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HALKALI-ISPARTAKULE-CERKEZKOY RAILWAY LINE

Environmental and Social Impact Assessment



70069878-ESIA
DECEMBER 2021

PUBLIC

12

GEOLOGY AND HYDROGEOLOGY

PUBLIC

12 GEOLOGY AND HYDROGEOLOGY

12.1 INTRODUCTION

12.1.1. This chapter reports the findings of the assessment of the potential geology and hydrology effects of the Project during both the construction and operational phases. For both phases, the type, source and significance of potential effects are identified, and the measures that will be employed to minimise these described.

12.2 LEGISLATIVE FRAMEWORK, POLICY AND GUIDANCE

12.2.1. The assessment has been undertaken in line with international best practice. The key international guidelines for the protection of drinking water quality are the World Health Organisation's (WHO) 'Guidelines for Drinking-Water Quality' (2011)[188].

12.2.2. Where appropriate when considering geology and soils and the groundwater environment, the following EU legislation has been considered during the completion of this assessment:

- The Landfill Directive (EEC/1999/31/EC) – which aims to prevent or reduce effects on the environment, particular pertinent to this assessment on groundwater and soils, from the landfilling of waste by introducing procedures for waste disposal sites;
- The Water Framework Directive (2000/60/EC) – which makes provision for the maintenance and improvement of the 'ecological and chemical status' of the water environment, which includes rivers, lakes, wetlands, artificial waterbodies, groundwater, estuaries and coastal waters; and
- Groundwater Directive (2006/118/EC) – which outlines the procedures for assessing the 'Chemical Status' of groundwater and protects groundwater by preventing direct discharge of 'hazardous pollutants' and limiting the direct discharge of non-hazardous pollutants.

12.2.3. In addition, where deemed appropriate, and where there is no suitable national guidance, UK guidance documents have been considered within this assessment, this is considered a reasonable approach as UK guidance is generally in accordance with EU legislation.

12.2.4. The following Turkish legislation has been considered during completion of this assessment:

- The Law on the Environment (1983) – as amended in 2006 and 2018 (Law No.5491 and Law No.7115 respectively). The Law forms the basis for all major environmental regulations in Turkey, those pertinent to geology and hydrogeology are summarised below. Of relevant to this assessment the Law outlines responsibilities which sit with the Ministry of Environment regarding the use and protection of natural resources and for the prevention of water, soil, and air contamination;
- Groundwater Law (1960) – which is applicable to all groundwater resources more than 10m below the surface except for private springs and wells. The Law sets priorities for the use of groundwater, such as for drinking, cleaning, in connection with animals and agriculture;

[188] WHO (2011). Guidelines for Drinking-Water Quality, Fourth Edition.

- Bylaw on the Protection of Groundwater Against Pollution and Deterioration (2012) – transposes the Groundwater Directive (2006/118/EC) into Turkish law;
- Regulation on Control of Water Pollution (2004) – as amended in 2010 and 2016, establishes standards / limits relating to pollution discharge into waterbodies, details the permitting system for discharge activities, and outlines a classification system for waterbodies in Turkey (high-quality waters, waters with minimal pollution, polluted waters, and highly polluted waters);
- Regulation on Environmental Permits and Licences (2014) – as amended in 2016, outlines the environmental permits and certification required (as summarised within the **ESMP**;
- Regulation on the Control of Soil Contamination and Point Source Pollution (2010) – this regulation outlines technical and administrative procedures and principles to prevent soil contamination, locate the contaminated areas and sectors, and to monitor and clean the contaminated soil and sites;
- Regulation on the Protection of Wetlands (2014) - this Regulation defines the principles of protection, management and development of wetlands and their habitats in Turkey's land borders and the continental shelf which includes protection of groundwaters which feed wetlands;
- Regulation on Control of Pollution Caused by Dangerous Substances in Aquatic Environment (2005) – sets forth technical and administrative standards for identifying dangerous substances that pollute surface water, estuaries, and regional waters. It also provides standards for preparing pollution reduction programs, for monitoring and preventing pollution, and for conducting inventories of dangerous substances discharged into water resources;
- Regulation regarding Protection and Management of Water Mains (2012) – this Regulation outlines protection measures for potable water mains for public drinking supply including from potentially contaminated sites; and
- Regulation on the Quality and Treatment of Water Intended for Potable Water Supply (2019) – this regulation outlines the procedures and principles of quality standards, treatment categories and treatment efficiency of water intended for potable water supply. It also details the principles of categorization of waters and appropriate standard methods of treatment for each category, the sampling and analysis methods and frequencies of analysis of drinking water.
- Regulation on Waste Oils (2008) - The purpose of this Regulation is the control and management of waste oils, to protect human health and to maintain environmental protection.

12.3 ASSESSMENT METHODOLOGY

12.3.1. This Chapter qualitatively assesses the potential effects of the Project on the surrounding area in terms of geology, soils and groundwater during both construction and operation.

12.3.2. Where appropriate it also identifies proposed mitigation measures to minimise or control likely adverse effects on geology, soils and groundwater arising from the Project. This Chapter should be read in conjunction with the introductory chapters (**Chapter 1: Introduction** to **Chapter 5: Approach to ESIA**), **Chapter 8: Ecology**, **Chapter 11: Surface Water Environment, Chapter 13: Materials and Waste** and **Chapter 16: Major Accidents and Disasters**.

12.3.3. The assessment methodology describing the magnitude of impact and significance is described in detail in **Chapter 5: Approach to the ESIA**.

12.3.4. The assessment of the Project has been undertaken primarily through a desk-based study using available information relating to geology, soils and groundwater.

12.3.5. The potential for land contamination has been broadly assessed with due regard to UK guidance such as:

- Part 2A of the Environmental Protection Act (1990)[189];
- best practice guidance from land contamination risk management set out in Land Contamination Risk Management (2020, LCRM)[190], and
- best practice guidance from land contamination risk management set out in the Construction (Design and Management) (CDM) Regulations (2015)[191].

12.3.6. Potential sources and receptors identified from the walkover and available information have been qualitatively assessed the possibility for land to be contaminated. The identification of potential sources and receptors has enabled an assessment to be undertaken in order to evaluate the plausible contaminant linkages and any changes (from baseline conditions) during construction and operational phases of the Project. The likely significance of the risk for each plausible linkage has been assessed and compared to determine beneficial and adverse effects of the Project against the baseline conditions.

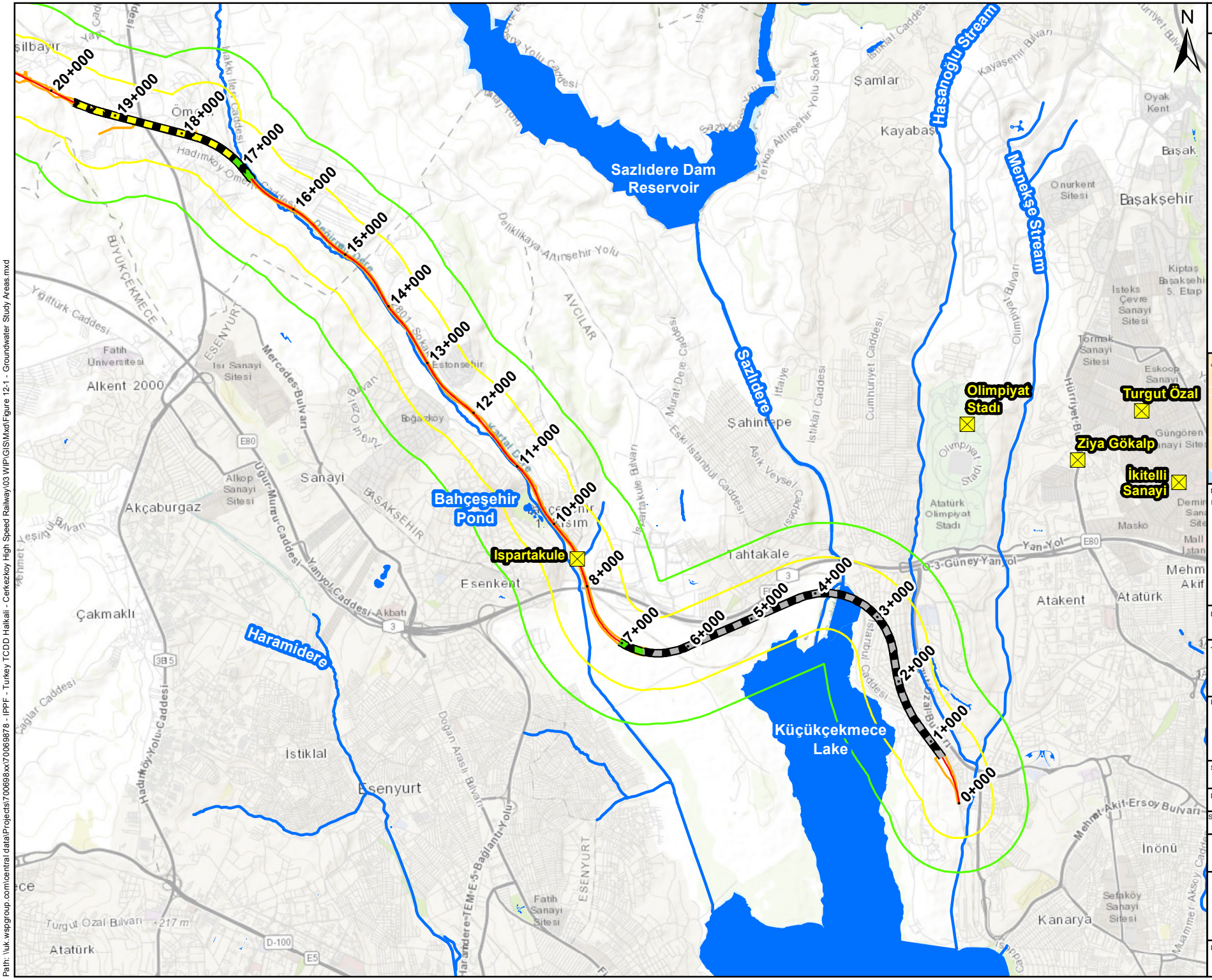
STUDY AREA

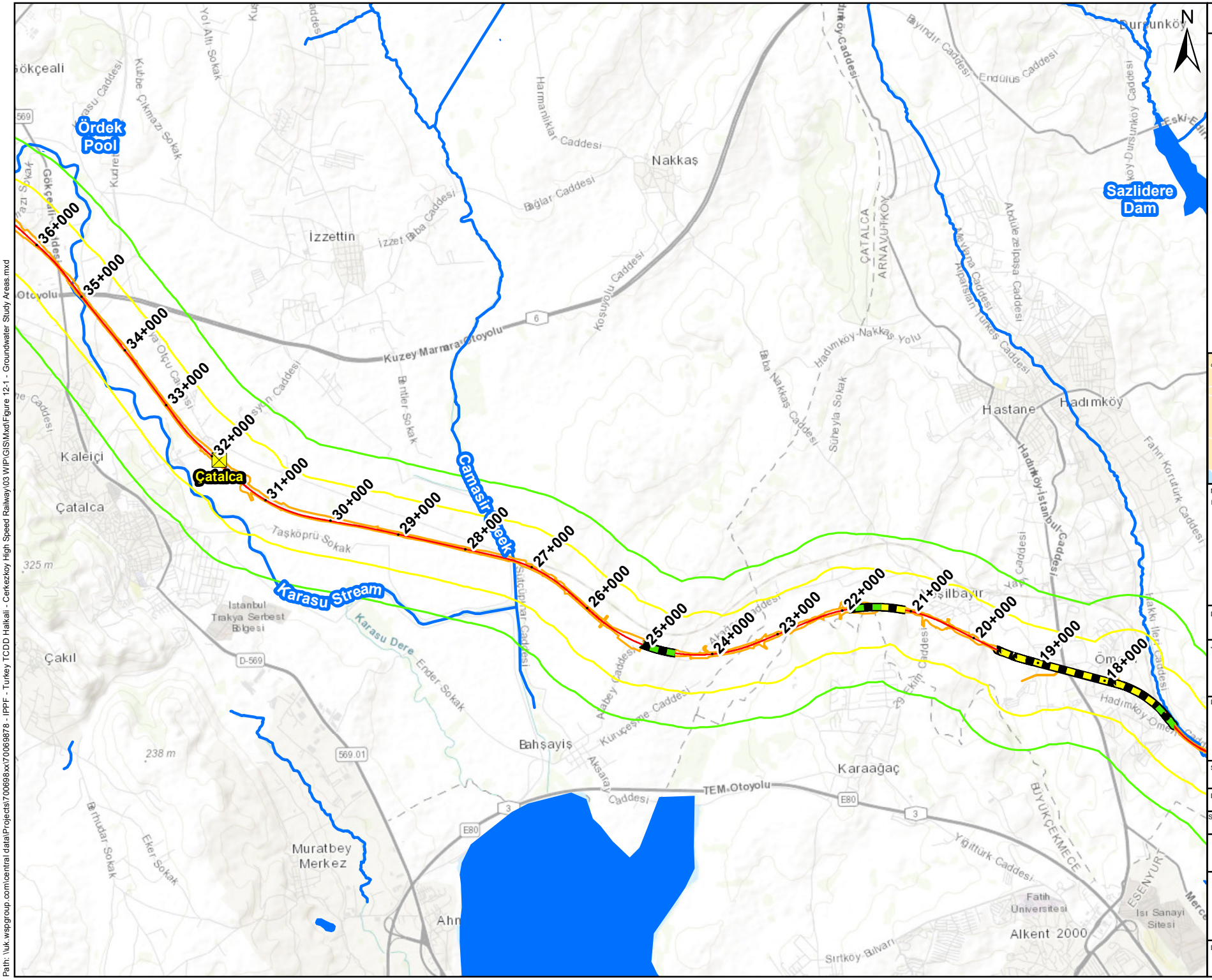
12.3.7. The study area considered for the purpose of this assessment consists of the area within the expropriation corridor. It is also defined by the potential receptors that may be affected by the Project according to potential groundwater flow paths that might extend away from the Project alignment towards surface waters and groundwater aquifers.

12.3.8. The study area typically encompasses groundwater aquifers up to 1km from the Project that have the potential to be affected directly by the Project (for example, associated with potential changes to groundwater conveyance, recharge or mobilisation and migration of pollutants to regional groundwater aquifers). The study area also includes human health receptors (such as local communities) and surface water features that are within 500m of the Project and are in hydraulic connectivity with the study area which may therefore be affected by direct or indirect impacts (for example, associated with anthropogenic pollutants released from soils during construction or anthropogenic pollutants which may migrate from groundwater into surface water features).

12.3.9. The study areas are shown in Figure 12-1.

[189] HMSO (1990). Part IIA of the Environmental Protection Act.
[190] HMSO (2020). Land Contamination Risk Management.
[191] HMSO (2015). Construction (Design & Management) Regulations.


Sazlıdere Dam Reservoir
Hasanoğlu Stream
Menekşe Stream
Sazlıdere
Bahçeşehir Pond
Haramidere
Küçükçekmece Lake
Ispartakule
Olimpiyat Stadı
Turgut Özal
Ziya Gökalp
İkitelli Sanayi
20+000
19+000
18+000
17+000
16+000
15+000
14+000
13+000
12+000
11+000
10+000
8+000
7+000
6+000
5+000
4+000
3+000
2+000
1+000
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Şamlar
Kayabaşı
Başakşehir
Alkent 2000
Akçaburgaz
Esenkent
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İstiklal
Esenyurt
Atakent
Kanarya
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Atatürk
Sanayi
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THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED AND ONLY WRITTEN DIMENSIONS SHALL BE USED
Legend
Railway Stations (Current)
Proposed Railway Route
Tunnel (TBM - Double Tube)
Tunnel (NATM)
Tunnel (Cut - Cover)
Waterway
Inland Water
Expropriation Corridor Study Area
Human Health Study Area (500m)
Groundwater Study Area (1,000m)
Cerkezkoy Station (Current)
Halkali Station (Current)
Note:
Data provided based on OpenStreetMap data.
Drawing Status
FINAL
Job Title:
HALKALI-ISPARTAKULE-CERKEZKOY RAILWAY LINE
Drawing Title
Figure 12-1 - Groundwater Study Areas
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Figure 12-1 (1/5)
Path: \\uk.wspgroup.com\central data\Projects\70069878-xx\70069878 - IPPF - Turkey TCDD Halkali - Cerkezkoy High Speed Railway\03 WIP\GIS\Mxd\Figure 12-1 - Groundwater Study Areas.mxd



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Legend

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- Proposed Railway Route
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Drawing Status: FINAL

Job Title: HALKALI-ISPARTAKULE-CERKEZKOY RAILWAY LINE

Drawing Title: Figure 12-1 - Groundwater Study Areas

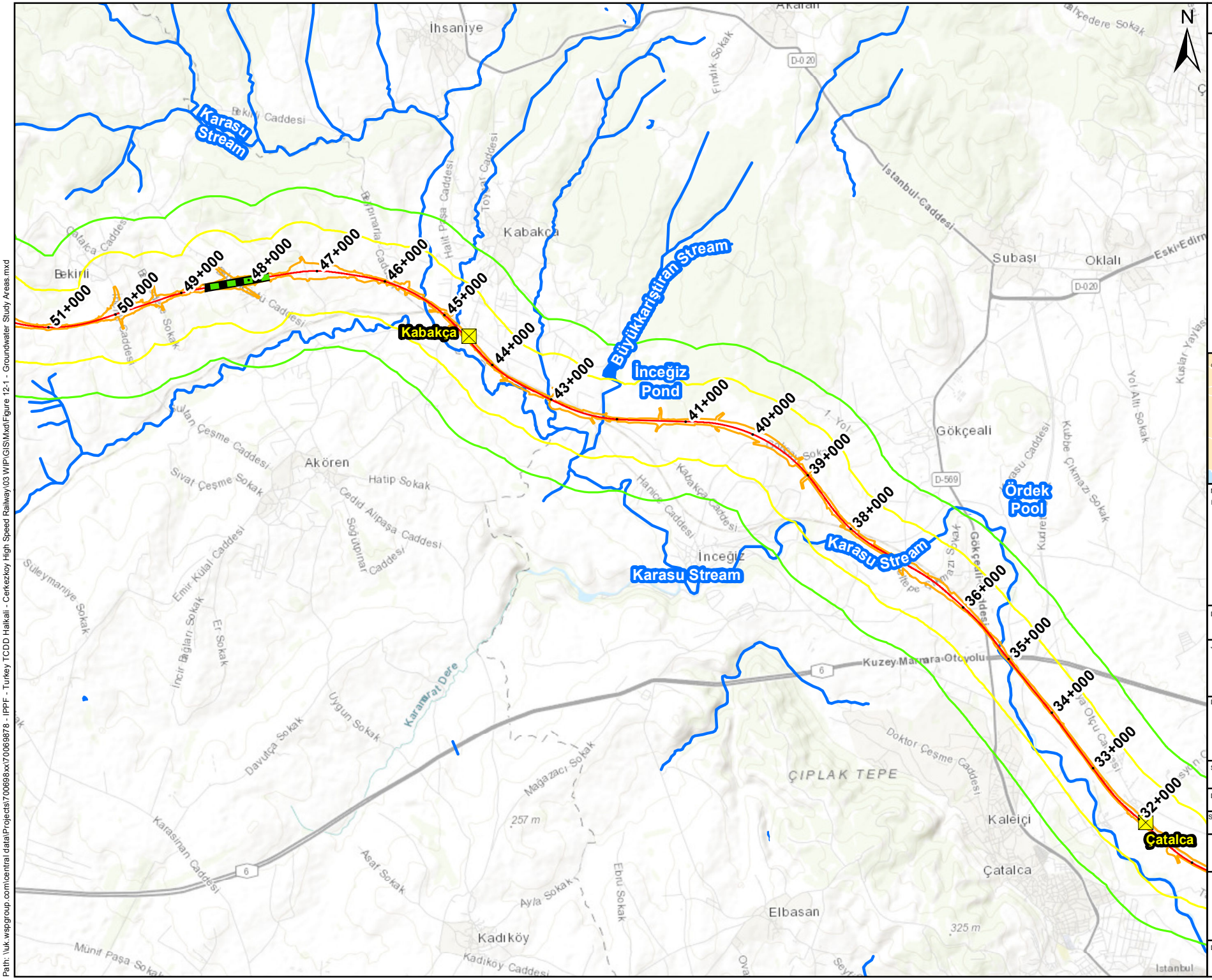
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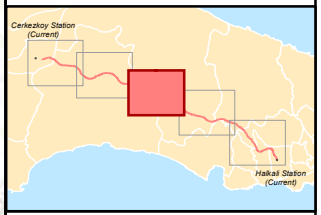
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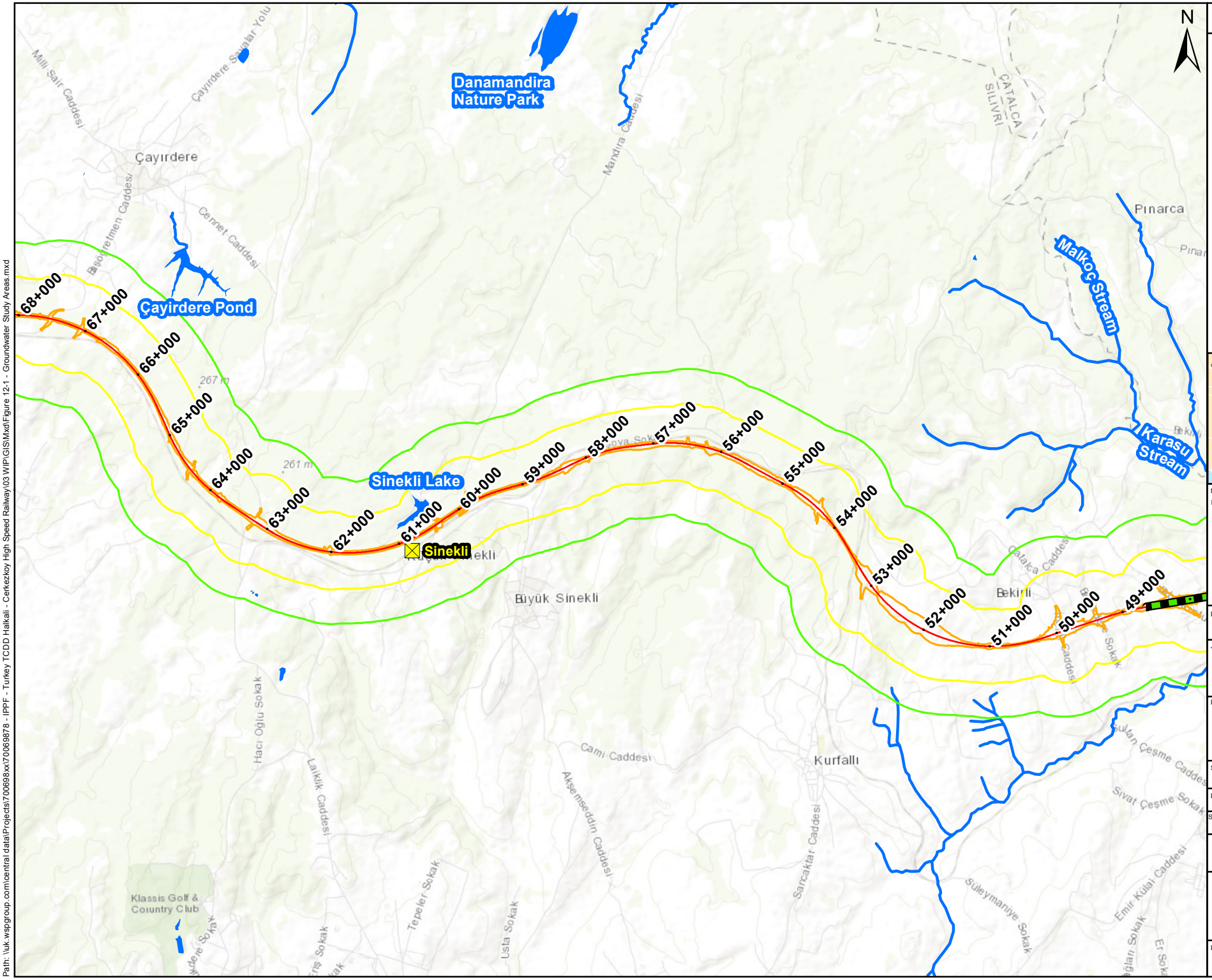
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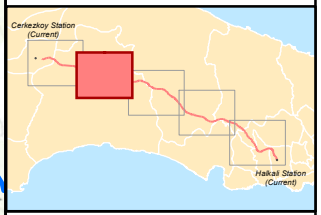
Path: \\uk.wspgroup.com\central data\Projects\70069878-xx\70069878 - IPPF - Turkey TCDD Halkali - Cerkezkoy High Speed Railway\03 WIP\GIS\Mxd\Figure 12-1 - Groundwater Study Areas.mxd



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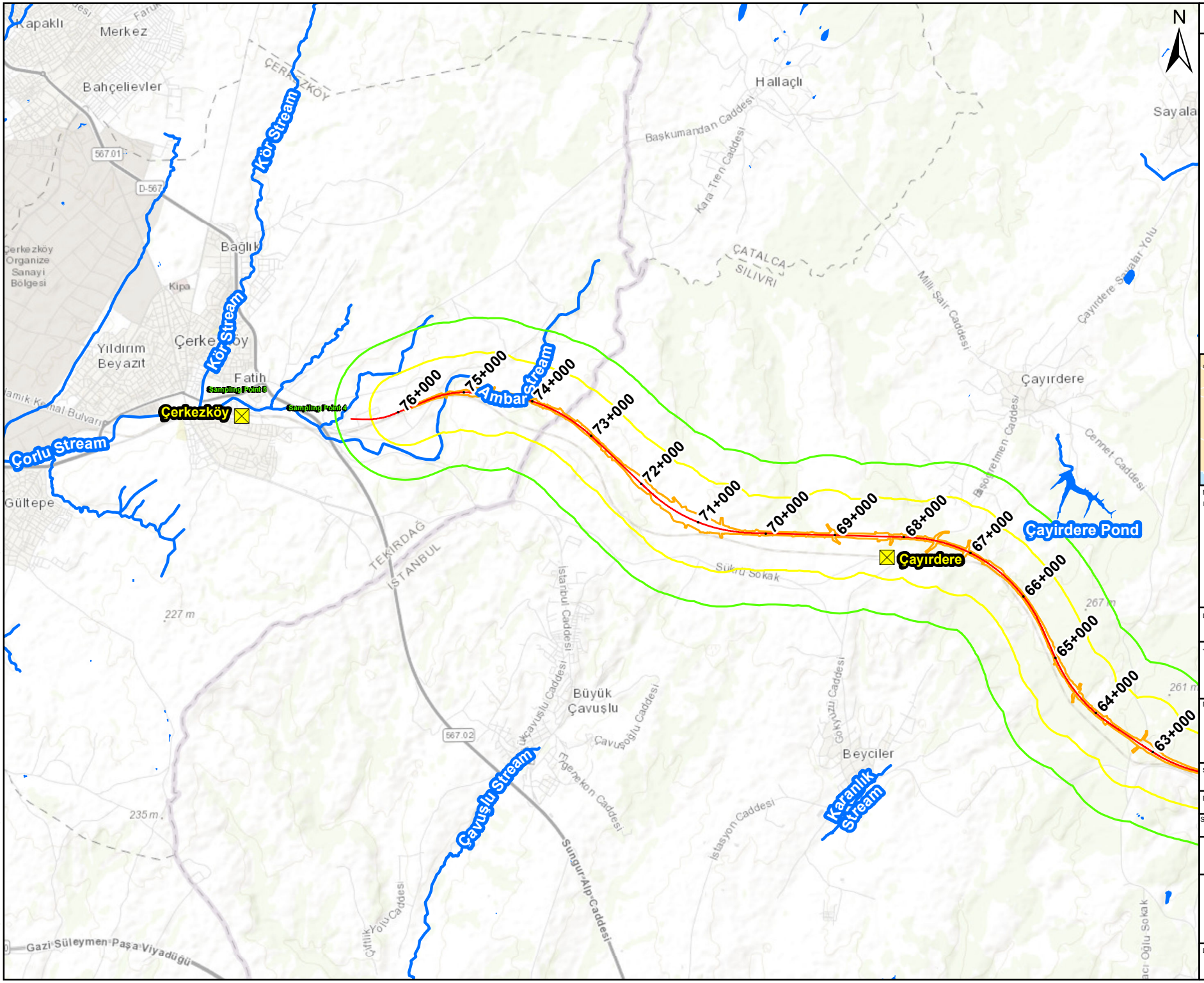
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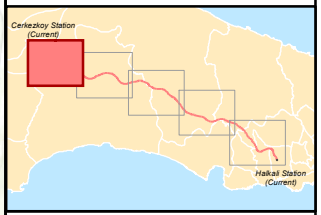
Path: \\uk.wspgroup.com\central data\Projects\700698xx\70069878 - IPPF - Turkey TCDD Halkali - Cerkezkoy High Speed Railway\03 WIP\GIS\Mxd\Figure 12-1 - Groundwater Study Areas.mxd



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Drawing Title
Figure 12-1 - Groundwater Study Areas

Scale at A4
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12.4 BASELINE CONDITIONS

12.4.1. Baseline data has been obtained through desk-based review of third party and consultation information. The baseline information has been based on the findings of the National EIA for the Project (2017)[192] for the Project and subsequent information provided by the Project Team.

12.4.2. Ecological receptors, including aquatic ecology and habitats, are discussed in **Chapter 8: Ecology**.

12.4.3. Surface waters, including chemical quality and flood risk are discussed in **Chapter 11: Surface Water Environment.**

12.4.4. The generation of arisings and requirement for material resources are discussed in **Chapter 13: Materials and Waste**.

12.4.5. Risks from major accidents and disasters including earthquakes are discussed in **Chapter 16: Major Accidents and Disasters.**

CURRENT SITE SETTING

12.4.6. The Project alignment intersects with the following: roads; utility services (underground and above ground); residential areas; commercial properties; forest lands; streams and lakes.

GEOLOGY

12.4.7. Geological mapping of the Project alignment (as shown in **Figure 12-2**) indicates the bedrock geology beneath the Project is comprised of Pliocene deposits of the Ergene group (sandy, shaley conglomerates) and sedimentary strata of Oligocene and Miocene deposits of the Yenimuhacir group (sandstones, shales, minor coal, siltstones, limestones). This is overlain in places by recent superficial deposits of Alluvium (sand, clays, silts and gravels). The Project alignment is largely located on topsoil, with Made Ground[193] present beneath the areas of hardstanding or the existing railway. Outcroppings of igneous or metamorphic rock are present to the north and south of the Project alignment.

12.4.8. The existing railway extends along the east of the Ergene basin. It is characterised by Yenimuhacir group outcropping in the eastern section and Ergene group outcropping in the western section. The geological characteristics of these groups are discussed below.

[192] Sweco Mühendislik Müşavirlik ve Tasarım Ltd. Şti.(2017). Halkali – Kapikule Railway Project EIA Report.
[193] A term used to describe soil which has been subject to human intervention, such as through farming, landscaping or construction activities.

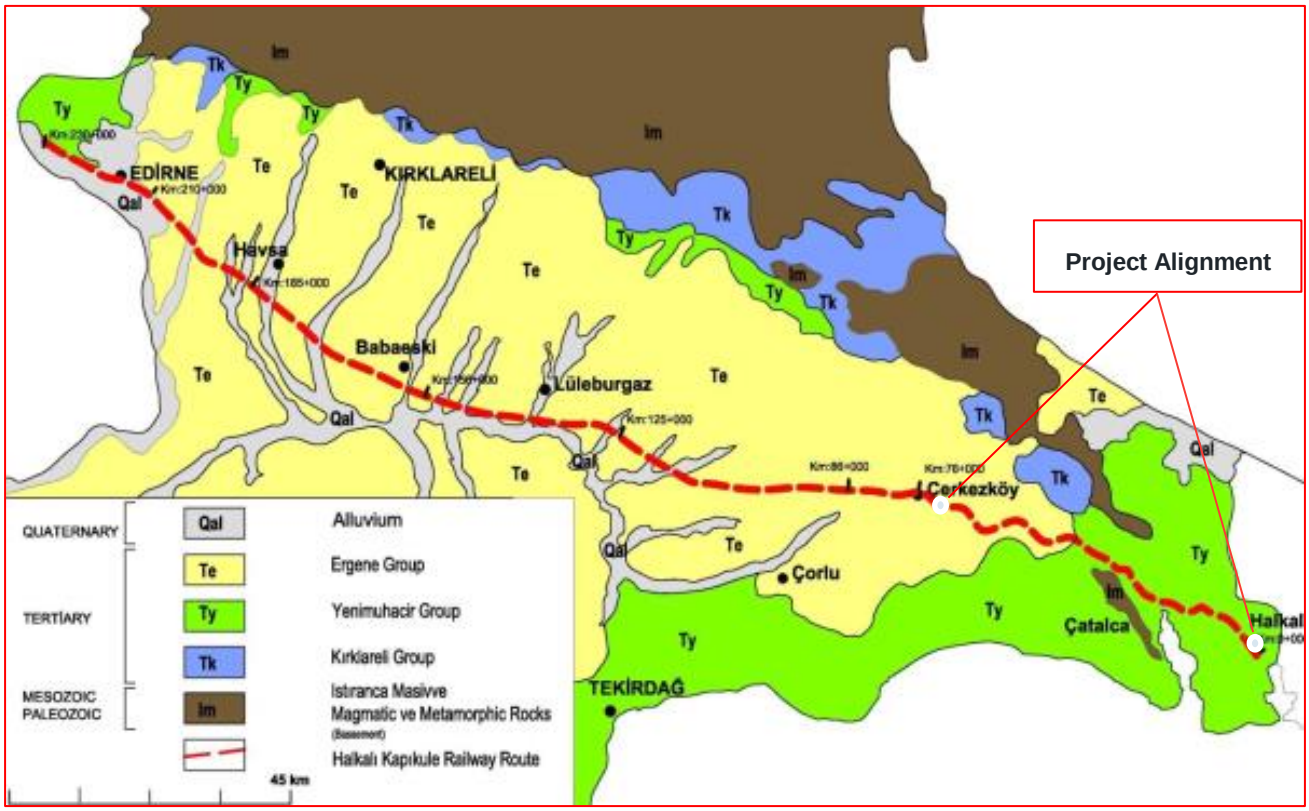


Figure 12-2 - Geological Map of Thrace Region[194]

Superficial Deposits: Alluvium

12.4.9. Alluvium deposits comprise sands, silts, gravels and clays associated with existing or historic rivers or floodplains. They may be observed along valley floors and may be unconsolidated and vary in thickness and lithology. As their deposition is associated with rivers, they have the potential to act as groundwater aquifers where the main component is granular (sand and gravel) or aquitard where there is a significant clay or silt component.

Bedrock: Ergene Group

12.4.10. The unit is composed of cross bedded conglomerates and sandstones of fluvial and lacustrine environment and sandstone and claystone lithologies with abundant plant and vertebrate fossils. The thickness at the Ergene basin margin is estimated to be 0-60m. It is likely to be present along the western section of the Project alignment.

[194] Sweco Mühendislik Müşavirlik ve Tasarım Ltd. Şti.(2017). Halkali – Kapikule Railway Project EIA Report.

Bedrock: Yenimuhacir Group

12.4.11. The Yenimuhacir group comprises the Danişmen Formation, Osmancik Formation, Pinarhisar Formation and Mezardere Formation.

12.4.12. The Danişmen Formation is present below approximately the first 40km in the east of the Project alignment. It is formed of interbedded siltstone, shale, sandstone with some coal and can be between 500-1000m in thickness.

12.4.13. The Osmancik Formation underlies the Danişmen Formation and is generally formed of sandstone and shale and can be 200-700 m in thickness. This is underlain by the Pinarhisar Formation (limestone) and Mezardere Formation (shale, siltstone, tuff) with thicknesses of 0-50m and 50-2,500m, respectively.

12.4.14. **Figure 12-3** shows the general geological sequence of bedrock along the Project alignment.

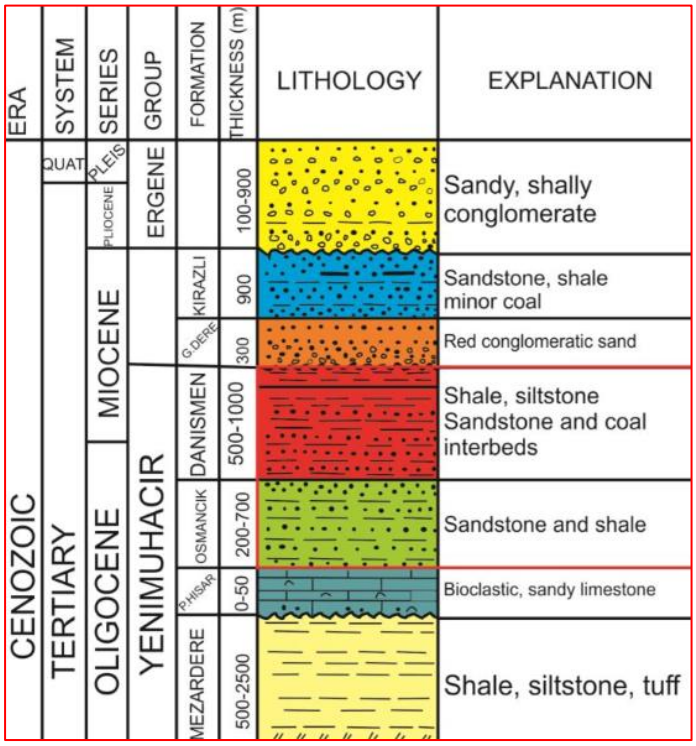


Figure 12-3 - Generalised Stratigraphy Section of Project Alignment[195]

[195] Diyarbakirli, Ali Can (2016). Stratigraphic Analysis and Reservoir Characterization of the Late Oligocene-Early Miocene, Upper Yenimuhacir Group, Thrace Basin, Turkey.

HYDROGEOLOGY

12.4.15. Where Alluvium is present it may have the potential to act as groundwater aquifers where the main component is granular (sand and gravel) or aquitard where there is a significant clay or silt component.

12.4.16. The Ergene and Yenimuhacir groups are permeable and are known to contain groundwater in quantities capable of supplying public water supply. The sensitivity of these permeable bedrock units is considered to be High.

12.4.17. The Project falls within the Marmara Basin which has a groundwater management reserve of 205 million m^3 of water per year. Groundwater reserves are used for surface irrigation, potable and industrial water provision. Use of groundwater resources are monitored and regulated by the government. However, effective implementation of this regulation faces several challenges such as the existence of unlicensed wells, the difficulty of preventing illegal use of wells and changing climate and precipitation patterns causing fluctuations in the regional groundwater table.

12.4.18. The western extent of the Project alignment falls within Tekirdağ Province. Total water potential of Tekirdağ Province is approximately 883 million m^3 per year. There are a large number of artificially opened wells in the settlements for industrial and industrial irrigation purposes. In recent years, uncontrolled well opening has been observed, especially in order to meet the growing water demand of industry in the region. However, in order to prevent this situation, the General Directorate of State Hydraulic Works in Turkey (DSI Regional Directorate[196]) has restricted the opening of wells. The groundwater level, which was 10-30m in the 1970s, has now dropped to 80-200m due to uncontrolled use.

12.4.19. The majority of the Project alignment falls within Istanbul Province. Total water potential in Istanbul province is 250 million m^3 per year. Groundwater is limited in Istanbul and is considered to be a water stressed area. Near Küçükçekmece Lake, the starting point of the Project alignment, the groundwater level is very close to the surface creating wetland habitats.

Drinking Water Resources

12.4.20. The Project alignment is upstream and in close proximity to two dams which provide reservoirs used for drinking water.

12.4.21. The Project alignment is located approximately 2km north of Büyükçekmece Dam. Büyükçekmece Dam is located at Lake Büyükçekmece and was opened in 1988 to provide a drinking water supply to Istanbul. It has an earth-fill embarkment dam of 13m height. The catchment area of the dam is 620km^2.The reservoir has a capacity of 162 million m^3 and a surface area of approximately 28km^2. The reservoir water is sanitised before being supplied. The annual water supply capacity of the dam is 100 million m^3.

[196] Regional Directorates operate on behalf of the General Directorate of State Hydraulic Works.

12.4.22. The Project alignment is located approximately 4km west of Sazlıdere Dam. The Sazlıdere Dam was constructed along the Sazli Stream in 1996 by the Istanbul DSI Regional Directorate to provide drinking water supply to the western side of Istanbul.

SURFACE WATERS

12.4.23. The Project alignment crosses or is located in close proximity to several key watercourses summarised in the **Table 12-1** below. Further information on surface waters is presented in **Chapter 11: Surface Water Environment.**

Table 12-1 - Key Watercourses

Watercourse	Chainage
Sazlı Stream	4+000
Hadımköy Stream / Eşkinoz Creek	7+500 – 17+200
Camasir Creek at inlet of Büyükçekmece Lake	27+260
Karasu Stream	27+260 – 38+980 42+150 – 46+390
Ambar Creek	74+053 – 75+268

12.4.24. The majority of the Project alignment passes through the drainage catchment of two lakes:

- Küçükçekmece Lake; and
- Büyükçekmece Lake.

12.4.25. Küçükçekmece Lake is a freshwater lake situated west of Istanbul where the Karasu stream reaches the Marmara Sea. The watercourses of the Sazli Stream, Hadımköy Stream/Eşkinoz Creek and Nakkas Creek discharge to the Küçükçekmece Lake. This site is comprised of wetlands and marshes and is important for wintering and passage waterbird species and also supports a range of breeding waterbirds. Regional groundwater aquifers are likely to be connected to this surface water.

12.4.26. Büyükçekmece Lake is a natural brackish lagoon situated to the west of Istanbul on the Sea of Marmara that supports a substantial numbers of wintering waterbirds.

12.4.27. Further information regarding the ecological designation and status of these wetlands are contained within **Chapter 8: Ecology**.

TOPOGRAPHY

12.4.28. Generally, the Project alignment passes through relatively flat land from Halkali before running along a valley floor from İnceğiz to Kurfalli. The surrounding terrain then increases in elevation (up to approximately 300m) between Kurfalli and Cerkezkoy.

POTENTIAL SOURCES OF CONTAMINATION

12.4.29. The following potential sources of contamination along the Project alignment include:

- Agricultural machinery on farms, with some potential for oil spills on bare ground;
- Potential presence of animal waste and animal carcasses on the farms;
- As there is unlikely to be a sewage system servicing existing residential properties along the alignment, unlined pits are likely to used for sewage and are therefore a potential source of contamination;
- The presence of potential of domestic or fly-tipped waste along the Project alignment;
- Potential waste and fuel storage at commercial properties which intersect the Project alignment at Omerli;
- Two substations located at Halkali (to be upgraded) and Kabakca (to be demolished and a new substation constructed) which may contain hydrocarbons including polychlorinated biphenyls (PCBs); and
- Quarrying activities (for sand) within 1km of the Project alignment, west of Sinekli and Bekirli.

SEISMIC CHARACTERISTICS

12.4.30. Based upon earthquake mapping from United States Geological Survey no earthquakes have been recorded along the route of the Project between 1900-2015[197] as shown in **Figure 12-4.**

[197] USGS (2020). Earthquake. Available at: https://earthquake.usgs.gov/earthquakes/eventpage/us60007ewc/map (Accessed 29/07/20).

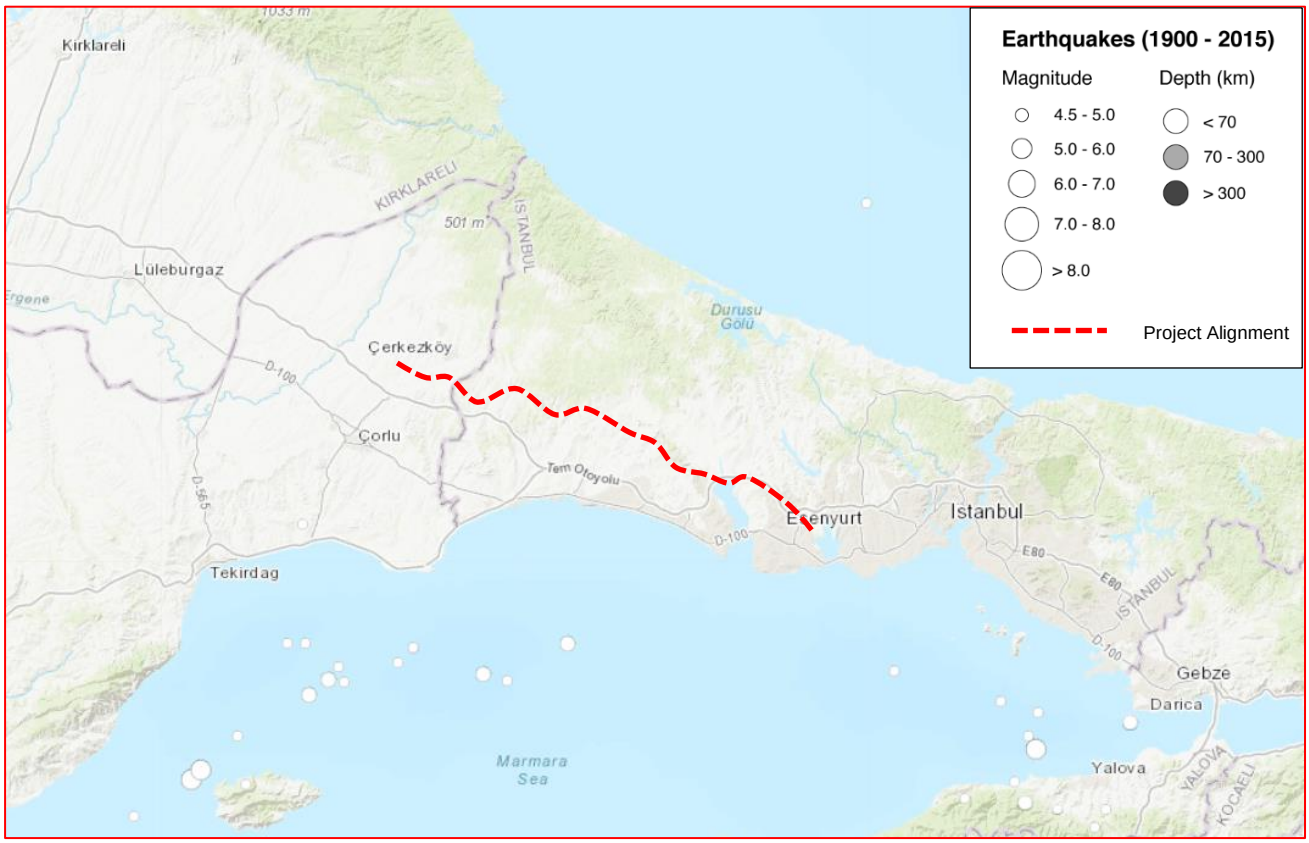


Figure 12-4 - Earthquakes in the Region of Project between 1900-2015

12.4.31. There is no fault line mapped along the Project alignment although a major fault line is known to be present within the Marmara Sea. **Figure 12-5** shows the updated Turkey Earthquake Hazard Map which came into force on 1st January 2019. The map shows the largest ground acceleration values rather than earthquake zones and replaces the 'earthquake zone' concept. **Figure 12-5** shows Peak Ground Acceleration (PGA) levels with 10% probability of exceedance in 50 years (standard probability value used globally). The Project alignment is within an area with moderate to high probability of PGA levels exceeding 10% within the next 50 years. Hazard maps can be used for land-use planning, mitigation, and emergency response over wider areas rather than defined site boundaries. Therefore, this indicates the Project alignment will need to consider mitigation measures against potential earthquakes within its design. Further details are provided within the assessment in **Section 12.5**.

12.4.32. In the event of an earthquake on the existing railway the following procedure is followed:

- The magnitude and the epicentre of the earthquake is established;
- A response level is applied depending the magnitude and the distance to the epicentre of the earthquake (such as, 'Level 1' trains continue with only speed restrictions, and 'Level 3' trains are stopped until track and structures inspections are complete); and
- Inspections of track and structures are undertaken, if required by the response level.

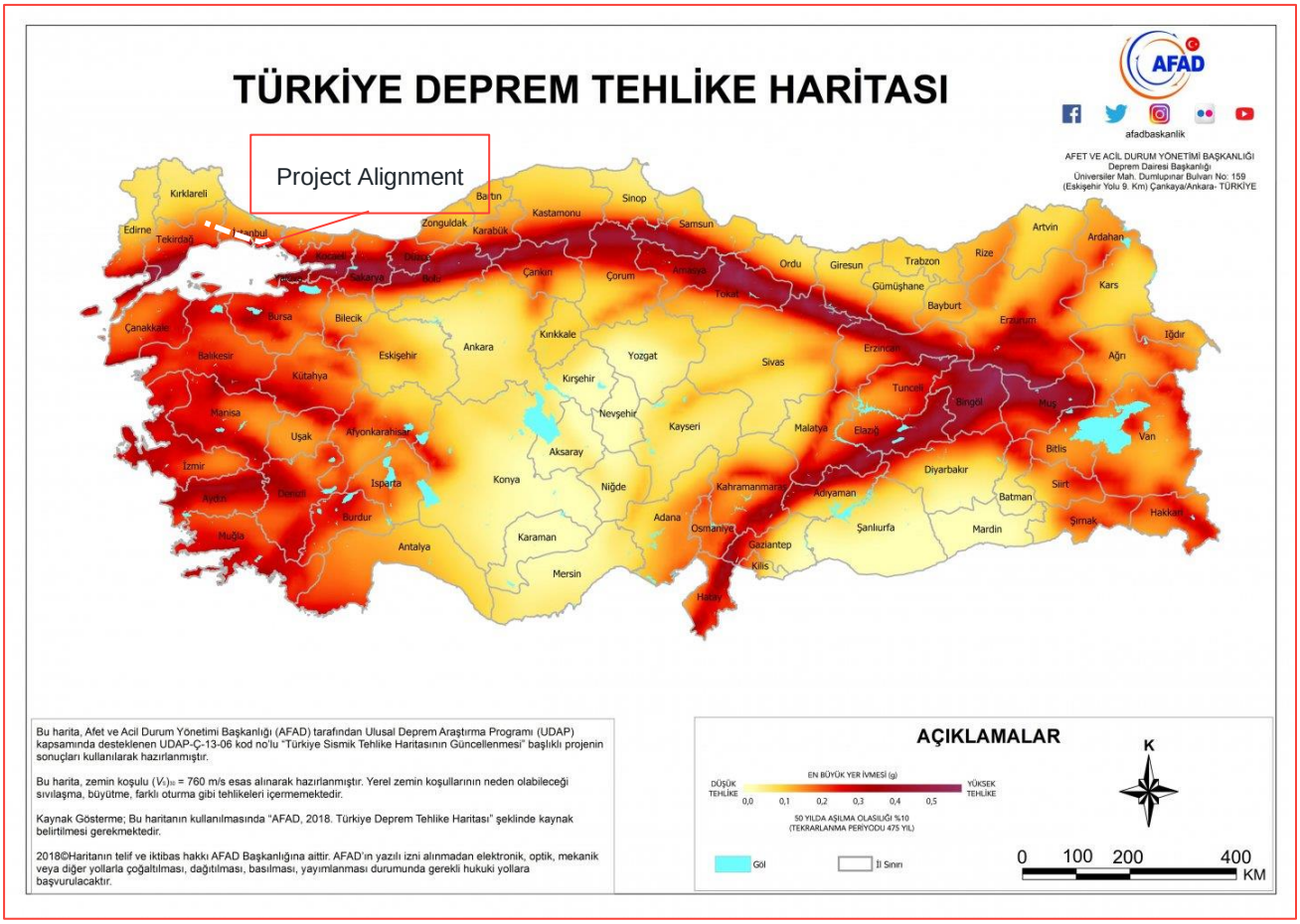


Figure 12-5 - Turkey's Earthquake Hazard Map[198]

LANDSLIDES

12.4.33. The Project passes through several areas which have a risk from landslides (see **Figure 12-6**). Chainages 42+000 and 51+000 pass through areas which contain old and active landslides (See **Figure 12-7**).

[198] Presidency of Earthquake Directorate of AFAD (2019). Turkey's Earthquake Hazard Map.

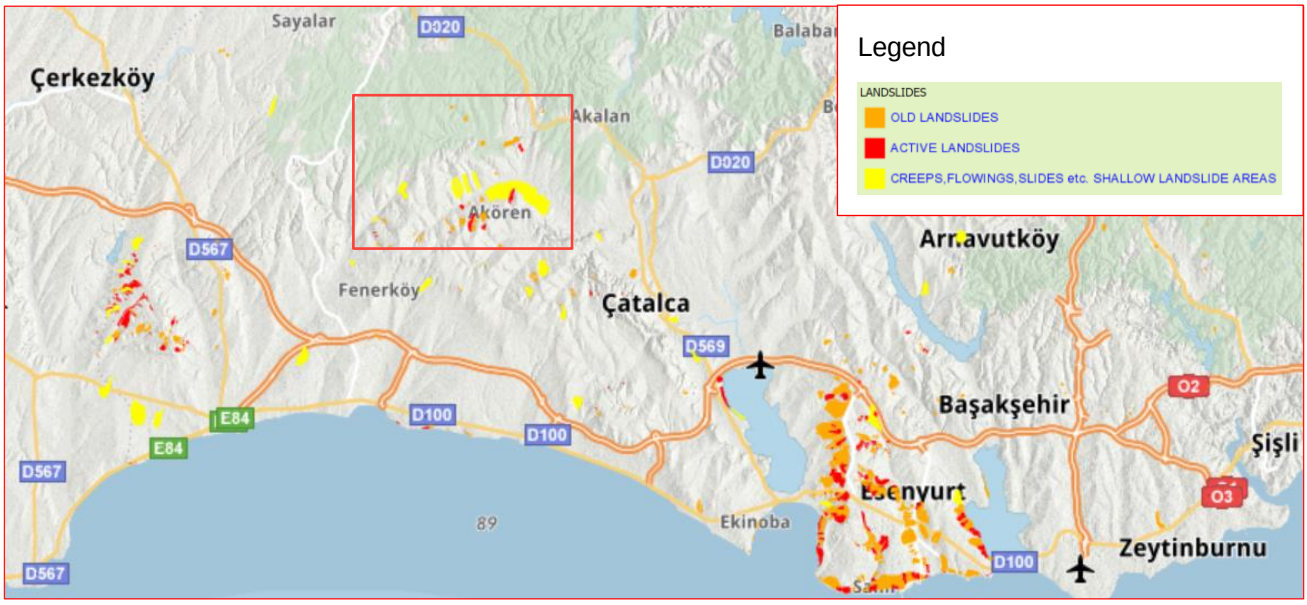


Figure 12-6 - Landslide Risk (wider Project area)[199] (red box shows area detailed in Figure 12-7)

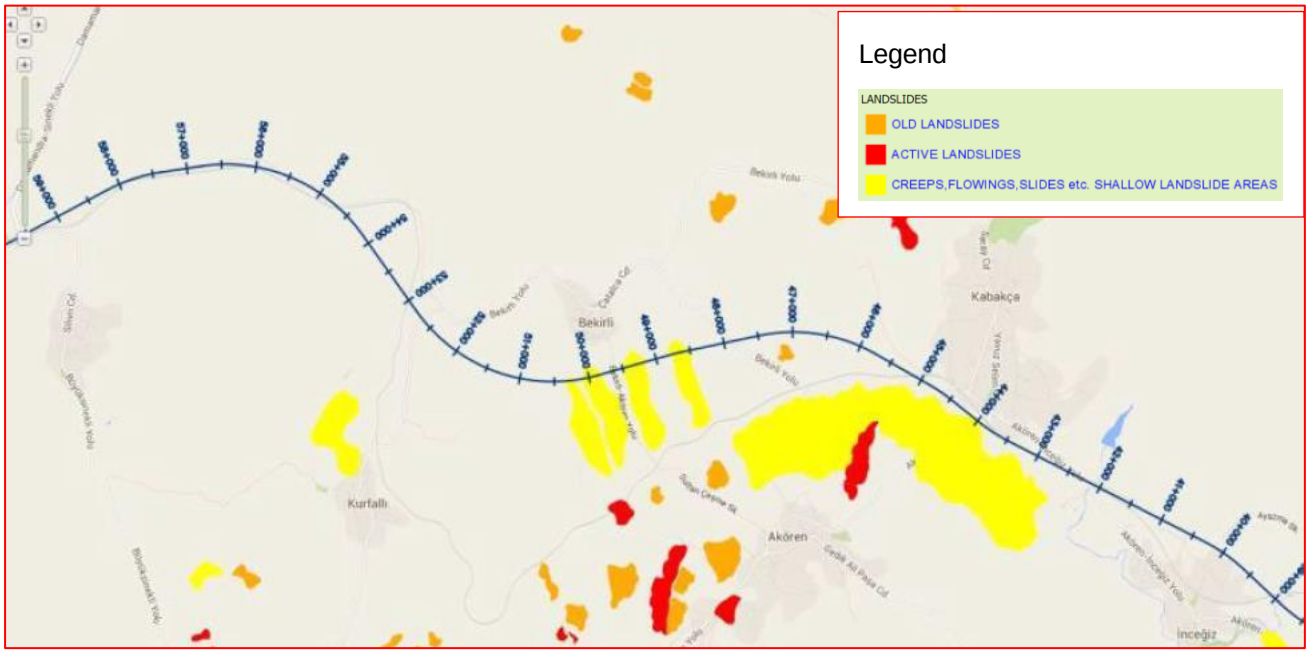


Figure 12-7 - Landslide Risk (along Project alignment north of Akören)[199]

[199] General Directorate of Mineral Research and Exploration (2020).GeoScience Map Viewer and Drawing Editor. Available at: http://yerbilimleri.mta.gov.tr/anasayfa.aspx (Accessed 29/07/20).

FUTURE BASELINE

12.4.34. Along areas of the Project alignment where the existing railway line is present the future baseline would be characterised by little change relative to the current baseline. In the offline areas (where the Project alignment is away from the existing railway), in particular the eastern section, areas of potential contamination associated with industry or other potentially contaminating land use (such as at Ömerli) will likely continue to leach into underlying soils and groundwater and would likely continue to deteriorate with time.

RECEPTORS

12.4.35. The sensitive receptors that have been identified and considered within this assessment are:

- Construction workers;
- Surrounding soils (mainly agricultural) and geology;
- Surface water bodies;
- Future site users (mainly maintenance workers, excluding railway passengers);
- Off-site users in the immediate vicinity of the Project (including nearby residents);
- Nearby residential dwellings with foundations; and
- Underground utility services (such as drainage, sewerage, potable water supplies and cabling).

12.5 POTENTIAL IMPACTS AND EFFECTS

CONSTRUCTION IMPACTS

Potential Impacts on Topsoil and Groundwater Quality from Leaks / Spills from HGVs, Machinery and Hazardous Material Storage

12.5.1. Both topsoil and groundwater are resources which when exposed to influencing factors, such as leaks and contamination, respond in different ways and often result in accelerated resource degradation. Accelerated degradation may lead to a reduction in the quality of the topsoil or groundwater by reducing the content of organic matter, contamination, salination, acidification, resulting in a loss of biodiversity.

12.5.2. The construction phase of the Project will result in additional traffic movements, associated with Heavy Good Vehicles (HGVs) and machinery. There is the potential for leaks / spills of oil and lubricants from the HGVs and construction machinery.

12.5.3. The construction phase of the Project will also require the storage of hazardous materials. If these materials are not stored in accordance with guidance and best practice measures there is the potential for leaks to occur, resulting in ground contamination.

12.5.4. It is expected there will be three construction compounds during the construction phase. The locations of these construction compounds will be determined by the Contractor once they have been appointed. Each construction compounds will contain construction workers accommodation, which will likely require the storage and use of fuel oils for generators as a backup source of power and heat.

12.5.5. The substation improvements at Halkali and Kabakca are required to provide suitable transformers connection. The existing infrastructure at the substations have the potential to contain polychlorinated biphenyls (PCBs) which are classified as an environmental pollutant and hazardous substance. PCBs were banned in Turkey in 1995 however, they have the potential to be present

within existing infrastructure such as old transformers and capacitors. Should the existing transformers within the substations, that are due to be replaced contain PCBs, these may present a risk to sensitive receptors if they leak into the environment. This risk will be assessed and managed by the Contractor through the implementation of good practice measures in the **ESMP**, as set out in **Section 12.6**.

12.5.6. The sensitivity of the shallow geology is **Low**, due to the limited potential for aquifers. The sensitivity of the topsoil is considered to be **Medium**, as it is likely to be of reasonable quality, with a relatively low likelihood of being contaminated.

12.5.7. The construction activities will be limited in time and physical extent, and therefore the soil function in the area surrounding the Project will not be altered. The magnitude of impact from the potential for leaks from HGVs, machinery, and hazardous material storage is considered to be **Slight Adverse** and will be managed though the implementation of good practice measures in the **ESMP**, as set out in **Section 12.6**.

12.5.8. Overall, it is considered that the potential for significant effects on topsoil and groundwater as a result of the leaks / spills from HGVs, machinery, and hazardous material storage is **Neutral or Minor Adverse (not significant)** without mitigation, and this risk will be reduced further with the implementation of mitigation.

Potential Impact on Soil Erosion from Construction Activities

12.5.9. During the enabling works for the Project (such as site clearance and preparation), there is the potential for changes to the topsoil surface. Such changes in the surface layer may change the sensitivity of the surface environment, and its susceptibility to erosion.

12.5.10. Soil erosion may occur as a result of exposure to wind and water runoff, removal of topsoil and Made Ground, exposure of buried structures, sedimentation, increased turbidity levels in rivers and streams and the local drainage system. At higher elevations along the Project alignment soil erosion is more likely to occur due to increased exposure. Furthermore, soil erosion is more likely to occur along the Project alignment at sections where extensive earthworks are to take place, such as for the tunnels, in particular Tunnel 1.

12.5.11. The construction activities likely to cause soil erosion will be limited in time and physical extent. However, there is the potential for soil erosion to extent to the surrounding areas. Therefore, the magnitude of impact from the potential for soil erosion is considered to be **Moderate**. The sensitivity of the topsoil is considered to be **Medium**.

12.5.12. Overall, it is considered that the potential for significant effects on topsoil associated with soil erosion is **Minor Adverse (not significant),** although this will be reduced though mitigation measures as set out in **Section 12.6**.

Potential Impact on Soil Loss and Degradation (borrow pits and material disposal sites)

12.5.13. Quarried resources from borrow pits are likely to be required to obtain subgrade material for the Project, as the arisings from the tunnel, and other excavations, is unlikely to meet the prescribed quality standards for required construction materials. Several quarries have been identified for the supply of sand, gravel, basalt, granite and limestone within the South Marmara region, as detailed in **Chapter 13: Materials and Waste**. The surplus fill material (cut volume minus the granular fill material to be reused) is noted in the National EIA for the Project (2017)[192] to be stored in excavation 'disposal sites' that, through consultation and approval with the Municipality, will be

formed along the Project alignment. The number and location of these sites is not yet known, however the **ESMP** details criteria for disposal sites to protect sensitive receptors.

12.5.14. The use of borrow pits has the potential to lead to soil loss, due to the soil stripping required to access material. Furthermore, the use of material disposal sites has the potential to lead to alterations in the soils ecological function, at these locations, due to compaction. There is also potential for the introduction of contamination at these locations, as the material will have been sourced from different areas along the Project alignment.

12.5.15. The sensitivity of the environment associated with the use of the borrow pits and material disposal sites is considered to be **Low**, as these locations are currently used for these purposes.

12.5.16. The use of the borrow pits and the material disposal sites will be limited in time and extent, however, there is the potential for the soil loss and degradation to be irreversible. Although, some soil will be stored for restoration of the borrow pits and the material disposal sites. Therefore, the magnitude of impact from the potential for soil loss and degradation is considered to be **Moderate**.

12.5.17. Overall, it is considered that the potential for significant effects associated with soil loss and degradation at the borrow pits and material disposal sites is **Neutral or Minor Adverse (not significant)**.

Potential Loss of Fertile Topsoil

12.5.18. The ground cover surrounding the Project alignment is generally comprised of covered agricultural land (largely grassland); areas of hardstanding associated with residential dwellings, commercial / industrial areas and roads; and areas of woodland, some of which is partially wetland. The agricultural land and the areas of woodland have well-preserved ecological functions and contain fertile topsoil.

12.5.19. The sensitivity of the agricultural land and areas of woodland is considered to be **High** due to the potential for impacts associated with fertile topsoil loss to impact upon the economic profitability of the agricultural land and the ecological value of the woodland. The construction phase of the Project will be limited in time and physical extent; regarding areas that will be temporarily used for construction such as construction camps, these areas can be restored to agricultural use. However, the loss of fertile soil within areas of land take for the Project will be irreversible. Some topsoil will be stored and used for landscaping. Therefore, the magnitude of impact from the potential for the loss of fertile topsoil is **Moderate**.

12.5.20. Overall, it is considered that the potential for significant effects associated with the loss of fertile soil is **Minor or Moderate Adverse (significant).**

Potential Soil Stability and Risk of Landslides

12.5.21. During construction, there is a risk that earthworks, excavations, quarrying and blasting activities will cause soil instability and landslides. The areas along the Project alignment that are within areas of current landslides and old landslides, are likely to be more susceptible to these risks.

12.5.22. The sensitivity of the undulating landscape along the Project alignment, is considered to be **Medium**, although is considered **High** along areas with existing or active landslides.

12.5.23. The construction phase of the Project will be limited in time and physical extent, and the good practice measures will be applied as set out in **Section 12.6**. Therefore, the anticipated magnitude of impact from the construction activities is **Slight**.

12.5.24. Overall, it is considered that the potential for significant effects associated with landslides is **Neutral or Minor Adverse (not significant).**

Potential Effects from Excavation of Potentially Contaminated Soils

12.5.25. There is the potential for pre-existing contamination within the soils along the Project alignment, particularly in the areas surrounding the existing railway, existing roads and industrial areas. The excavation activities associated with the construction phase of the Project have the potential to mobilise contaminants. The mobilisation of such contaminants has the potential to affect the local community, the construction workforce and the surrounding surface waters. The health and safety implications of contaminated land are addressed in **Chapter 15: Social** and potential effects on surface waters addressed in **Chapter 11: Surface Water Environment**

12.5.26. The sensitivity of the local community, the construction workforce and the surrounding surface waters is considered to be **High** due to the potential for impacts on human health and the ecological value of the surrounding rivers and streams.

12.5.27. The construction phase of the Project will be limited in time and physical extent. However, there is potential for large impacts, should the construction activities create pathways that enable the contaminant to reach sensitive receptors. This has the potential to have adverse impacts on the local community, the construction workforce and the surrounding rivers and streams. Therefore, the magnitude of impact from the potential for contamination is considered to be **Moderate**.

12.5.28. Overall, it is considered that the potential for significant effects associated with the excavation of potentially contaminated soils is **Minor or Moderate Adverse (significant)**, and this will be managed in accordance with appropriate mitigation measures, as set out in **Section 12.6.**

Potential Effects on Groundwater Quality, Flow, and Recharge

12.5.29. The Project alignment crosses several groundwater aquifers which are used for the supply of drinking water as well as irrigation for agriculture and industry. The majority of the Project alignment will run in parallel with the existing railway, and will also include bridges, viaducts, tunnels, overpasses and underpasses.

12.5.30. The lengths of the track which are to be constructed at ground level, with limited below ground disturbance or construction required, are unlikely to result in adverse impacts upon the groundwater quality, flow or recharge of those underlying aquifers. They are also unlikely to have an adversely impact on the quality of these resources or alter the provision of potable water to: local communities; industry; or the wider environment, which may depend upon these resources.

12.5.31. The proposed bridges, viaducts, overpasses, underpasses and cut and cover tunnels, are likely to require construction methods, such as deeper foundations or piling, which could penetrate into geological strata which are considered to be aquifers. They could also cause connections between shallow and deeper groundwater aquifers with the potential to degrade the quality of this resource. However, potential adverse effects will be managed through suitable construction techniques which are detailed within the **ESMP**, as set out in **Section 12.6**.

12.5.32. The Project alignment includes a twin-bore Tunnel (Tunnel 1) for 6km at the beginning of the Project alignment, which passes under residential areas, a government nuclear training facility (titled 'Çekmece Nuclear Research and Training Center') and the proposed Kanal Istanbul project (further information regarding the Kanal Istanbul project is provided within **Chapter 2: Description of the Project and Chapter 17: Cumulative Effects**). It is understood the tunnel would begin at ground

level at chainage 0+700 and reach a maximum depth of 54m below sea level under the proposed Kanal Istanbul before re-emerging into a cut and cover tunnel at chainage 6+678. It will pass to the north of Küçükçekmece Lake where the tunnel will be at a depth of 40m-50m below ground level. Küçükçekmece Lake is comprised of wetlands and marshes which are likely connected with underlying regional groundwater aquifers. The tunnel will likely pass through shallow Alluvium comprising sands, clays silts and gravel and into the Yenimuhacir group comprising sandstones, siltstones, and limestones. Detailed information regarding groundwater levels within these strata was not available. However, shallow groundwater is likely within the Alluvium deposits which support the wetland area on the north of Küçükçekmece Lake. Additionally, the limestones and sandstones of the Yenimuhacir group is known to provide groundwater to İstanbul for drinking water which is considered to be a water stressed area.

12.5.33. Tunnel 1 will be constructed using tunnel boring machines which breaks the soil and rock creating the tunnel which is then lined with precast concrete segments. The diameter of Tunnel 1 will be 8.3m. Due to the limited size of this tunnel in comparison to regional aquifer it is unlikely to affect natural groundwater flow as any groundwater would likely flow around the tunnel walls. As the majority of the tunnel will be below ground it is unlikely to inhibit infiltration of rainwater or affect recharge of the aquifer. During construction of the tunnel there is potential for the groundwater turbidity to increase due to the action of the tunnel boring machine which may affect groundwater quality in the short term.

12.5.34. The sensitivity of the groundwater aquifers along the Project alignment are considered **High** due to their regional importance as a source of drinking water for communities, agriculture and industry, as well as contributing to marshes and wetlands.

12.5.35. The construction phase of the Project will be limited in time and physical extent. However, there is potential for large impacts, should the construction activities affect the quality of the groundwater resource as a potable water supply. This has the potential to have adverse impacts on the local community. Therefore, the magnitude of impact from the changes in groundwater quality is considered to be **Moderate**. The magnitude of impact from changes to groundwater flow and recharge are considered to be **Slight**.

12.5.36. Overall, it is considered that the potential for significant effects associated with the Project alignment, and in particular the tunnelled sections, is **Moderate Adverse (significant)**, and therefore this will be managed, in accordance with appropriate mitigation measures, as set out in **Section 12.6**.

OPERATIONAL PHASE

Potential Effects on Topsoil Quality and Soil Erosion

12.5.37. Topsoil contamination may occur during the operation of the Project, as a result of accidental leaks and spillages of chemicals used for the maintenance of the Project. Maintenance activities are described in **Chapter 2: Description of the Project**. Contaminants include oil and / or petroleum leaks / spills.

12.5.38. Should the contamination settle adjacent to the Project alignment the topsoil quality may become degraded. This may lead to a reduction in the growth of vegetation, thus increasing the likelihood of erosion.

12.5.39. There is also a risk associated with the potential mobilisation of loose materials if disturbed surfaces are not stabilised or successfully revegetated following the construction activities. The mobilisation of such loose materials may lead to soil erosion. The soils in the areas surrounding the bridges, viaducts, tunnel entrances, embankments and soil disposal areas, are likely to be most prone to soil erosion, together with those areas where the Project alignment runs through undulating terrain however these risks will be managed appropriately through maintenance measures in the **ESMP**, as set out in **Section 12.6**.

12.5.40. The sensitivity of the topsoil adjacent to the Project alignment once it is operational is considered to be **Low**, as it is likely to have been disturbed during the construction phase, generally follows the existing railway where topsoil quality may have already been compromised and fencing will be provided 25m either side of the centreline of the Project alignment. The topsoil that is located outside the fencing, is unlikely to be affected during operational phase.

12.5.41. There may measurable reduction in topsoil quality and soil erosion during the operational phase of the Project, but the losses are likely to be minor and limited to the areas surrounding the bridges, viaducts and those areas where the Project alignment runs through undulating terrain. The magnitude of the impact is considered to be **Slight**.

12.5.42. Overall, it is considered that the potential for significant operational effects associated with the contamination of topsoil and soil erosion is **Minor Adverse (not significant)**, this effect will be reduced following the implementation of the measures set out in the mitigation **Section 12.5**.

Potential Soil Stability and Risk of Landslides

12.5.43. Sections of the Project alignment will be located within areas where there are current landslides and old landslides, and these areas are likely to be more susceptible to these risks over time during the operation of the Project.

12.5.44. The undulating landscape along the Project alignment, is considered to be of **Medium** sensitivity.

12.5.45. The operational phase of the Project will be limited in physical extent, and the good practice measures will be applied as set out in **Section 12.6**. Therefore, the anticipated magnitude of impact during operational phase will be **Slight**.

12.5.46. Overall, it is considered that the potential for significant effects associated with landslides is **Neutral or Minor Adverse (not significant)**.

Potential Effects on Groundwater Quality, Flow, and Recharge

12.5.47. The above ground lengths of the track are unlikely to result in a significant effect upon the groundwater quality, flow or recharge of those underlying aquifers, such as would affect the quality of these resources or alter the provision of potable water to local communities and industry, or the wider environment which may depend upon these resources.

12.5.48. The Project alignment will run within a twin-bore Tunnel (Tunnel 1) for 6km at the beginning of the Project alignment passes under residential areas, a government nuclear training facility (titled 'Çekmece Nuclear Research and Training Center') and Kanal Istanbul project (further information regarding the Kanal Istanbul project is provided within **Chapter 2: Description of the Project and Chapter 17: Cumulative Effects**). Due to the limited size of this tunnel in comparison to regional aquifer it is unlikely to affect natural groundwater flow as any groundwater would likely flow around

the tunnel walls during operation. As the majority of the tunnel will be below ground it is unlikely to inhibit infiltration of rainwater or affect recharge of the aquifer.

12.5.49. The sensitivity of the groundwater aquifers along the Project alignment are considered **High** due to their regional importance as a source of drinking water for communities, agriculture and industry as well as contributing to marshes and wetlands.

12.5.50. The impacts would be limited in physical extent. The design of the Project, which would include either a watertight concrete or a plastic geomembrane, to prevent water entering or egressing the tunnel, would reduce the potential for adverse effects on the groundwater resource as a potable water supply and baseflow to surface waters and wetlands, therefore the magnitude of impact from groundwater flow, quality and recharge is expected to be **Slight**.

12.5.51. Overall, it is considered that the potential for significant effects associated with the Project alignment during operation is **Minor Adverse (not significant)**, and this will be managed with appropriate mitigation measures, as set out in **Section 12.6**.

Seismic Activity

12.5.52. The Project alignment is within an area with moderate to high probability of PGA levels exceeding 10% within the next 50 years which indicates the region which the Project alignment runs through may experience potentially damaging seismic activity within the next 50 years. Mitigation measures against potential earthquakes will be incorporated within the Project design to reduce the likelihood of damage during operation of the railway in the event of an earthquake. The sensitivity of the environment is therefore **High**.

12.5.53. As outlined in the Infrastructure General Technical Requirements for the Project, various measures have been designed into the Project to ensure that it can withstand seismic events. These measures are designed to ensure the Project will experience negligible impact due to seismic events. Such measures include:

- Consideration of seismic activity in the foundations of structures and ancillary structures, through ensuring designs are complaint with seismic activity and earthquake standards including applicable Eurocodes and American Association of State Highway and Transportation Officials (AASHTO) Guidance (as detailed in **Chapter 2: Description of the Project**);
- Consideration of seismic activity in the joint systems used for the track; and
- Incorporating measures to detect seismic activity into structures and ancillary structures (where appropriate).

12.5.54. In addition, TCDD has confirmed that all the civil engineering designs are compliant with Turkish civil, structural, environmental and earthquake engineering standards. The potential significance of effect due to seismic activity is therefore considered to be **Neutral (not significant)** and no further mitigation is required.

12.6 MITIGATION AND ENHANCEMENT MEASURES

12.6.1. The mitigation and enhancement measures which are listed below are also reflected within the **ESMP**.

CONSTRUCTION PHASE

12.6.2. The mitigation and enhancement measures proposed for the construction phase of the Project are outlined in Table 12-2. During the construction phase of the Project these plans will be reviewed, as a minimum quarterly, and with changes to international and national legislation, as appropriate.

Table 12-2 - Geology and Hydrogeology Mitigation Measures (Construction)

Effect	Mitigation Measure
Potential Impacts on Topsoil and Groundwater Quality from Leaks / Spills from HGVs, Machinery, and Hazardous Material Storage	During the construction phase of the Project, the Contractor will implement the **ESMP** which includes measures to reduce pollution and contamination associated with airborne substances and oil and / or petroleum leaks / spills, such measure includes: ▪ Careful construction and thorough quality control processes (including for substations improvements, including sampling of existing transformers for the presence of PCBs in line with European Union: Council Directive 96/59/EC sampling requirements); ▪ Provision of spill kits to contain leaks / spills; ▪ Program to ensure good driver behaviour / maintenance of vehicles; and ▪ Testing and removal of material arisings in accordance with the **Materials Management Plan** and the **Site Waste Management Plan**. ▪ In accordance with the **ERF**, an **Emergency Response Plan** will be produced prior to construction (including a **Spill Management Plan**), which will include a procedure for leak / spill prevention from HGVs, machinery, and hazardous material storage and earthquake response during construction. ▪ Method Statements for temporary activities which will include the following activities: Storage Areas, construction of river crossings, tunnels, viaducts, Storage and Access Roads.
Potential Impact on Soil Erosion from Construction Activities	The detailed design of the Project will also incorporate the following measures to reduce the likely release of loose material or material with the potential to become loose in-situ: ▪ Slope stabilisation – including mulching (straw mulching), brushwood mulching, erosion control blankets, soil binders (e.g. polyacrylamide) and gravelling; ▪ Retaining walls – to retain loose materials on slopes where it would not naturally be held, for example on near vertical or vertical slopes; ▪ Sediment traps and basins – which will intercept and retain sediment-laden runoff; ▪ Drainage channels – which will divert run-off water; ▪ Treatment systems – to remove material contained within the run-off water; and

Effect	Mitigation Measure
	▪ Revegetation – The **ESMP** includes the requirement for a **Landscape Management Plan** which will include measures to increase the stability of the loose materials and surfaces which become exposed during the construction phase of the Project.
Potential Impact on Soil Loss and Degradation (Borrow pits and Surplus Material Disposal Sites)	The **ESMP** incorporates measures to ensure the stability of the quarry resources and excavated material disposal sites and reduce the likelihood of soil loss and contamination, respectively. Such measures include appropriate compaction, erosion control measures and consideration of groundwater levels. The **Materials Management Plan** sets out the criteria for borrow pits and disposal sites, ensuring that they are located away from sensitive locations.
Potential Loss of Fertile Topsoil	Limited temporary land take of agricultural land is proposed during construction, however the **ESMP** includes measures to restore lost fertile topsoil following completion of the Construction Phase where suitable.
Potential Soil Stability and Risk of Landslides	The **ESMP** includes measures associated with erosion protection, such as temporary vegetation planting and measures to improve the stability of slopes during Project construction, such as protective nets.
Potential Effects from Excavation of Potentially Contaminated Soils	Mitigation against potential effects from potentially contaminated soils will be managed through implementation of the **ESMP** which includes: ▪ A **Materials Management Plan**, which outlines measures to protect the quality of soils used during construction or directly impacted by construction activities. The Plan includes measures for contaminated land. The **Health and Safety Plan**, which will outline measures to keep the construction workers safe including personal protection equipment requirements. ▪ **Construction Plans and Method Statements** (as included in the **ESMP**) – Slope stabilisation, bridge construction, viaducts construction, underpass and overpass construction, tunnel construction, storage, access, **Tunnel Handover Plan** and **Blasting Management Plan**, which will outline measures to ensure a safe environment for construction workers and will be produced by the Contractor. ▪ In accordance with the **ERF**, an **Emergency Response Plan** will be produced prior to construction (including a **Spill Management Plan**), which will include a procedure for leak / spill prevention from HGVs, machinery, and hazardous material storage.

Effect	Mitigation Measure
Potential Effects on Groundwater Quality, Flow, and Recharge	▪ A detailed Hydrogeological Model and Risk Assessment and Ground Investigation should be undertaken in particular for the design of Tunnel 1 to understand geological and hydrogeological conditions. ▪ Long term and seasonal groundwater monitoring should ideally be undertaken prior to construction to allow for baseline conditions to be understood and monitor changes (such as those to turbidity and groundwater levels) during boring of Tunnel 1 such as to identify potential degradation of the groundwater resource or potential quality of water supply. Long term should ideally comprise at least 1 year of consistent modelling, although a minimum of 2 seasons of data should be obtained prior to construction. Further action would be needed to address the degradation of groundwater quality during construction such as adjustments to drilling duration or speed. ▪ Foundation Risk Assessments and Piling Risk Assessments will be undertaken for bridges, viaducts, overpasses, underpasses and cut and cover tunnels. They should outline measures to protect groundwater resources as part of the design and during construction. ▪ **Construction Plans and Method Statements** Tunnel Construction, Tunnel Handover Plan and Blasting Management Plan to prevent impact to groundwater resources during construction activities.

OPERATIONAL PHASE

12.6.3. The mitigation and enhancement measures proposed for the operational phase of the Project are outlined in **Table 12-3**.

Table 12-3 - Geology and Hydrogeology Mitigation Measures (Operation)

Effect	Mitigation Measure
Potential Effects on Topsoil Quality and Soil Erosion	▪ In order to prevent soil erosion, loss and degradation along the Project alignment the **Operational Soil Management Plan** in the **ESMP** will be prepared. It will include measures to: • Maintain sediment traps and basins, drainage channels and treatment systems; and • Maintain slope (cuttings and embankment). ▪ In accordance with the **ERF**, an **Emergency Response Plan** will be produced prior to operation. As specified in the **ERF**, the **Emergency Response Plan,** will include details of the emergency response team(s) who will assess the risk of

Effect	Mitigation Measure
	hazardous material releases and working to avoid any harmful effects in the event of an accident or incident and details and procedure for reporting emergencies, including coordination with the national relevant authorities. It will also include: • Maintenance and thorough quality control processes including inspections for maintenance depots; • Leak/ spill management; • Procedure to be followed to prevent pollution / contamination of soil and groundwater; and – Natural disaster response. ▪ Document control procedures for the storage of maintenance materials, including the use of Material Safety Data Sheets.
Potential Soil Stability and Risk of Landslides	▪ In order to mitigate risks from soil stability and landslide along the Project alignment the **Operational Soil Management Plan** in the **ESMP** will be prepared. It will include revegetation and/or maintenance of vegetation to increase the stability of potentially loose materials and surfaces which may develop during the operational phase of the Project in particular between chainages 42+000 and 51+000 which pass through areas which contain old and active landslides.
Potential Effects on Groundwater Quality, Flow, and Recharge	▪ **Operational Maintenance Plan** will be produced and will include maintenance and repair plans. ▪ A **Tunnel Operational Management Plan** will be prepared.
Seismic Activity	▪ In accordance with the **ERF** an **Emergency Response Plan** will be produced prior to operation.

12.7 RESIDUAL EFFECTS

12.7.1. The construction phase mitigation measures summarised above will significantly reduce the risk to the geological and hydrogeological receptors during the construction of the Project.

12.7.2. The operational phase mitigation measures proposed for the design of the Project are considered sufficient to manage all likely impacts relating to topsoil quality, soil erosion, landslides, groundwater and seismic activity to negligible levels.

12.7.3. With the mitigation measures in place, it is anticipated that effects to geology and hydrogeology as a result of the Project will be **Neutral (not significant)** or **Minor Adverse (not significant)** during construction and **Neutral (not significant)** during operation.

12.8 SUMMARY

Table 12-10 – Summary of Potential Impacts, Effects and Mitigation (Geology and Groundwater)

Topic	Baseline Summary	Phase	Potential Impact(s)	Effect (without mitigation)	Mitigation Measures	Residual Effects (after mitigation)
Geology and Hydrogeology	The bedrock geology beneath the Project is comprised of Ergene group (sandy, shaley conglomerates) and Yenimuhacir group (sandstones, shales, minor coal, siltstones, limestones). This is overlain in places by recent superficial deposits of Alluvium (sand, clays, silts and gravels). Where Alluvium is present it may have the potential to act as groundwater aquifers where the main component is granular (sand and gravel) or aquitard where there is a significant clay or silt component. The Ergene and Yenimuhacir groups are permeable and are known to contain groundwater in quantities capable of supplying public water supply. The sensitivity of the shallow geology is Low, due to the limited potential for aquifers. The sensitivity of the permeable Ergene and Yenimuhacir groups is considered to be High due to their potential as potable water resources.	Construction	Potential Impacts on Topsoil and Groundwater Quality from leaks / spills from HGVs, Machinery, and Hazardous Material Storage	Neutral or Minor Adverse (not significant)	▪ During the construction phase of the Project, the Contractor will implement the **ESMP** (Chapter 19) which includes measures to reduce pollution and contamination associated with airborne substances and oil and / or petroleum leaks / spills. ▪ Testing and removal of material arisings in accordance with the **Materials Management Plan** and the **Site Waste Management Plan**. ▪ An **ERF** (including a **Spill Management Plan**), ▪ Method Statements for temporary activities which will include the following activities: Storage Areas, construction of bridges, tunnels, viaducts, storage and access roads.	Neutral (not significant)
		Construction	Potential Impact on Soil Erosion from Construction Activities	Minor Adverse (not significant)	The detailed design of the Project will also incorporate the following measures to reduce the likely release of loose material or material with the potential to become loose in-situ: ▪ Slope stabilisation – including mulching (straw mulching), brushwood mulching, erosion control blankets, soil binders (e.g. polyacrylamide) and gravelling; ▪ Retaining walls – to retain loose materials on slopes where it would not	Neutral (not significant)

Topic	Baseline Summary	Phase	Potential Impact(s)	Effect (without mitigation)	Mitigation Measures	Residual Effects (after mitigation)
					naturally be held, for example on near vertical or vertical slopes; ▪ Sediment traps and basins – which will intercept and retain sediment-laden runoff; ▪ Drainage channels – which will divert run-off water; ▪ Treatment systems – to remove material contained within the run-off water; and Revegetation – to increase the stability of the loose materials and surfaces which become exposed during the construction phase of the Project.	
		Construction	Potential Impact on Soil Loss and Degradation (Quarry Resources and Surplus Material Disposal Sites)	Neutral or Minor Adverse (not significant)	The **ESMP** (Chapter 19) will incorporate measures to ensure the stability of the quarry resources and excavated material disposal sites and reduce the likelihood of soil loss and contamination, respectively. Such measures will include appropriate compaction and consideration of groundwater levels. The **Materials Management Plan** will set out the criteria for borrow pits and disposal sites, ensuring that they are located away from sensitive locations.	Minor Adverse (not significant)
		Construction	Potential Loss of Fertile Topsoil	Minor or Moderate Adverse (significant)	Limited temporary land take of agricultural land is proposed during construction, however the **ESMP** (Chapter 19) includes measures to restore lost fertile topsoil following completion of the	Minor Adverse (not significant)

Topic	Baseline Summary	Phase	Potential Impact(s)	Effect (without mitigation)	Mitigation Measures	Residual Effects (after mitigation)
					Construction Phase where suitable.	
		Construction	Potential Soil Stability and Risk of Landslides	Neutral or Minor Adverse (not significant)	The **ESMP** (Chapter 19) includes measures associated with erosion protection, such as vegetation planting and measures to improve the stability of slopes during Project construction, such as protective nets.	Neutral (not significant)
		Construction	Potential Effects from Excavation of Potentially Contaminated Soils	Minor Adverse (not significant) to Minor or Moderate Adverse (significant)	Mitigation against potential effects from potentially contaminated soils will be managed through implementation of the **ESMP** (Chapter 19) which will include: ▪ A **Materials Management Plan**, which will outline measures to protect the quality of soils used during construction or directly impacted by construction activities. The Plan will include measures for contaminated land. ▪ The **Health and Safety Plan**, which will outline measures to keep the construction workers safe including personal protection equipment requirements. ▪ **Construction Plans and Method Statements** – Slope Stabilisation, bridge construction, viaducts construction, underpass and overpass construction and tunnel construction, Tunnel Handover Plan and Blasting Management Plan, which will outline measures to ensure a	Minor Adverse (not significant)

Topic	Baseline Summary	Phase	Potential Impact(s)	Effect (without mitigation)	Mitigation Measures	Residual Effects (after mitigation)
					safe environment for construction workers. ▪ In accordance with the **ERF**, an **Emergency Response Plan** will be produced prior to construction (including a Spill Management Plan), which will include a procedure for leak / spill prevention from HGVs, machinery, and hazardous material storage.	
		Construction	Potential Effects on Groundwater Quality, Flow, and Recharge	Neutral or Minor Adverse (not significant)	▪ A detailed Hydrogeological Model and Risk Assessment and Ground Investigation should be undertaken in particular for the design of Tunnel 1 to understand geological and hydrogeological conditions. ▪ Long term and seasonal groundwater monitoring should be undertaken prior to construction to allow for baseline conditions to be understood and monitor changes (such as those to turbidity and groundwater levels) during boring of Tunnel 1 such as to prevent degradation of the groundwater resource or potential quality of water supply. ▪ Foundation Risk Assessments and Piling Risk Assessments for bridges, viaducts, overpasses, underpasses and cut and cover tunnels. They should outline measures to	Minor Adverse (not significant)

Topic	Baseline Summary	Phase	Potential Impact(s)	Effect (without mitigation)	Mitigation Measures	Residual Effects (after mitigation)
					protect groundwater resources as part of the design and during construction.	
		Operational	Potential Effects on Topsoil Quality and Soil Erosion	Minor Adverse (not significant)	▪ In order to prevent soil erosion, loss and degradation along the Project alignment the **Operational Soil Management Plan** in the **ESMP** (Chapter 19) includes measures to: ○ Maintain sediment traps and basins, drainage channels and treatment systems; and ○ Maintain slope (cuttings and embankment). ▪ In accordance with the **ERF**, an **Emergency Response Plan** will be produced prior to operation which will include details of the emergency response team(s) who will assess the risk of hazardous material releases and working to avoid any harmful effects in the event of an accident or incident and details and procedure for reporting emergencies, including coordination with the national relevant authorities. It will also include: ○ Maintenance and thorough quality control processes including inspections for maintenance depots;	Neutral (not significant)

Topic	Baseline Summary	Phase	Potential Impact(s)	Effect (without mitigation)	Mitigation Measures	Residual Effects (after mitigation)
					○ Leak/ spill management; ○ Procedure to be followed to prevent pollution / contamination of soil and groundwater; and ○ Natural disaster response. ▪ Document control procedures for the storage of maintenance materials, including the use of Material Safety Data Sheets; An **Operational Maintenance Plan** will be prepared.	
		Operational	Potential Soil Stability and Risk of Landslides	Minor Adverse (not significant)	In order to mitigate risks from soil stability and landslide along the Project alignment the **Operational Soil Management Plan** in the **ESMP** (Chapter 19) will be prepared. It will include revegetation and/or maintenance of vegetation to increase the stability of potentially loose materials and surfaces which may develop during the operational phase of the Project.	Neutral (not significant)
		Operational	Potential Effects on Groundwater Quality, Flow, and Recharge	Minor Adverse (not significant)	**Operational Maintenance Plan** will be produced to manage maintenance and repairs.	Neutral (not significant)
		Operational	Seismic Activity	Neutral (not significant)	In accordance with the **ERF**, an **Emergency Response Plan** will be produced prior to operation.	Neutral (not significant)