6.0 GEOLOGY, SOILS AND CONTAMINATED LAND

6.1 Scope

This chapter presents an evaluation of the predicted impacts of the Project related to geology and soils. The following issues are addressed:

- Seismic activity risks
- Contaminated land risks
- Soil impact risk

A description of the significance criteria to complete the impact assessment is provided followed by a description of the baseline situation. The potential impacts for the issues noted above are discussed and the proposed mitigation measures are presented together with the residual impacts.

The results from the following desktop studies and site-specific soil investigations were used to establish the baseline information:

- Literature survey
- The General Directorate of Mineral Research and Exploration (MTA) publications
- Elazig Environmental Status Report (2014)
- Soil Investigation and Geotechnical Engineering Report prepared by Kilci Mühendislik, Müşavirlik Proje İnşaat Taahhüt Sanayi ve Ticaret Ltd Şti. in August 2014 (Kilci, 2014) and in February 2015 (Kilci, 2015). The 1st site investigation (Kilci, 2014) included the drilling of 11 boreholes within the Project area, sample collection and laboratory analysis to assess subsurface soil profile and the soil parameters necessary for geotechnical design. Ten (10) of the boreholes were drilled to a depth of 20 m below ground level (bgl) and one borehole was drilled to a depth of 25 m bgl. The study provided soil profiles across the site as well as the ground bearing capacity and seismic design requirements for the buildings to be constructed at the site. The 2nd site investigation (Kilci, 2015) included a total of 30 boreholes that were advanced with depths varying between 15 m-25 m bgl and the scope was similar with that of the 1st site investigation.

Necessary criteria (e.g. appropriate standards, regulations, etc.) will be taken into account in the design of the facilities to address the seismic risks. This will be conducted considering the defined parameters that need to be used in the design of structures located in 2nd degree earthquake zone where the Project site is located. The geotechnical site investigation performed by Kilci (2014) identified the geotechnical parameters for seismic and foundation design. The following significance criteria are suggested related to the contamination of soils and presence of contaminated land.

Impact Significance	Description
Negligible	- Temporary use of land (with soil surface) for the storage of excavated materials and construction equipment
Minor	- Temporary small-scale oil spills during construction activities on soils that lead to contamination below generic contamination levels stated in the Turkish Regulation on Soil Pollution Control and Point Source Contaminated Sites (Soil Pollution Control Regulations) - In case of disturbance of existing contaminated soils: increase contamination in

Impact Significance	Description
	nearby non-contaminated soils to above the background level but below the generic contamination levels stated in the Soil Pollution Control Regulations
Moderate	- Continuous/long-term oil spills during construction activities on soils and during operation (e.g. accidents) (concentrations of pollutants in the soil defined in the Soil Pollution Control Regulations are exceeded above the generic contamination levels but below the long term cancer and hazard risk) - In case of disturbance of existing contaminated soils: increase contamination in nearby non-contaminated soils to above the background level that are above the generic contamination levels stated in the Soil Pollution Control Regulations but below long term cancer and hazard
Major	- Continuous/long-term oil spills during construction activities on soils and during operation (e.g. accidents) (concentrations of pollutants in the soil defined in the Soil Pollution Control Regulations are exceeded to cause long term cancer and hazard risk) - In case of disturbance of contaminated soils, increase contamination in nearby non-contaminated soils to above the background level that will be hazard to human health

6.2 Existing Environment

6.2.1 Geology

Regional Geology

The Project area is located at the upper Euphrates part of the Eastern Anatolia region. The general topography of the region is broad plains surrounded with mountains. General geology of the region covering the Project area is illustrated in Figure 6-1.

The basic geological unit of Elazig and its environment is Permo-carboniferous aged Keban metamorphites. Keban metamorphites are composed of marble, calcareous schist and recrystallized limestone. These metamorphites are sheared by the granitic and dioritic rocks that belong to Cenonian aged Elazig magmatites which are fundamentally composed of granite, granadiorite, tonalite, diorite, diabase, micro-diorite, aplite, dacite, lamprophyre, basalt, andesite, basaltic pillow lava, agglomerate and pyroclastics which in turn are tectonically layered by Meryem Mountain and Keban metamorphites in the north of Abdullahpasa neighborhood. The Maastrichtian aged Harami Formation outcrops around Huseynik, Harput and Yedigoz and forms angular unconformity on the volcanic units of Elazig magmatites. The deposition of the formation which is made up of red-colored conglomerate sandstones at the bottom and recrystallized limestones at the upper parts originates in fan delta and in shallow marine facies. This quite faulted and fissured unit forms pretty close tectonic contacts with Elazig magmatites. Harami formation is covered by angular unconformity by mid-upper Eocene aged Kirkgecit formation which covers huge areas in Elazig and its surroundings. Kirkgecit formation outcrops around Esentepe, Hirhirik and Zafran Neighborhoods close to Elazig, on the northern parts of Abdullahpasa Neighborhood and around Meryem Mountain. This formation is basically composed of conglomerate, sandstone, sandy limestone and marl and the deposition has started in shelf - deep sea facies. The formation is layered with tectonic contact by Elazig magmatites and Keban metamorphites at the south of Harput and north of Abdullahpasa neighborhoods. Kirkgecit formation is covered by lower Pliocene aged Karabakir formation with angular unconformity. This formation outcrops on the south of Aksaray neighborhood and around Tepekoy and Doktorevleri and it is fundamentally composed of mudstone, argillaceous limestone, basalt, tuff and pyroclastics. The formation was deposited in terrestrial-lacustrine facies. Pliocene-quaternary aged Palu formation outcrops around Yenikoy. This unit is basically composed of conglomerate and sandstones. The younger unit of the region is comprised of quaternary alluviums which covers the bottom layers with unconformity. These deposits are basically composed of non-fixed and weakly cemented silt, sand and gravel groups.

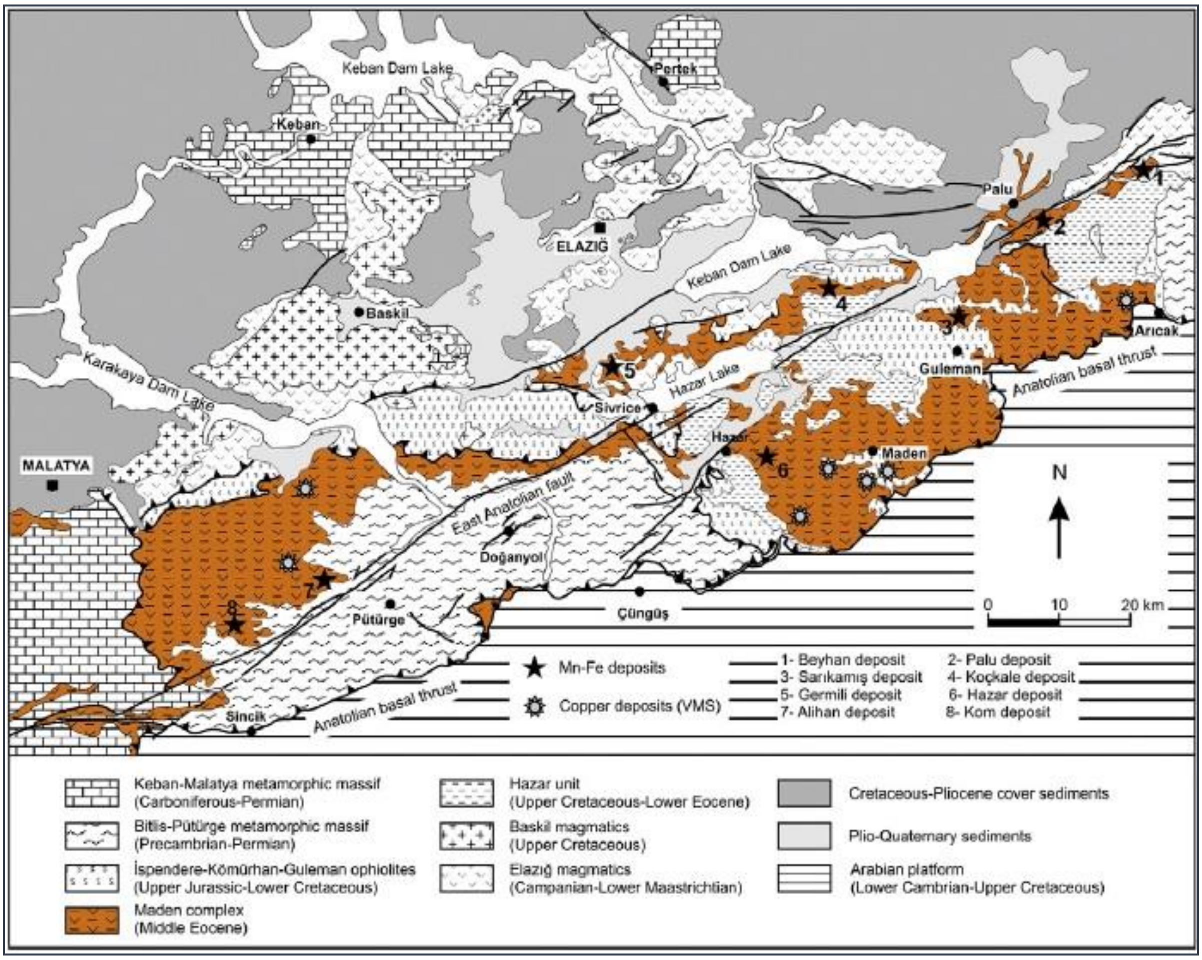

Figure 6-1: General geology map of Elazig-Malatya region (Sasmaz *et al*., 2014)

There are several important fault zones within the borders of Turkey. Around the examination site and its environment, there are extensions of Keban overthrust (near Meryem Mountain and Abdullahpasa neighborhood) and Oymaagac overthrust (south of Harput) which belong to the Paleotectonic epoch. Around the city, it is possible to identify the traces of faulted and folded structures which particularly belong to Alpine epoch. When the tectonic structure of the region is examined on a macro scale, it can be stated that Elazig lies in between the Eastern Anatolia Fault on the south and Ovacik Fault on the north.

Geological features of the Project area

Soil investigations were undertaken at the Project area to assess the lithological characteristics of the soil, alterations in the vertical direction, groundwater table and to determine the engineering properties. The first soil investigation study was conducted in the Project area between 01.06.2014 and 14.06.2014 by Kilci Mühendislik, Müşavirlik Proje İnşaat Taahhüt Sanayi ve Ticaret Ltd Şti (Kilci, 2014). The soil investigation study included the drilling of eleven boreholes within the Project site. Ten of the boreholes were drilled to a depth of 20 m below ground level (bgl) and one borehole was drilled to a depth of 25 m bgl. The second soil investigation was undertaken between December 2014-January 2015 following the finalization of the architectural projects and locations on the Project site. A total of 30 boreholes were advanced with depths varying between 15m-25m bgl. The site investigation was again conducted by Kilci (2015).

At the end of the investigations, the lithological characteristics of the Project area was found to be as follows: (i) 0.15 m - 0.30 m top soil, (ii) between 2.00 m – 4.00 m, uncontrolled filling materials (with low clay content and large gravels, accompanied by occasional lime formations and pieces of roof tiles), and (iii) further down to 25 m deep, weathered claystone belonging to the Karabakir Formation which dates back to Upper Miocene era.

The general stratigraphy of the Project area is illustrated in Figure 6-2.

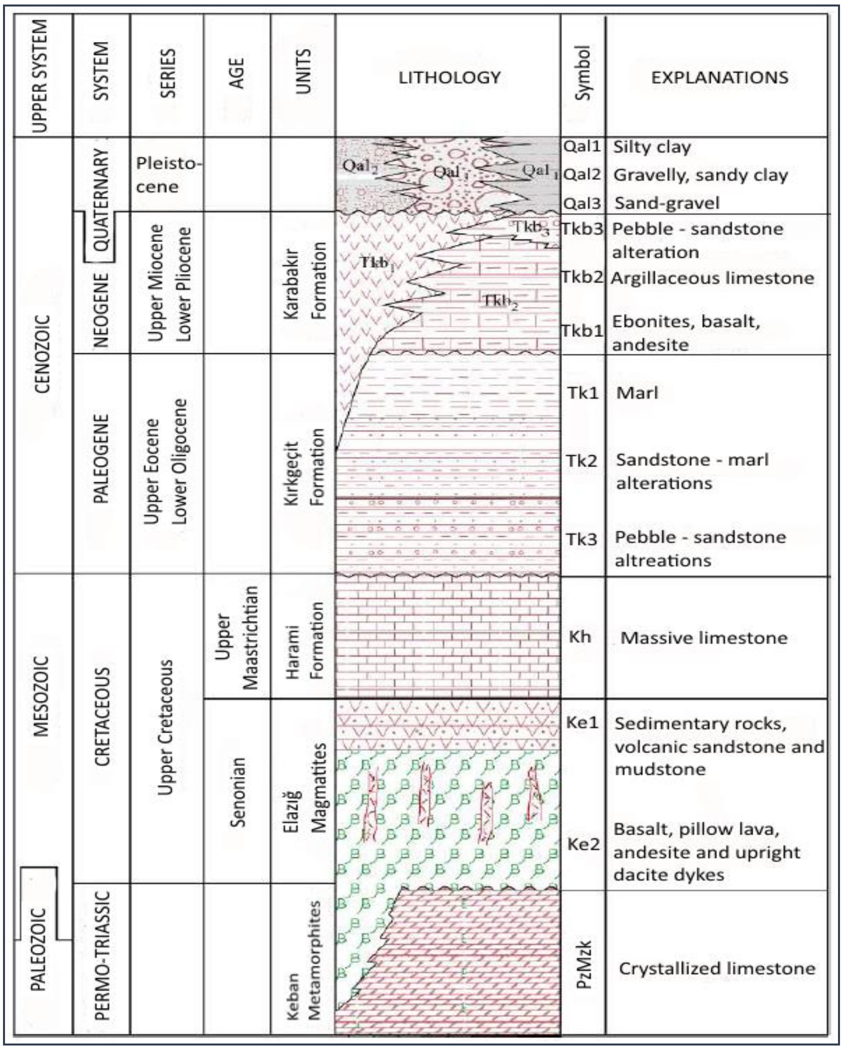

Figure 6-2: Generalized stratigraphic column section of the study area and its vicinity (Kilci, 2014)

The locations of the boreholes for the 1st and 2nd site investigations are provided in Figure 6-3. During the study, Standard Penetration Tests were also conducted to analyze the consistency of soil layers. The summary of the Project area lithology is provided in Table 6-1 based on the laboratory analysis of the samples collected from 11 boreholes collected during the initial study. The information collected from the second site investigation confirmed the findings of Table 6-1.

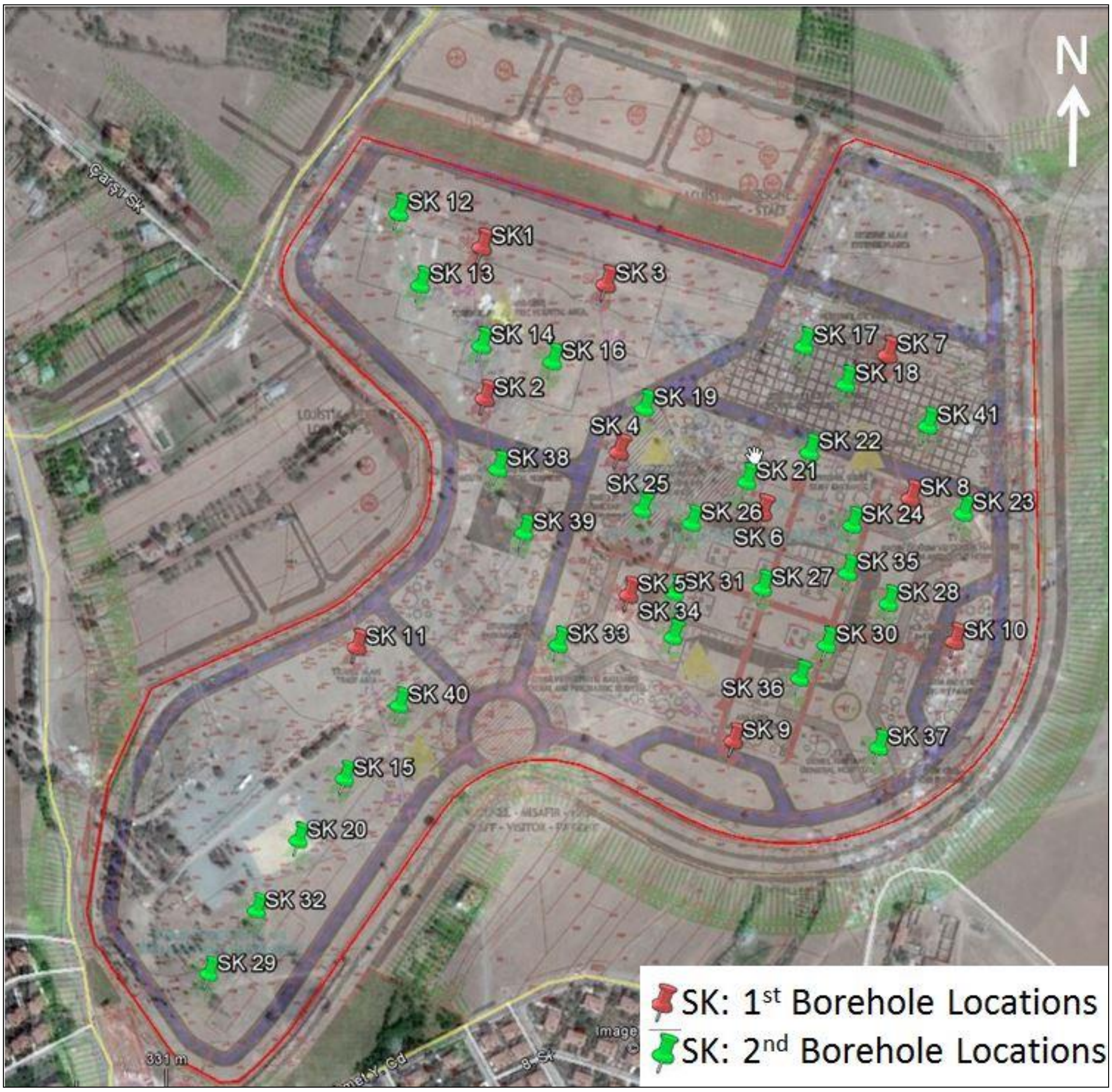

Figure 6-3: Location of the boreholes during 1st soil investigation (Kilci, 2014) and 2nd soil investigation (Kilci, 2015)

Table 6-1: Summary of the Project area lithology (Kilci, 2014)

Borehole No.	Borehole Depth (m)	Formation- Lithology
SK-1	20.00	0.00-0.25 m: Top soil 0.25-3.00 m: Uncontrolled filling material 3.00-20.00 m: Weathered clay stone
SK-2	20.00	0.00-0.20 m: Top soil 0.20-4.00 m: Uncontrolled filling material 4.00-20.00 m: Weathered clay stone
SK-3	20.00	0.00-0.30 m: Top soil 0.30-2.50 m: Uncontrolled filling material 2.50-20.00 m: Weathered clay stone

Borehole No.	Borehole Depth (m)	Formation- Lithology
SK-4	20.00	0.00-0.30 m: Top soil 0.30-2.00 m: Uncontrolled filling material 2.00-20.00 m: Weathered clay stone
SK-5	20.00	0.00-0.30 m: Top soil 0.30-3.00 m: Uncontrolled filling material 3.00-20.00 m: Weathered clay stone
SK-6	20.00	0.00-0.20 m: Top soil 0.20-3.00 m: Uncontrolled filling material 3.00-20.00 m: Weathered clay stone
SK-7	20.00	0.00-0.10 m: Top soil 0.10-3.00 m: Uncontrolled filling material 3.00-20.00 m: Weathered clay stone
SK-8	20.00	0.00-0.25 m: Top soil 0.25-2.75 m: Uncontrolled filling material 2.75-20.00 m: Weathered clay stone
SK-9	20.00	0.00-0.15 m: Top soil 0.15-2.00 m: Uncontrolled filling material 2.00-20.00 m: Weathered clay stone
SK-10	20.00	0.00-0.30 m: Top soil 0.30-2.50 m: Uncontrolled filling material 2.50-20.00 m: Weathered clay stone
SK-11	25.00	0.00-0.30 m: Top soil 0.30-3.00 m: Uncontrolled filling material 3.00-25.00 m: Weathered clay stone

Based on the soil investigation conducted by Kilci (2014, 2015), the following conclusions were provided by Kilci (2014, 2015):

- fill materials have been detected in the Project area. It was recommended in the reports prepared by that the filling materials need to be cleared out from the site.
- Groundwater was not encountered in the boreholes
- Bearing capacity along with geotechnical parameters were calculated for each of the buildings. Settlement calculations showed the expected values were within acceptable limits

6.2.2 Seismic and Liquefaction Risks

Elazig province is located in the Eastern Anatolia region of Turkey where significant tectonic features are present and active. According to the Map of Turkey Seismic Zones published in 1996 by the Ministry of Public Works and Settlement, General Directorate of Disaster Affairs, Earthquake Research Department, Elazig central district is located in the 2nd degree seismic zone; while, Palu, Kovancilar, Sivrice and Karakocan districts are located in the 1st degree seismic zone (Figure 6-4).

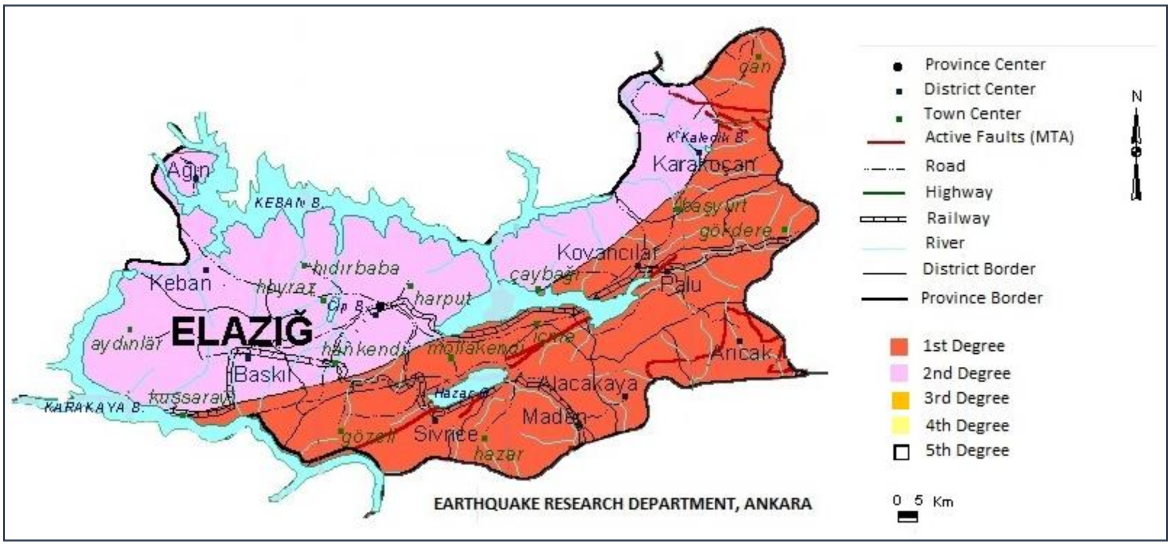

Figure 6-4: Seismic zone classification map of Elazig Province (Source: Map of Turkey Seismic Zones, Ministry of Public Works and Settlement, General Directorate of Disaster Affairs, Earthquake Research Department, 1996)

Elazig province is located between Northern Anatolia Fault Zone (NAFZ) and Eastern Anatolia Fault Zone (EAFZ). A simplified tectonic map of Turkey is provided in Figure 6-5 illustrating major tectonic structures and plates in Turkey as well as in the study area which also covers the Project area.

Due to the seismic activity of the region, Elazig province witnessed several important earthquakes. The historical earthquakes recorded in Elazig with magnitudes higher than five (Mw>5) are listed in Table 6-2.

Table 6-2: Historical earthquakes in Elazig region with M_w>5

Date	Location	Magnitude	Details
1905	Elazig	6.8	No Information
1961	Sivrice, Elazig	-	Minor damage
1977	Palu, Elazig	5.2	8 deaths, severe damage
2004	Sivrice, Elazig	5.5	Severe damage
2007	Gozeli, Elazig	5.1	Minor damage
2007	Sivrice, Elazig	5.7	Severe damage
2010	Karakocan, Elazig	6.1	42 deaths, severe damage

Recent major earthquake (also called as Elazig – Kovancilar and Elazig – Palu earthquakes) occurred in the region was on 8th March, 2010 in Karakocan district with a magnitude of 6.1 M_w. According to the Evaluation Report for Elazig Earthquakes of 8th March, published by the Turkish Republic Prime Ministry Disaster and Emergency Management Presidency, Directorate of Earthquake Research, 42 people died and 137 people injured during the earthquake event. This earthquake was also felt strongly in the central district and caused severe damage in the buildings. The epicenters of Elazig Earthquakes of 8th March, 2010 are shown in Figure 6-6.

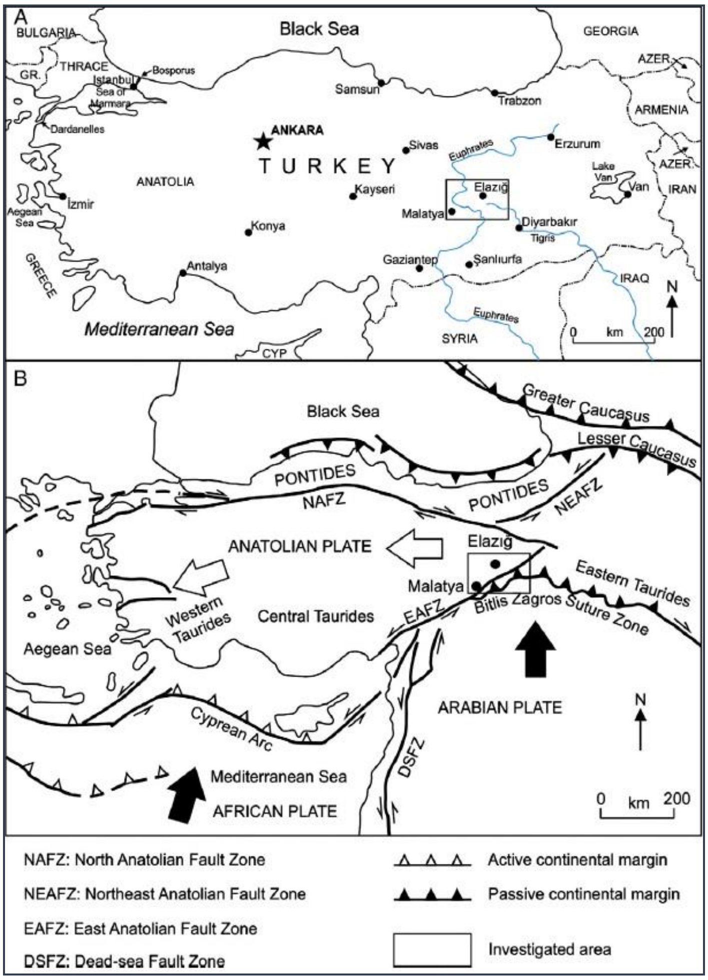

Figure 6-5: Simplified tectonic map of Turkey showing a) location of the study area and b) major tectonic structures and plates (Sasmaz *et al*., 2014)

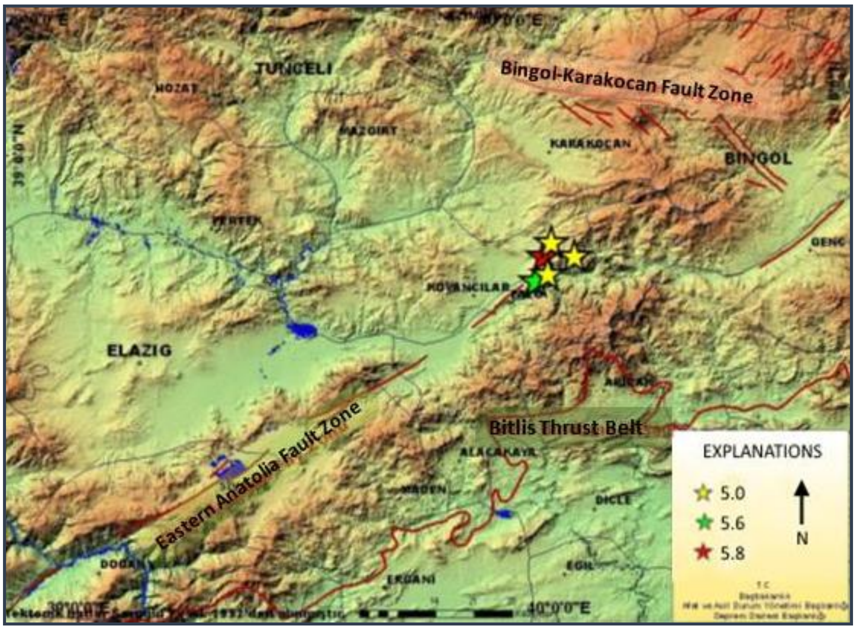

Figure 6-6: Epicenter of Elazig Earthquakes of 8th March, 2010 and aftershocks (Source: Evaluation Report for Elazig Earthquakes of 8th March, published by the Turkish Republic Prime Ministry Disaster and Emergency Management Presidency, Directorate of Earthquake Research, May 2010)

According to the Spatial and Statistical Distribution of Natural Disasters in Turkey report prepared by Disaster Affairs General Directorate of the Ministry of Public Works and Settlement in 2008, earthquakes mainly occurred in the mid part, southern and eastern parts of the city, slightly away from the Project area as illustrated in Figure 6-7. The comparison of Figure 6-4 and Figure 6-7 clearly shows that the location of earthquake incidents occurred in Elazig province overlap mostly with the areas of active fault presence.

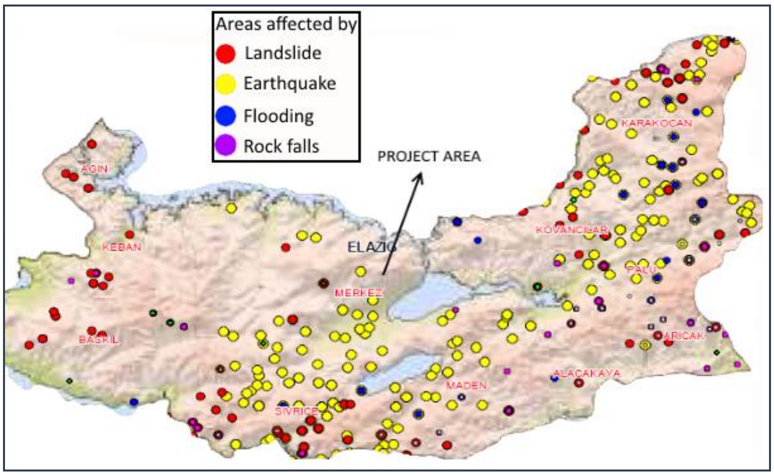

Figure 6-7: Disaster events in Elazig province (Source: Spatial and Statistical Distribution of Natural Disasters in Turkey report prepared by Disaster Affairs General Directorate of the Ministry of Public Works and Settlement, 2008)

It should be kept in mind that the Project area is located within the influence zone of Eastern Anatolia Fault. Therefore, provisions of “Regulation on Buildings to be built in Seismic Zones” need to be met in the calculations for the buildings to be constructed in Elazig. According to the measurements and calculations made during the soil investigation study by Kilci (2014), it was indicated that the earthquake design loads should be based on the following conditions (based on “Regulation on Buildings to be built in Seismic Zones”):

- Soil type: B
- Groundwater level: Not encountered
- Local soil class: Z_2
- Ground spectrum periods: T_0=0.40, T_A = 0.15, T_B = 0.40
- Dynamic bedding coefficient: Ks=2060 t/m^3.
- Based on pressiometer and laboratory experiments, the bearing capacity of soil was determined to be q_{all}=400 kPa

Separate studies were undertaken by Erdik et al. (2006, 2015) for assessing the structural system and adequacy of the earthquake isolation technology that is proposed to be used in the buildings to be erected in the IHC. The study included earthquake hazard assessment and the ground motion predictions from expected earthquake events. The fault systems nearby the IHC site, the earthquakes measured in the last century were studies as part of the study. The study showed that the earthquake design conditions at the site should be conducted using a two criteria approach:

- Earthquake conditions with a 475 year recurrence period: this earthquake level represents infrequent but strong earthquake based ground motions that are not very likely to occur within the operational lifespan of the buildings. The probability of the earthquake exceedance within a fifty year period is 10% with an average return period of 475. The proposed design of the buildings and the use of earthquake isolation system would prevent the ground motions to create any building damage and the facilities would stay within the operational phase.

- Earthquake conditions with a 2,475 year recurrence period: this earthquake level represents the strongest earthquake based ground motions. The probability of the earthquake e exceedance within a fifty year period is 2% with an average return period of 2475. The earthquake isolation system would not be damaged and structural system would satisfy the immediate use performance criteria.

6.2.3 Soil Structure of Elazig Province

According to the report prepared by academics from Firat University on the natural characteristics of the Elazig province (http://web.firat.edu.tr/cografya/eg/dogal.html, accessed on 19.02.2015), the arable land in Elazig is approximately 264,180 ha (30.6% of Elazig's total area). Of this potential land area, 122,615 ha corresponds to 1st class (46%), 65,243 ha to 2nd class (25%), 4,220 ha to 3rd class (2%) arable land and the rest is 4th class. On the other hand, when the existing type of land use in Elazig province is assessed in terms of land ability classes (Figure 6-8), it is observed that 1st, 2nd and 3rd class lands account for 4%, 6% and 9%, respectively which corresponds to an area of 40,525 ha, 58,921 ha and 86,697 ha for 1st, 2nd and 3rd class, respectively. This suggests that the arable land potential of Elazig is not being used sufficiently.

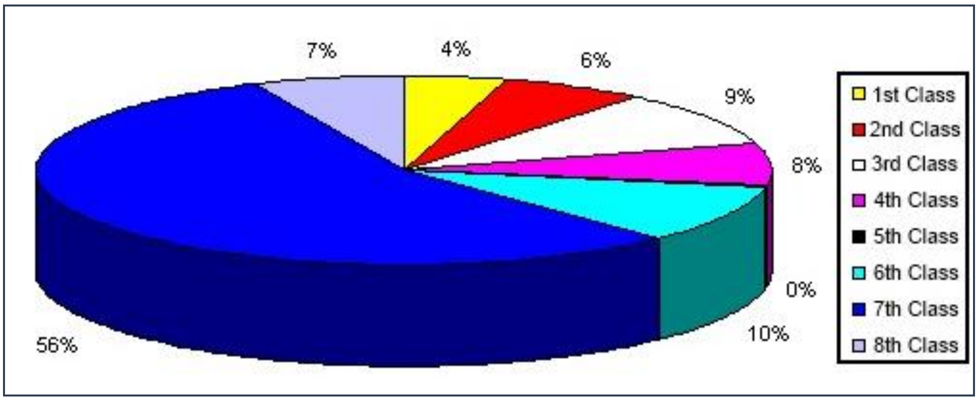

Figure 6-8: Distribution of land ability classes in Elazig Province
(Source: http://web.firat.edu.tr/cografya/eg/dogal.html, accessed: 19.02.2015)

6.2.4 Site Soils and Contaminated Land

A soil and groundwater investigation was undertaken to assess the soil and groundwater quality at the Site. The site investigation aimed to evaluate the presence contaminants that might have been associated with former site activities and the liabilities with regard to the applicable regulations. Fieldwork was conducted on 16-22 February 2015 by ELC drilling team under the supervision of Hasan Ertuzun (ELC Geologist). The results of the site investigation have been assessed according to the "Regulation on Soil Pollution Control and Point-Source Contaminated Sites" ('RSPC') (Official Gazette Date/Number: 08.06.2010/ 27605). The results are reported in Annex G including photographs taken during the site survey.

The scope of the study involved borehole advancement, soil sampling and analysis at the locations given in Figure 6-9:

- Borehole advancement and soil sampling: eight boreholes (SK-1 through SK-8) were advanced to depths between 10-20 m below ground level (bgl) depending on drilling location topographic elevation; two soil samples were collected from each of the boreholes. Six shallow borings (D-1 through D-6) were advanced to approximately 1 m depth in the site area that is being used to store on-site excavated soil materials; one soil sample was collected from each of these shallow boring.
- Groundwater assessment: the presence of groundwater was investigated during the borehole advancement. Previous geotechnical investigations did not indicate the presence of ground water at the site. Groundwater strike was not noted during the present site drilling works which confirmed the previous site results. For further confirmation, one of the 20 m deep boreholes (SK-4) was constructed as a groundwater monitoring well to monitor potential presence; no groundwater was encountered within the well during the site investigation period.
- Soil sample analysis: soil samples were screened during drilling for presence of organic and volatile contamination through the use of a portable photo-ionization detector (PID). Based on the PID screenings and visual observations, a total of twenty two soil samples from fourteen drilling locations were selected and sent for laboratory analysis. Samples were shipped to Agrolab in Germany (accredited laboratory) to be analyzed for Total Organic Halogens (TOX), Total Petroleum Hydrocarbons (TPH), Volatile Organic Compounds (VOCs) including Benzene, Toluene, Ethyl benzene and Xylenes (BTEX), Polycyclic Aromatic Hydrocarbons (PAH) and Metals (As, Ba, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Sn, V, Zn); these parameters were selected which in accordance with the RSPC conditions.

Figure 6-9: Borehole locations for soil quality assessment

The above parameters were identified as the target contaminants in accordance with the RSPC. The laboratory analytical report is presented in Annex G. In the assessment of potential exposure with respect to TPH, PAHs, TOX, VOCs, BTEX and Heavy Metals in soil, the transport pathways defined by the RSPC, i.e. *"Ingestion of soil and dermal exposure", "Inhalation of volatile pollutants in outdoor air"* and *"Inhalation of dust in outdoor air"* were taken into consideration. With regard to the groundwater quality, the RSPC limit values defined for the *"Transport to groundwater and drinking"* pathway were not taken into consideration since groundwater was not detected to depths of 20 m bgl. The soil sampling results showed that:

- Aromatic and Aliphatic TPH C16-35 compounds were detected above laboratory limits at sampling points SK-1/2, SK-2/2 and SK-8/1. These levels were well below the Generic Risk Limits[1] (i.e. generic contaminant limit value as stated in the RSPC). The detected levels do not require remediation to be undertaken at the site and there is no risk to human health at these locations.
- Arsenic and Chromium were noted to exceed the Generic Risk limit values in all collected soil samples. Arsenic levels exceeded the RSPC limit value for "*Ingestion of soil and dermal exposure"* (0.4 mg/kg) with detections ranging from 3.2 to 8.1 mg/kg. Chromium levels exceeded the RSPC limit value for "*Inhalation of dust in outdoor air"* (24 mg/kg) at all sampling locations, with detections ranging from 25 to 76 mg/kg. It is most likely that these metals are naturally present in the site soils and are not due to any contamination that might have occurred at the site. This is attributed to the fact that the levels of arsenic and chromium in the shallow and deep soil samples in each borehole (SK-1 through SK-8) showed similar/close values which are also similar to the values of shallow soil samples collected from the excavated soil materials stored on site. Based on these similar results, it can be concluded that arsenic and chromium levels are naturally present in the site soils. (For this reason, the use of the excavated material (i.e. 400,000 m^3 of excavated soils that was transferred to the surrounding lands upon the request of landowners) in areas where agricultural activities are being undertaken as fill material to level off roads or level topography is not expected to cause human health risk from the naturally existing conditions that are likely to be present in the nearby areas. This is to mean that the levels found within the soil within the site are likely to be the same in the areas where they have been used as fill material).
- Analytical results for the samples collected from the two deep soil borings advanced in the vicinity of the former material deposition areas indicated comparable levels of chemical

[1] Generic contaminant limit value (GCLV) as defined in Turkish Regulation on Soil Pollution Control and Point Source Contaminated Sites: GCLV is the concentration given in the Annex 1 Generic Contaminant Limit Values List, which is calculated or determined considering human health risks in the case that existing or future use of the contaminated site is residential and assuming human exposure to a contaminant within a reasonable period at maximum level. In case the generic risk limits are exceeded at a point, one needs to do a site specific risk assessment and obtain site specific risk limits. This exercise will provide allowable parameter limits to be higher than generic risk limits. In other words, arsenic is 0.4 mg/kg (inhalation limits) for generic risks, site specific risk limits may turn out to be 30 mg/kg since the exposure scenarios will be different. In other words, if there is contaminated soil one needs to do more studies and assess who will be exposed under what conditions and obtain new numeric numbers. If despite all of the work that is conducted, the parameters are still higher than the new risk limits than one goes into remediation process according to the Turkish Regulation on Soil Pollution Control and Point Source Contaminated Sites. This is considered to be a low probability at Elazig site.

parameters with the remaining portions of the Site. No signs of contamination were noted in the samples.

- Analysis of soil samples (D-1 through D-6) collected from the on-site excavated soil material storage area did not show any sign of contamination.

6.3 Impacts

6.3.1 Impacts related to Geology and Seismic Risk

In the event of earthquakes during construction and operation, significant impacts on the environment as well as on the community and workers' health and safety and on patients may arise following accidents, spills, fire, etc. related to the seismic incident. During all construction works within the Project area, the Regulation on Buildings to be Built in Seismic Zones (Official Gazette date/no: 06.03.2007/26454) will be complied with. The Project area lies within a 2^{nd} degree seismic zone and the geotechnical site investigation performed by Kilci (2014) in the area indicated the following parameter values:

- Soil type: B
- Groundwater level: Not encountered
- Local soil class: Z_2
- Ground spectrum periods: T_0=0.40, T_A = 0.15, T_B = 0.40
- Dynamic bedding coefficient: Ks=2060 t/m^3
- Based on pressiometer and laboratory experiments, the bearing capacity of soil was determined to be q_{all}=400 kPa

The Project design will take into account the Turkish regulatory requirements related to seismic design and risk assessment. In addition earthquake isolation system will be implemented in all the buildings at the IHC. An earthquake assessment study showed that the building design and the earthquake isolation system would perform satisfactorily for two criteria (Earthquake conditions with a 475 and 2475 year recurrence period) based on the faults near the Site and the earthquake history in the area.

6.3.2 Impacts on Soils

Impacts during Construction

Temporary use of land for construction can, if not properly managed and operated, lead to impacts on soil quality by events such as compaction and accidental spills of liquid cement (excluding hazardous material spills). All these events may be expected to have a minor-moderate impact. It should also be noted that parts of the site was used as a waste disposal facility by the municipality and parts of the site were covered with domestic waste. The soil and groundwater investigation conducted at the Project site showed that there was no leaching of contaminants from these wastes. Construction activities on soils and storage of construction equipment and materials on soils have a potential to affect soil through spills of hazardous material such as oils, fuel or other materials (i.e. during fuel loading for machinery operating at the site). The vulnerability of soil is considered high in case of any spill. If good construction practices are not applied to provide protection against soil, potential impacts are expected to range between minor to major significance depending on the duration of the spills that may range from temporary small-scale spills to continuous/long-term spills.

Impacts during Operation

During operation, soils may become contaminated from spills of hazardous materials, poor management of hazardous wastes generated at the site, leakage from underground pipes used for sanitary wastewater discharges. These spills and leakages may lead to impacts that are considered to range between minor to major depending on the spill size, nature of contaminants and impacted areas.

The following conditions were set in the EHS based design criteria and infrastructure requirements (extracted from Technical Specifications provided by the MoH) as stated in Annex E-6 for the IHC facility:

- The building underground sanitary drainage system will be sized to serve the loads of the proposed facility. A system of sanitary waste and vent piping will be routed throughout the building to vent and collect the discharge from all of the plumbing fixtures and drains.
- Multiple double-walled underground fuel oil tanks or above ground tanks with dikes will be provided near the central energy plant to serve the emergency generators and the boilers. Individual remote fill points will be provided. A leak detection and level monitoring control system will be provided in the central energy plant to monitor the piping system and fuel oil tanks.

The Project will therefore be designed with the necessary protection systems against spills from hazardous materials and wastewater generated at the site. Therefore, the risks of soil pollution during operations are deemed to be negligible if these protections are in place and appropriately operated.

6.4 Mitigation Measures

Mitigation measures to avoid and/or mitigate the predicted impacts will include the following:

- The Project will be designed, constructed and operated in accordance with the Turkish regulations and standards for protection against seismic activity and therefore, risks will be as low as technically and financially feasible.

Specific measures for protection of soil media during the construction phases will include the following:

- All contractors will be required to adopt good construction site practices for the protection of soils and to follow the General IFC EHS Guidelines.
- Provisions will be taken for the protection of newly exposed soil surfaces from rainfall and wind erosion such as silt fences.
- Contaminated soils (if generated any) will be disposed of in an appropriately licensed disposal site.
- The use of cement and wet concrete in or close to any exposed areas will be carefully controlled.

- Hazardous and non-hazardous materials and waste during construction will be handled according to the Integrated Quality, Environment, Health and Safety Management System to be prepared by ELZ A.S. and where needed, further site-specific management plans will be developed (i.e. Hazardous Material Management Plan). Details of waste generation and management methods are provided in *Chapter 8: Material Resources and Waste Management*.
- Fuels, oils and chemicals will be stored on an impervious base protected by bunds to 110% of capacity. Drip trays will be used for fuelling mobile equipment. Any spillages from handling fuel and liquids will be immediately contained on site and the contaminated soil removed from the site for suitable treatment and disposal.
- Spoil and other surplus material arising from the works which is classed as "acceptable fill" shall, wherever practicable, be recovered and used in the construction works. Relevant authorities shall be consulted regarding this on a site by site basis to ensure the re-use of waste materials is acceptable.
- Surplus construction material will be made available to third parties for reuse on local development projects if it cannot be utilized on site.
- Operation of a closed drainage system and implementation of Emergency Preparedness and Response Plan in the event of spills, fire etc. will prevent significant impacts on soils during construction.

Specific measures for protection of soil media during the operation phase will include the following:

- Hazardous and non-hazardous materials and waste during operation will be handled according to the Integrated Quality, Environment, Health and Safety Management System to be prepared by ELZ A.S. and where needed, further site-specific management plans will be developed (i.e. Hazardous Material Management Plan). Details of waste generation and management methods are provided in *Chapter 8: Material Resources and Waste Management*.
- Fuels, oils and chemicals will be stored on an impervious base protected by bunds to 110% of capacity. Drip trays will be used for fuelling mobile equipment. Any spillages from handling fuel and liquids will be immediately contained on site and the contaminated soil removed from the site for suitable treatment and disposal.
- Operation of a closed drainage system and implementation of Emergency Preparedness and Response Plan in the event of spills, fire etc. will prevent significant impacts on soils during operation.

6.5 Residual Impacts

With the implementation of mitigation measures mentioned above, the residual impact on soil is estimated to be insignificant.

6.6 Summary of Analysis Outcome

The evaluation of the predicted impacts of the Project related to geology and soils was presented in this Chapter.

The Project area lies within a 2nd degree seismic zone and is located within the influence zone of Eastern Anatolia Fault. The Project design will take into account the Turkish regulatory requirements (i.e. Regulation on Buildings to be built in Seismic Zones) related to seismic design and risk assessment. A Soil Investigation and Geotechnical Study has been carried out by ELZ A.S. The study showed that there were fill materials inside the Project area and groundwater was not encountered. Separate studies were also carried out by ELZ A.S. for assessing the structural system and adequacy of the earthquake isolation system that will be placed in the buildings at the IHC. The study included earthquake hazard assessment and the ground motion predictions from expected earthquake events. The earthquake assessment study showed that the building design and the earthquake isolation system would perform satisfactorily for two criteria (Earthquake conditions with a 475 and 2475 year recurrence period) based on the faults near the Site and the earthquake history in the area.

A soil and groundwater investigation study was undertaken to assess the soil and groundwater quality at the Project site. The site investigation aimed to evaluate the presence contaminants that might have been associated with former site activities and the liabilities with regard to the applicable regulations. Groundwater was not encountered in this study. Soil samples were analyzed for Total Organic Halogens (TOX), Total Petroleum Hydrocarbons (TPH), Volatile Organic Compounds (VOCs) including Benzene, Toluene, Ethyl benzene and Xylenes (BTEX), Polycyclic Aromatic Hydrocarbons (PAH) and Metals (As, Ba, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Sn, V, Zn). The study revealed that none of the soil samples showed exceedance of the Turkish standards except exceedance of Generic Risk Limits for Arsenic and Chromium parameters in all soil samples and this exceedance was attributed to the naturally presence of these metals in site soils rather than any contamination that might have occurred at the site.