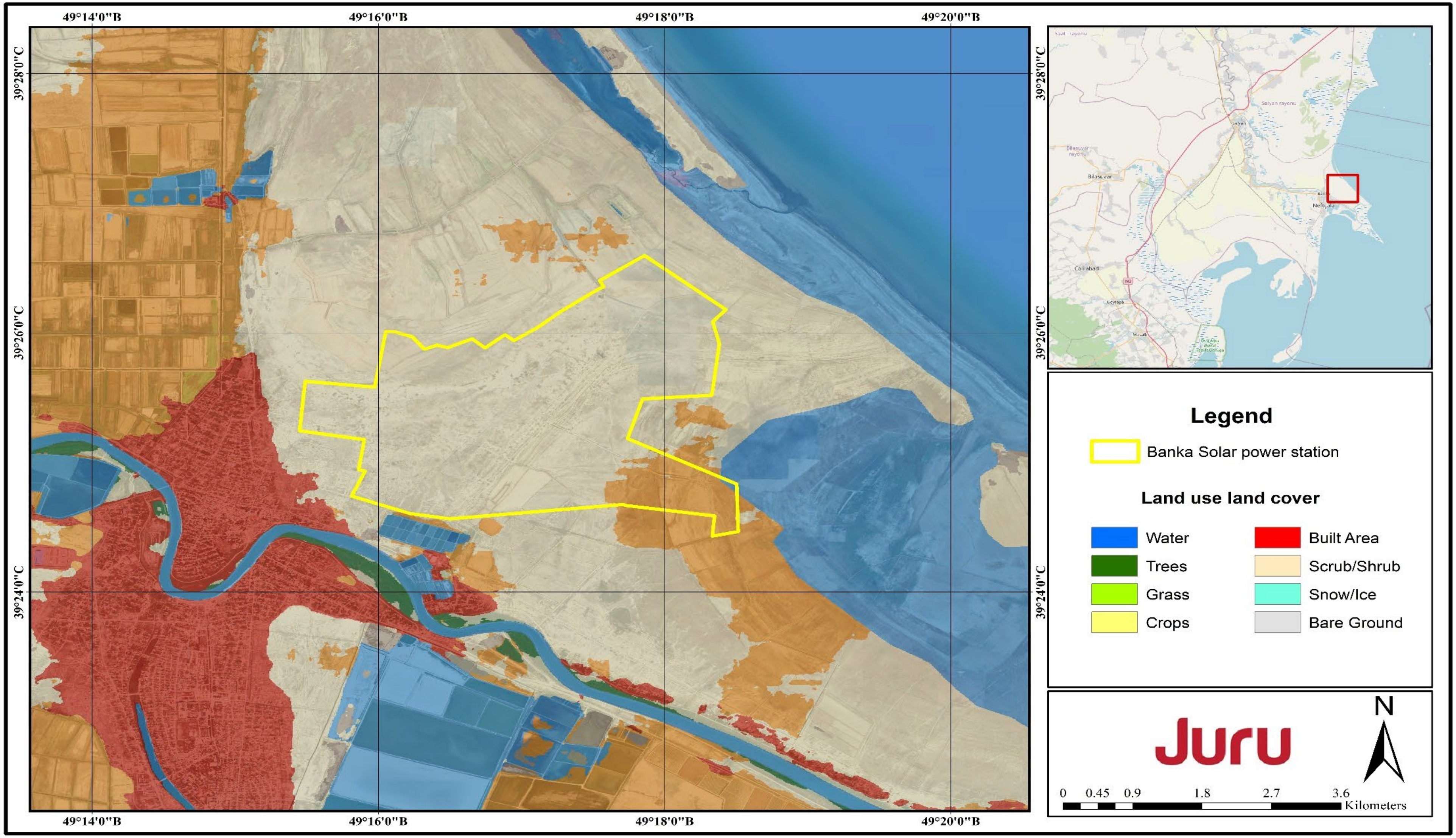


Figure 3.5: Land use and land cover map of the territory

3.5.4. FLOOD HYDROGRAPH DETERMINATION WITH INFILTRATION

In hydrological research, the direct rainfall method (DRM) is employed. DRM involves directly applying rainfall to the hydrodynamic surface-flow model. Advantages of this approach include the facilitation of cross catchment flows, a high definition of flow behavior in catchments, and the approach can replace the requirement for hydrological models within the 2D model domain. One of the most utilizable advantages of DRM method is to implement the infiltration of precipitation with relevant land cover and soil data for all meshes of basin.

For soil data, the Global Hydrological Soil Groups (HYSOGs250m) are used. This dataset represents hydrological soil group data set at a global scale with a spatial resolution of 250 m. According to this dataset, soil classes HSG-C: moderately high flow potential and HSG-C/D: undrained (<50% sand and 20-40% clay) dominate the region. Based on these data and relevant literature, suitable curves for different strata for the project area are presented. In addition, it should be noted that initial precipitation can also be determined for the infiltration layer.

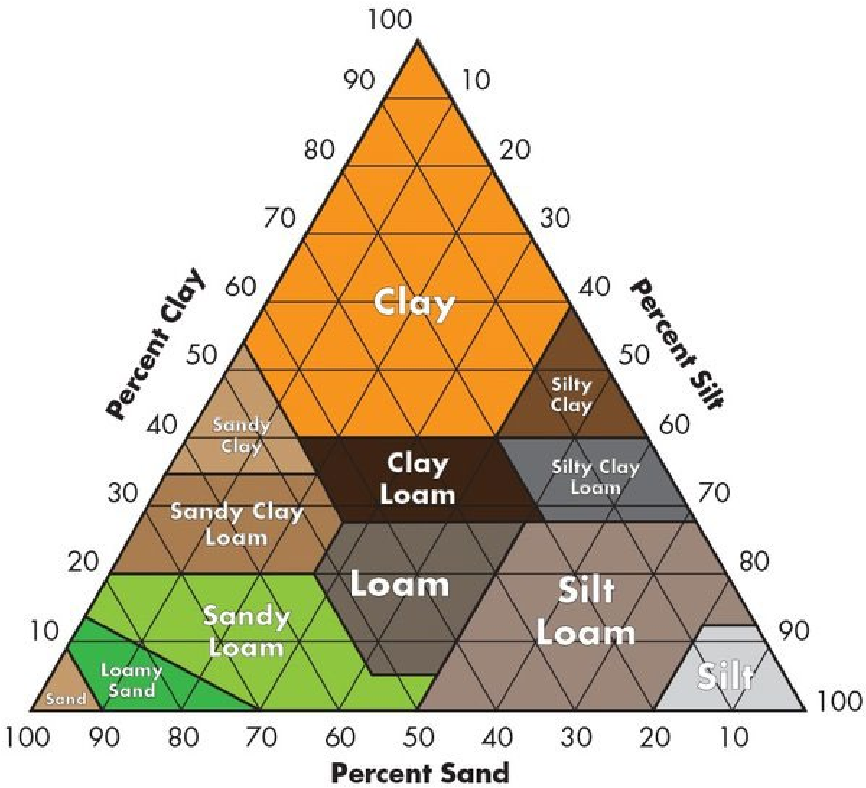


Figure 3.6: USDA soil textural triangle

HEC-RAS allows the user to create an infiltration layer with the Deficit Constant, Soil Conversation Service (SCS) Curve Number, and Green and Broad methods. The SCS curve number estimates the amount of precipitation that becomes runoff and the amount of infiltration into the soil. It is very useful and provides dynamically infiltrated excess precipitation in different layers obtained with knowledge of soil and land cover. In this study, the SCS Curve Number method is used to estimate the water depth and hydrographs for the project areas. The method requires a combination of soil and land cover infiltration, which allows calculation of layer curves.

Flood modeling was done using HEC-RAS 2D software. Full 2D modeling approach is used, taking into account the topographical characteristics and hydrodynamic response of wind farms. The workspace was generated from a Digital Surface Model (DSM) with a spatial resolution of 0.5 m.

Surface roughness parameters are normally categorized into three groups according to its functionality. These groups are defined as amplitude parameters, spacing parameters, and hybrid parameters.

The Gauckler–Manning coefficient, often denoted as n, is an empirically derived coefficient, which is dependent on many factors, including surface roughness and sinuosity.

A variable Manning roughness factor is applied to account for the geological formation, surface features and land use of the site using the above satellite products. The coefficient of roughness (n) is selected based on the data available in the literature. Roughness parameters have ranges, especially in a complex region such as cropland, even the type of crops and vegetation height can change the roughness parameters. To avoid these effects, average safe values of the ranges for the roughness parameters are chosen.

Manning's equation is an empirical formula estimating the average velocity of a liquid flowing in a conduit that does not completely enclose the liquid, open channel flow. However, this equation is also used for calculation of flow variables in case of flow in partially full conduits, as they also possess a free surface like that of open channel flow. All flow in so-called open channels is driven by gravity.

3.5.5. RAINFALL INTENSITY-DURATION-FREQUENCY DEFINITION

The rainfall intensity duration frequency (IDF) curves are graphical representations of the probability that a given average rainfall intensity will occur within a given period of time.

Providing mathematical relationship between the rainfall intensity, the duration, and the return period (or equivalent to the annual frequency of exceedance), the IDF curves allow for the estimation of the return period of an observed rainfall event or conversely of the rainfall intensity corresponding to a given return period. The deriving procedure of IDF curves involves utilization of long-term historical rainfall observations.

Tables 3.2, 3.3 and 3.4 below show the distribution parameters of rainfall observed at the Neftchala meteorological station for 3 hours, 12 hours and 24 hours.

Table 3.2: Distribution parameters of the maximum 3 hour and daily Rainfall for mm.

Range	Year	Maximum 3-hour rainfall, mm	P_{Pr}	$-\ln(P_{Pr})$	$-\ln(-\ln(P_{Pr}))$
1	2017	12.3	0.0186	3.9850	-1.3825
2	2000	13.2	0.0518	2.9605	-1.0854
3	1994	13.7	0.0850	2.4652	-0.9023
4	2008	13.7	0.1182	2.1354	-0.7587
5	1993	16.2	0.1514	1.8879	-0.6354
6	2001	16.8	0.1846	1.6896	-0.5245
7	2002	18.5	0.2178	1.5242	-0.4215
8	1992	18.6	0.2510	1.3823	-0.3238
9	1995	20.1	0.2842	1.2581	-0.2296
10	2003	20.6	0.3174	1.1476	-0.1377
11	1997	21.3	0.3506	1.0481	-0.0470
12	2007	21.4	0.3838	0.9576	0.0433
13	2004	22.8	0.4170	0.8747	0.1339
14	2021	23.0	0.4502	0.7981	0.2256
15	2014	23.2	0.4834	0.7269	0.3190
16	2010	23.4	0.5166	0.6605	0.4148
17	2018	23.6	0.5498	0.5982	0.5138
18	2020	24.0	0.5830	0.5396	0.6170

Range	Year	Maximum 3-hour rainfall, mm	P_{Pr}	$-\ln(P_{Pr})$	$-\ln(-\ln(P_{Pr}))$
19	2019	25.8	0.6162	0.4842	0.7253
20	1998	26.7	0.6494	0.4317	0.8400
21	2006	27.7	0.6826	0.3818	0.9627
22	2012	27.8	0.7158	0.3343	1.0956
23	1996	28.7	0.7490	0.2890	1.2413
24	1999	28.7	0.7822	0.2456	1.4039
25	2009	31.2	0.8154	0.2041	1.5893
26	2013	39.7	0.8486	0.1642	1.8069
27	2015	40.2	0.8818	0.1258	2.0732
28	2016	41.2	0.9150	0.0888	2.4211
29	2005	47.7	0.9482	0.0532	2.9340
30	2011	60.1	0.9814	0.0188	3.9756

Table 3.3: Distribution parameters of the maximum 12 hour and daily Rainfall for mm.

Range	Year	Maximum 12-hour rainfall, mm	P_{Pr}	$-\ln(P_{Pr})$	$-\ln(-\ln(P_{Pr}))$
1	2007	24.4	0.0186	3.9850	-1.3825
2	2000	25.1	0.0518	2.9605	-1.0854
3	1998	30.5	0.0850	2.4652	-0.9023
4	1999	32.8	0.1182	2.1354	-0.7587
5	2009	35.6	0.1514	1.8879	-0.6354
6	2017	38.4	0.1846	1.6896	-0.5245
7	2001	39.2	0.2178	1.5242	-0.4215
8	2002	39.6	0.2510	1.3823	-0.3238
9	1995	41.9	0.2842	1.2581	-0.2296
10	2008	43.0	0.3174	1.1476	-0.1377
11	2003	44.1	0.3506	1.0481	-0.0470
12	1996	44.3	0.3838	0.9576	0.0433
13	2013	44.5	0.4170	0.8747	0.1339
14	2015	45.0	0.4502	0.7981	0.2256
15	1993	46.7	0.4834	0.7269	0.3190
16	2018	46.8	0.5166	0.6605	0.4148
17	2010	47.1	0.5498	0.5982	0.5138

Range	Year	Maximum 12-hour rainfall, mm	P_{Pr}	$-\ln(P_{Pr})$	$-\ln(-\ln(P_{Pr}))$
18	2004	48.8	0.5830	0.5396	0.6170
19	2014	49.2	0.6162	0.4842	0.7253
20	2020	50.9	0.6494	0.4317	0.8400
21	2019	54.7	0.6826	0.3818	0.9627
22	1994	54.8	0.7158	0.3343	1.0956
23	1997	57.8	0.7490	0.2890	1.2413
24	2006	58.7	0.7822	0.2456	1.4039
25	2012	58.9	0.8154	0.2041	1.5893
26	1992	59.3	0.8486	0.1642	1.8069
27	2011	60.1	0.8818	0.1258	2.0732
28	2005	77.3	0.9150	0.0888	2.4211
29	2016	91.8	0.9482	0.0532	2.9340
30	2021	114.8	0.9814	0.0188	3.9756

Table 3.3: Distribution parameters of the maximum 24 hour and daily Rainfall for mm.

Range	Year	Maximum daily rainfall, mm	P_{Pr}	$-\ln(P_{Pr})$	$-\ln(-\ln(P_{Pr}))$
1	2018	46.8	0.0186	3.9850	-1.3825
2	2001	50.2	0.0518	2.9605	-1.0854
3	2000	51.5	0.0850	2.4652	-0.9023
4	2017	51.8	0.1182	2.1354	-0.7587
5	1993	58.8	0.1514	1.8879	-0.6354
6	1995	58.9	0.1846	1.6896	-0.5245
7	1997	59.2	0.2178	1.5242	-0.4215
8	1994	61.8	0.2510	1.3823	-0.3238
9	2003	61.9	0.2842	1.2581	-0.2296
10	1998	64.4	0.3174	1.1476	-0.1377
11	2008	64.4	0.3506	1.0481	-0.0470
12	1996	67.9	0.3838	0.9576	0.0433
13	1992	69.4	0.4170	0.8747	0.1339
14	2007	72.9	0.4502	0.7981	0.2256
15	2010	72.9	0.4834	0.7269	0.3190

Range	Year	Maximum daily rainfall, mm	P_{Pr}	$-\ln(P_{Pr})$	$-\ln(-\ln(P_{Pr}))$
16	2015	73.4	0.5166	0.6605	0.4148
17	2020	73.8	0.5498	0.5982	0.5138
18	2019	81.6	0.5830	0.5396	0.6170
19	2002	86.3	0.6162	0.4842	0.7253
20	2012	86.3	0.6494	0.4317	0.8400
21	1999	90.2	0.6826	0.3818	0.9627
22	2005	94.6	0.7158	0.3343	1.0956
23	2014	97.6	0.7490	0.2890	1.2413
24	2021	99.4	0.7822	0.2456	1.4039
25	2013	101.9	0.8154	0.2041	1.5893
26	2009	103.2	0.8486	0.1642	1.8069
27	2004	104.4	0.8818	0.1258	2.0732
28	2016	107.6	0.9150	0.0888	2.4211
29	2011	117.9	0.9482	0.0532	2.9340
30	2006	195.2	0.9814	0.0188	3.9756

The data in the above table was analyzed according to the laws of distribution and the distribution probabilities were determined. The EVA analysis was carried out assuming a Gumbel distribution with a method of moments (MoM) estimator.

Due to the unavailability of observed rainfall data for time intervals smaller than 3 hours, an extrapolation adjustment was made. As a result of this extrapolation adjustment, it was possible to determine the values of precipitation amount up to the amount that can fall in an interval of up to 30 minutes.

The distribution of actual 10-minute maximum rainfall over time was calculated using the coefficients given in SN-63-76, “Guidelines for the Analysis of Storm Water Runoff from Small Reservoirs”.

Figure 3.2 below shows a plot of observed precipitation versus logarithmic distribution parameters.

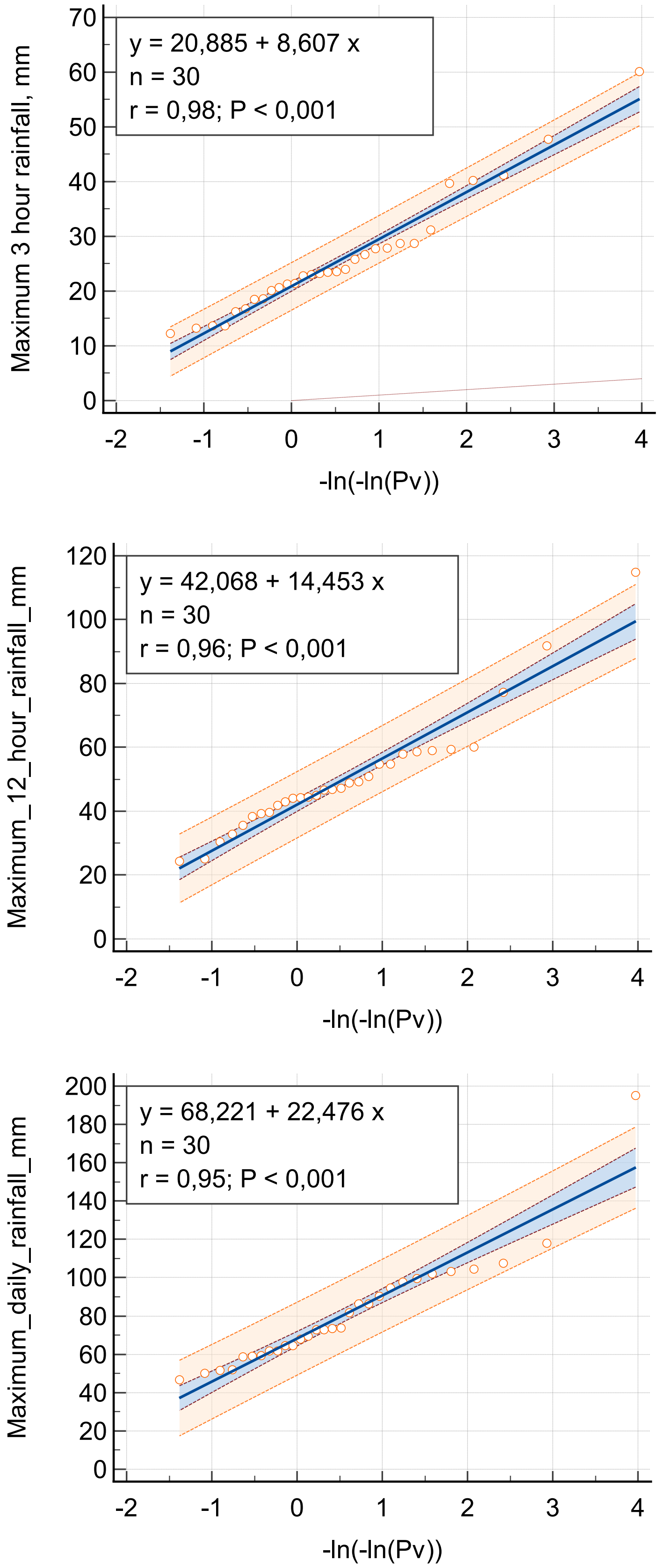


Figure 3.7: Extreme Value Type I distribution of maximums 3-hour, 12 hour and daily rainfall

Table 3.4: The Rainfall Depth Duration Frequency for Neftchala meteorological station, mm

Return period, year	AEP, %	EV Factor	Rainfall depth in mm.		
			3 hour	12 hour	24 hour
2	0.5	0.3665	24.0	47.4	76.5
5	0.8	1.4999	33.8	63.8	101.9
10	0.9	2.2504	40.2	74.6	118.8
20	0.95	2.9702	46.4	85.0	135.0
50	0.98	3.9019	54.5	98.5	155.9
100	0.99	4.6001	60.5	108.6	171.6

Rainfall analysis was performed to generate intensity duration frequency (IDF) and depth duration frequency (DDF) curves needed to estimate rainfall depth for different event durations and frequencies. Determining design phenomena for further analysis, such as surface flow rates, attenuation volume requirements, and designing drainage components requires information from the IDF curve.

The Intensity Duration Frequency values of the final precipitation are shown in Table 3.5

Table 3.5: Intensity Duration Frequency, Rainfall intensity for mm/hour

Duration, hour	Return Period, years					
	2	5	10	25	50	100
0.5	23.8	27.1	32.0	36.7	41.3	46.4
1	18.4	20.9	24.7	28.3	31.9	35.8
2	10.1	13.7	16.2	18.6	20.9	23.5
3	8.0	11.3	13.4	15.5	18.2	20.2
12	4.0	5.3	6.2	7.1	8.2	9.1
24	3.2	4.2	5.0	5.6	6.5	7.2

4. FLOOD HYDRAULIC MODEL RESULTS

The software used to perform the hydraulic simulation has been HEC-RAS in version 6.1. HEC-RAS is a numerical model of simulation of turbulent flow in free flow and non-permanent regime conditions, and of environmental processes in river hydraulics. The hydrodynamic module, which is the basis of HEC-RAS, solves the two-dimensional shallow water averaged in depth equations.

Flood maps of the area were developed based on the results of hydraulic modeling. Flood levels are assessed using the following flood index criteria. Flood risk is identified by criteria in the table below.

Table 4.1: Flood Hazard Index classes

Flood Hazard Index	Flood depth, m	Flood Velocity, m/s	Classification
H1	<0.5	<0.2	Very low
H2	0.5-1.0	0.2-0.5	Low
H3	1.0-2.0	0.5-1.0	Medium
H4	2.0-5.0	1.0-3.0	High
H5	>5.0	>3.0	Extreme

Flood Hazard Index H1 does not cause inconvenience to people's lives, transportation, and detailed operation of buildings and power lines. The depth of the flood water is up to 0.5 meters and the speed is up to 0.2 m/sec.

Flood Hazard Index H2 causes inconvenience to people's lives, transport supply and detailed operation of buildings and power lines. In this case, the depth of the flood water is up to 1.0 meters and the speed is up to 0.5 m/sec.

Flood Hazard Index H3 prevents people's lives, transportation, and the detailed operation of buildings and power lines. In this case, the depth of the flood water is up to 2.0 meters and the speed is up to 1.0 m/sec.

Flood Hazard Index H4 and H5 pose a threat to human life, the transport system is completely disrupted, and buildings and structures are destroyed.

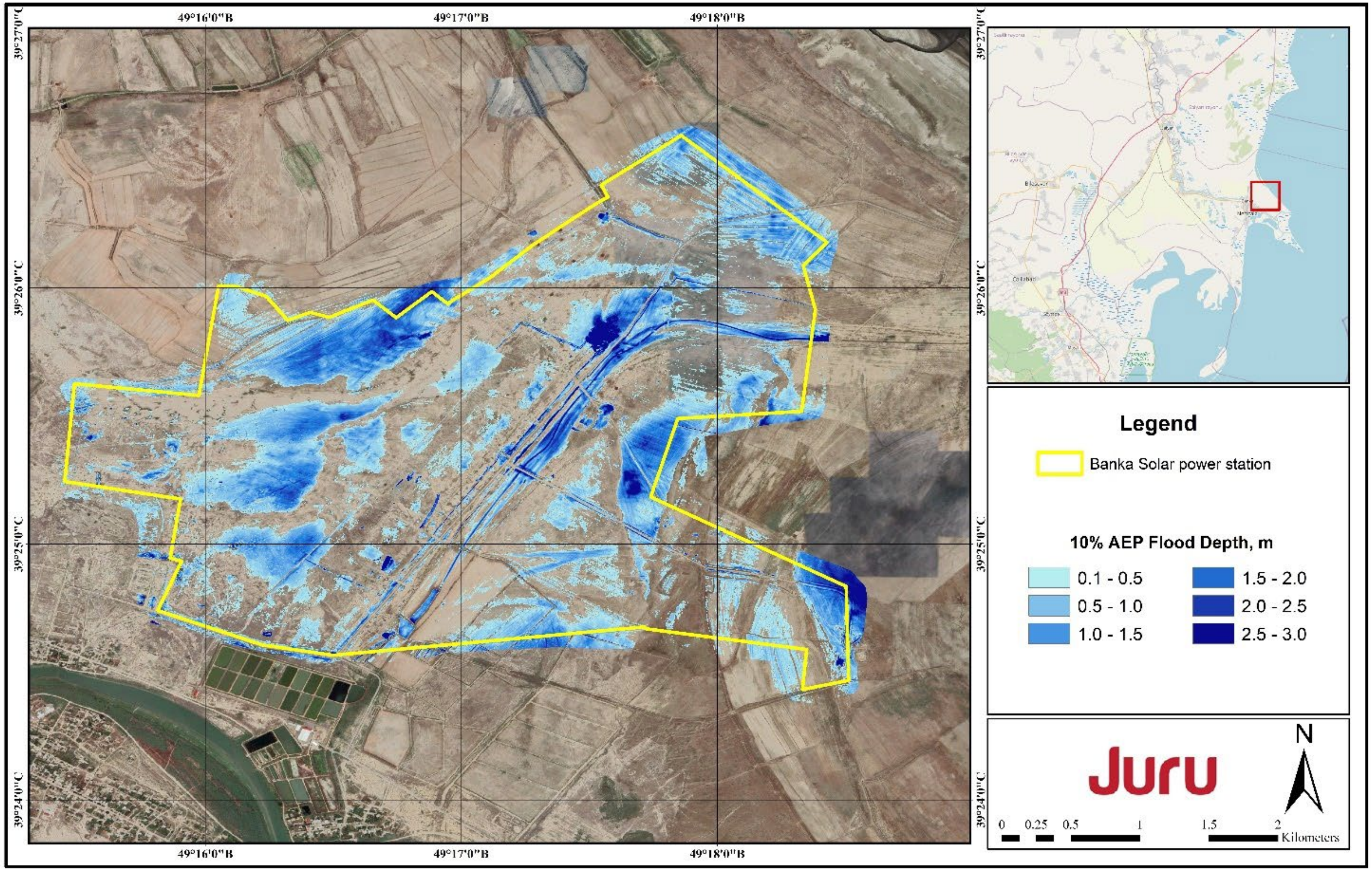


Figure 4.1: Modeling results 10% AEP Flood Depth Map (Return period for 10 years)

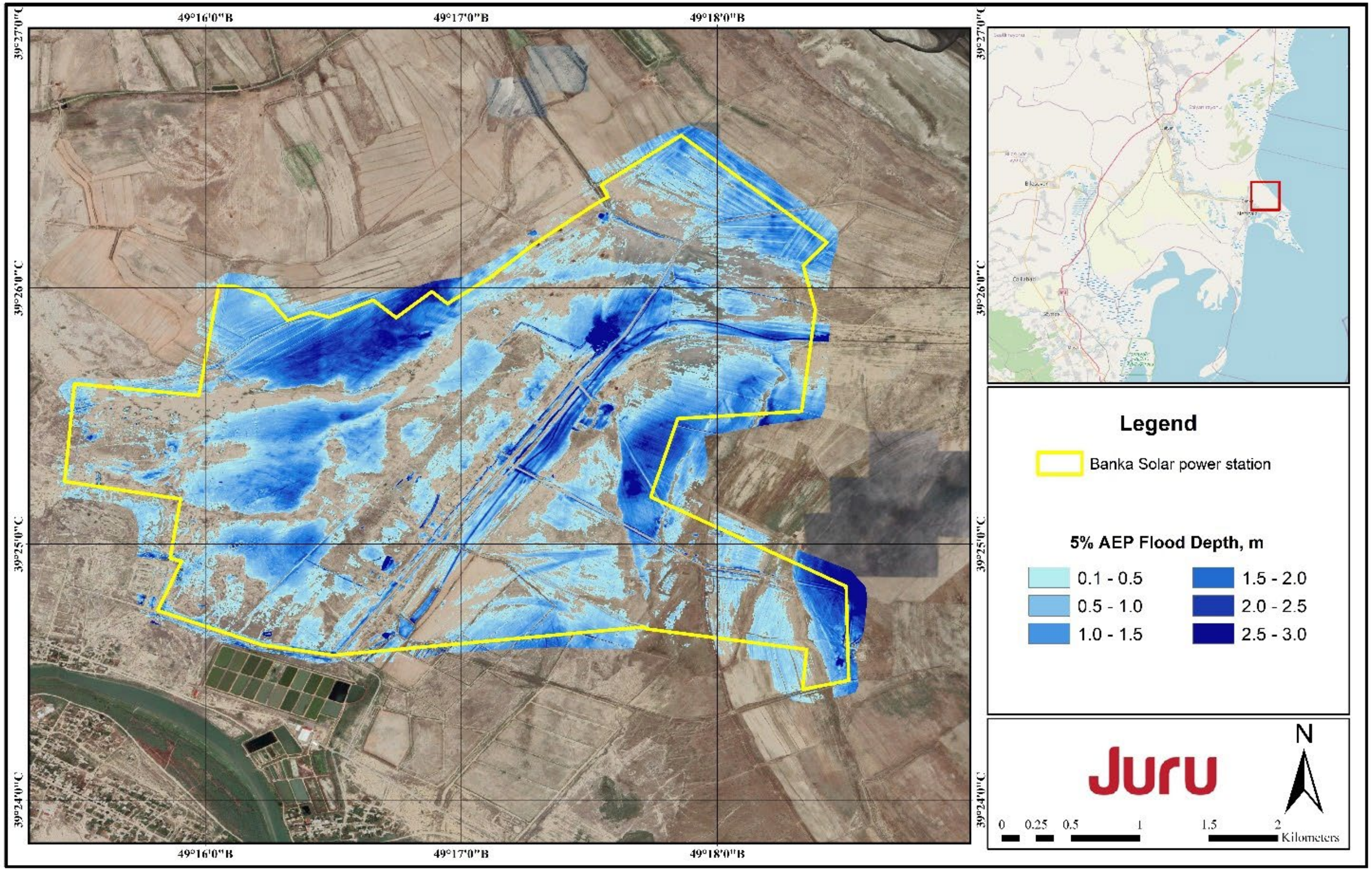


Figure 4.2: Modeling results 5% AEP Flood Depth Map (Return period for 20 years)

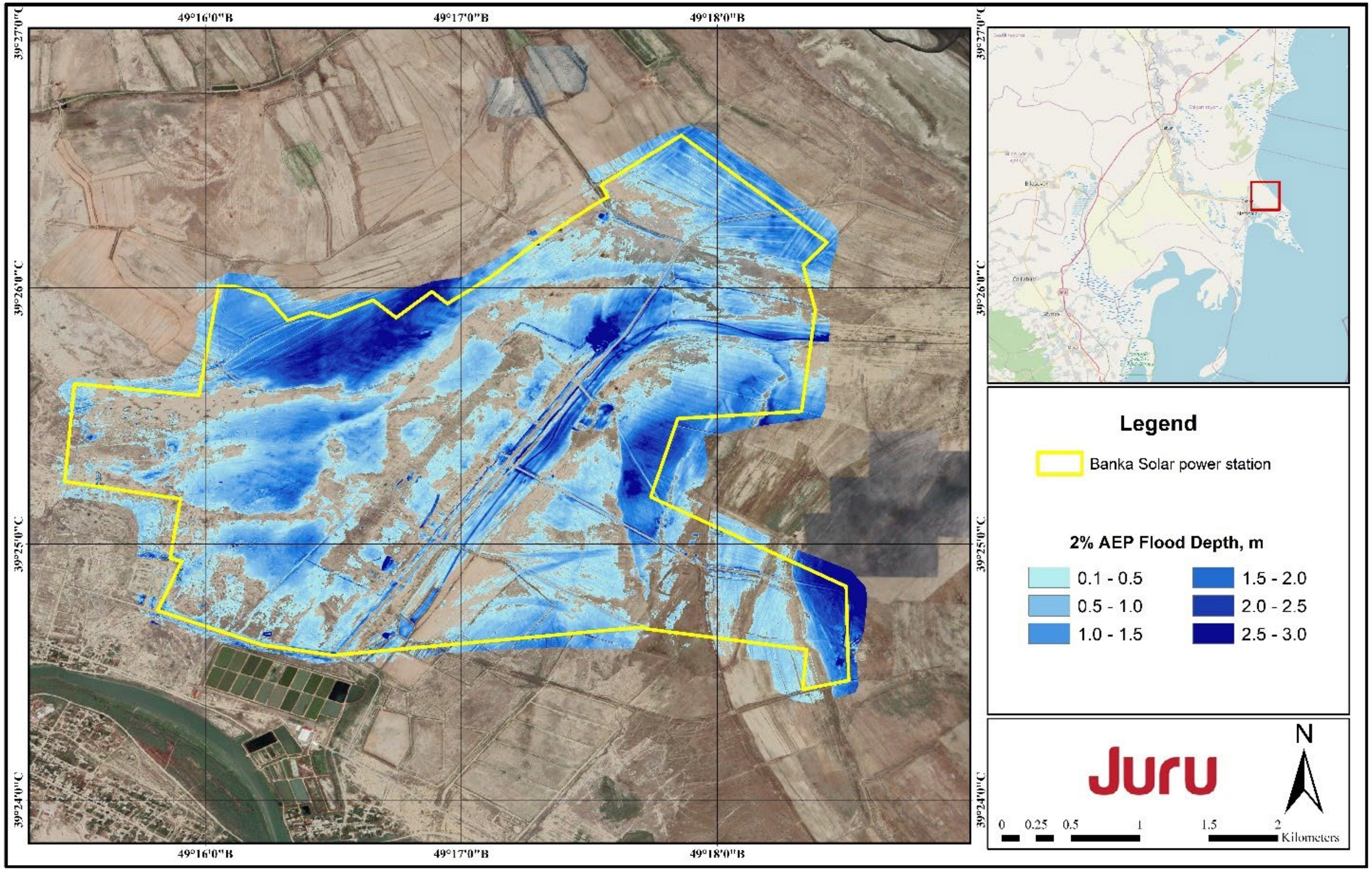


Figure 4.2: Modeling results 2% AEP Flood Depth Map (Return period for 50 years)

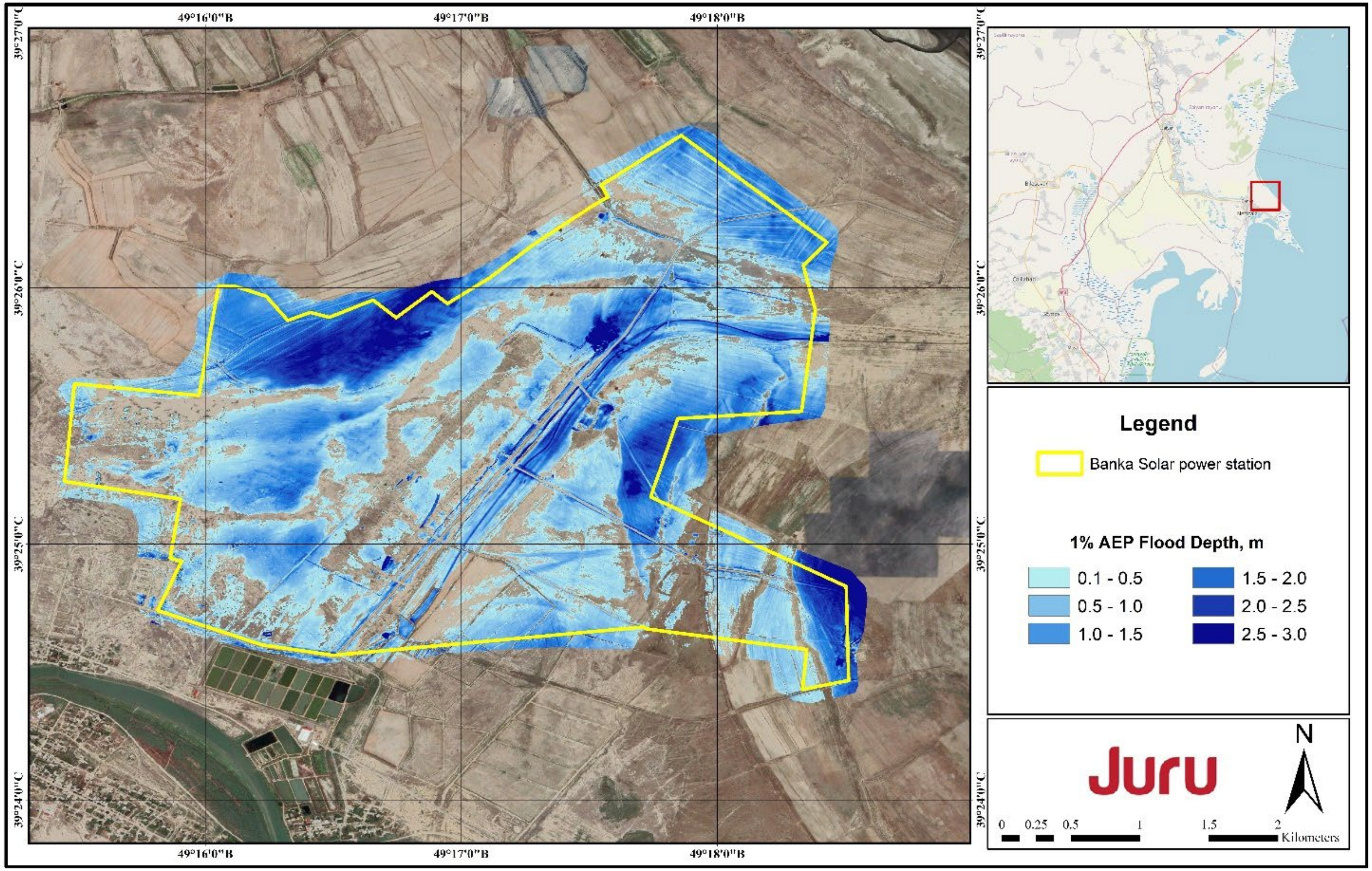


Figure 4.3: Modeling results 1% AEP Flood Depth Map (Return period for 100 years)

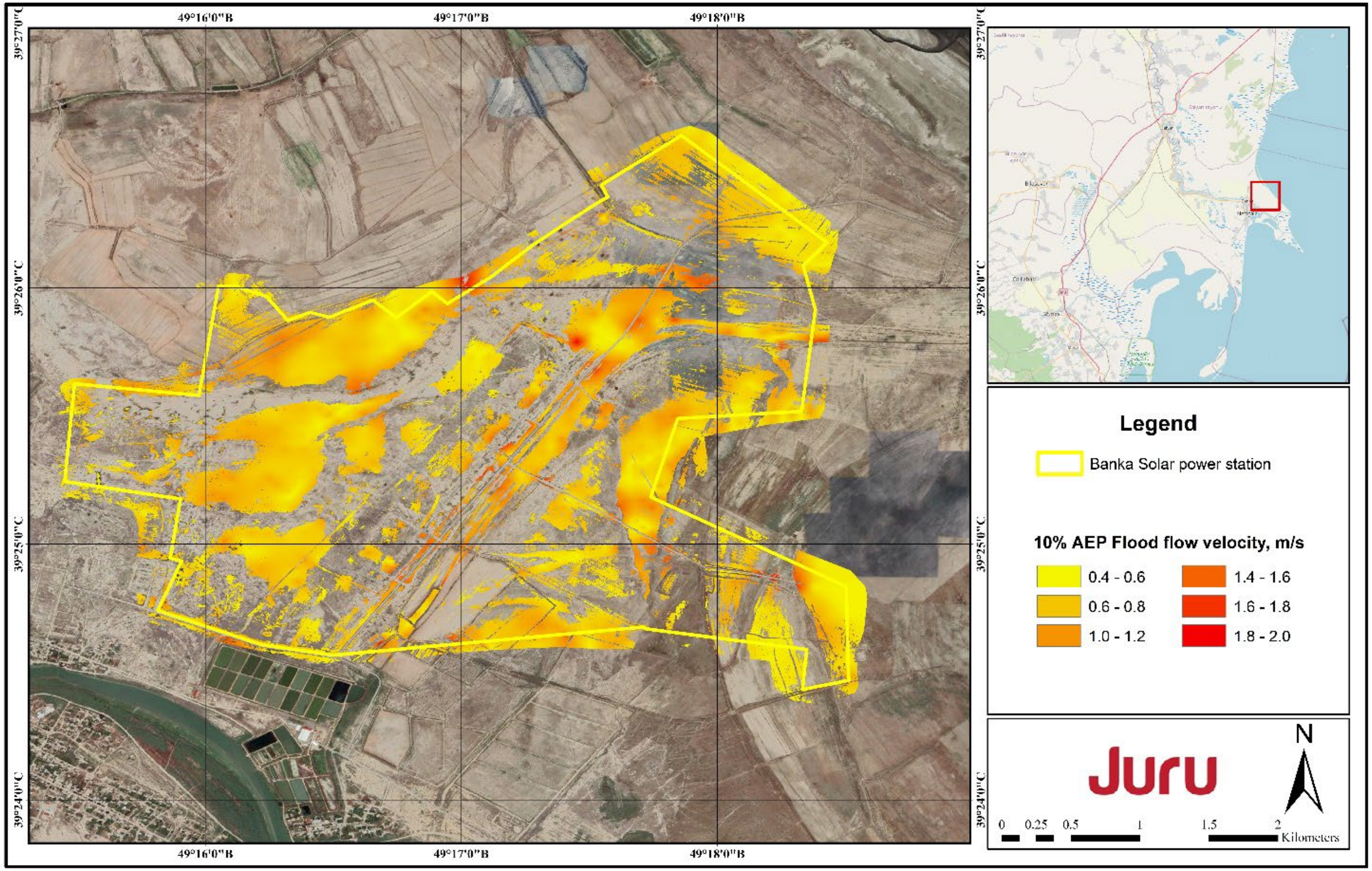


Figure 4.4: Modeling results 10% AEP Flood Velocity Map (Return period for 10 years)

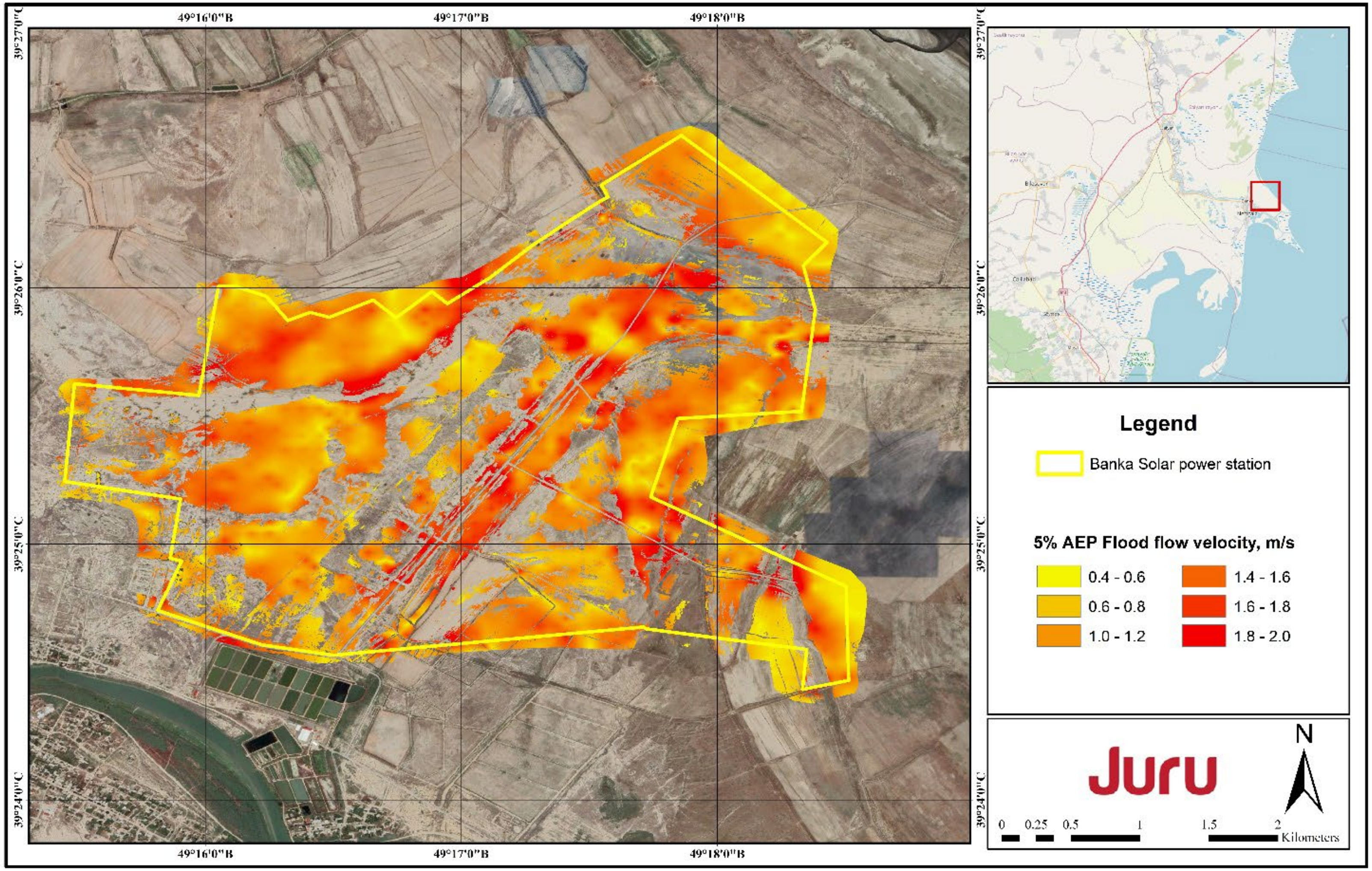


Figure 4.6: Modeling results 5% AEP Flood Velocity Map (Return period for 20 years)

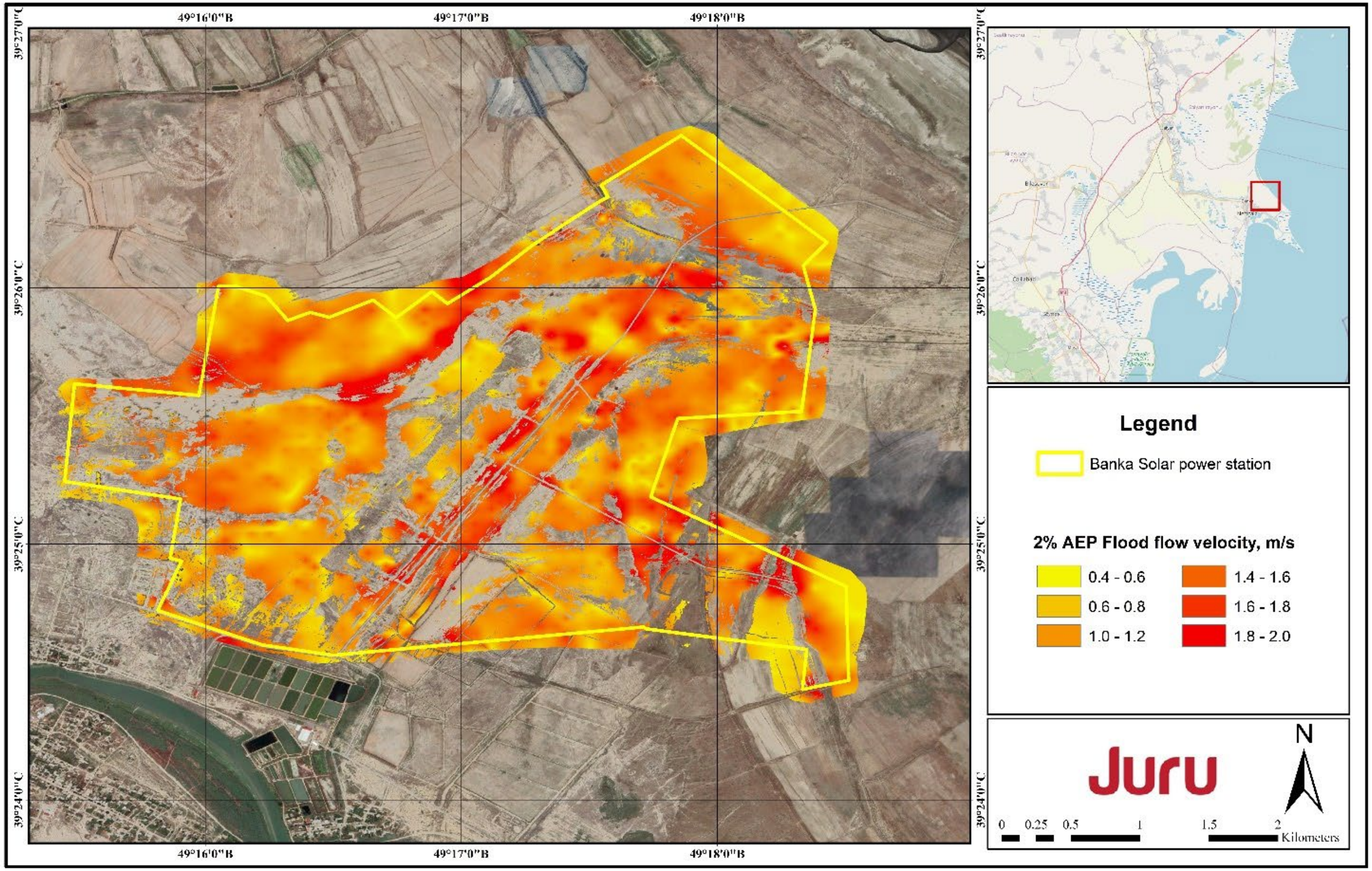


Figure 4.7: Modeling results 2% AEP Flood Velocity Map (Return period for 50 years)

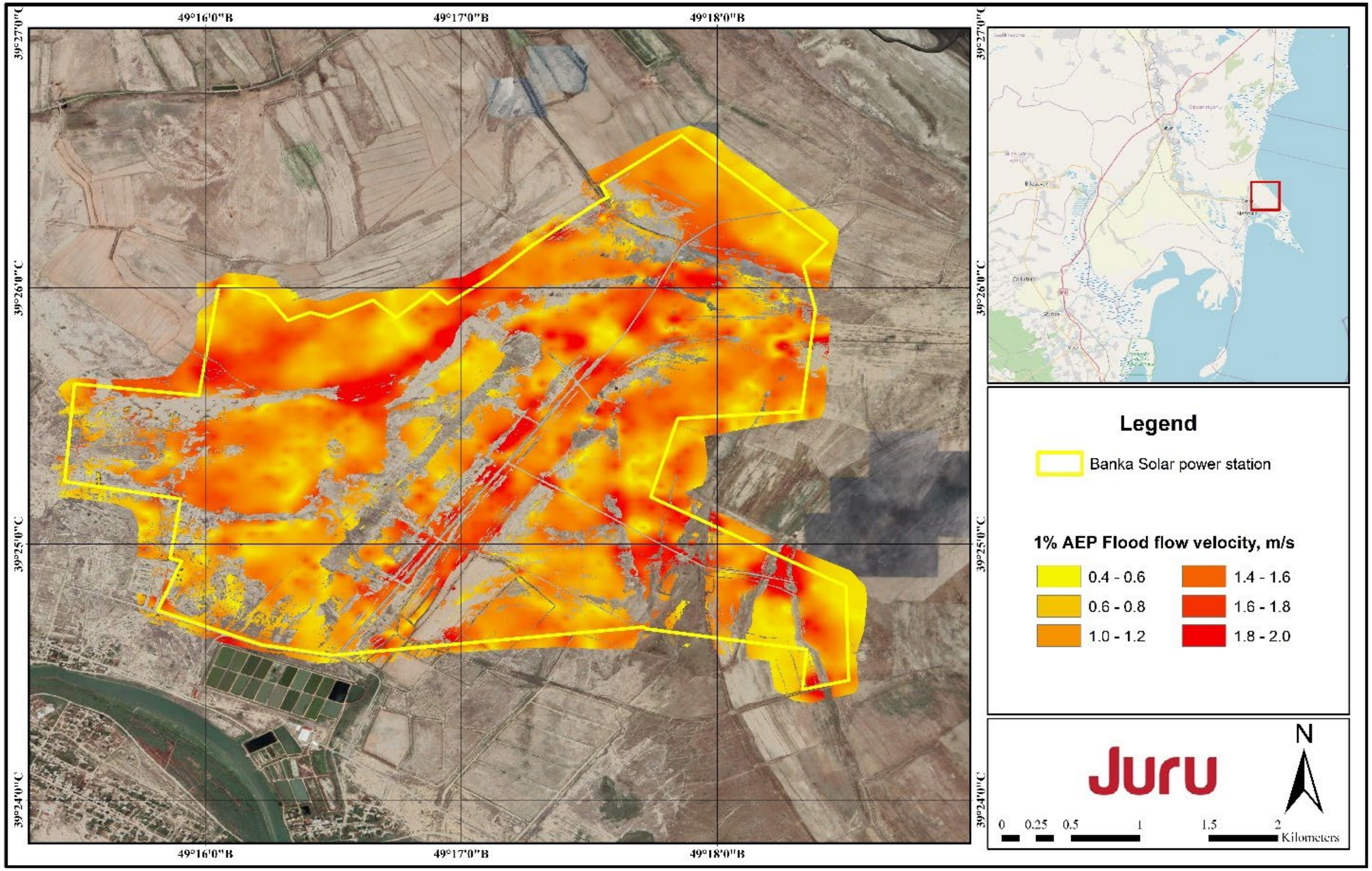


Figure 4.8: Modeling results 1% AEP Flood Velocity Map (Return period for 100 years)

5. COASTAL FLOODING

The purpose of coastal inundation modeling is to provide a technical basis for determining coastal inundation risk and for planning land use in the project area against flood development. Flood mapping is an important first step in developing a flood risk management plan, as flood plain maps identify flood hazards and provide information on the spatial distribution of flood construction levels.

Historically, the main causes of coastal flooding have been attributed to astronomical (waves) and meteorological factors (storms). Inundation risk assessments associated with waves and storm surges are usually based on an assumption of stationary mean sea level.

The coastal Flood Construction Level can be estimated as the sum of the following components:

- ✓ the higher high-water level tide elevation;
- ✓ an allowance for future sea level rise, tied to a particular time horizon, such as 2100;
- ✓ the estimated storm surge associated with the selected design storm;
- ✓ the estimated wave effect associated with the design storm.

The figure below shows the conceptual basis of coastal flooding.

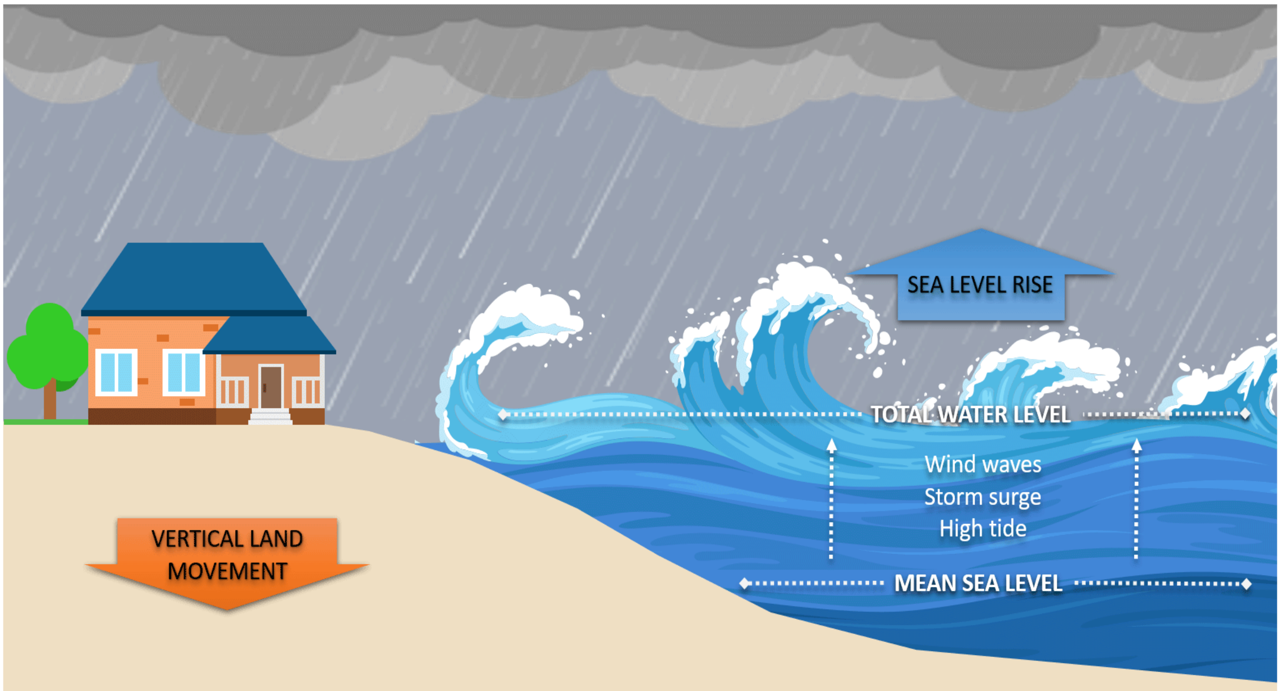


Figure 5.1: Conceptual basis of coastal flooding

6. CASPIAN SEA LEVEL RISE

According to the latest report of the Intergovernmental Panel on Climate Change (IPCC), ongoing climate change processes will lead to a rise in MSL in the medium term. This sea level rise should be taken into account as it corresponds to the lifetime of the Banka solar power plant.

Systematic observations of water levels in the Caspian Sea began in 1837. As measurements have shown, over the first century (until 1930) the sea level remained almost unchanged, fluctuating between minus 25 and minus 26 meters. Between 1929 and 1941 there was a sharp decrease of almost two meters (from minus 25.88 to minus 27.84 m). Subsequently, over the next thirty-seven years, the sea, either increasing or decreasing in its level, slowly fell, reaching its lowest point during measurements in 1977 - minus 29.01 m.

The continuous decrease in its background level, observed in 1930-1977, was 3.2 m with an average intensity of about 4 cm/year. Starting from 1979, the level of the Caspian Sea began to rise sharply and during the period from 1979 to 1991. rose by 2.35 m with an average intensity of about 14.3 cm/year.

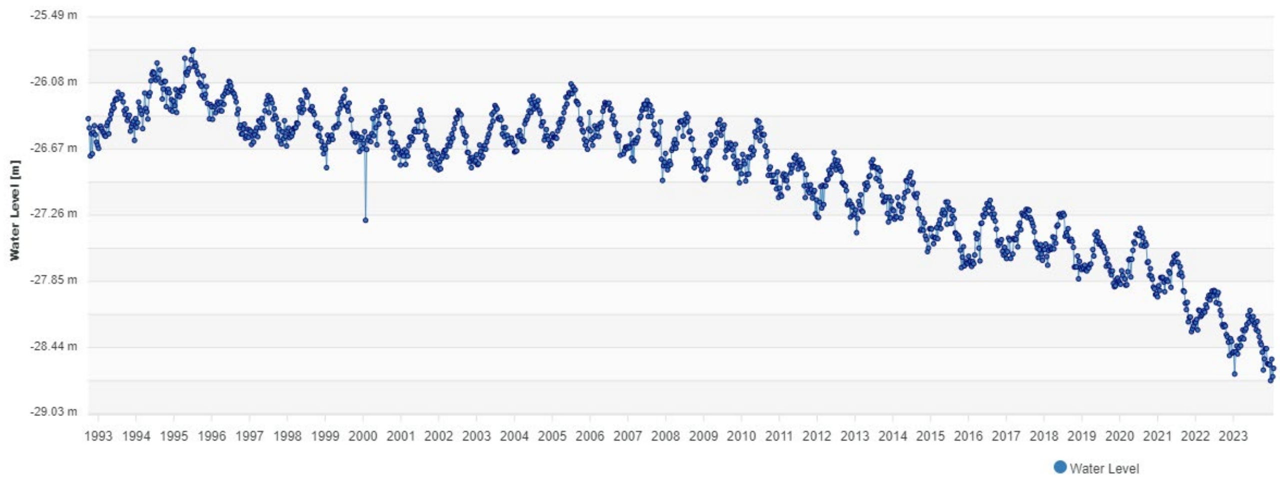


Figure 5.2: Caspian Sea water level change graph

In subsequent years, the average sea level dropped by almost 50 cm, reaching minus 27.17 m in 2001. From 2001 to the present, the level began to rise again: in 2002 by 2 cm, in 2003 by 4 cm, in 2004 by 8 cm, in 2005 by 12 cm. At the moment, the level of the Caspian Sea has reached 27.0 m.

The results of studying atmospheric processes and global climate changes make it possible to assume that by 2015 sea level will rise by 1 m from the current absolute level.

The sea level assessment document near the study site analyzes several scenarios and concludes that the MSL rise in 2100 will be -0.20 m.

Conditions	Current (2023), m	Climate Change (2100), m
Maximum sea level rise	-25.8	-25.6
Minimum sea level rise	-28.7	-28.5
Maximum sea level rise (T = 100 years)	-24.2	-24.0

6.1. TIDAL WATER LEVELS

In the practice of designing offshore structures, the design characteristics of hydrometeorological phenomena that are possible once every N year are usually considered as extreme, where N years corresponds to the class of the structure.

The tidal range in this part of the Caspian Sea is relatively small, with spring tide ranges (most extreme tidal range) up to 0.4 m.

Taking into account the astronomical tide levels from Atlas of waves and winds of the Middle and Southern Caspian Sea Maps with seasonal variations and meteorological tide (or surge) from real observations, design water levels are.

Table 5.1: Tidal Water Levels in Caspian Sea

Conditions	Level above Chart Datum, m	Meters above Mean Sea Leve, m
Highest Meteorological Tide	0.4	-26.5
Highest Astronomical Tide	0.7	-26.2
Mean Sea Level	0.0	-26.9

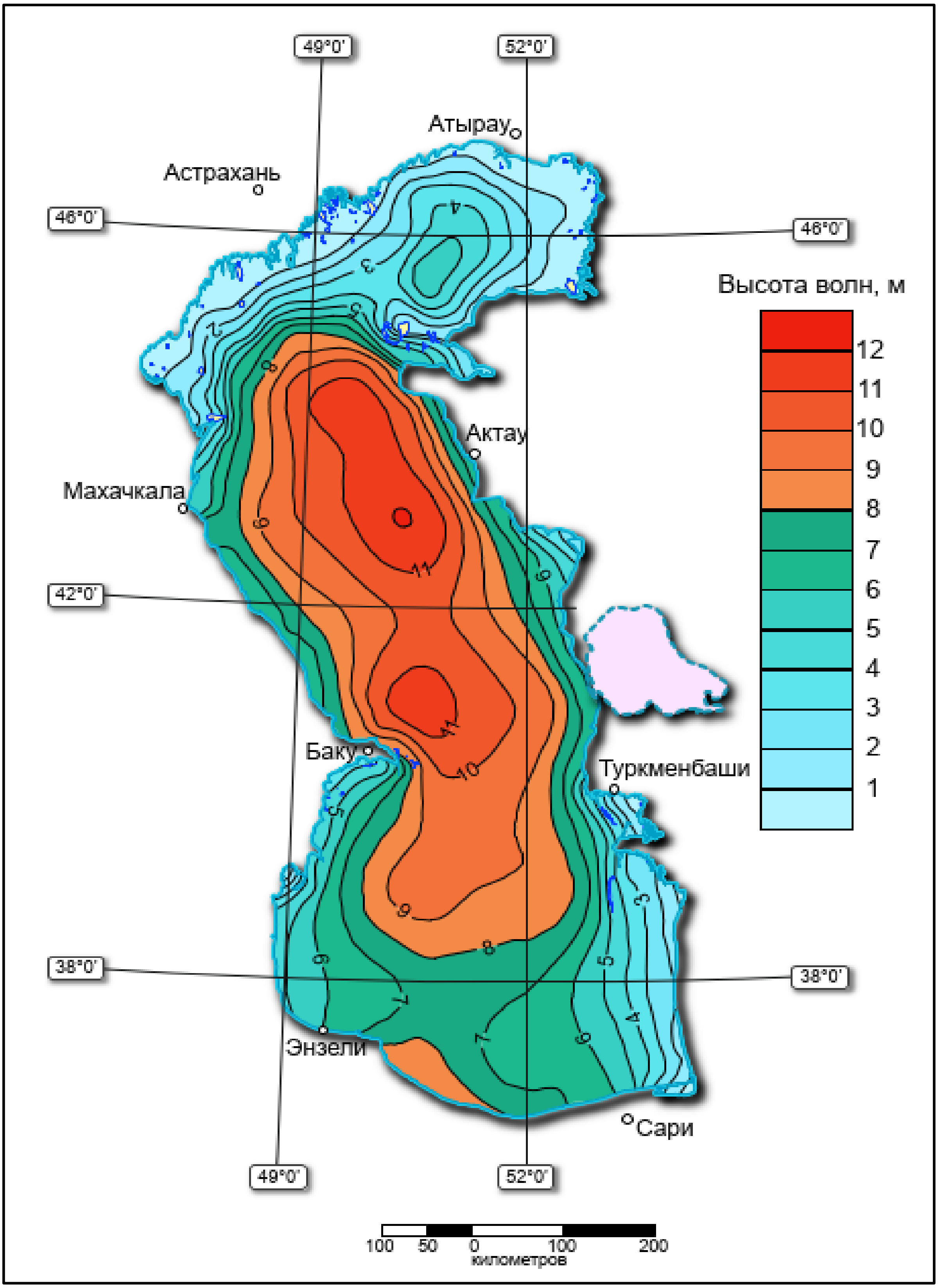


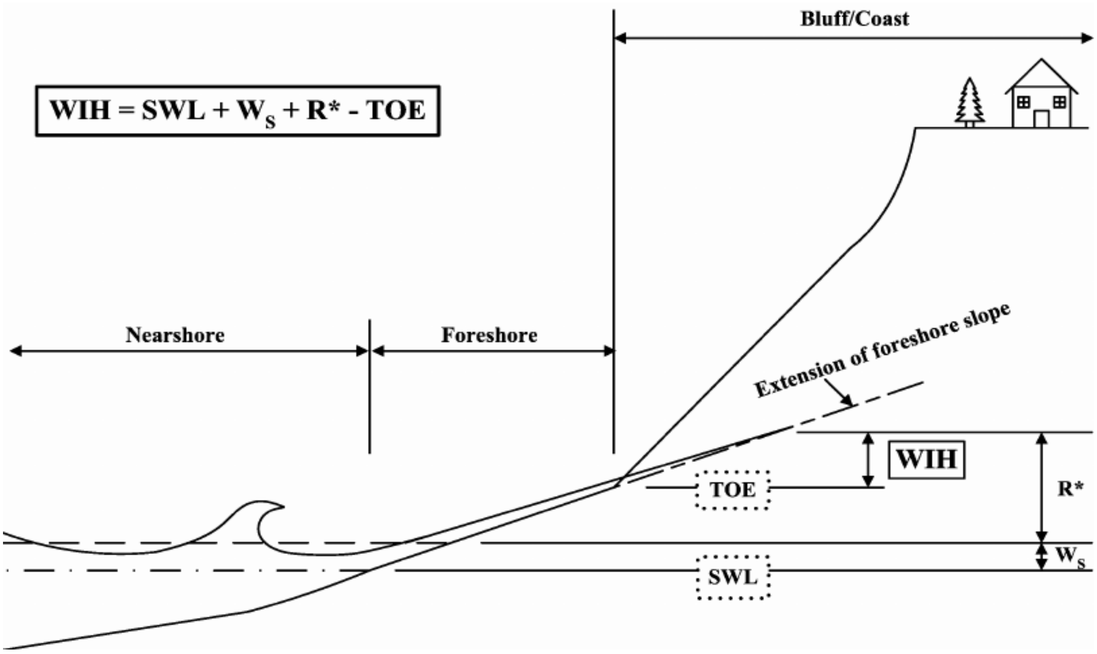
Figure 5.3: Wave height map in the Caspian Sea (source: Atlas of waves and winds of the Caspian sea)

6.2. WAVE RUN UP PREDICTION

Coastal flood hazards originate from a variety of sources and combinations of sources including tides, storm surges, waves, seiches, rainfall, river flows and tsunamis.

The maximum elevation of wave uprush on the shore above the still water level. Wave uprush consists of two components: superelevation of the mean water level due to wave action (wave set-up) and fluctuations about that mean (swash).

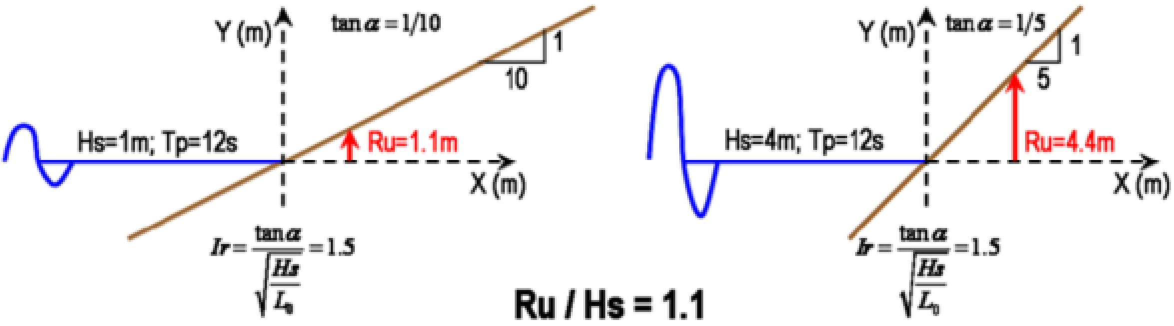
The maximum vertical extent of wave uprush on the beach above the still water level is known as wave Run-up.



$$WAVE(1.2) = SWL(-26.9) + W_S(0.4) + R(0.5) - TOE(-24.0)$$

There is a fixed ratio that links the Run-up with the significant wave height, due to the Iribarren parameter.

The probability of this coastal flooding event is, actually, much lower than a 100 years period return event, since several conditions (maximum seasonal tide, maximum meteorological tide and expected sea level rise in 2100) with their own success probability are required. These two maximum water levels are considered as safety limits for solar power plant design.



$$\boldsymbol{RUN\ UP(1.3) = 1.1 * WAVE(1.2)}$$

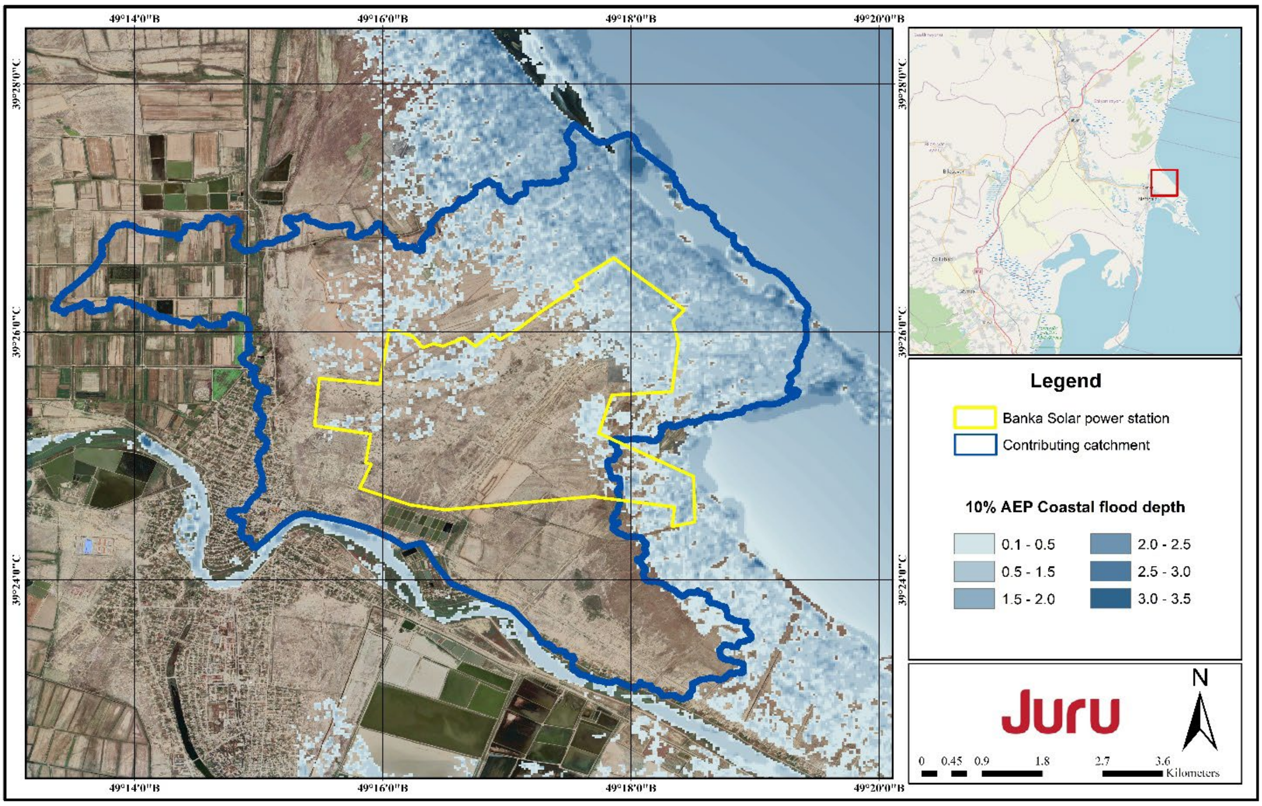
The maximum water level because of coastal flooding due to a 10, 50- and 100-years period return wave event in deep waters with specific direction, is composed by the following parameters:

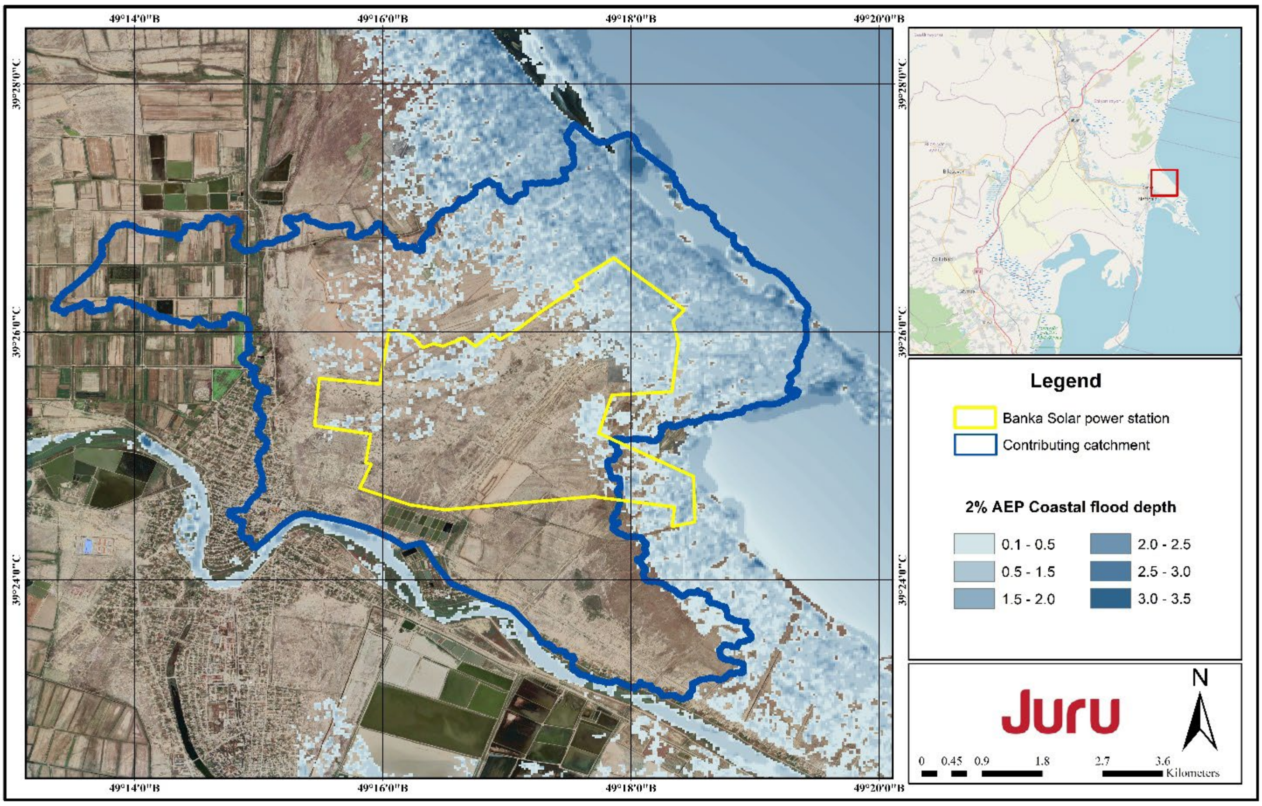
Conditions	10 years	50 years	100 years
Maximum sea level rise	-25.8	-25.7	-25.6
Maximum seasonal tide above MSL	-26.2	-26.1	-25.9
Maximum meteorological tide	-26.5	-26.1	-25.7
Mean Sea Level (Run up)	-25.2	-24.8	-24.4

According to the results of the above analysis, the flood risk of the Caspian Sea water to the planned Banka solar power plant is -24.4 meters for 100-year probability. The time of rise and fall of the water level for the Caspian sea is 3 hours under the influence of astronomical factors.

6.3. RESULTS OF COASTAL FLOOD SIMULATION

In order to calculate coastal flood loads for a specific building and site, the Design Stillwater Depth needs to be determined. This is the vertical distance between the eroded ground elevation and the Stillwater Elevation associated with the design flood. This vertical dimension will help designers and engineers determine Design Flood Elevation (DFE), or the Design Flood Protection Depth, which is the height at which floodproof construction methods should be employed to resist flood-related damage to a building. The Design Stillwater Depth is used to determine the hydrostatic load, hydrodynamic load, flood velocity, design wave height, local scour depth, and debris impact loads.


Legend
Banka Solar power station
Contributing catchment
10% AEP Coastal flood depth
0.1 - 0.5
0.5 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
Juru
N
0 0.45 0.9 1.8 2.7 3.6 Kilometers


Legend
Banka Solar power station
Contributing catchment
2% AEP Coastal flood depth
0.1 - 0.5
0.5 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
Juru
N
0 0.45 0.9 1.8 2.7 3.6 Kilometers

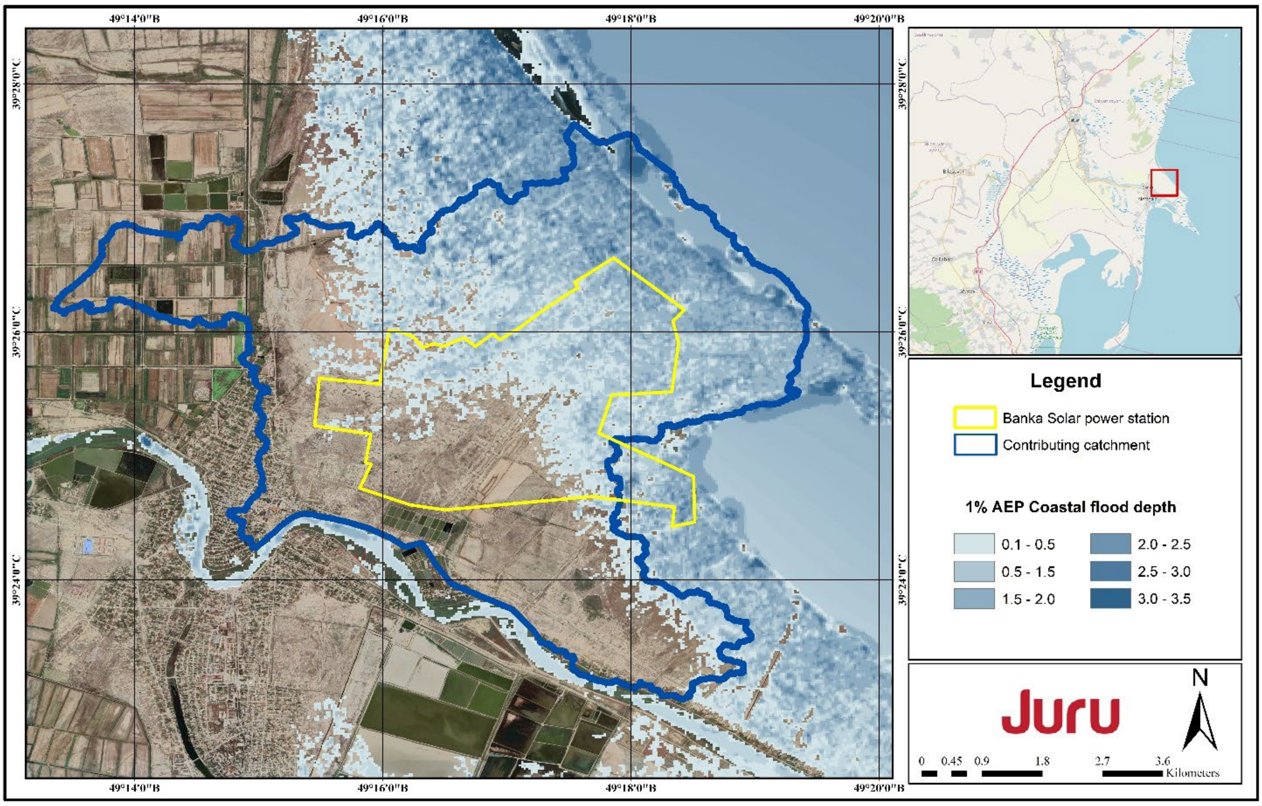


Figure 6.1: Coastal flood maps

7. FLOOD MITIGATION FOR SOLAR POWER STATION CONSTRUCTION AREA

The practice of taking actions or measures to control or limit flood risk by reducing vulnerability is commonly referred to as flood mitigation.

The studied area is located in the flood zone, which can occur as a result of the coast and rainfall. Document FEMA 55: Coastal Construction Manual provides extensive instructions on how to determine site-specific loads regarding coastal flood hazards. Additionally, American Society of Engineers (ASCE) 7-98 Minimum Design Loads for Buildings and Other Structures is an accepted reference to determine other loads, such as dead and live loads, to be used in combination with coastal flood loads to determine structural capacities of building components.

General Design of structures within flood hazard areas shall be governed by the loading provisions of ASCE 7 Minimum Design Loads for Buildings and Other Structures (ASCE/SEI 2010).

According to the ASCE 24-14 normative document, the studied area is classified as Coastal A Zone, High Hazard Area. The planned construction will be included in the 3rd category according to the type of Use or Occupancy of Buildings and Structures.

Development mitigation measures during the design phase of construction:

- ✓ Certain system components (such as piping) and fixtures (such as outdoor faucets and showers) may be located below the DFE and meet the requirement to prevent the release of sewage into floodwaters and prevention of infiltration of floodwaters into the plumbing system (especially potable water). However, other components and fixtures (such as toilets and sinks) are not allowed. Backwater or backflow prevention devices may be used, for example, for floor drains but are not to be used to allow plumbing installations below the required elevation unless otherwise allowed by this section. In addition, plumbing system components and fixtures should not be installed in enclosures below elevated buildings, because the uses of such enclosures are to be restricted to building access, parking, and limited storage;
- ✓ Sanitary Systems Designers are advised to consult with the appropriate regulatory authority, an experienced sanitation expert, or other professional regarding design and installation of on-site sanitary systems in order to provide adequate functioning without adverse health effects during flood conditions. Post-disaster inspections have frequently identified failures in sanitary systems, including septic tanks dislodged by buoyant forces, underground tanks filled with floodwater and debris, interior drains that have backed up into buildings from overflowing sewage disposal systems, and drain system collapse from saturated soil covering the drain field;
- ✓ In addition to the stated requirements, portions of utility systems that extend below the required elevation, such as piping, are to be designed to resist anticipated flood loads and erosion and scour expected during the design flood conditions. If portions of these systems are in protective floodproofed enclosures that are attached to structures, the enclosures and the structures are to be designed for flood loads, including loads transmitted to the structures. FEMA P-55, Coastal Construction Manual (FEMA 2011) provides more specific guidance on designing in the coastal environment, including the design of supporting exterior platforms for utilities and attendant mechanical equipment;

- ✓ Installations of certain components of electrical service that are exterior to structures may be regulated by state public service commissions and may not be subject to local requirements. If elevating these components makes access difficult, a low platform or an automated meter reading system may be appropriate. Similarly, damage is minimized if transformers, switchgear, and other exterior equipment associated with electrical distribution are located above the design flood elevation.

Flood mitigation measures for construction structures are recommended:

- ✓ According to the requirements of ASCE 24-14 regulatory document Top of lowest floor must be at, or above, Base Flood Elevation; electrical heating, ventilation, plumbing, and air conditioning equipment and other service facilities (including ductwork) must be designed and or located so as to prevent water from entering or accumulating within the components during flooding. Structural fill shall not be used unless design and construction of the structural fill accounts for consolidation of the underlying soil under the weight of the fill and the structure, differential settlement due to variations in fill composition and characteristics, and slope stability and erosion control during conditions of the design flood;
- ✓ Structures and fill shall not be constructed or placed in floodways unless it is demonstrated that those structures and fill will not increase the flood level during occurrence of the base flood discharge, and reduce the conveyance of the floodway;
- ✓ Land leveling does not reduce the risk of coastal flooding, coastal flood prevention measures increase the cost of the project. Taking into account the above, it is desirable that the height of the feet of the solar panels fixed to the ground should be 0.3 meters higher than the height of the flood in relation to the levelled terrain during the hundred-year return period;
- ✓ Structures and fill shall not be constructed or placed unless it has been demonstrated that the cumulative effect of proposed structures and fill, combined withal other existing and anticipated development, will not increase the base flood elevation more than 0.3 meter;
- ✓ Ingredients of concrete, including admixtures and reinforcing steel, quality of concrete, and the design and construction thereof shall comply with ACI 318 Building Code Requirements for Structural Concrete and Commentary (ACI 2014) with special consideration for requirements

concerning durability, including protection from chlorides and sulfates found in a saltwater environment;

- ✓ It is necessary to build drainage networks based on the natural slope in order to remove the water collected during the rain. Drainage lines will be determined by the designer after final planning. According to the results of hydrological analysis, it is recommended to build open drainage in the area. The approximate direction of drainage is chosen perpendicular to the Kura River;
- ✓ New construction and substantial improvements shall not be constructed at the apex of an alluvial fan, in the fan's meandering flow paths, or in areas of the fan that have characteristics and evidence that the natural processes that form alluvial fans are active on the fan ' s surface, including braided channels, erratic flow paths, and sediment transport. Construction in other areas of the alluvial fan shall meet the following requirements: The elevation of the lowest floor shall be a minimum of 0.3 meter above the highest adjacent grade, or higher, if required on a community's flood hazard map; Foundations shall be designed and constructed to resist scour caused by the actual flow velocity but not less than 2 m/s. Determination of actual flow velocities shall be based on a review of a community 's flood hazard map and flood hazard study or on hydraulic calculations; and Design and construction shall resist all load combinations specified in the following: Flood loads shall be combined with other loads as specified in ASCE 7 Minimum Design Loads for Buildings and Other Structures (ASCE/SEI 2010), either by using the allowable stress design method load combinations or by using the strength design method load combinations.

8. POSSIBLE COASTAL FLOOD MITIGATION MEASURES

The proposed mitigation measure is just a high level recommendation of one of the possible solutions and shall be further assessed and analyzed by the plant designer with other possible protection measures to come up with the most technically and economically feasible solution.

It was not predicted that the northern part of the area where the construction of the solar power station is planned will be flooded with the rise of the sea level. Taking into account that the seawall is 1.5 km away from the object border, it is considered that mitigation measures that directly strengthen the wall will not work.

In such a case, measures to mitigate the risk of sea water flooding are applied locally for the object being designed.

According to the requirements of the regulatory document SP 104.13330.2016 “Engineering protection of the territory from flooding”, it is advisable to surround the border with a dam from the sea side.

Before enclosing the project area with a dam, it is advisable to level the land first. After the area is brought to the design level, the density of soils will be increased in the place where the dam is to be built.

A schematic diagram of the dam is shown in the figure below, taking into account the coastal flood height for a 100-year return period.

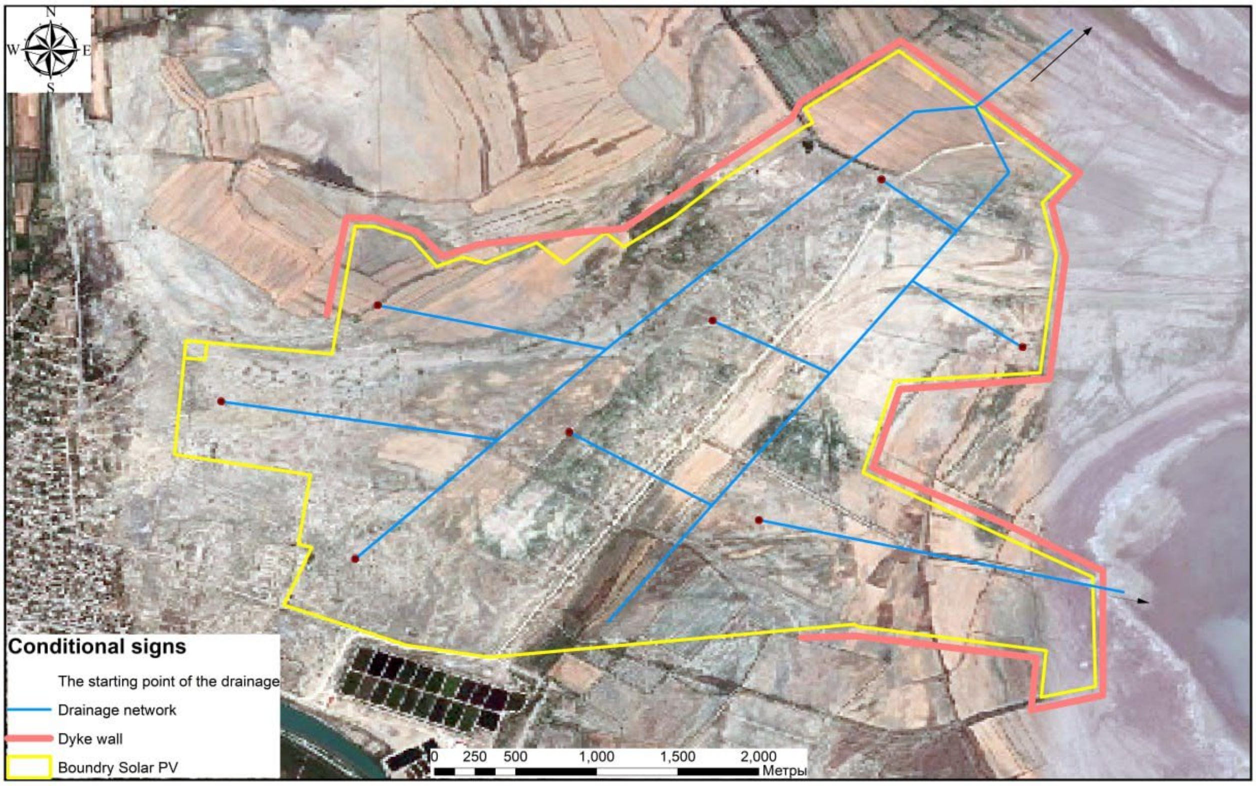


Figure 8.1: Project drawing of the flood protection dam

The dam profile (flat or compressed) is selected taking into account the availability of local construction materials and work technology.

Taking into account the above, the types of dams shown in figure 8.2 and 8.3 below are recommended.

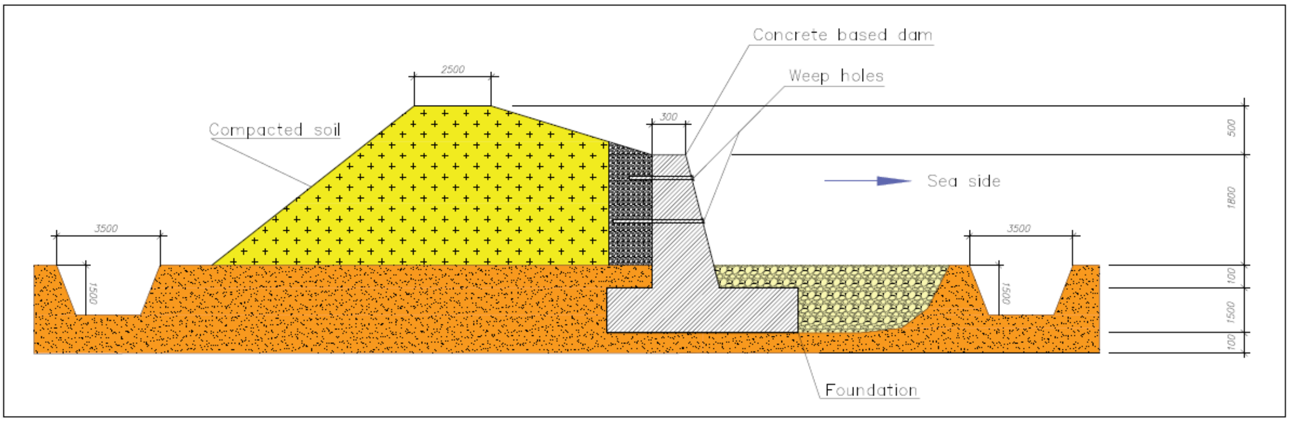


Figure 8.2: Dyke Wall-type semi-ground dam(mm)

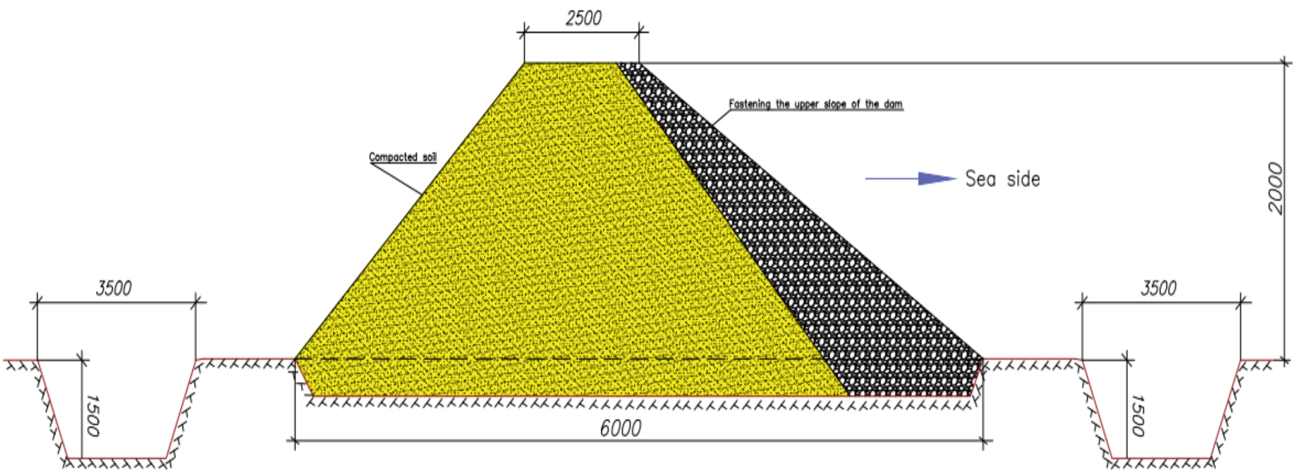


Figure 8.3: Traditional ground dam scheme(mm)

The design parameters of these proposed flood barrier dams' levees are derived for the maximum case.

These parameters can be changed and accepted by the designer for acceptable conditions after the earth leveling works. The sea level rise forecast for the area is 1.2 meters per 100-year return period.

As a result of closing the north side of the planned object with a dam, the natural drainage of rainwater will be limited.

As a result, the task of providing the territory with artificial drainage networks is imposed.

From the hydrological point of view, two types of horizontal drainage networks are recommended.

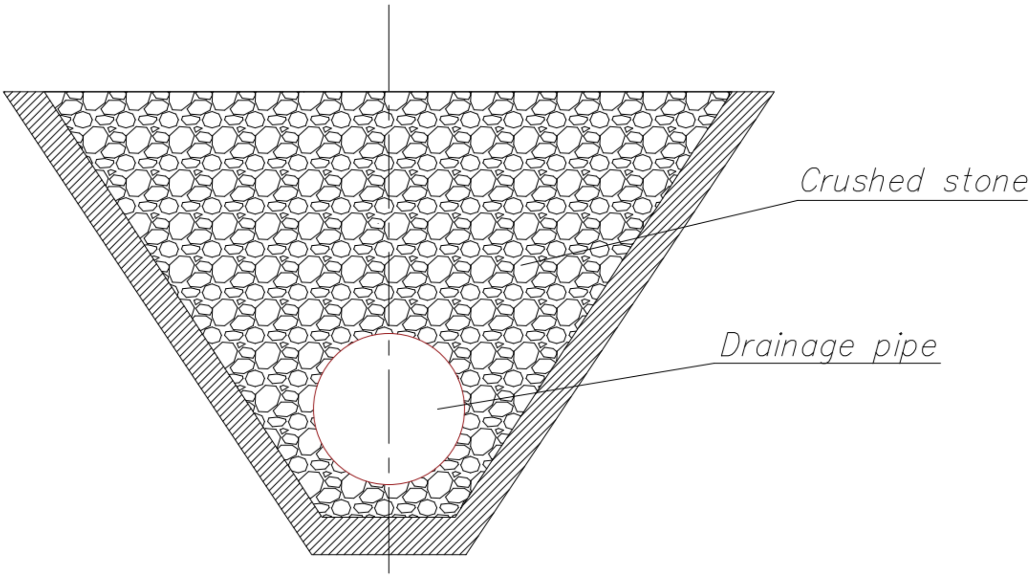


Figure 8.4 below shows a cross-section of a closed horizontal drain and its water-collecting culvert.

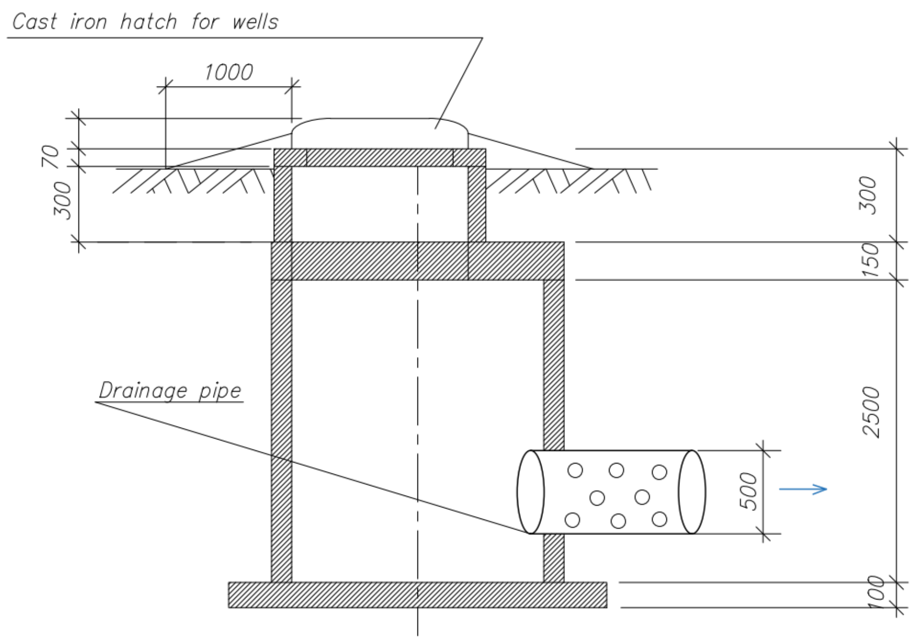


Figure 8.4: Cross-section of a closed horizontal drain and its water-collecting culvert

Dimensions in this design are for maximum sizes and are subject to change.

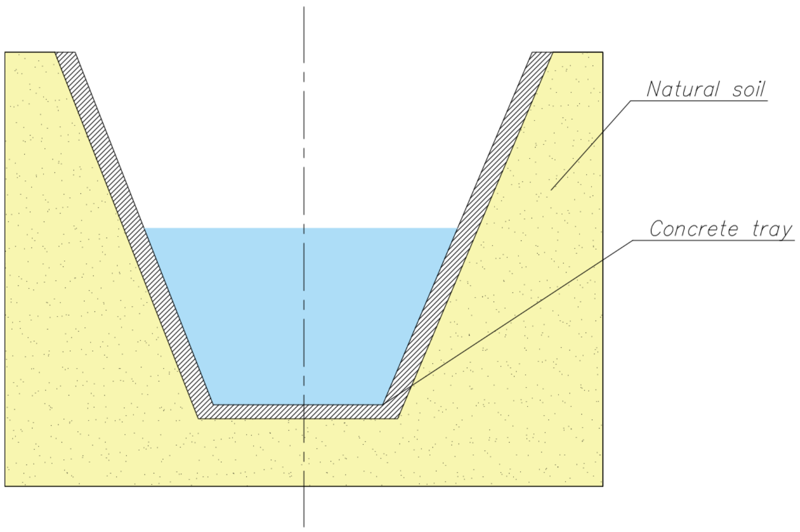


Figure 8.5: Cross section of open horizontal drainage

Both types can be used in the design of the drainage network. There are no hydrological restrictions.

When constructing the drainage network, it is necessary to ensure that the slope of the drainage network does not decrease by 3%.

500 mm diameter asbestos or other seawater resistant composite pipe shall be used for the main water collection collector part of the drainage network.

8.1. Measures for the durability of the flood protection dam

The slopes of earthen dams should be protected with special fastenings designed to withstand the effects of waves, ice, water currents, changes in water level, precipitation, wind, and other climatic and other factors that destroy the slope. To protect the upper slope, as a rule, the following types of fastenings should be used: a) stone (bulk); b) monolithic concrete, prefabricated reinforced concrete and monolithic with conventional and prestressed reinforcement; c) asphalt concrete; d) biological.

The fastening of the upper slope of the dam is divided into the main one, located in the zone of maximum wave and ice impacts that occur during the operational period, and the lightweight one - below the main fastening.

Stone fastening of slopes is arranged at a wave height of up to 1.5 m in the form of casting or paving over a preparation layer that plays the role of a reverse filter.

Stone materials for fastening slopes should be used from igneous, sedimentary and metamorphic rocks that have the necessary strength, frost resistance and water resistance, with a specific gravity k>24 kN/m^3. To secure slopes with rock fill, as a rule, unsorted stone (rock mass) should be used.

The fastening of the downstream slope should be selected depending on the material from which the downstream prism of the dam is constructed, in order to protect it from atmospheric influences and destruction by digging animals. To secure a downstream slope from sandy or clayey soils, sowing grass over a plant layer 0.2-0.3 m thick, filling crushed stone or gravel with a layer 0.2 m thick and other types of lightweight coatings should be used.

9. RECOMMENDATIONS FOR CONSTRUCTION STRUCTURE

Structural steel exposed to direct contact with saltwater, salt spray, or other corrosive agents known to be present shall be hot-dipped galvanized after fabrication. Secondary components such as angles, bars, straps, and anchoring devices shall be stainless steel or hot-dipped galvanized after fabrication in accordance with the following:

Metal Connectors and Fasteners Metal plates, connectors, screws, bolts, nails, and other fasteners exposed to direct contact by floodwater, precipitation, or wind-driven water shall be stainless steel or equivalent corrosion resistant material, or hot-dip galvanized in accordance with ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products (ASTM 2012d), ASTM A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware (ASTM 2009), ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process (ASTM 2011a), or ASTM A924/A924M Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process (ASTM 2010a).

Structural Steel pipe piles shall conform to ASTM A252/252M Standard Specification for Welded and Seamless Steel Pipe Piles (ASTM 2010b). Steel H piles and steel sheet piling shall conform to ASTM A572/A572M Standard Specification for High-Strength Low Alloy Columbium-Vanadium Structural Steel (ASTM 2012a) or ASTM A690/A690M Standard Specification for High-Strength Low-Alloy Nickel, Copper, Phosphorus Steel H-Piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments (ASTM 2012b). Rolled steel shapes other than H piles shall conform to ASTM A36/A36M Standard Specification for Carbon Structural Steel (ASTM 2008a), ASTM A572/A572M Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel (ASTM 2012a), and ASTM A992/A992M Standard Specification for Structural Steel Shape s (ASTM 2011b). Cast steel shoes, where provided, shall conform to ASTM A148/A148M Standard Specification for Steel Castings, High Strength, for Structural Purposes (ASTM 2008b).

10. CONCLUSION

These engineering and meteorological surveys were carried out in connection with the upcoming development of design documentation for the facility: **«COMBINED CAPACITY OF 835MWAC SOLAR PV POWER PLANTS IN AZERBAIJAN-BONKA SOLAR PV»**

The main indicators of the temperature regime are the average monthly maximum and minimum ambient temperatures. According to the data analysis in the table in the territory the average annual air temperature is +15.5 °C, absolute minimum air temperature was -12.1 °C. the absolute maximum was +43.3 °C. The coldest month of the year is January with an average monthly ambient temperature of 4.4 °C. the warmest is July with an average monthly temperature of +27.3 °C.

Flood mitigation measures for construction structures are recommended:

- ✓ According to the requirements of ASCE 24-14 regulatory document Top of lowest floor must be at, or above, Base Flood Elevation; electrical heating, ventilation, plumbing, and air conditioning equipment and other service facilities (including ductwork) must be designed and or located so as to prevent water from entering or accumulating within the components during flooding. Structural fill shall not be used unless design and construction of the structural fill accounts for consolidation of the underlying soil under the weight of the fill and the structure, differential settlement due to variations in fill composition and characteristics, and slope stability and erosion control during conditions of the design flood;
- ✓ Structures and fill shall not be constructed or placed in fl oodways unless it is demonstrated that those structures and fill will not increase the flood level during occurrence of the base flood discharge, and reduce the conveyance of the floodway;
- ✓ Land leveling does not reduce the risk of coastal flooding, coastal flood prevention measures increase the cost of the project. Taking into account the above, it is desirable that the height of the feet of the solar panels fixed to the ground should be 0.3 meters higher than the height of the flood in relation to the levelled terrain during the hundred-year return period;
- ✓ Structures and fill shall not be constructed or placed unless it has been demonstrated that the cumulative effect of proposed structures and fill, combined withal other existing and anticipated development, will not increase the base flood elevation more than 0.3 meter;

- ✓ Designs for Coastal High Hazard Areas and Coastal Zones shall account for local scour and erosion and shall be designed to resist loads from the following: Waves breaking against the bracing, side of the structure, and underside of the structure, Drag, inertia, and other wave-induced forces acting on structural members supporting elevated structures, Uplift forces from breaking waves striking the undersides of structures, and Wave runup forces including those deflected by the structure;
- ✓ In the coastal flood zone, it is recommended to secure the foundations or supports of solar panels and other structures to the ground. These measures must withstand the hydrostatic pressure of the sea wave;
- ✓ Ingredients of concrete, including admixtures and reinforcing steel, quality of concrete, and the design and construction thereof shall comply with ACI 318 Building Code Requirements for Structural Concrete and Commentary (ACI 2014) with special consideration for requirements concerning durability, including protection from chlorides and sulfates found in a saltwater environment;
- ✓ It is necessary to build drainage networks based on the natural slope in order to remove the water collected during the rain;
- ✓ New construction and substantial improvements shall not be constructed at the apex of an alluvial fan, in the fan's meandering flow paths, or in areas of the fan that have characteristics and evidence that the natural processes that form alluvial fans are active on the fan ' s surface, including braided channels, erratic flow paths, and sediment transport. Construction in other areas of the alluvial fan shall meet the following requirements: The elevation of the lowest floor shall be a minimum of 0.3 meter above the highest adjacent grade, or higher, if required on a community's flood hazard map; Foundations shall be designed and constructed to resist scour caused by the actual flow velocity but not less than 2 m/s. Determination of actual flow velocities shall be based on a review of a community 's flood hazard map and flood hazard study or on hydraulic calculations; and Design and construction shall resist all load combinations specified in the following: Flood loads shall be combined with other loads as specified in ASCE 7 Minimum Design Loads for Buildings and Other Structures (ASCE/SEI 2010), either by using the allowable stress design method load combinations or by using the strength design method load combinations.