

### 3. GEOLOGY AND HYDROGEOLOGY OF ÇUKUROVA BASIN AND ITS VICINITY

#### 3.1. Geology

Southeast Mediterranean region involving the area affected by the recent earthquake consists of three main basins in Tertiary age which are separated by two main tectonic zones striking in NE-SW (Figure 3.1). In these basins basement rocks of Pre-Miocene age are different and belong to different tectonic zones (Kozlu, 1987). These are namely İskenderun Miocene Basin (Amanos Mountains and the Vicinity of İskenderun Bay), Adana Miocene Basin (South part of the East Taurus Belt), and Misis-Andırın Tertiary Basin which is located between these two basins (Figure 3.1). Figure 3.2, 3.3 and 3.4 show the generalized stratigraphical columns of the geologic units in the Adana and Misis-Andırın Basins where the recent earthquake was severely felt, and in the vicinity of Osmaniye, respectively.

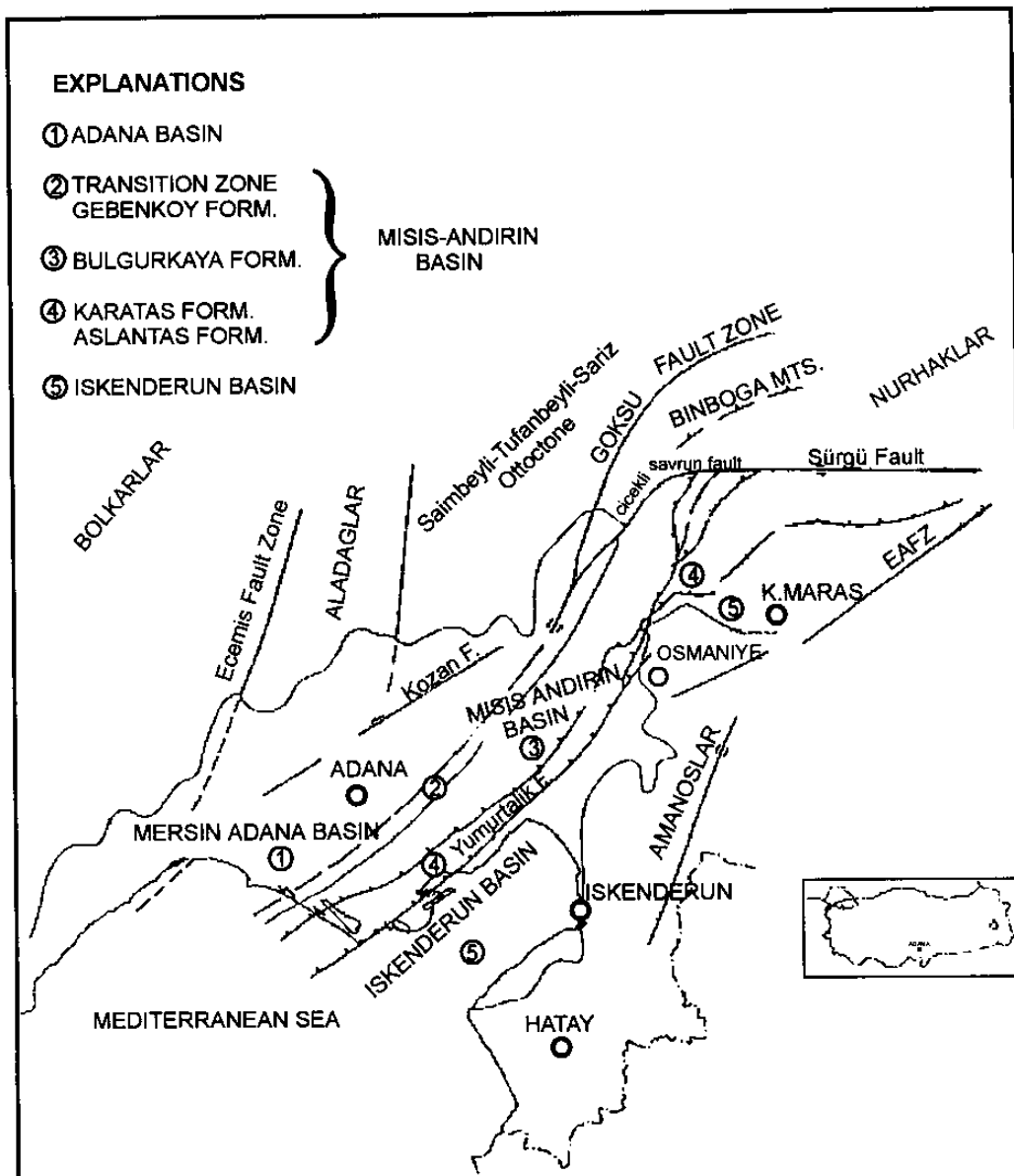


Figure 3.1 Tectonic map of the earthquake region (after Kozlu 1987)

AGE	FORMATION	THICKNESS (m)	LITHOLOGY	DESCRIPTION
QUATERNARY UPPER PLIOCENE	KURANSA	50-400		Sandy conglomerate
LOWER PLIOCENE UPPER MIOCENE	HAHDERE	400-800		Sandy shale with conglomerate and sandstone lenses
UPPER-MIDDLE MIOCENE	KUZGUN	800-1000		Conglomerate and sandstone
LOWER-MIDDLE MIOCENE	GÜVENÇ			Shale with sandstone bants
	C'YNGÖZ	1200-3500		Conglomerate-sandstone and shale
				Alternation of Sandstone and shale
				Sandstone with shale bants
	KÖPEKLI	0-400		Sandy conglomerate
KARAIŞALI KAPLANKAYA	0-250	Sandy marl		
		Limestone		
OLIGOCENE	GİDIRLU SEBİL	10-500	Gravelly sandstone Conglomerate	
PALAOGENE MESOZOIC PALEOZOIC			Basement rocks (Pre-Oligocene)	Units belonging to Geyikdağı- Aladağ-Bozkır-Bolkar Mountains

Figure 3.2 Generalised stratigraphical column of the Neogene sequence of Adana Basin

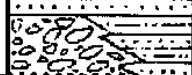
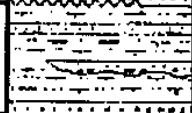

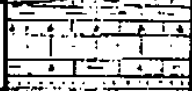



AGE	GROUP	FORMATION	THICKNESS (m)	SYMBOL	LITHOLOGY	DESCRIPTION
LANGHIAN		HOKKADAG	1500 2000	Mh-Mcd		Conglomerate Sandstone-shale
BURDIGALIAN		GEBENKOY	300-600	Tqb		Sandy marl Conglomerate Sandy marl
UPPER EOCENE-OLIGOCENE		BULGURKAYA	500-700	Tbul		OLISTOSTROME: Blocks: Andirin Limestone Upper Cretaceous flysch Metamorphic rocks Olistostromal facieses: Debris flow Sandy-gravel mudstone Brecciated conglomerate Matrix: Sandy marl with sandstone intercalation Clayey limestone-Marl-Silicified Limestone
UPPER CRETACEOUS-PALEOCENE MIDDLE EOCENE	CAMLIBEL	BODRUMKALE	20-80	Tçb-KTçb		Calsi-Turbidite
		DOKUZTEKNE	50-500	Kçd-KTçb		Conglomerate-Sandstone Agglomerate Tuff-Tuffite Silicified Limestone-Micritic Clayey Limestone-Marl
MIOCENE UPPER		ASLANTAS	800	Ta		Tectonic Conglomerate with blocks Sandy Marl Alteration of Sandstone-Shale-Marl (Tectonic flych)
MIOCENE MIDDLE		KARATAS	2000	Tmk		Tectonic Alternation of Sandstone-Shale (Turbidites) Calsi-Turbidite

Figure 3.3 Generalised stratigraphical column of the Misis-Andirin sequence (after Kozlu, 1987)

Geochronology				Thickness (m)	Stratigraphy	Lithology
Era	Period	Lower period	Epoch			
Cenozoic	Quaternary			50-60		Talus
				40-50		Alluvium: Gravel Sand, Clay
				1-5		Caliche
	Tertiary	Neogene	Pliocene			Basalt
						Calcareous clay Conglomerate
		Miocene		Sandstone		
Mesozoic			Upper	300-500		Claystone, Limestone
						Serpantinite

Figure 3.4 Generalised stratigraphical column of the formations in the vicinity of Osmaniye (DSI, 1975)

Figure 3.5 shows a geological map of Çukurova Basin, prepared by Gülen et al. (1987). The basin is extensively covered by aluvial deposits of Quaternary period. According to Kozlu (1987), the rock units of the Çukurova Basin belong to Upper Cretaceous, Oligo-Miocene, Pliocene and Quaternary, and andesite and travertines. Rock units of Upper Cretaceous are found in the south-east of the basin, namely, in Harami, Cebelinur and Dede Mountains. Rock units show volcanosedimentary stratigraphy and consist of tuff, sandstone, marl and agglomerates. The ridge of these mountains is in the direction of NE-SW.

Conglomerate and sandstone of Miocene age crop out in the south of the basin and they are called as *Güvençli* formation. Sandstone, siltstone, marl and mudstone of Pliocene age is known as *Handere* formation and they are observed in the north-west of the basin.

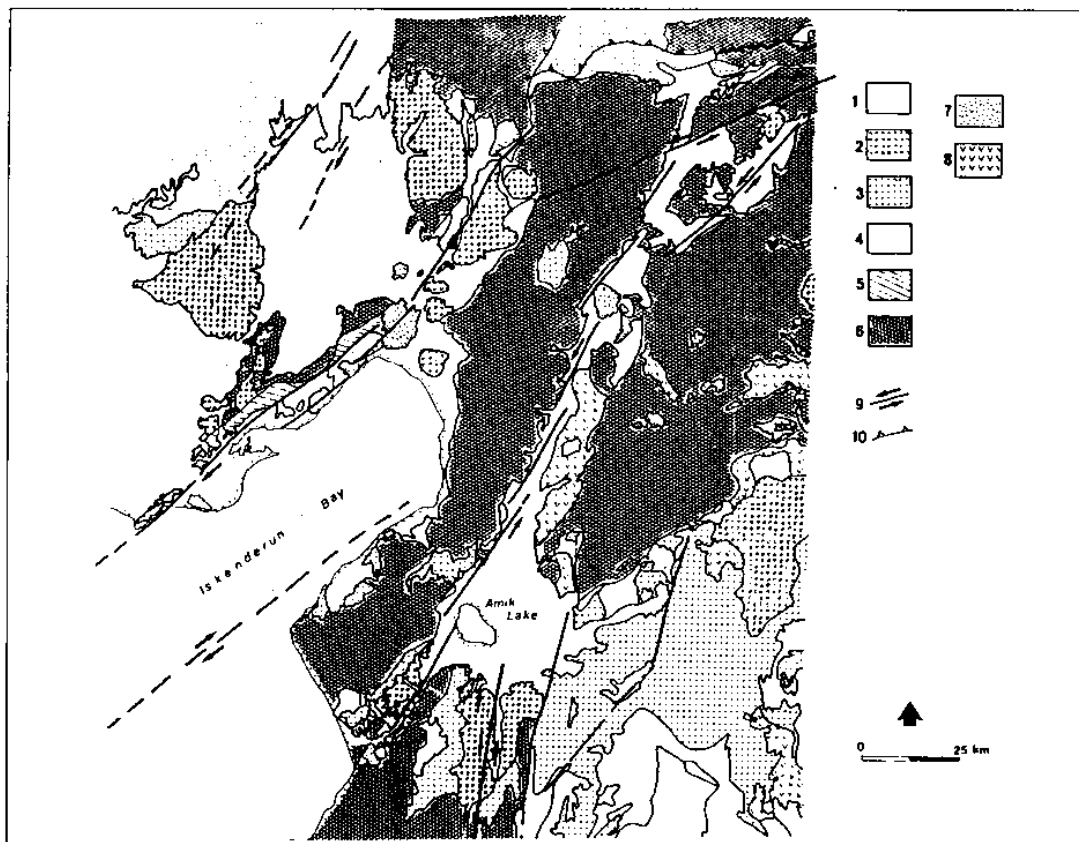


Figure 3.5 Geology of Çukurova basin (after Gülen et al. 1987)

In the investigated area the Quaternary deposits are represented by the alluvial soils and caliche (travertine). Caliche is found as a narrow band in the east of Adana city and also around Cebelinur Mountain. This unit in the Adana Basin is divided into two types. The first type takes place at the southern part of the basin and overlies the Handere formation. It is overlain by the alluvial soils of the Adana Basin towards south. The other type of caliche crops out west to east at Çakıt, Körkün, Eğlence Suyu and along Seyhan River (Yetiş and Demirkol, 1986). Adana Organized Industrial Zone where damages on structures occurred during the June 27 Earthquake is located on the caliche.

This rock unit is a product of sedimentation of desolved  $\text{CaCO}_3$  from nearby mountains consisting of limestone units. The caliche and terrace levels in the basin has an inclination ranging between  $2^\circ$  to  $4^\circ$  towards south and its thickness increases towards south with a maximum value of 30 m.

The deposition and redistribution of the Quarternary sediments carried into the Ceyhan Basin primarily by the Ceyhan River has led to the accumulation of thick alluvial deposits (Figure 3.6). These alluvial deposits consist of intercalated gravel, sand, silt and clay layers. Because of the rapid and rather dynamic sedimentation processes, the sediments range from well to poorly graded and are generally loosely compacted. On the basis of the geological information available from the borings by Devlet Su İşleri (DSİ) (State Hydraulic Works), it is evident that an alluvial sedimentary layer of 100 to 300 m under Ceyhan, Misis and their vicinity overlies the basement rocks.

The boreholes drilled by DSİ along N-S directed section which begins at Ceyhan town and passes from Büyük Mangıt, Mercimekköy and Çukurova Harası to the north, indicate that these sedimentary deposits thicken towards northern part of the basin and reaches up to 320 m at Mercimekköy and then gradually becomes thinner. Their thickness is about 170 m just beneath Ceyhan town (DSİ, 1984). Along N-S direction the alluvial deposits mainly consist of clayey and silty material, however, sandy and gravelly layers lie at shallow depths. Alluvial layers between Ceyhan and Osmaniye involve coarser grains when compared to those at Ceyhan Basin (Figure 3.7). Figures 3.8 to 3.13 show typical logs of the boreholes drilled by Turkish Highway General Directorate (TCK) near some bridges on the roads between Kozan and Ceyhan, Adana and Kozan, and Kadirli and Osmaniye. The depth of these boreholes changes between 11 and 33 m. At the top there is generally a sand or sandy gravel layer of 4-5 m thick. Groundwater table in these boreholes is very shallow ranging between 4 m and 5 m from the ground surface. In two boreholes artesian conditions were also encountered.

The liquefied sandy layers are well observed near the Ceyhan River. Its depth is about 4 to 5 m and overlain by silty and clayey layers. This sand is mainly fine grained. Its properties are stated in Chapter 10 in detail.

(a)



(b)



Figure 3.6: (a) Sequences of alluvial deposits on the bank of Ceyhan River; (b) Caliche at Nacarlı.

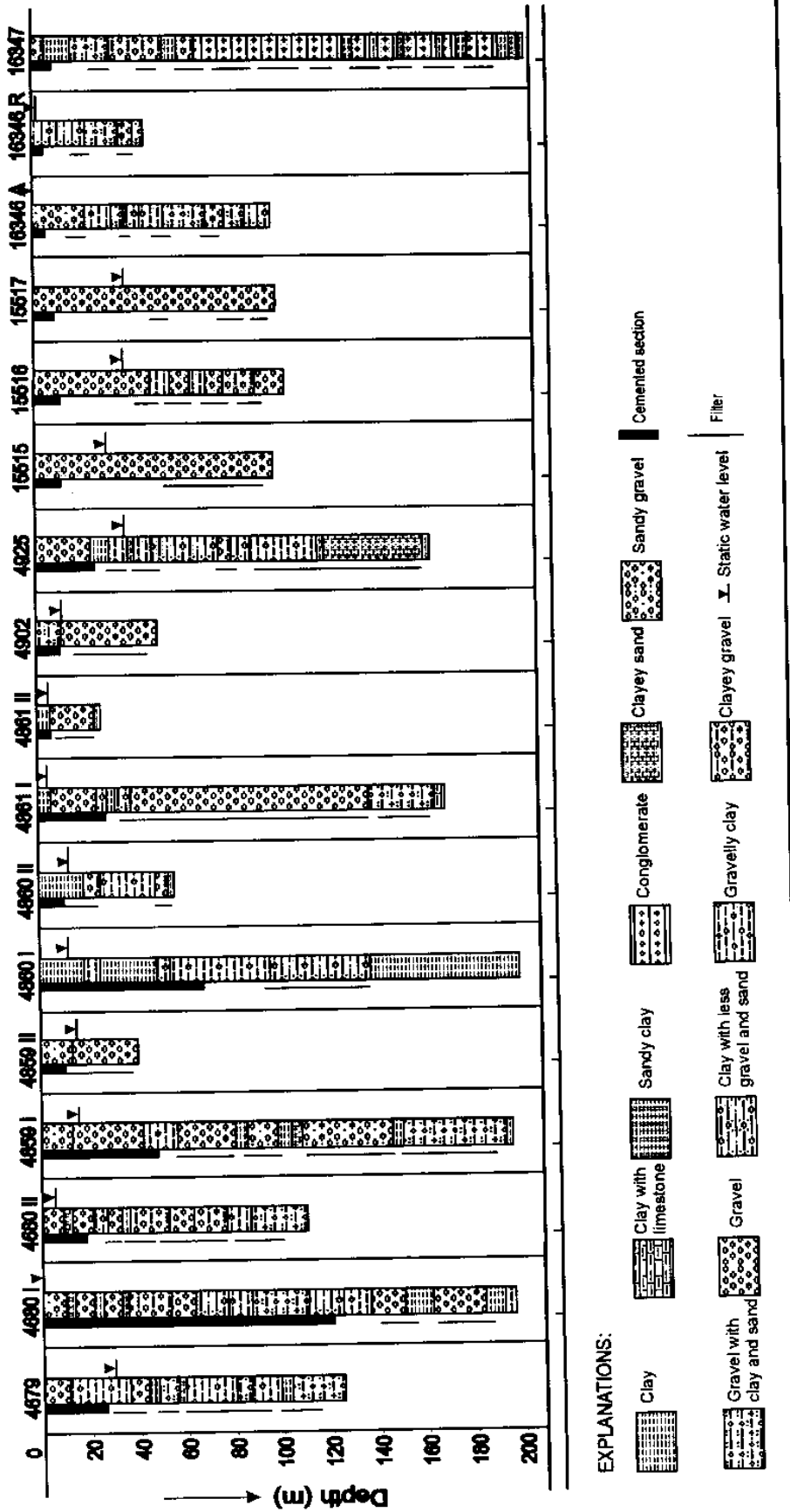


Figure 3.7 Logs of the boreholes drilled in the alluvium by DSI in Osmaniye basin illustrating variations of lithology and position of static water level (after DSI, 1975)



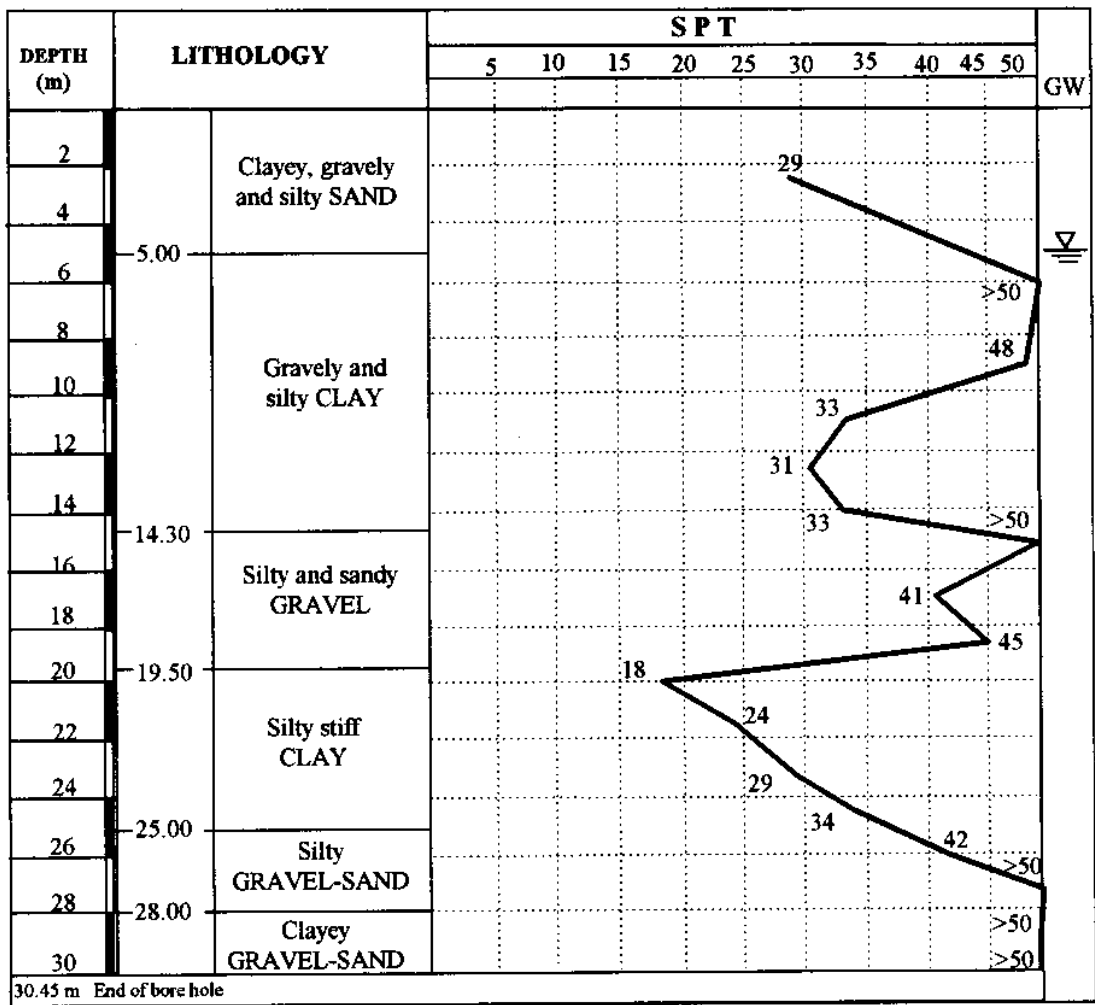


Figure 3.8 Summary log of Borehole SK-1 at Adana-Kozan road Tirmil Bridge in Ceyhan Basin (redrawn from Akar 1995)

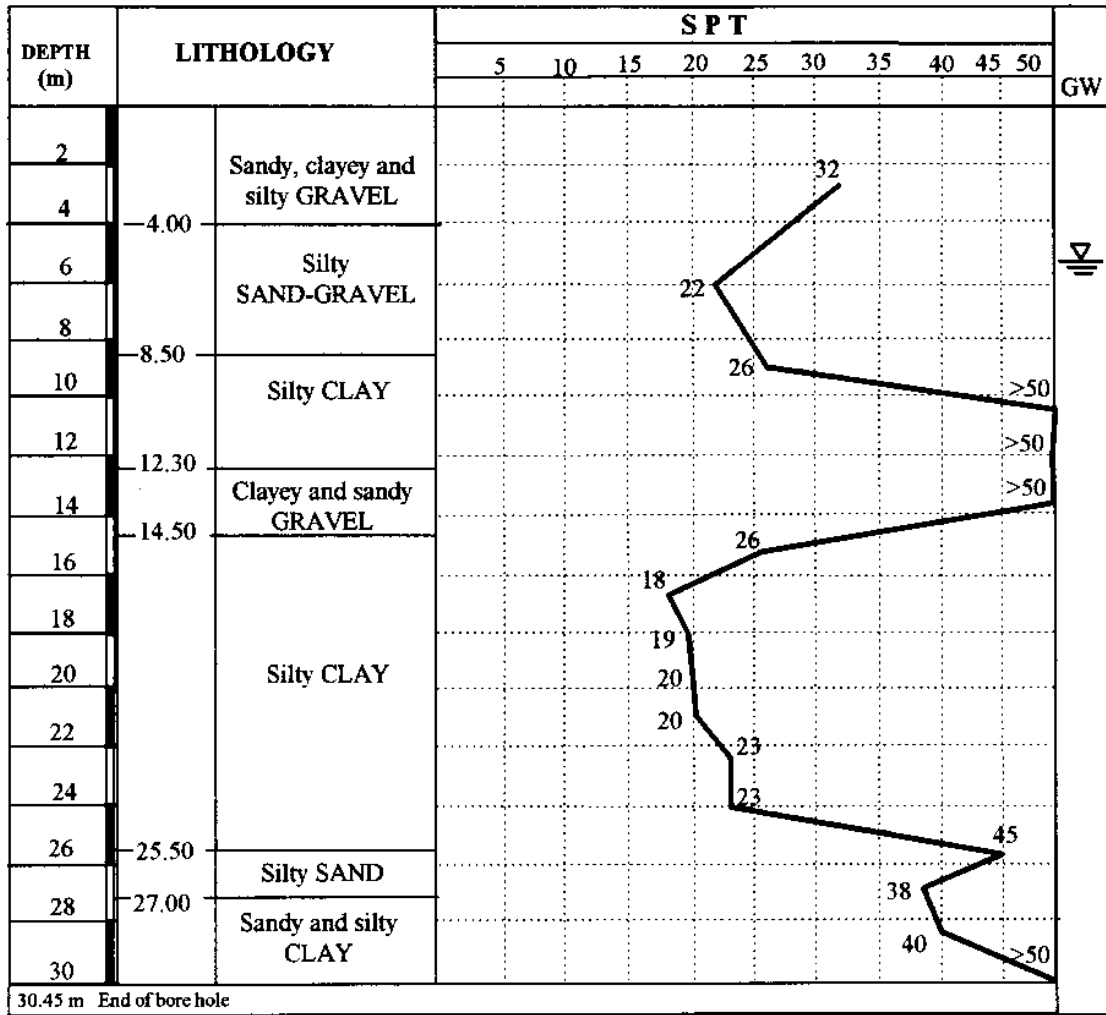


Figure 3.9 Summary log of Borehole SK-2 at Adana-Kozan road Tırmıl Bridge in Ceyhan Basin (redrawn from Akar 1995)

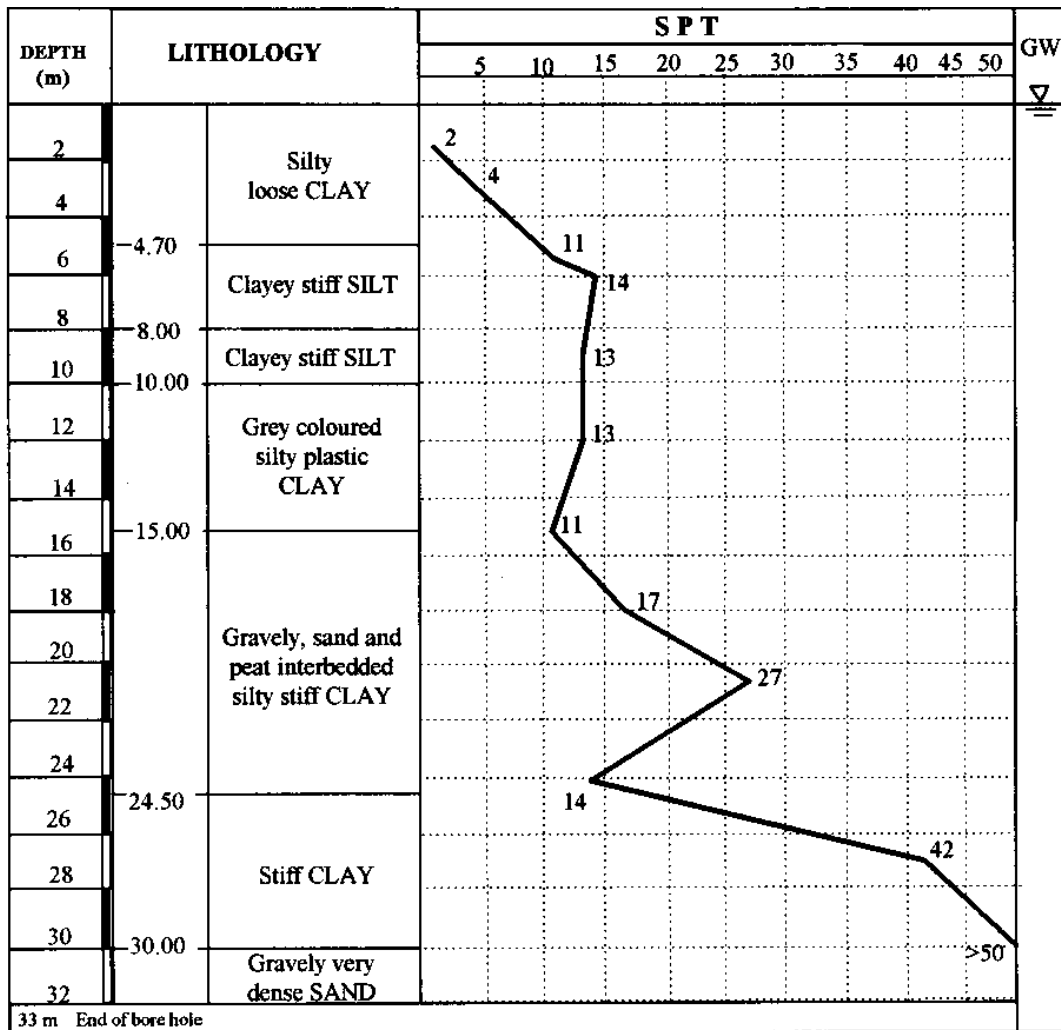


Figure 3.10: Summary log of borehole SK-1 at Sumbaş Stream on Kadirli-Ceyhan road. (reconstructed from Çetin, 1995)

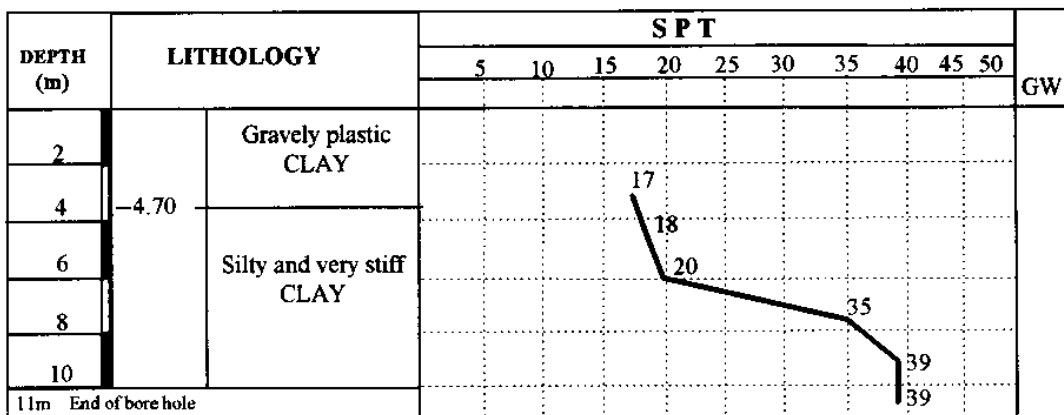


Figure 3.11: Summary log of borehole SK-2 at Canal Bridge of DSİ on Kadirli-Osmaniye road. (reconstructed from Çetin, 1995)

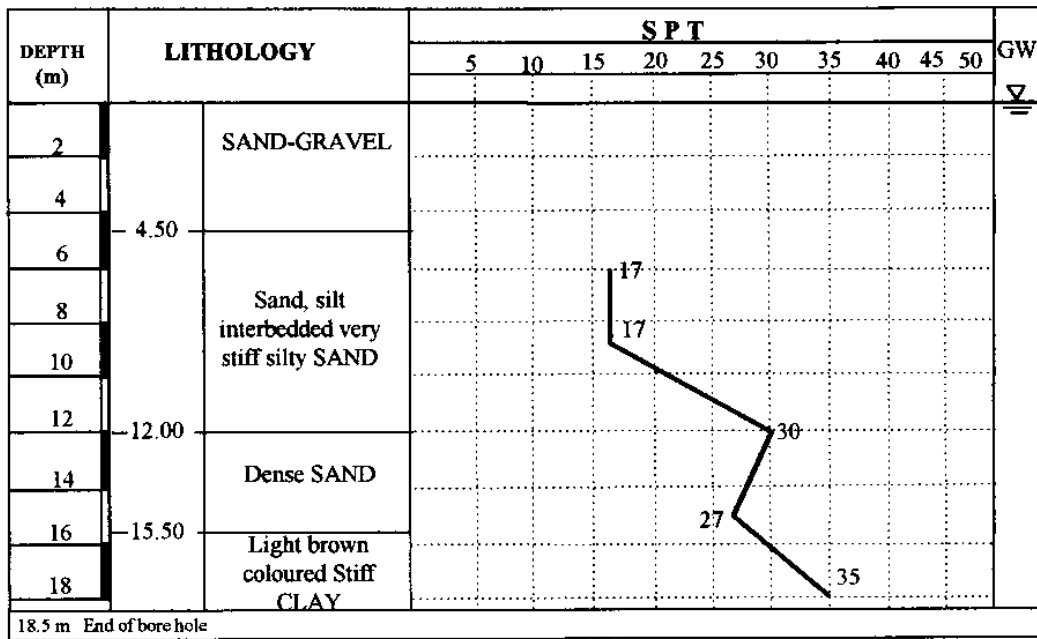


Figure 3.12: Summary log of borehole SK-3 at Ceyhan River Bridge on the Kadirli-Osmaniye road.(reconstructed from Çetin, 1995)

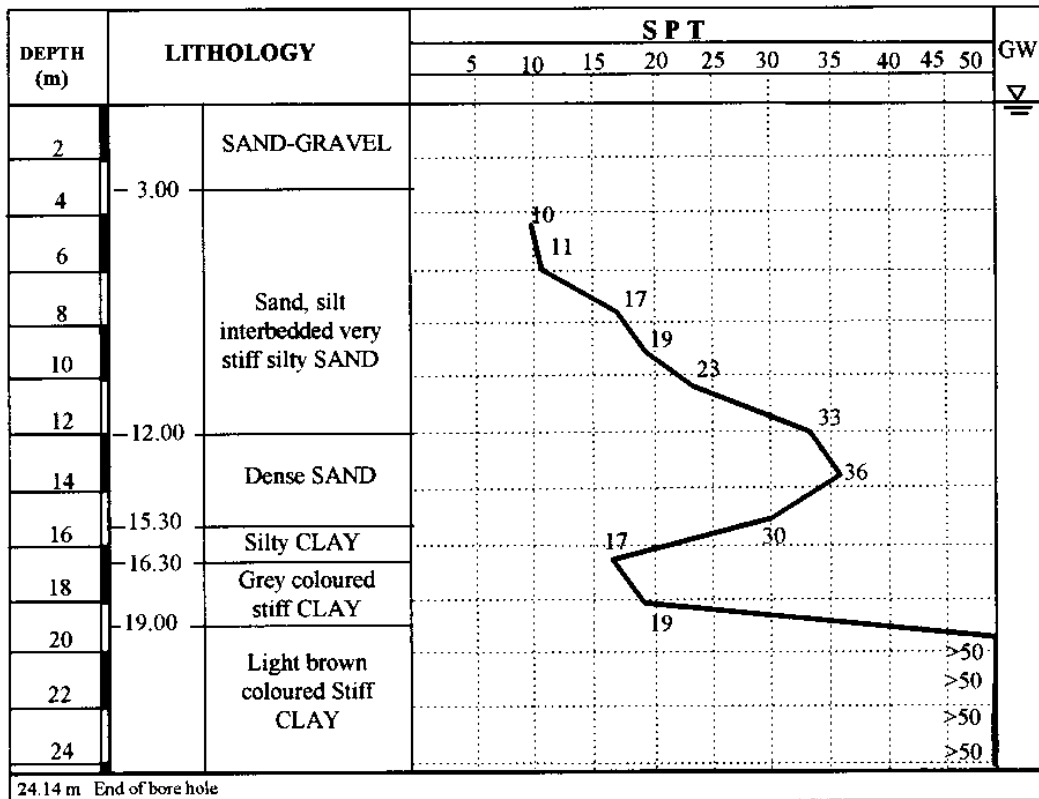


Figure 3.13: Summary log of borehole SK-4 near Ceyhan River Bridge on Kadirli-Osmaniye road. (reconstructed from Çetin, 1995)

### 3.2 Hydrogeology

Ceyhan and Seyhan Rivers originated from Toros Mountains (Taurides) flow through the basin and terminates at Mediterranean Sea. The Çukurova Basin is one of the largest plains of Turkey and it is famous with its cotton production. The alluvial deposits are due to these and they are loosely packed with a high porosity.

The longest river in the region is Ceyhan River (Figures 3.14 and 3.15). It originates from the mountains near Andırın, and carries substantial flows of water and sediment into the basin throughout the year. Some of the riverine water infiltrates into the basin through the distributary channel systems; the remainder flows overland towards its delta located on the coast of İskenderun Bay. Çeperce, Kesiş, Kilgen, Deliçay, Sarısu, Sumbaş, Kesik, Savrun and Andırın are the main streams joining the Ceyhan river from northern part of the region. Sabun, Hamis and Karasu are the other streams running from east to Ceyhan River (Figure 3.15).

Figure 3.16 shows monthly averages of precipitation for 9 years, evaporation for 30 years and temperature for 9 years measured by DSİ at Osmaniye Station. The highest precipitation generally occurs during January and April while the highest evaporation occurs during July and September.

Water table is generally close to the ground surface. Figure 3.17 shows monthly average of groundwater level and average precipitation at a well at Mamure (Osmaniye) in the north-east of the basin for years between 1970-1972 (DSİ, 1975). The groundwater level is closely associated with the amount of precipitation. When the ground level becomes quite high when the monthly precipitation is high. It seems that highest groundwater level is observed in June in years with high precipitation. The groundwater level fluctuates between 2-6 meters near Ceyhan River. Because of El Nino phenomena, the precipitation in 1998 is quite is high. Therefore, the groundwater level is expected to be quite high at the time of the earthquake of June 27, 1998.

On the basis of the latest general evaluation covering the basin by DSİ, depth of static water level from the surface ranges between 2 to 5 m (Figure 3.18). At the north of Mercimekköy, between Kirit and Yeniköy at a NW-SW directed large area with an elliptic shape, and in another small area bounded by Köşreli and Altıgöz Bekirli artesian conditions (Figure 3.18) were reported by DSİ (1984). Both shallow groundwater level and artesian conditions were also confirmed by more recently drilled boreholes by T.C.K in 1995 (see Figures 3.10, 3.12 and 3.13). Direction of groundwater flow through the aquifer in the alluvium is towards the Ceyhan River (Figure 3.19). Since there is generally impervious clayey and silty layers underneath of sandy-gravelly layers and/or semipervious silty clay at shallow depths.



Figure 3.14 A view of Ceyhan river and Ceyhan Ovası from Nacarlı village

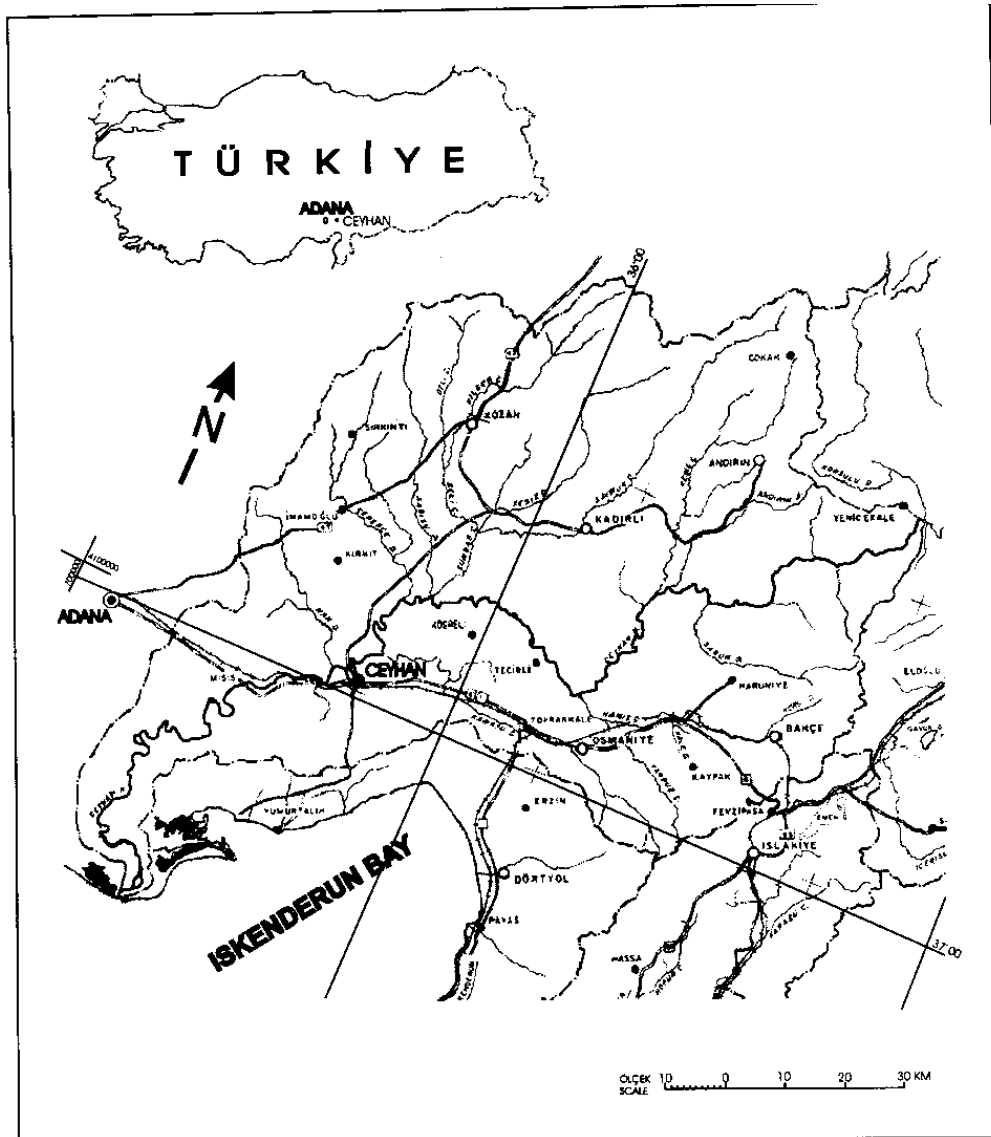


Figure 3.15 Main rivers and streams in Çukurova Basin

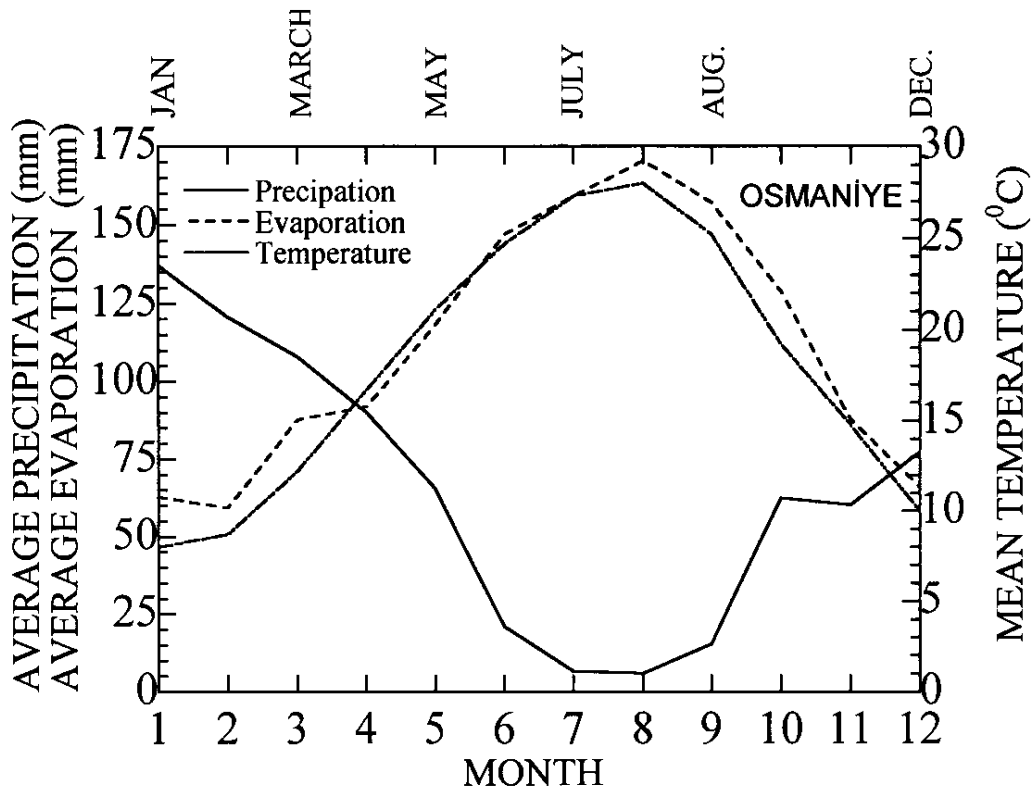


Figure 3.16 Monthly averages of precipitation, evaporation and temperature at Osmaniye (DSI)

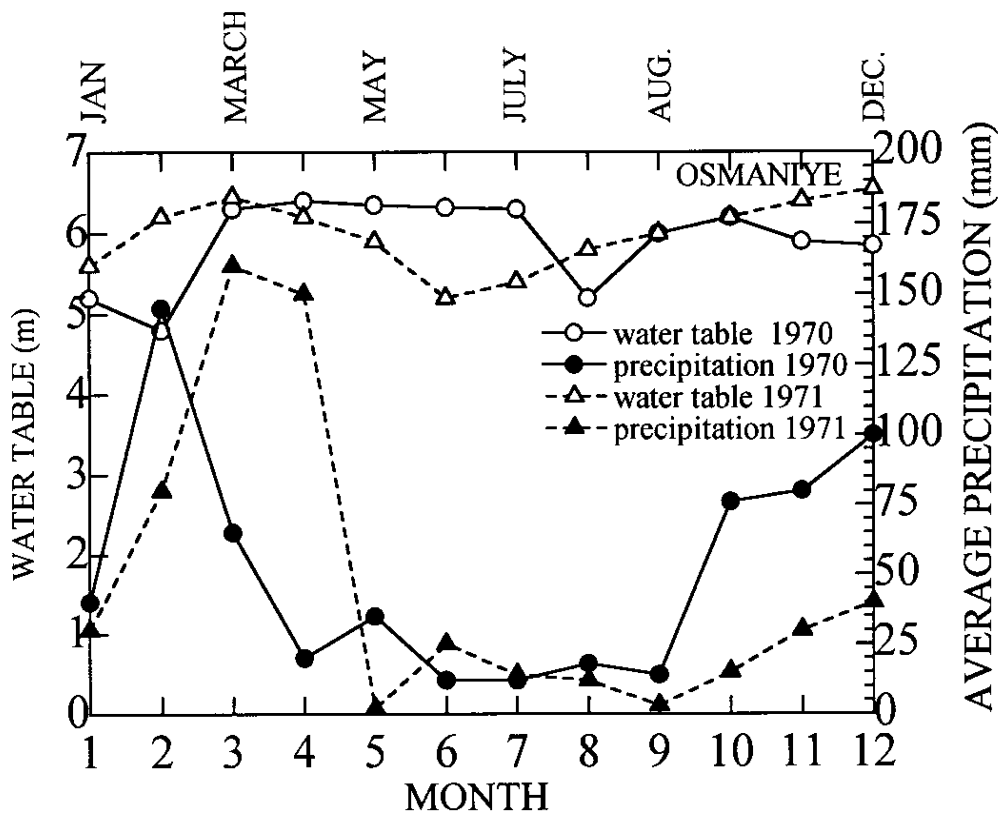


Figure 3.17 Monthly averages of ground water level and average at a well at Mamure (Osmaniye) (DSI)

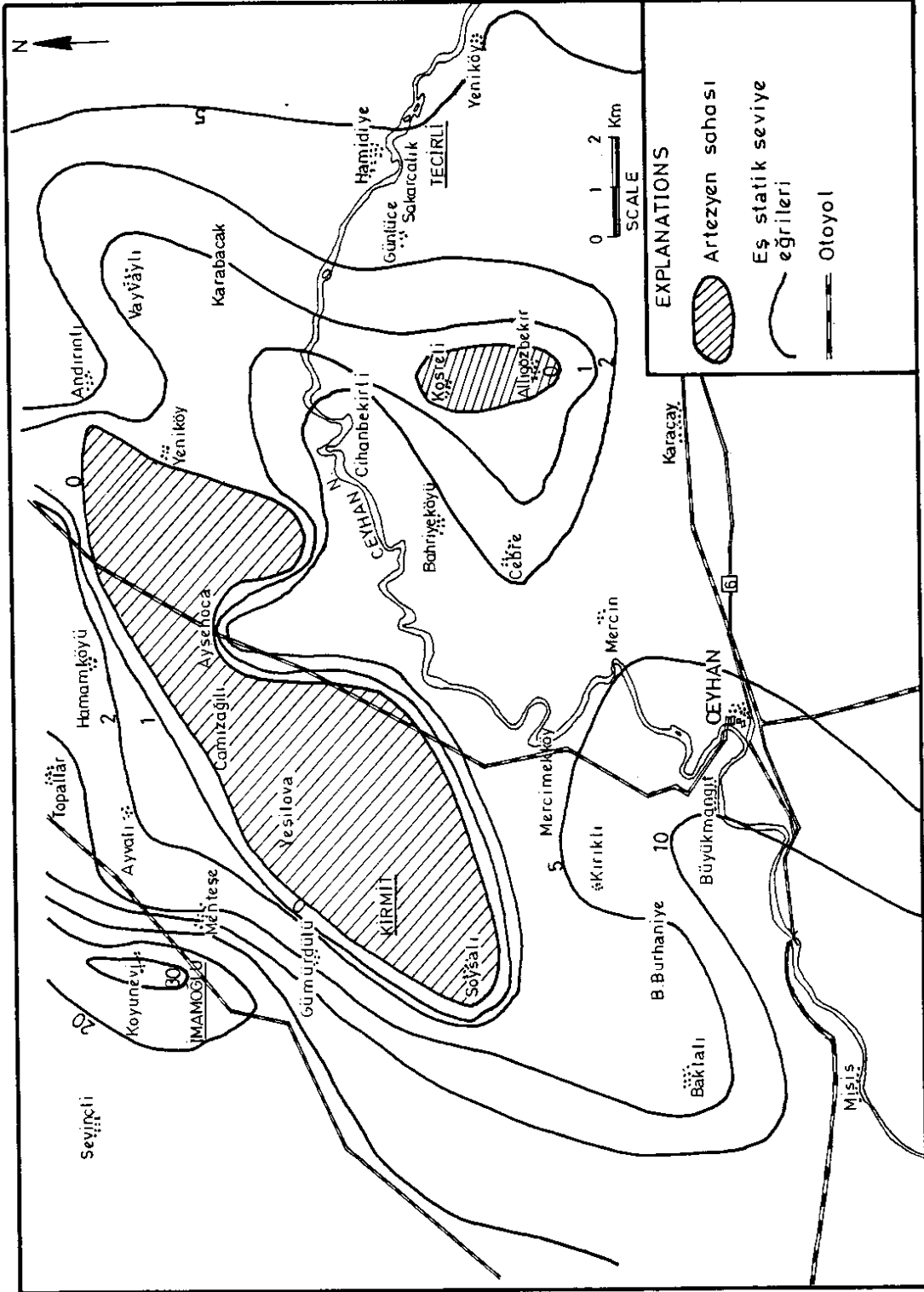


Figure 3.18 Static ground water level map of Ceyhan Basin (after DSI, 1984)



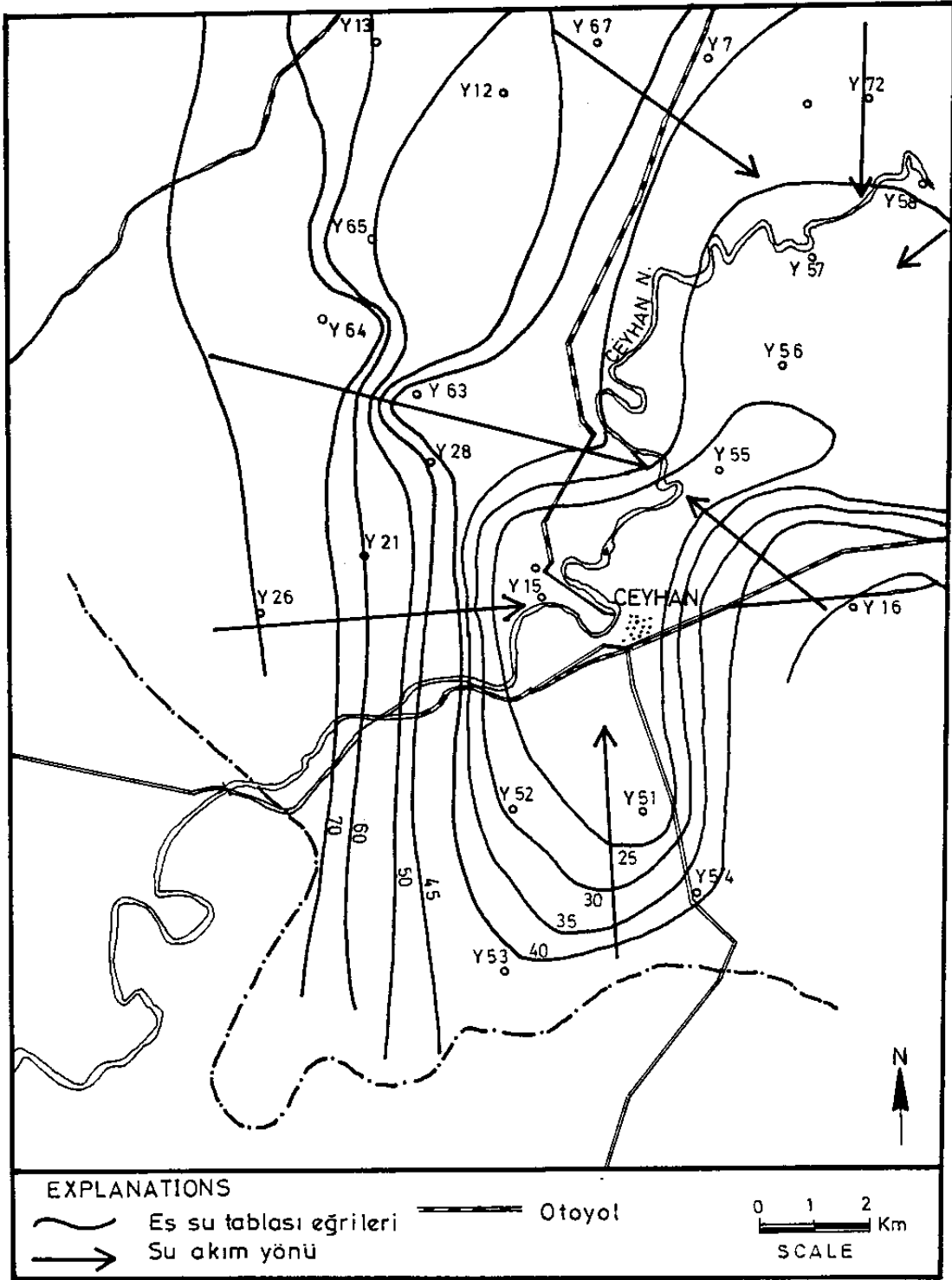


Figure 3.19 Groundwater table contours and general direction of groundwater flow at Ceyhan Basin (after DSI, 1984)