5.11 Roads and Railways

5.11.1 Roads

(1) Nationwide Road Network

1) Network

The total length of Turkey's roads is 381,245 km as of 1st January, 1996. The length of state highways and provincial highways is 59,999 km, mortorways is 1,246 km as of 1st January,1994. Three mortorways, ① between Ankara, Istanbul, Edirne and Kapikule, ② between Pozanti and Gaziantep, ③ between Cesme, Izmit and Aydin are open to traffic or under construction. (See Figure 5.11.2 and Figure 5.11.3)

The ratio of paved road are 95% for state highways, and 74% for provincial highways. Major roads are used for international transportation between Europe and the Middle East as well as for domestic use.(See Figure 5.11.1)

TABLE 5.11.1 The Distances of Motorway, State, Province and Village Roads According Surface Types

(kilo meter)

Road Type	Asphalt Concrete	Surface Paving	Parquet	Stabilized	Soil	No Transition	Total
Motorway	1246						1246
State Highway	4700	24,983	39	1230	82	388	31422
Provincial Road	135	20866	82	5322	1248	924	28577
Village Road		36000		157000	74000	53000	320000
Total	6081	81849	121	163552	75330	54312	381245

Source : T.C.K.

Note : Figures were given as of 1.1. 1996.

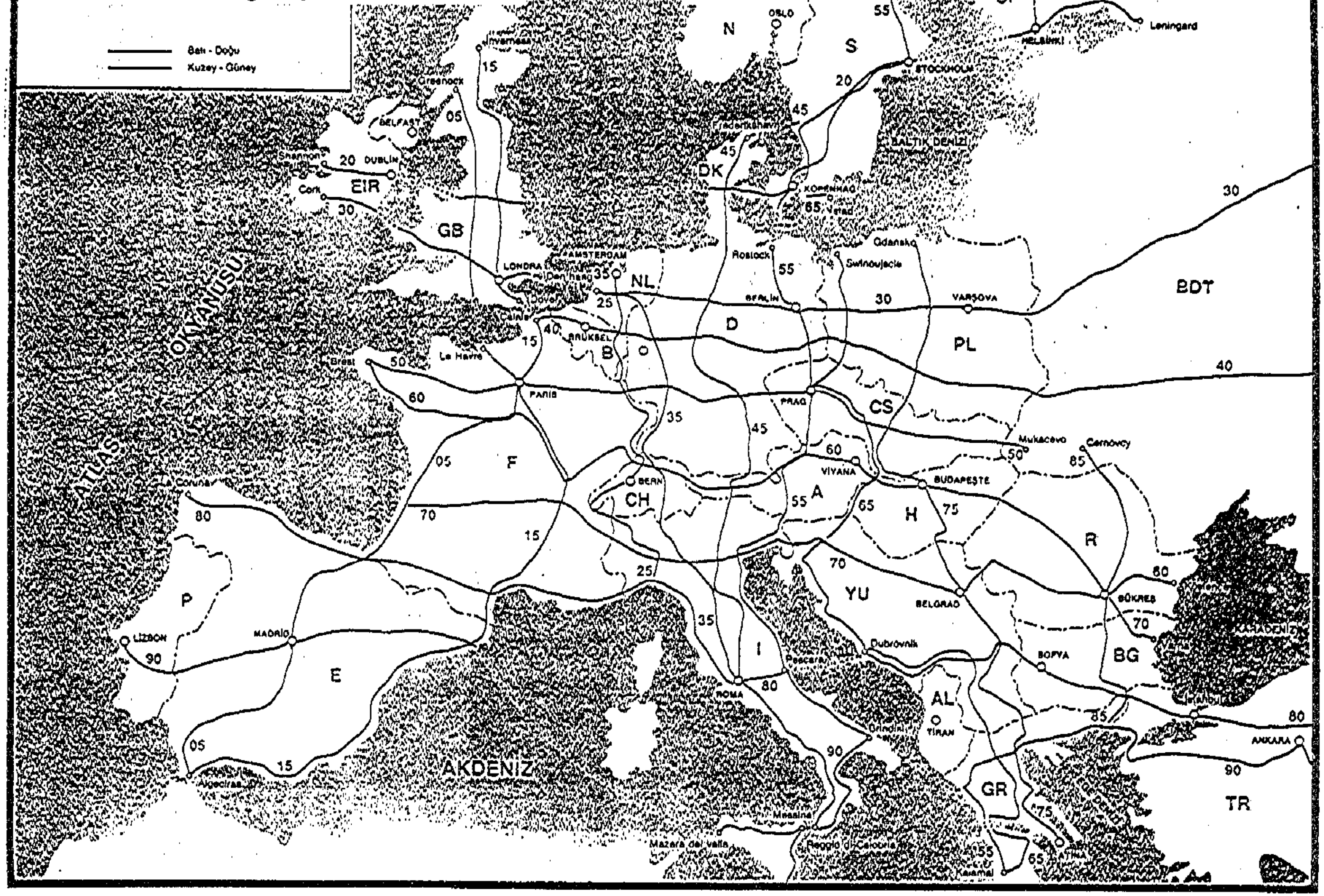
2) Activity

87.6% of cargo transportation (ton-km) and 95.4% of passenger transportation (passenger-km) in Turkey are realized through highway.

The responsible agencies for planning, construction, and maintenance of roads are the General Directorate of Highways (TCK, for motorway, national and provincial highways), the General Dorectorate of Village Services (KHGM, for village roads), and the General Directorate of Forest (OGM, for forest roads).

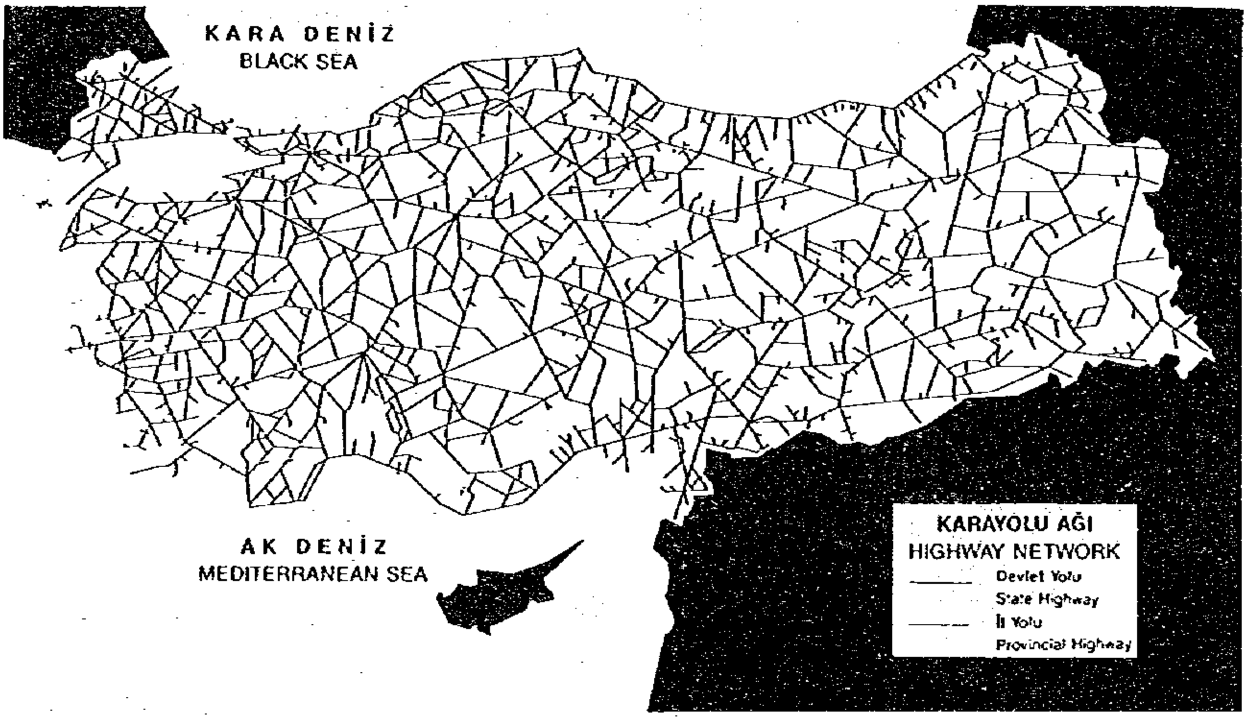
Among the agencies, TCK plays the most important and vital role in road policy.

FIGURE 5.11.1 Highway Network in Europe



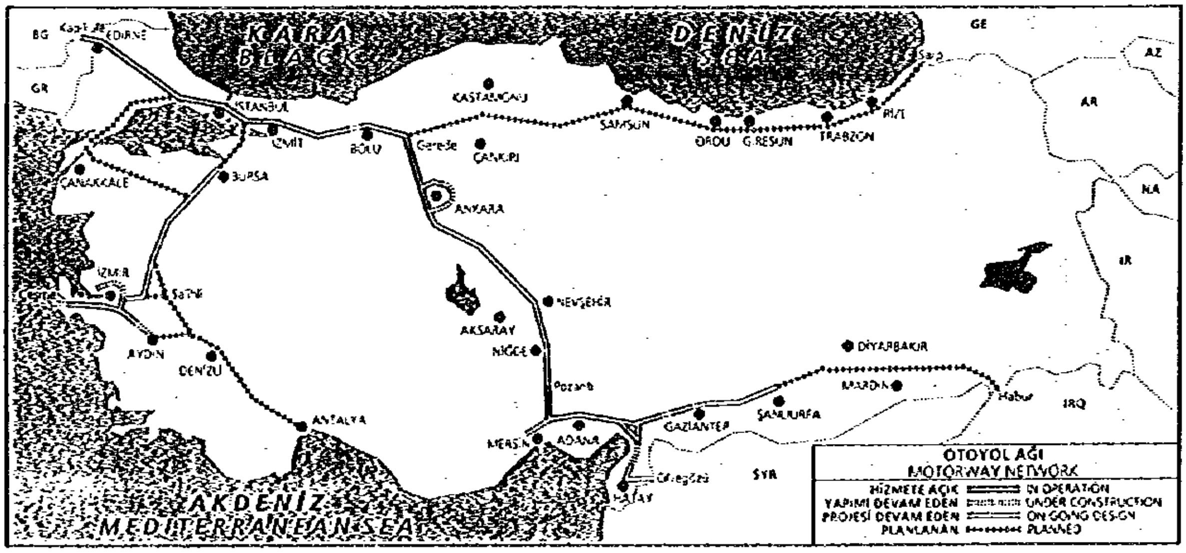
Source : TCK

FIGURE 5.11.2 Highway Network In Turkey



Source : TCK

FIGURE 5.11.3 Motorway Network In Turkey



Source : TCK

3) Improvement Program

Road traffic is generally smooth, except for the Istanbul area.

The present target of road improvement are ① to reconstruct roads for heavy vehicles, ② to improve the physical set-up.

In addition to the above, motorway construction has started employing tool road system.

The motorways under construction are Edirne - Istanbul - Bolu - Ankara, Izmir - Aydin, and Pozanti - Adana - Gaziantep. The total length of the motorways will be 3,000 km by the year 2000. The motorway around the Sea of Marmara is included in the long-term concept of an 11,000km-long motorways plan.

The Bursa-Canakkale motorway may be constructed earlier than scheduled.

(2) Marmara Region Road Network

1) Network

The road network in the Marmara region is shown in Figure 5.11.4 and 5.11.5. The length of the road in the 1st and 17th Division(Istanbul) is 4,172 km and it is 4,701 km in the 14th Division (Bursa). The motorway which is open to traffic, located in these division, is Tranc-European North-South Mortorway, E80.

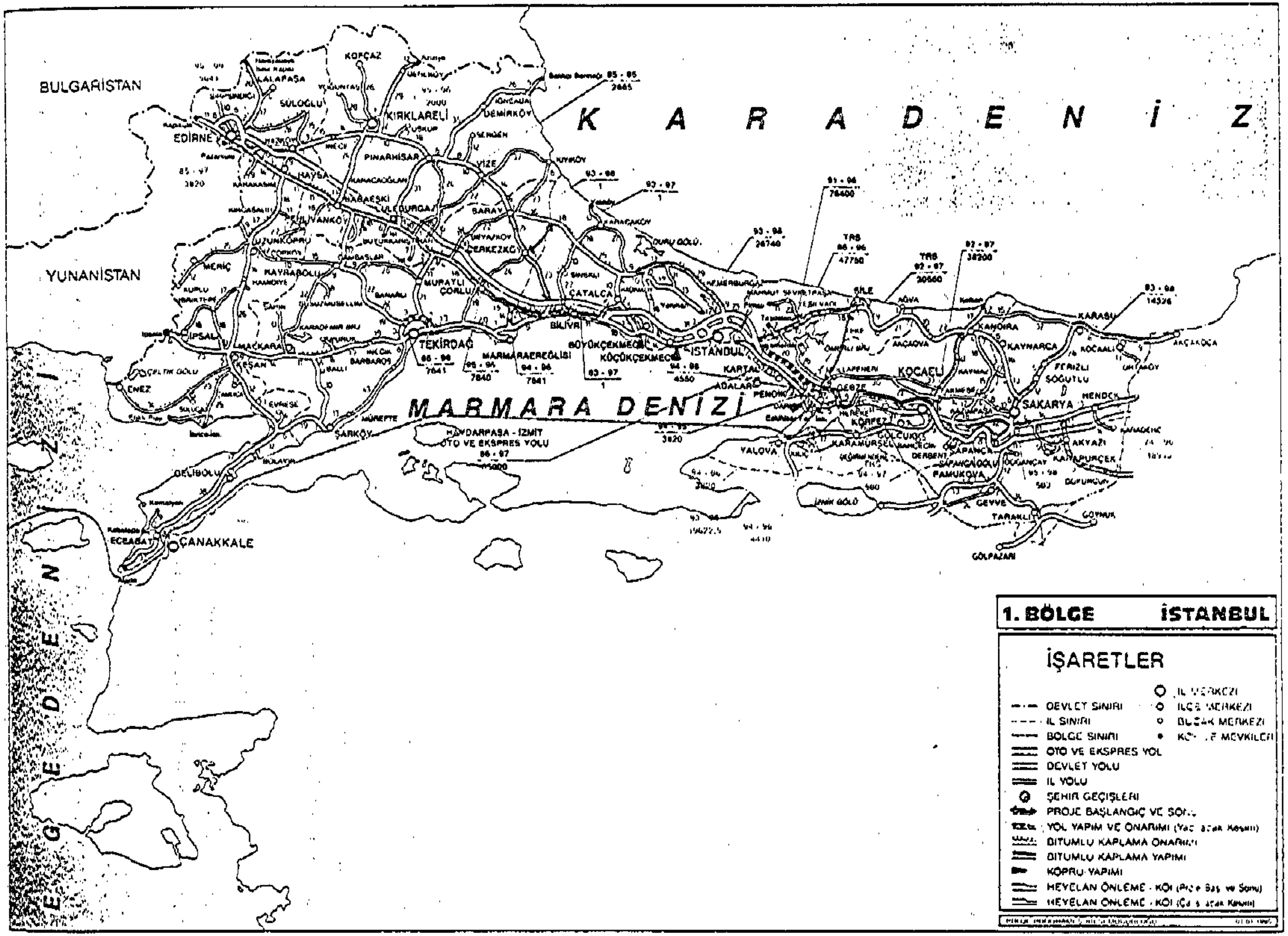
2) Traffic

According to the .Highway Transportation Survey in 1994, the most congested section in the first division of which annual average daily traffic value is 70,565, is Istanbul and Gebze and the second congested section (22,340), is between Izmit and Golcuk. The annual average daily traffic value of the section in Tekirdag is changing between 4,500 and 5,500. Sixteen percent (16%) of traffic is truck and trailer in the former section and 24% of total traffic in the latter section.
(See Figure 5.11.6 and Table 5.11.2)

The most congested sections in the 14th division of which annual average daily traffic values is 16,390, is Yalova and Gemlik and the second congested section, having a traffic volume of 9,310, is between Bursa and Bandirma.(See Figure 5.11.7)

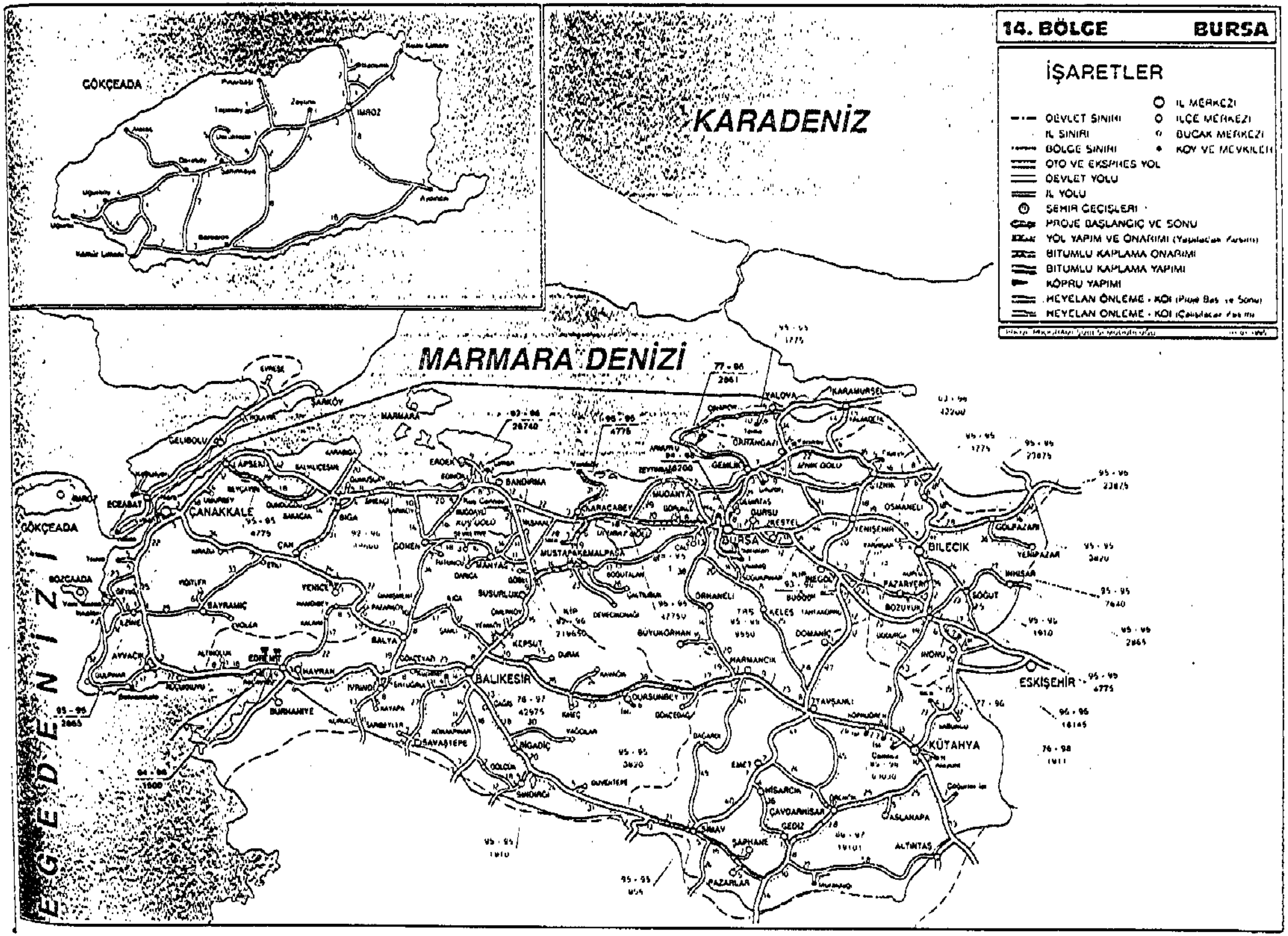
The number of vehicles passed the two bridges crossing the Bosphorus Strait are shown in Table 5.11.3. 5.11.4. The total number of first bridge's vehicles is 64,051,228 cars/year in 1995, namely some 180,000 car/day. The number of second bridge's is 36,471,792 cars/year, namely some 100,000 car/day.

FIGURE 5.11.4 Highway Network in Marmara Region (Istanbul)



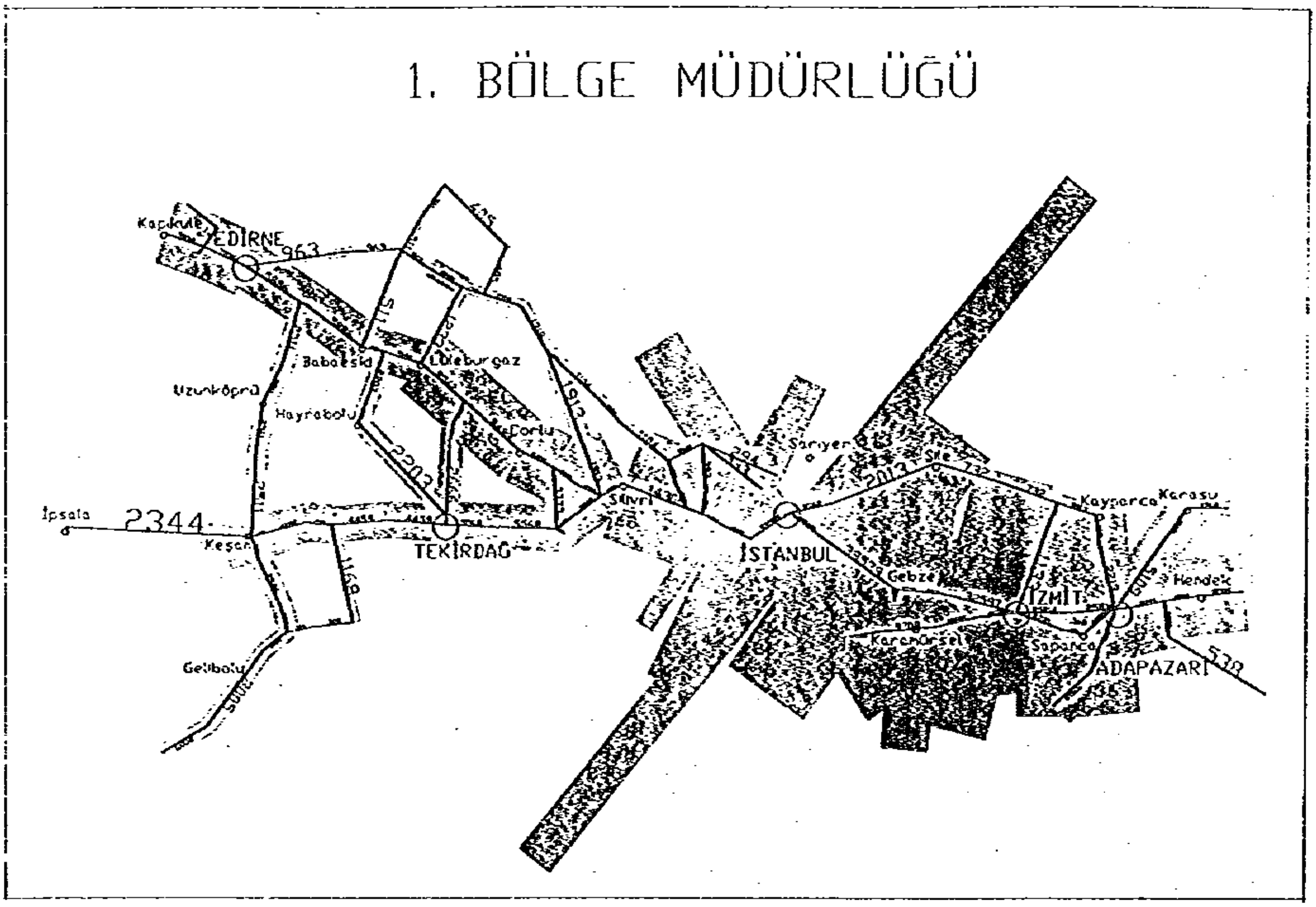
Source : TCK

FIGURE 5.11.5 Highway Network in Marmara Region (Bursa)



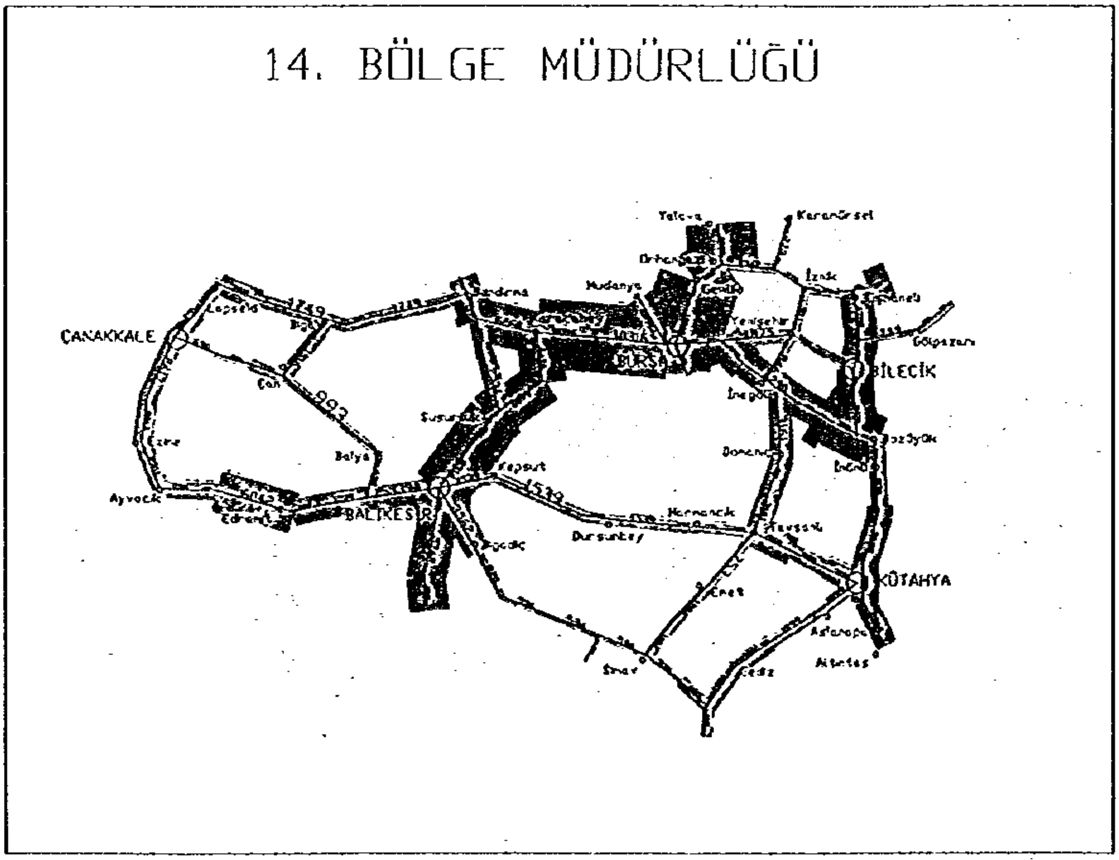
Source : TCK

FIGURE 5.11.6 Annual Average Daily Traffic in Marmara Region (Istanbul)



Source : TCK

FIGURE 5.11.7 Annual Average Daily Traffic in Marmara Region (Bursa)



Source : TCK

TABLE 5.11.3 The Numbers and Classes of the Vehicles passing the Bosphorus Bridge

YEAR	VEHICLE CLASS								
	CLASS 1 AUTOMOBILE STATION WAGON IS INCLUDED	CLASS 2 MOTORCYCLE	CLASS 3 MINIBUS MINITRUCK	CLASS 4 MIDIBUS	CLASS 6 BIG BUS HAVING THE SEATS OF OVER 50	CLASS 7 TRAILER WITH 3-7 AXES	CLASS 8 MUNICIPALITY BUS & PUBLIC BUS	CLASS 9 TRUCK WITH MAX LOAD	TOTAL
1973	1.391.742	6 810	144 937	1.729	17.355	2 647	16 504	114.753	1 695 505
1974	9 715.079	49 936	967.206	14.283	145 022	28 263	92 845	856 353	11 869 933
1975	13 803.152	52 636	1.452 666	24.947	338 512	79.150	109 200	1.372.743	17 243 025
1976	18 848 363	54 041	1 999.819	35 635	458.550	157.454	137.710	1.772.734	23 494 314
1977	22.107.359	72 156	2.465.523	52.452	566.275	170.494	139 220	2 093.765	27 672 255
1978	22 278.325	71.659	2 583.774	75 364	591.605	127.193	142 971	2.137.721	28 008 610
1979	20.788 004	72 355	2.457.065	113 114	593 921	85.199	136 399	2.199.574	26.447.651
1980	21 944 952	60 474	2.443 312	117.565	636 829	128 221	229.447	2 263.730	27.794.525
1981	23.703 645	41 926	2 430.726	131.964	680 824	213.442	325.354	2 333.495	29 865 280
1982	27.226.772	45 512	2 665.442	157.748	774 532	258 576	349 652	2 837.254	34 317.035
1983	23 537 360	45 222	3 029 620	233 200	872.792	242 970	427 254	2 794.410	37.182 826
1984	29 619 550	47.844	3.131.886	242 604	961.065	258.782	676 422	2.727.384	37.665 569
1985	29.811 652	47 593	3.442 262	224 856	1 003.114	230 670	895 355	2 756.272	38.411 974
1986	34 576 292	48.510	4 624.192	252.476	1.130.598	194 252	1 074 834	3 033 056	44 934.017
1987	35.734.954	51.926	5.369.693	321.428	1 203 308	210.944	1 019.149	3 350 695	45.291.094
1988	38 807.422	65 014	5 694 554	385.506	1 325.889	245 510	894.912	3 566.136	50 935 942
1989	40.449 078	66 792	5 396.755	454 592	1.366.424	218.452	849.943	3 078.155	51.853 207
1990	41.804 252	76.394	5 267.884	667.882	1.411.276	12.143	783.700	1.169 076	51.153 634
1991	36.129 545	91 246	4.674 033	716.476	1 356.414	4 814	676 498	692 552	44 341.576
1992	44.855 664	135 176	5.478 650	422 530	714.878	1.162	689.768	436.155	52 704.015
1993	51 753.458	176 435	6.192 249	328.665	216.774	554	778 052	128 216	59 574 336
1994	51.457.116	234 712	6 076 845	307.864	187.645	269	868 832	55.644	59.229 535
1995	55.784.092	223 632	6.558.736	283 158	201.626	370	912 912	86.702	64.651 223
TOPLAM	703.128 077	1.838 633	84.578 843	5 576 947	18 756 240	2 871 524	12.234 812	41.888 591	858 873 673

Source : TCK

TABLE 5.11.4 The Numbers and Classes of the Vehicles passing the Faith Sultan Mehmet Bridge

YILLAR	ARAÇ SINIFI								
	1 SINIF (OTOMOBİL STEYŞIN DAHİL	2 SINIF (MOTORSİKLET)	3.SINIF (MİNİBÜS KAMYONET,JEEP LAND ROVER, HER CİNS AMBULANS VE CENAZE ARABASI)	5 SINIF (KÜÇÜK OTOBÜS)	6 SINIF (BÜYÜK OTOBÜS 30 VE DAHA YUKARI OTURMA YERİ OLAN)	7.SINIF (3-7 AKSLI TREYLER ÇEKİCİ DAHİL	8 SINIF (BELEDİYE OTOBÜSÜ HALK OTOBÜSÜ DAHİL)	9 SINIF (KAMYON AZAMİ YÜKLÜ AĞIRLIĞI 3.5 TONDAN BÜYÜK OLAN	TOPLAM
1988	1.218 741	1.687	147.847	4.767	6.816	4.803	444	129.178	1.514 283
1989	5 827.229	8.789	786 095	29 435	42.100	54.731	3 884	886.421	7 638.676
1990	11.514 665	20 892	1.681.139	83.096	95 995	295 224	25.068	2 859.400	16 621.652
1991	16.250.380	29 950	2 344.482	193.052	193.932	278 232	75.742	3 363 799	22.729 600
1992	15.303.312	39.020	2 615.244	358.690	857.262	256 274	146.555	3.707.516	23 295 884
1993	18.901.190	47.948	3.321.006	445.714	1.530.882	357.456	183.978	4 868 500	29.656 654
1994	20.454.920	47.012	3.665 230	469 054	1.371.914	309.744	327.916	4.600 648	31.156.638
1995	24 842.984	55.708	4.263 236	393 826	1.225.804	379.536	314.048	4.995 650	36.471.792
TOPLAM	114.323 622	251.027	19 824.271	1.993.834	5 324.736	1.938.010	977.646	25.452 303	169 085 219

Source; TCK

TABLE 5.11.2 Annual average Daily traffic (1994)

Section	Sec. No.	Automobile	Bus	Truck	Trailer	Total
1.Izmit～Golcuk	130-01,3	15063	1911	4995	365	22340
2.Istanbul～Gebze	100-06,1	89326	4951	11134	326	100637
	100-06,2	28229	4581	11134	326	44270
	100-07,1	28223	4581	11134	326	44270
	Average	54408	4707	11134	326	70565
3.Yalova～Gemlik	Average	9149	964	5632	645	16390
4.bursa～Bandirm:	200-03,4	3393	281	2033	84	5791
	200-03,5	4290	227	2130	74	6721
	200-04,1	4290	227	2130	74	6721
	200-04,2	6113	612	4631	292	11658
	200-05,0	6118	612	4631	237	11658
	Average	5172	447	3992	199	9310

3) Development Plan

The projects planned around Marmara Region are as follows ;
(See Figure 5.11.3)
① Izmit Bay Bridge project :
Total length of road in this project is 45 km, and bridge between Dil-quay and Hesek point is 3 km in length. It is a part of planned "Marmara Corridor Motorway" (tentative name). Feasibility Study has been implemented until 1996. "BOT" is being considered as financing method.
② Canakkale Strait Bridge project :
Total length of road (including approach road) in this project is 20 km, and bridge crossing the Strait is 1,500 m in length. Feasibility Study has already finished.
③ Third Bosphorus Bridge project :
This idea is considered by Istanbul Municipality.

5.11.2 Railways

(1) Network

Turkish railway system covers all of Turkey. The system's total length reaches 8,452km in1994. Most of the lines are single-track, and only three percent of the total, 288km by double line by 1994. Eleven percent of total, 939km has been electrified. The map which indicates the railway network is shown in Figure 5.11.8.

The railway network is divided into 6 regions. The first region includes Istanbul, Eskisehir, Balikesir, and the second region covers Eregli, Zonguldak, Karabuk, Cankiri, Irmak, Ankara, and Bogazkopru. The other regional units operate in the southwestern part, the northern part, the central eastern part, and the south eastern part of the country.

(2) Activity

The railroad activity by in total transportation became smaller. The share of railway in passenger transport was 4.2% and freight transport was 8.0% in 1994. The railway service could not maintain a positive image and TCDD has suffered from deficit in recent years.

In order to recover the reliability in railway system, TCDD is trying to improve productivity by means of technical innovation, electrification, and the upgrading of tracks.

(3) Development Plan

The railway development plans around Marmara Region are as follows (See Figure 5.11.9);

① Bandirma ~Bursa~Adapazari(Zonguldak) new railway project:
The feasibility study is conducted until 1997 by DLH. The purpose is to reduce the load of the Izmit bay. Main cargo will be minerals.

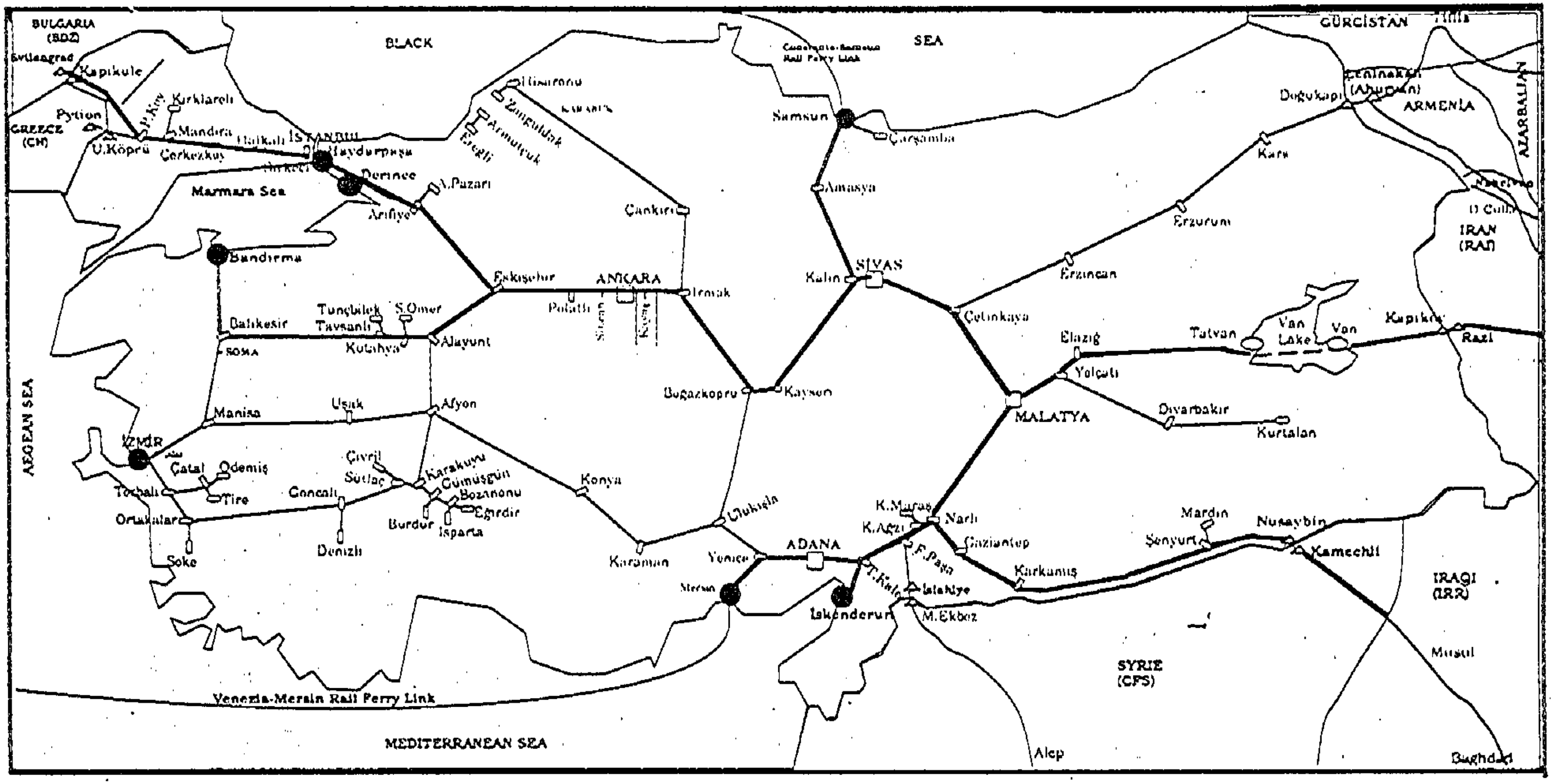
② Canakkale~Bandirma~Baliukesir new railway corridor project :
The feasibility study for the project is expected to be completed conducted in 1996 by DLH.

③ Ankara-Istanbul high speed railway & Istanbul Bosphorus crossing project:
The construction works between Ankara and Cayirhan, which is 85 km in length, has been conducted by DLH. 80% of the total 85 km, has been already completed. The Ayas tunnel is under construction. Main purpose of the project is to transport passengers and to reduce traffic congestion in Bosphorus. According to a person in charge, the first thing to be prioritized is to commence a tube-tunnel construction (total cost : 1.5 billion US$) crossing the Bosphorus, second is to complete the Ayas tunnel (Ankara and Cayirhan), third this to renovate the line between Istanbul and Arifiye, and fourth is to reinforce a line between Istanbul and Bulgaria.

④ Tekirdag~Muratli new railway branch project :
The feasibility study was implemented by DLH in 1982.

FIGURE 5.11.8 Railway Network in Turkey

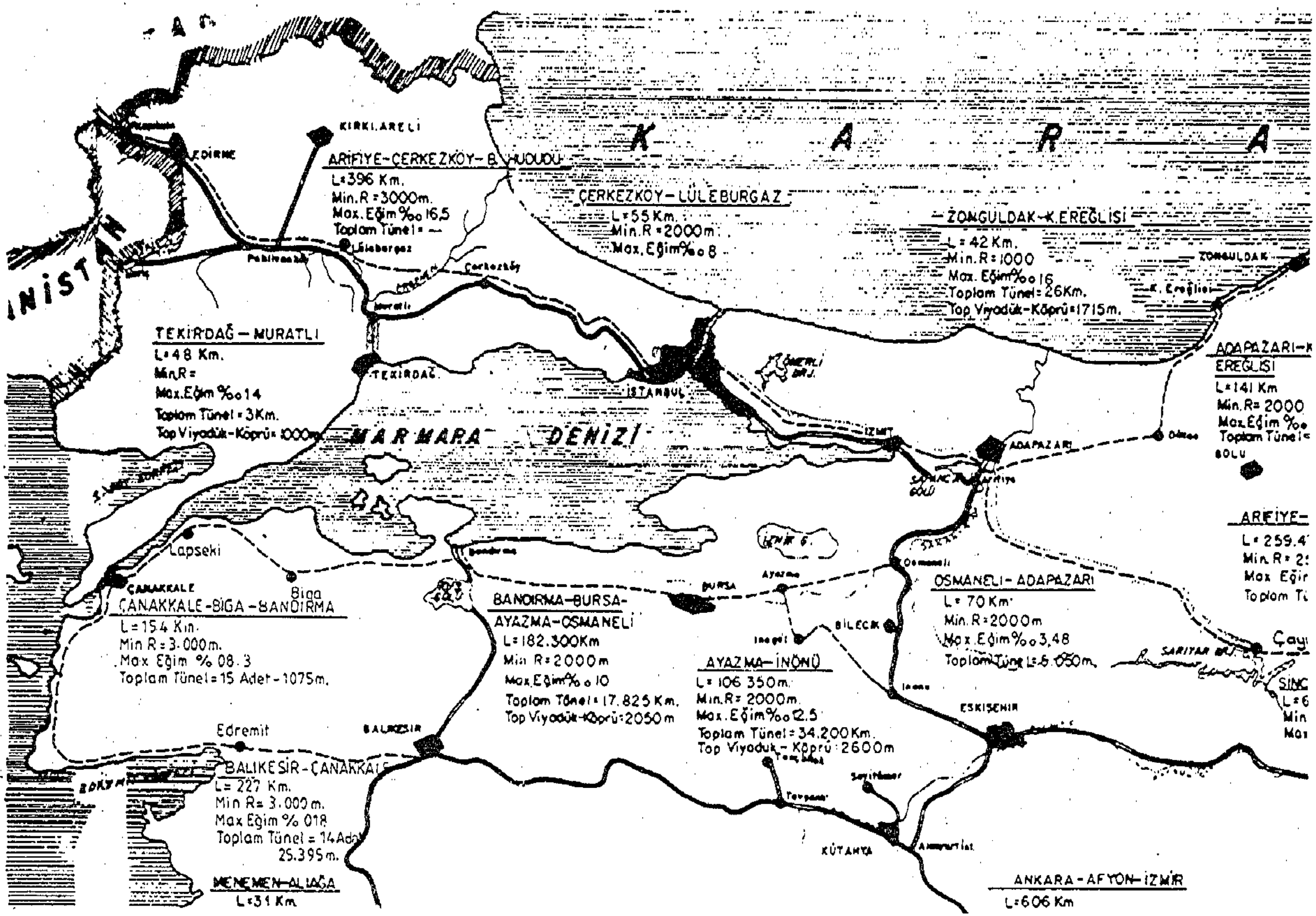
RAILWAY NETWORK AND THE PORTS OPERATED BY TURKISH STATE RAILWAYS (TCDD)



- ACTC (European Agreement on Important International Combined Transport Lines and Related Installations) (TCDD)
- Turkish Railways Network (TCDD)
- AGC and TER (Trans-European North - South Railway project) lines (TCDD)
- International Ports Operated by Turkish State Railays (TCDD)
- Van Lake Rail Ferry Pier
- International Rail Border Crossing Points
- Regional Directorates
- Important Stations

Source : DLH

FIGURE 5.11.9 Railway Projects in Marmara Region



Source : DLH

5.12 Recreation (Marina & Fishery)

(1) Marina

There are 10 official yacht harbors which are licensed by the Ministry of Tourism in Turkey and Kalamis Amiral , Atakoy and Atabay are located at the Sea of Marmara. Most of yacht harbors are located at the cost of the Aegean Sea. The official yacht harbor must provide facility in international standards.(See Figure 5.12.1)

The number of calling yacht firstly at Turkey's yacht harbors had been changing between 3,500 and 4,000 by 1990, and fell down to approximately 2,500 by sudden decrease of foreign yacht's calling. In these three years, the number has been constant at around 3,000. Calling by private foreign yacht has gradually increased.

About 50% of the total calling is by U.K., Germany, France, following by U.S.A. Australia, and Greece. Commercial calling has a share of about 20%, in 1994. On the other hand, two third of Greece calling yachts are commercial.

The number of calling is highest at Marmaris harbor, with share of around 30%, second highest at Bodrum harbor, with 18%. Istanbul harbor has a share of 3% of total. According to the length of yacht, 34% of total are 9m to 12 m, 25%of total are 12 m to 15 m, 15% of total are 15 m to 18 m, and 20% of total are over 18 m.

In Istanbul harbor, yachts with Germany flag are most calling, with 13% of total, following is U.K.. 70% of yachts are calling during four months from June to September. 60% of calling yacht at Istanbul has a length between 9m to 15 m and 20% has a length between over 18m.

(2) Picnic Area

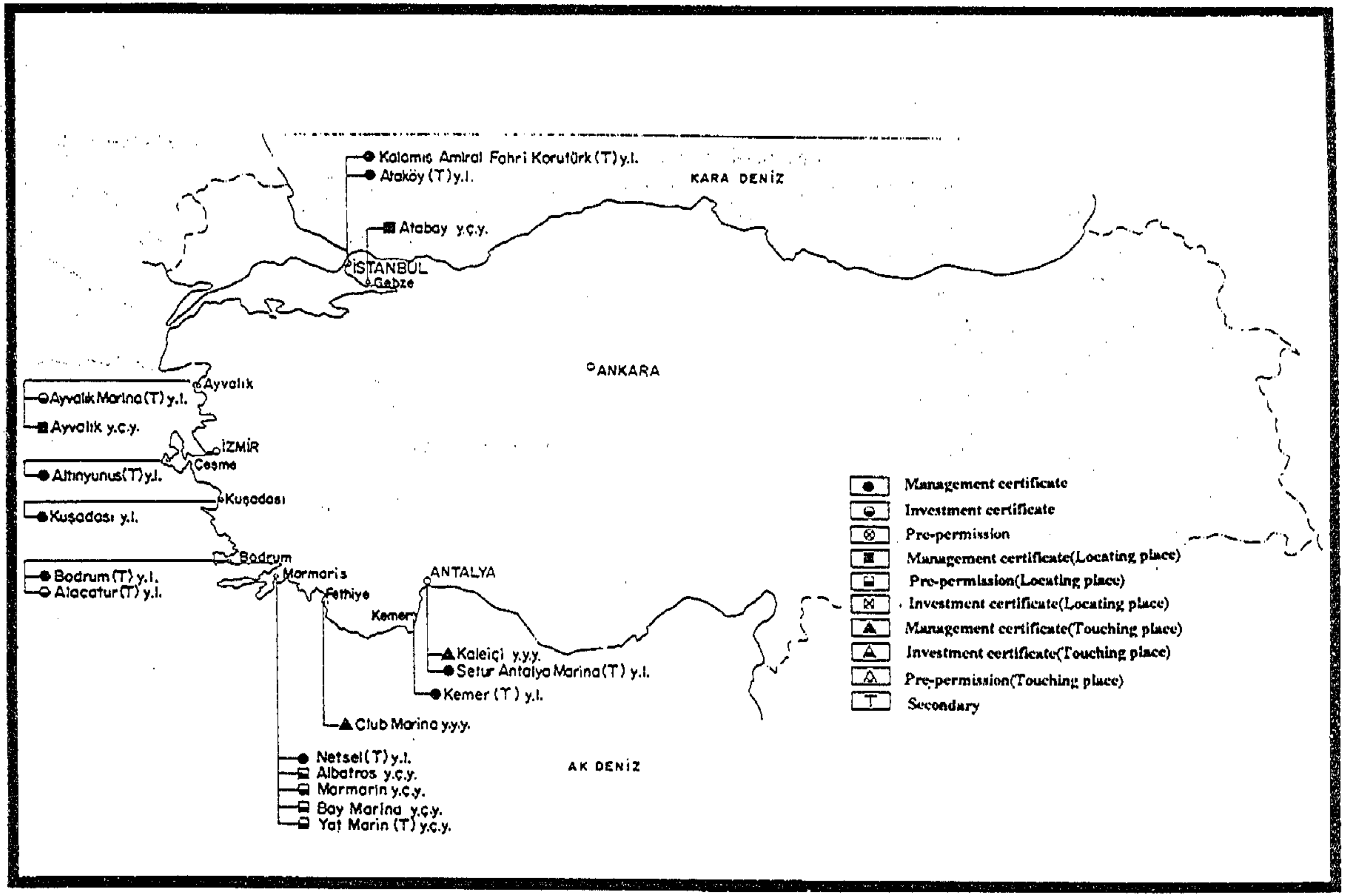
There are 18 picnic areas in the forest on the coastal zone around Marmara Sea.(See Figure 5.12.2)

(3) Fishery

Fishery products in Turkey has been changing between 300,000 and 600,000 tons/year. The products has increased gradually since 1991. Sixty percent (6%) of total products is Anchovy at North Atlantic. Main products are Atlantic horse mackerel, Atlantic bonito, and Chub mackerel.

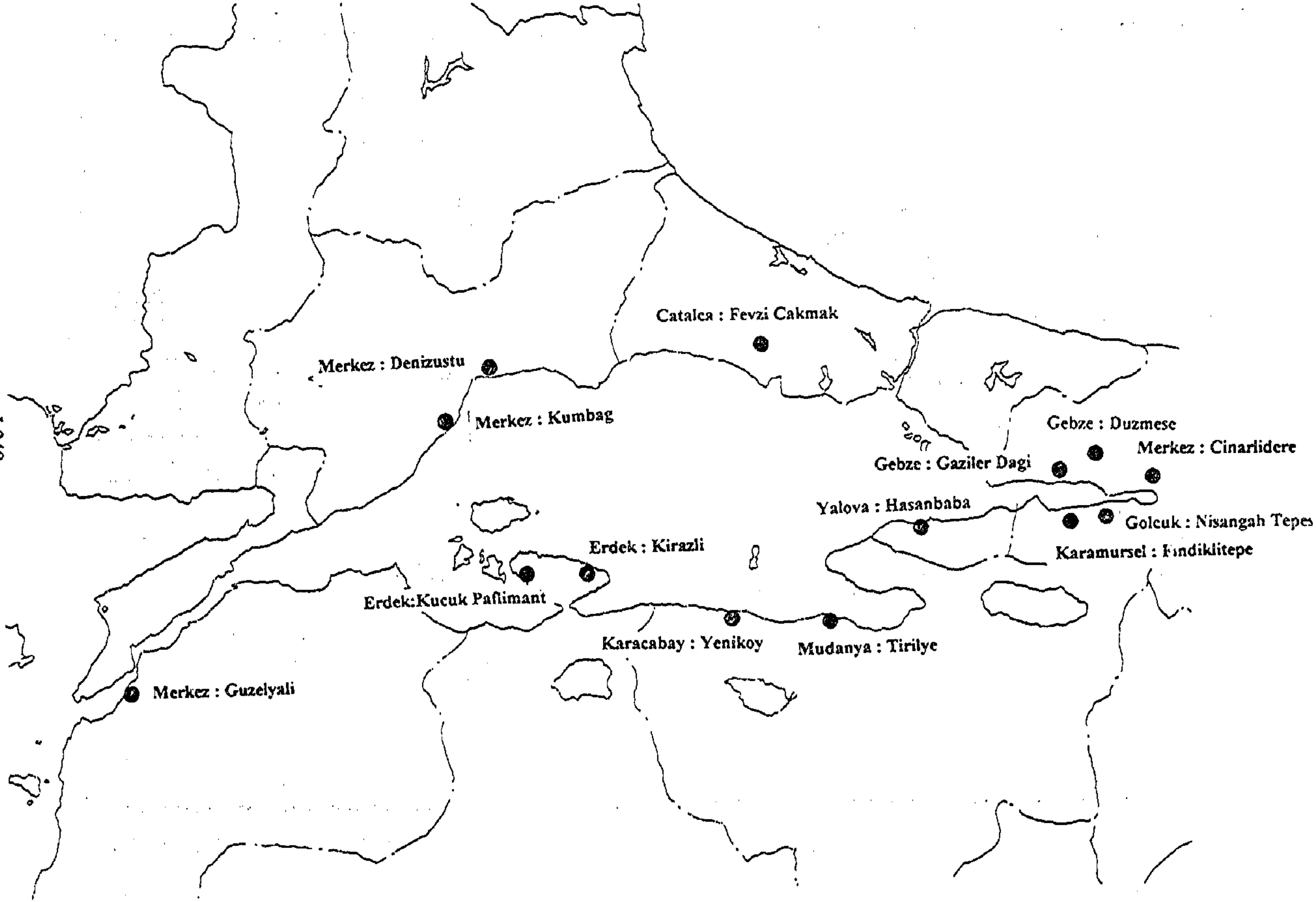
Marmara Region has important contribution to the regional development from the

FIGURE 5.12.1 Location of Yacht Harbor in Turkey



Source : Ministry of Tourism

FIGURE 5.12.2 Location of Picnic Area in the forest around Marmara Sea



point of fishing. On the coastal part of Ergene region included in Marmara Region, fishing is a important income source. Additionally, on the south part of the region, Saros Gulf is important from the point of fishing. According to article from newspaper, extinction of fish species which had a number of approximately 200 is resulted from water pollution caused by ships. Today , only 8 to 10 fish species survive in Marmara Sea.

It is said that there are 124 fishery ports in Turkey, which are operated by Municipalities and fishery associations..

6 NATURAL CONDITIONS IN THE PROPOSED PORT SITE

6.1 Geography

6.1.1 General Topographic Condition

The proposed site is located in the military-owned coastal plain, approx. 2 km long and 100 m wide. The coastal terrace behind the beach line lies 10-15 m above the sea level. The coastal beach extending in front of the military-owned coastal plain is rather narrow, about 2 to 5 m in width. Inshore of the military-owned coastal land runs an old national highway No. 110 is called E25 (TEM). The western boundary of the military-owned land is formed by Hacimuratli River. The location map of proposed port site is shown in Fig. 6.1.1.

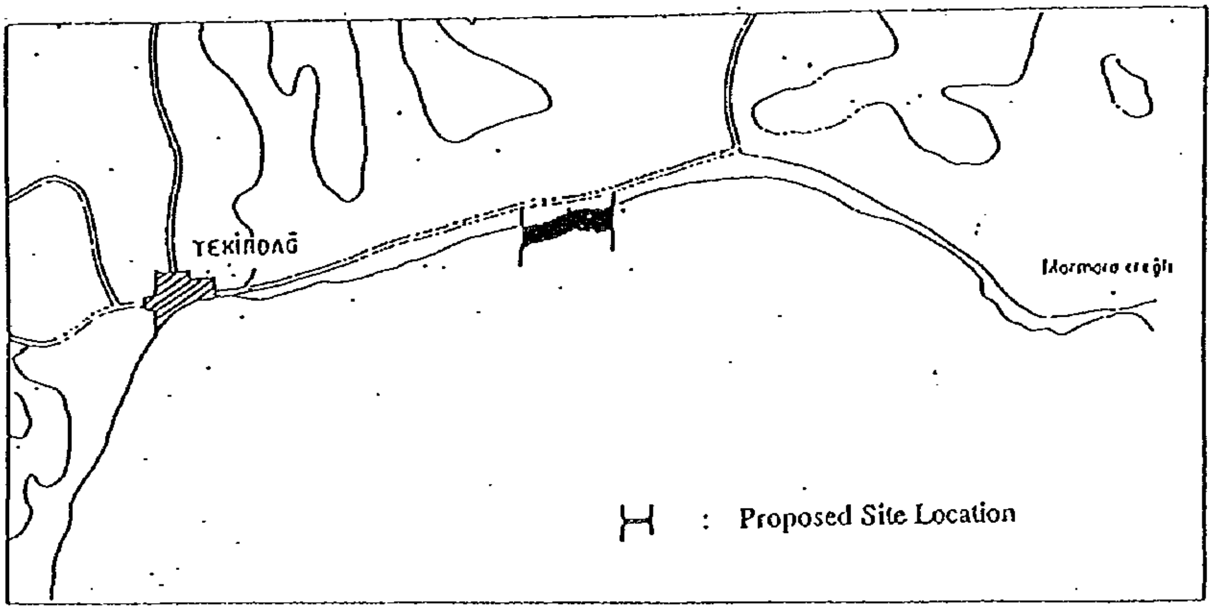


FIGURE 6.1.1 Proposed Site Location

6.1.2 Topographic Survey

The central survey control station has been established by installing Rec Elta 4 that is the topographic survey equipment with an accuracy of ±0.1 mm for distance measurement and ±1" for angle reading. For the site operation, the bench marks have been set up on the shore with a reference to the existing authorized bench marks established by the government. The survey has been carried out under the contract with the organization (SEMIH SOHTORIK MANAGEMENT & AGENCY INC., Department of Navigation Hydrography and Oceanography Turkish Navy).

The survey points observed by the field team has been transferred to the notebook computer via central survey control station and their data has been released into the chart drawing program prepared by the Turkish Navy. The maps have been produced in a scale of 1:1,000 and 1:10,000 have been produced.

The maps show al the existing surface feature of topography on the survey area (approximately 3 km^2) and also indicates the shoreline at a low water spring tide, with contour lines of 0.5 m intervals in a scale of 1:1,000.

There is no contour lines in the map of a scale of 1:10,000 for the general use as shown in Fig. 6.1.2 for the example. The survey area is almost flat and the higher zone (about 55 meter is located) at the northern part of the area. Some houses are dotted at the east and north-east part of the area, and marshy area and a transformer lie on the north-west part of the survey area.

The description of the survey are as shown in Fig. 6.1.2.

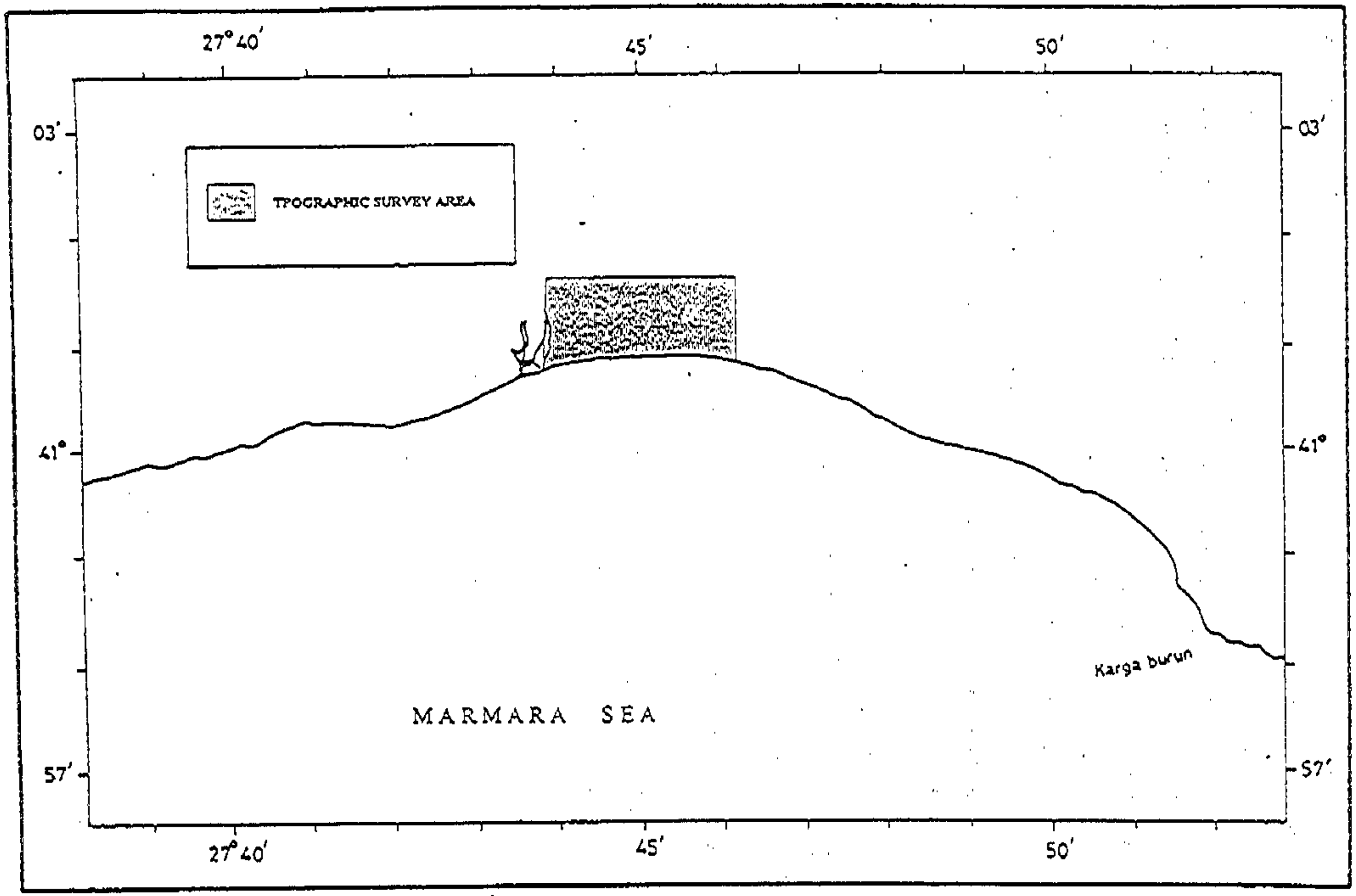


FIGURE 6.1.2 Topographic Survey Area

6.1.3 Bathymetric Survey

The main survey lines have been set perpendicular to the shoreline, and supplemented by the additional survey lines parallel to the shoreline for controlling purposes. Trisponder and transit have been used for the positioning. Elac Laz 721 echosounder have been used for the water depth measurements. The same survey equipment has been mounted on the small vessel for the shallow area where the survey boat TCG Mesaha 1 could not navigate due to her draft.

The shore stations for the positioning have been established at; P1, P2 and P3. The positions of these shore stations are given on a 1:2,000 scale maps with the coordinates shown as below.

Point Name	Latitude	Longitude	Height (m)	Ground Sign
P1	40º 00'52".15	27º 45'50".49	1.123	Iron pin
P2	41º 00'50".24	27º 44'36".25	0.556	Iron pin
P3	41º 00'53".24	27º 45'26".93	0.565	Iron pin

Each survey point has been positioned by reading through WildT2 transit, a distance as well as an angle from the shore stations. The equipment performance transit has been checked in advance of operation, and found to be within such an allowable tolerance as the accuracy in distance measurements remains within ±1 meter and the accuracy in angle readings within ±2".

Trisponder and transit have also been calibrated before the survey by measuring the distance between the two points where coordinates are already known precisely. The echosounder has also been calibrated and confirmed with a ±5 cm precision.

The average sounding velocity in the sea water has been measured from a SBE CTD system and applied to the echosounder. The possible water depth errors in measurement has remained within an acceptable tolerance allowed by International Hydrographic Office.

The results of water depth survey measurements have been mapped at vertical intervals of 1 meter and a scale of 1:2,000 and 1:10,000. The rocky areas which lie in the shallow waters have been pointed with the marks "+" on the map. The seabed at the site has a rather steep slope of 1/100, and the water depth contour line of -15 m lies about 1.5~2.0 km off the coast line, and-10 m contour lien about 0.8~1.5 km.

The description of the survey area is shown in Fig. 6.1.3.

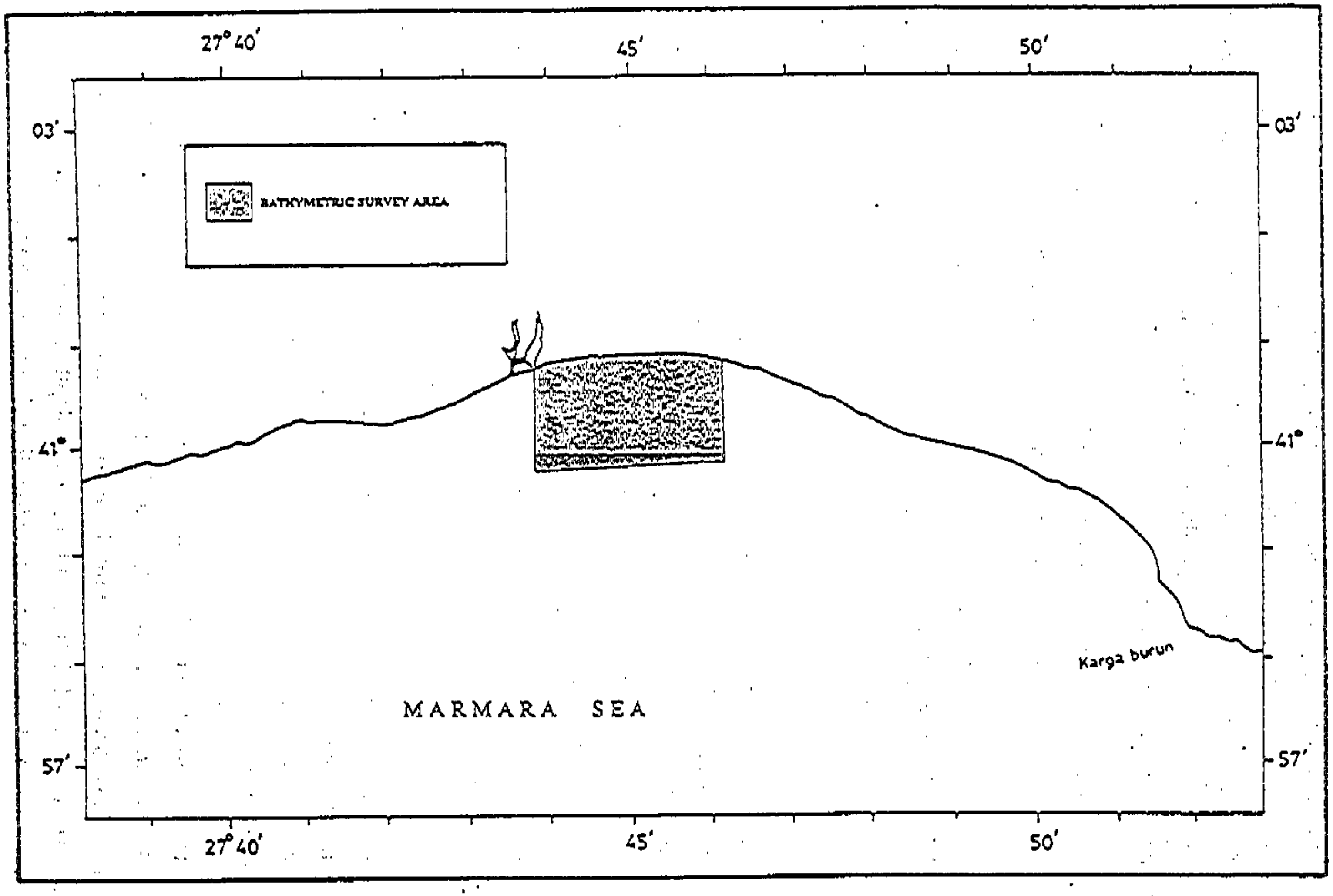


FIGURE 6.1.3 Bathymetric Survey Area

6.2 Winds

To analyze the wind characteristics at the proposed site, the wind data has been gathered from Tekirdag Meteorological Station, which is located approximately 20 km west of the port site and operated by the General Directorate of State Meteorological Works (GDSMW). In the wind analysis, two kinds of wind records have been utilized, one from the wind data compiledisdn19990by the Dutch Consultant, Delft Hydraulics, and another from the GDSMW's own data.

Delft Hydraulics gathered the wind data faster than 3 m/sec in speed from the hourly wind table of 10 years duration between 1975-9184, and the wind occurrence by directions are illustrated in the wind rose as shown in Fig. 6.2.1.

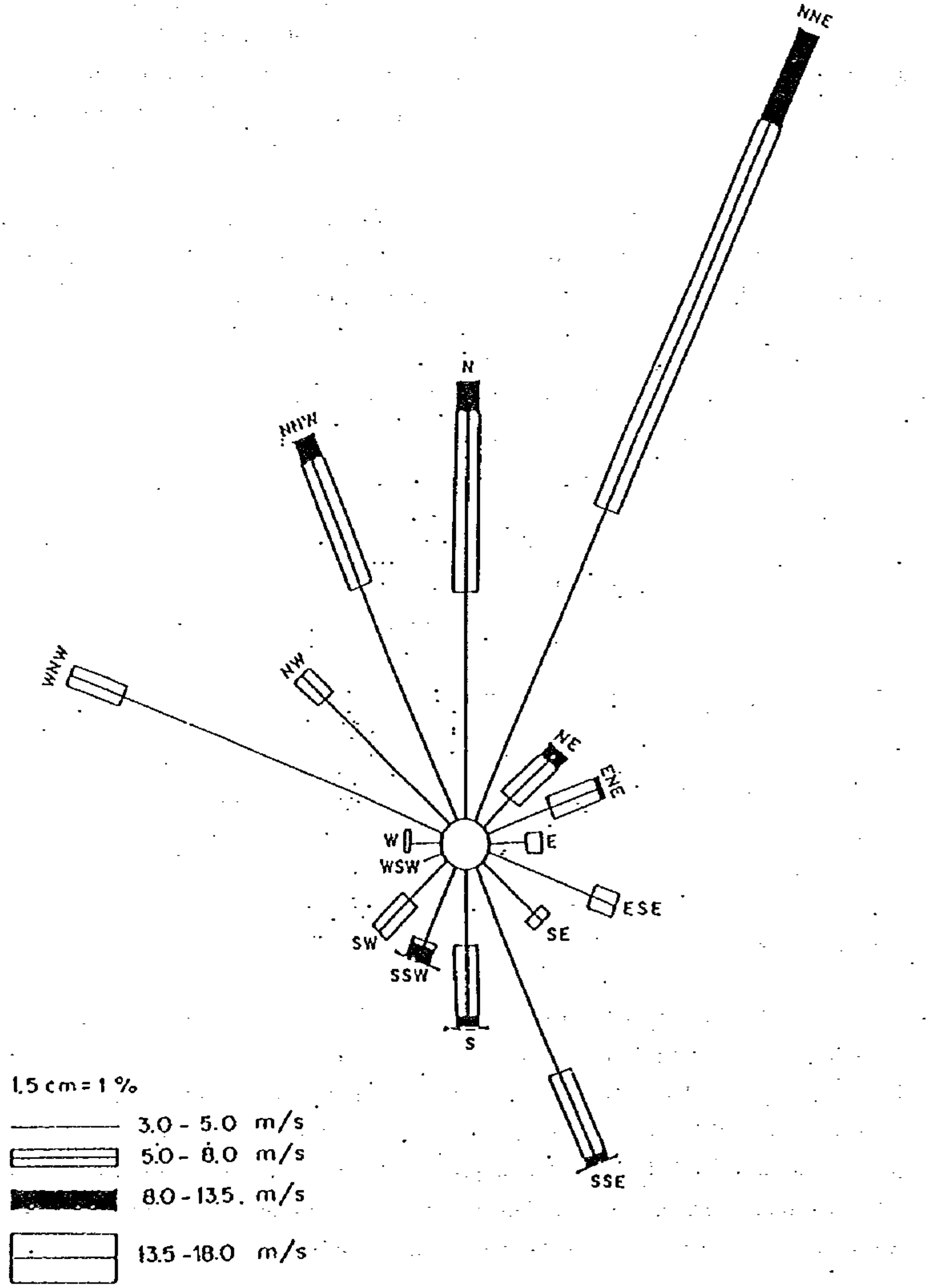
According to this wind rose, the most predominant wind direction is NNE, followed by N, NNW, WNW and SSE. In terms of extreme wind speed, NNE is also prevailing. The proposed port site is open to the sea in the direction of SW counter-clockwise to ESE, among which SSE is the most dominant direction, followed by S.

In the meantime, the GDSMW's own data accumulated from the year 1930 to 1970 (see Table 6.2.1) shows somewhat different wind patterns in the dominant direction as shown in Fig. 6.2.2, where NE is most prevailing, followed by NW and SE. This deviation seems to come from the fact that the GDSMW's wind rose was developed using all the wind data, including the wind records less than3 m/sec., while Delft Hydraulic's wind rose was developed by use of the winds faster than 3 m/sec.

The wind rose developed by Delft Hydraulics would be more.essential than that of GDSMW's in terms of wave hindcasting analysis and also insetting up the alignment of the navigation channel in port planning study. Nevertheless, in the study of environmental consideration such as air pollution analysis, GDSMW's historical data would be quite helpful.

The wind speeds with various return periods occurring from all the direction, according to the Delft Hydraulic's study, are summarized in Table 6.2.2. The highest hourly average wind speeds with a 50-year return period are seen to be 23.8 m/s form NE, 19.5 m/s from SSW, 18.0 m/s from S and 17.4 m/s from SSE. These past wind records indicates a mild wind climate at the proposed port site. The maximum wind speeds with a return period of 50 year in the wind directions that will influence the wind-generating waves was projected at 19.5 m/sec in SSW and 17.5 m/sec in SSE.

FIGURE 6.2.1 Wind Rose for Dominant Wave Direction

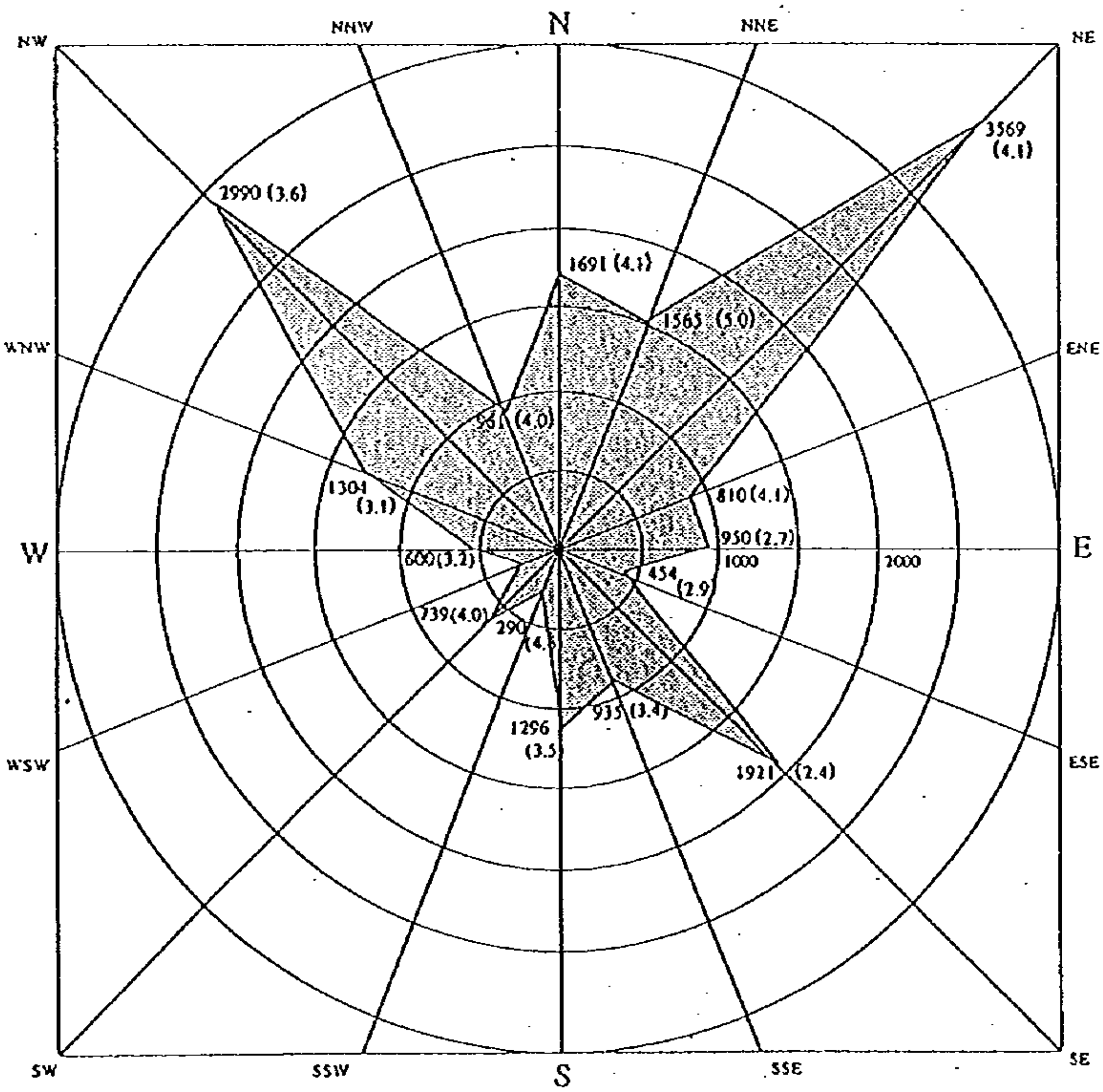


	Obs Period	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
N	22	5.9 - 183	5.2 - 143	4.3 - 140	3.0 - 88	3.2 - 66	2.8 - 137	3.5 - 147	3.4 - 147	3.5 189	4.3 - 183	4.4 - 120	4.8 - 148	4.1 - 1691
NNE	22	6.2 - 136	6.2 - 122	5.2 - 135	4.8 - 107	4.0 - 76	4.0 - 100	4.5 - 168	4.4 - 169	4.8 - 160	5.5 - 179	4.6 - 104	5.5 - 109	5.0 - 1565
NE	22	4.8 - 226	4.1 - 219	4.5 - 354	3.4 - 218	3.6 - 247	3.9 - 228	1.6 - 419	4.1 - 459	3.9 - 398	4.5 - 366	3.7 - 244	4.3 - 191	4.1 - 3569
ENE	22	4.6 - 70	3.4 - 58	3.7 - 94	3.7 - 75	3.0 - 58	4.3 - 77	4.0 - 62	4.5 - 88	5.1 - 54	4.5 - 57	4.0 - 57	4.2 - 60	4.1 - 810
E	22	3.0 - 69	2.9 - 67	2.4 - 82	2.2 - 107	2.4 - 118	2.5 - 65	2.7 - 87	3.1 - 74	3.2 - 53	3.1 - 67	2.7 - 84	2.8 - 77	2.7 - 950
ESE	22	3.5 - 43	2.6 - 32	3.3 - 42	2.6 - 49	2.4 - 53	2.7 - 44	3.3 - 30	3.6 - 42	2.6 - 24	2.8 - 24	2.5 - 38	2.4 - 33	2.9 - 454
SE	22	2.6 - 105	2.4 - 115	2.4 - 168	2.4 - 212	2.2 - 287	2.4 - 198	2.5 - 165	2.6 - 158	2.6 - 136	2.3 - 138	2.4 - 127	2.6 - 112	2.4 - 1921
SSE	22	4.1 - 43	4.1 - 56	3.6 - 51	3.3 - 77	2.7 - 87	3.0 - 109	3.1 - 105	3.2 - 116	3.2 - 94	3.3 - 64	4.1 - 86	2.7 - 47	3.4 - 915
S	22	4.3 - 104	3.8 - 92	3.4 - 73	2.9 - 102	3.2 - 110	3.2 - 127	3.0 - 144	3.4 - 113	2.9 - 109	3.3 - 88	3.9 - 103	4.6 - 131	3.5 - 1296
SSW	22	3.5 - 28	4.9 - 39	4.2 - 21	5.5 - 31	3.3 - 16	4.8 - 20	2.6 - 9	3.9 - 5	4.0 - 10	4.0 - 15	5.4 - 41	4.7 - 55	4.6 - 290
SW	22	4.1 - 77	4.3 - 112	5.6 - 71	4.8 - 56	4.5 - 55	3.4 - 34	4.1 - 13	2.4 - 21	3.0 - 31	3.0 - 57	3.5 - 87	3.4 - 125	4.0 - 739
WSW	22	4.3 - 28	4.3 - 24	4.1 - 33	5.1 - 45	4.1 - 34	3.1 - 19	2.2 - 14	2.7 - 10	2.8 - 10	3.8 - 17	3.3 - 24	3.3 - 25	3.9 - 283
W	22	3.0 - 63	3.5 - 67	4.0 - 50	36 - 75	3.0 - 46	2.6 - 51	2.6 - 25	2.4 - 23	2.7 - 26	2.6 - 45	3.8 - 62	3.1 - 67	3.2 - 600
WNW	22	3.4 - 138	.8 - 110	2.7 - 94	3.2 - 90	2.7 - 83	2.8 - 94	2.8 - 82	2.7 - 88	2.9 - 104	3.1 - 122	3.0 - 156	3.4 - 143	3.1 - 1304
NW	22	4.3 - 334	4.1 - 250	4.0 - 231	3.4 - 171	2.8 - 177	3.4 - 259	3.3 - 202	3.0 - 226	3.4 - 236	3.3 - 278	3.2 - 295	4.1 - 331	3.6 - 2990
NNW	22	4.7 - 111	4.2 - 55	4.5 - 89	3.4 - 58	3.4 - 50	3.0 - 53	4.0 - 101	3.5 - 87	3.4 - 112	4.0 - 74	4.2 - 75	4.8 - 96	4.0 - 961

TABLE 6.2.1 GDSMW's Wind Data

FIGURE 6.2.2 Wind Rose for Dominant Wave Direction

TEKIRDAG



Note : Average wind velocity and total occurence number.

1691 → Total occurece number

(4.1) → Average wind velocity (m/sec)

TABLE 6.2.2 Wind Speeds in m/s for Various Return Periods

Wind Directions	Return Periods (Years)				
	1	5	10	25	50
N	11.7	13.8	14.7	15.9	16.8
NNE	12.0	13.8	14.6	15.7	16.5
NE	14.4	18.3	19.9	22.1	23.8
ENE	10.2	12.6	13.6	14.9	15.9
E	7.2	8.8	9.5	10.4	11.1
ESE	9.0	10.9	11.8	12.9	13.8
SE	8.8	10.9	11.9	13.1	14.1
SSE	11.5	13.9	15.0	16.3	17.4
S	11.7	14.3	15.4	16.9	18.0
SSW	11.9	15.0	16.4	18.2	19.5
SW	8.7	10.6	11.4	12.4	13.2
WSW	6.2	7.9	8.7	9.6	10.4
W	6.1	7.5	8.1	8.9	9.4
WNW	9.1	10.7	11.4	12.3	13.0
NW	9.2	11.0	11.8	12.9	13.7
NNW	11.6	13.8	14.7	15.9	16.9

6.3 Waves

6.3.1 Wave Data Collected

There has been no wave measurement in and around the port site. In order to determine the wave climate affecting the port development area, wind-generated waves were hindcast by Delft Hydraulics, Middle East Technical University and General Directorate of Meteorology. Hereinafter described are the briefs from these 3 reports.

For hindcasting wind-generated waves, the fetch lengths of the site for the directions of SW, SSW, S, SSE, SE have been computed and shown in Fig. 6.3.1 to 6.3.6.

(1) Wave analysis by Delft Hydraulics

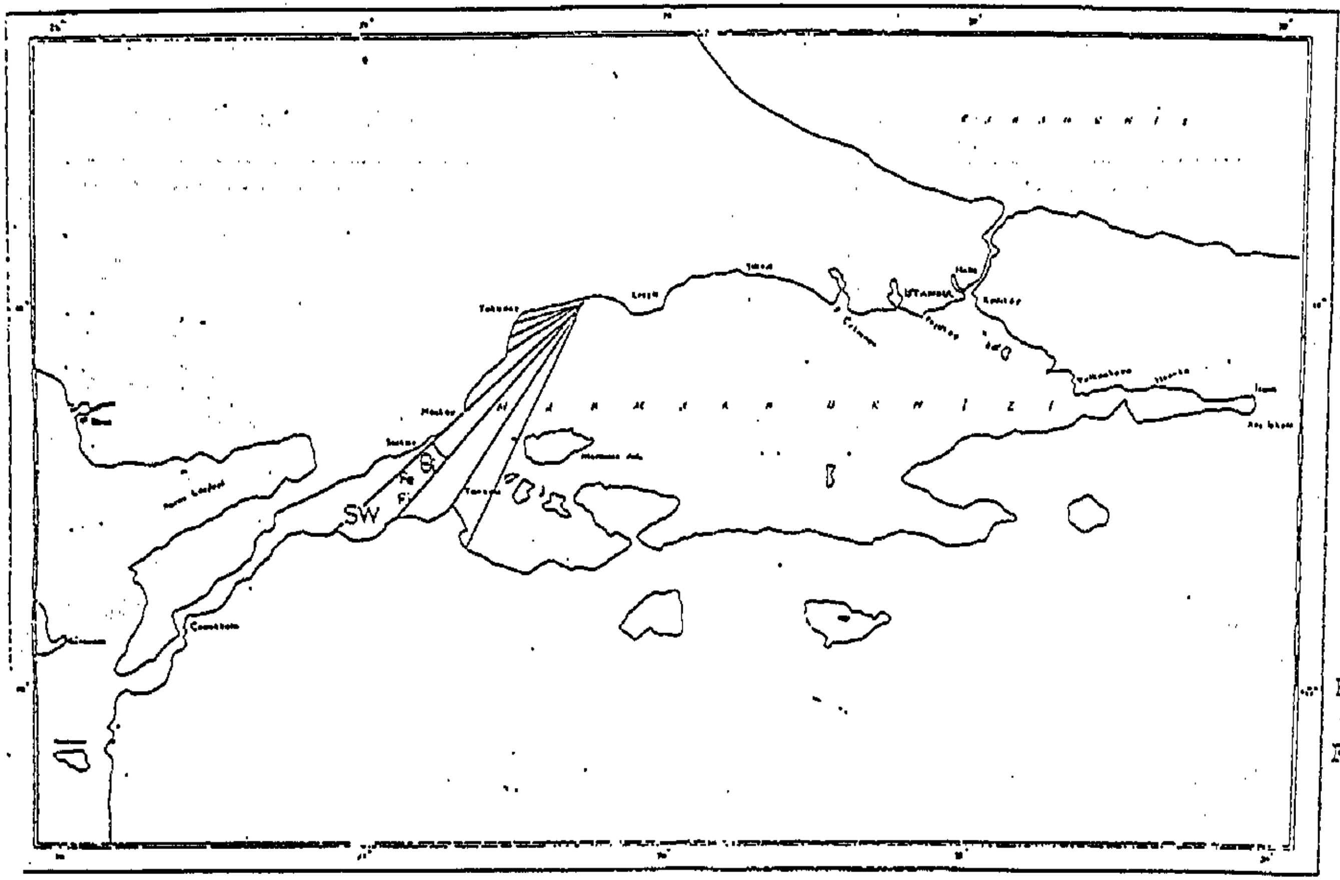
The wave analysis was made to identify the design wave characteristics at LNG Terminal that was planned in the vicinity of Marmara Ereglisi, which is as close as 13 km east of the proposed port site. The wave hindcasting were undertaken by use of the Pierson - Moskowitz spectrum method.

The seabed profiles at the proposed port site, particularly in the shallow water zone, differ from those in Marmara Ereglisi, though, it is understood that the offshore wave climate on both sites would be quite similar. As such, the offshore wave data at the proposed site have been taken from the past study by Delft Hydraulics.

In this process the difference in natural geography of both sites have been taken in to account. The LNG Terminal was planned to the east of the local cape that will provide the natural shelter against the offshore waves from the west quadrant, while the proposed site will be located entirely open to the sea from the direction of SW counterclockwise to ESE.

In addition, the effective fetch lengths for the wave hindcasting of LNG Terminal in Marmara Ereglisi and for that or the proposed site are quite similar except for *SSW* and SW directions as shown in Table 6.3.1.

As shown in Table 6.3.1, the effective fetch lengths that will generate the offshore waves at the proposed site would be similar to those in LNG Terminal planned at Marmara Ereglisi, which means that Delft Hydraulic's hindcast offshore waves could be considered adequate to develop the wave expected at the proposed site.



YÖN :SW
DİRECTİON :SW

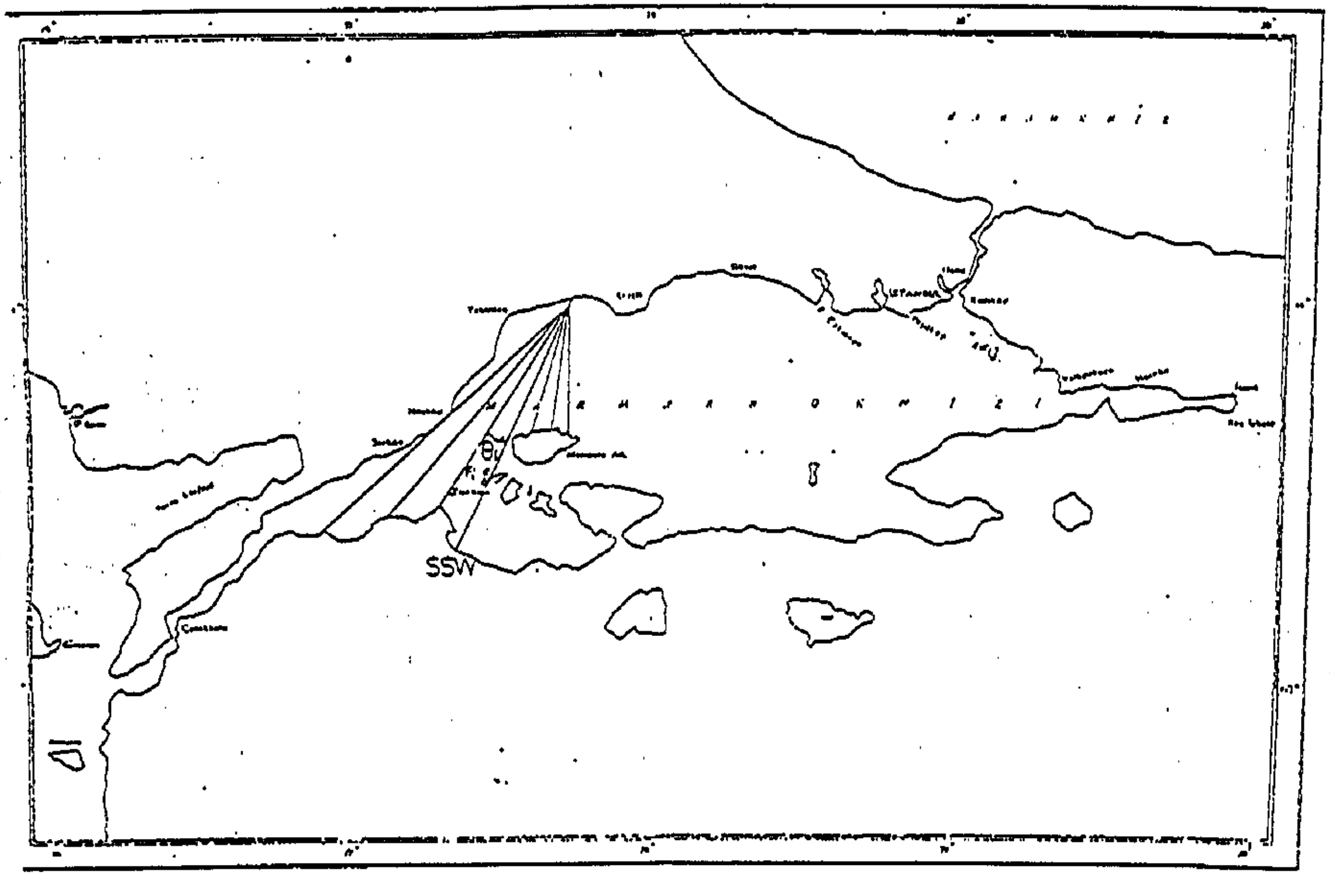
θ_i	F_i(Km)	$F_i \cos\theta_i$
-22.5	20.0	18.478
-15.0	25.0	24.148
-7.5	30.5	30.239
0	90.0	90.000
7.5	76.5	75.845
15.0	71.0	68.581
22.5	77.5	71.601
		Σ 380.892

$$Fe = \frac{F_i \cos\theta_i}{\cos\theta_i} = \frac{380.89}{6.7622}$$

Fe = 56.028 Km.

Şekil 1: SW yönündeki etkin kabarma uzunluğunun hesaplanması

FIGURE 6.3.1 Computations of Effective Fetch Length in SW Direction



YÖN : SSW
DİRECTİON : SSW

θ_i	F_i(Km)	$F_i \cos\theta_i$
-22.5	90.0	83.149
-15.0	76.5	73.893
-7.5	71.0	70.392
0	77.5	77.500
7.5	41.5	41.145
15.0	39.0	37.671
22.5	53.5	49.428
		Σ 433.178

$$F_e = \frac{F_i \cos\theta_i}{\cos\theta_i} = \frac{433.18}{6.7622}$$

F_e = 64.056 Km.

Şekil 2: SSW yönündeki etkin kabarma uzunluğunun hesaplanması

FIGURE 6.3.2 Computations of Effective Fetch Length in SSW Direction

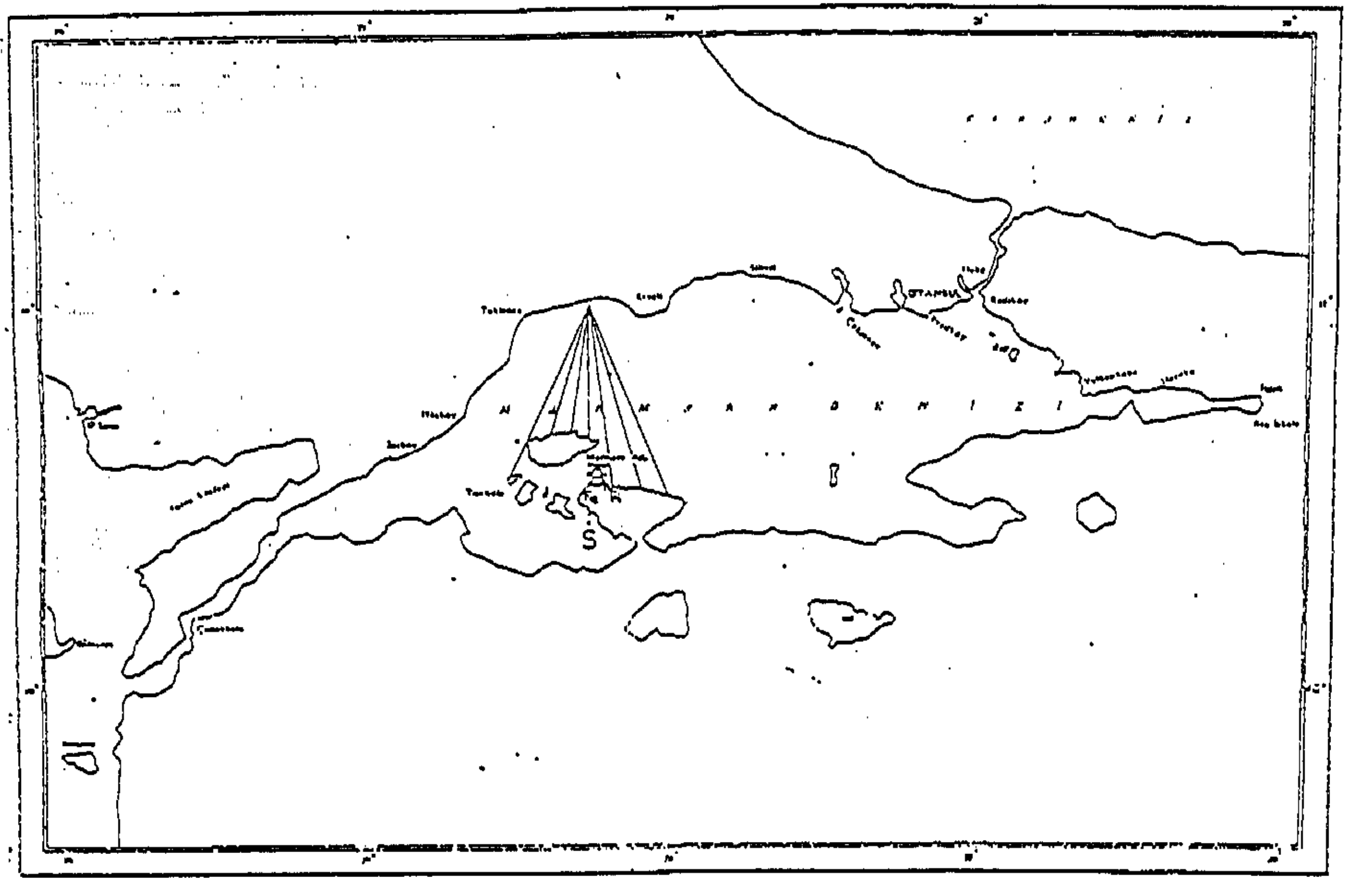
YÖN :S

DIRECTION :S

θ_i	F_i(Km)	$F_i \cos\theta_i$
-22.5	77.5	71.600
-15.0	41.0	39.603
-7.5	40.0	39.658
0	53.5	53.500
7.5	55.0	54.529
15.0	56.0	54.092
22.5	65.0	60.052
		Σ 373.034

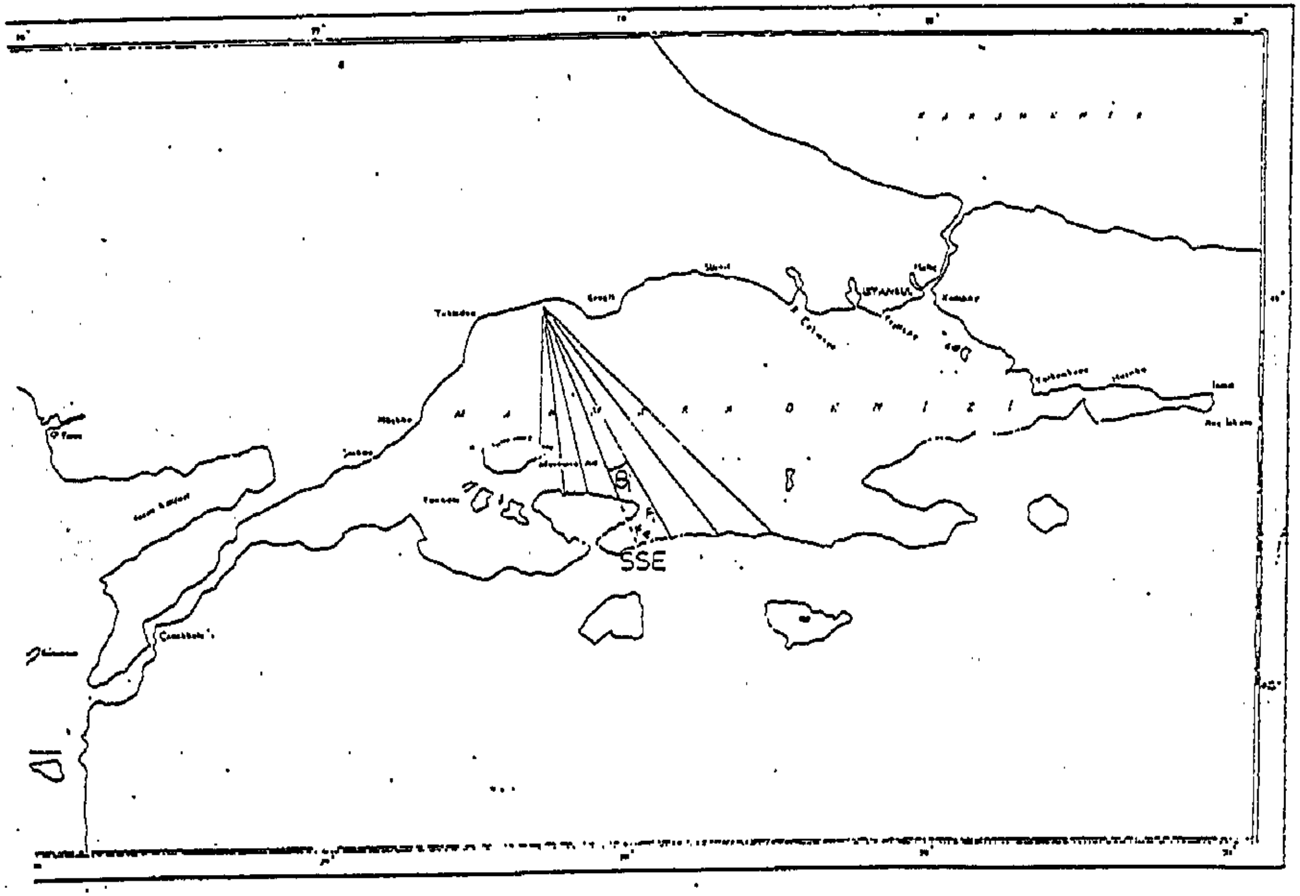
$$Fe=\frac{F_i \cos\theta_i}{\cos\theta_i}=\frac{373.034}{6.7622}$$

Fe=55.162 Km.



Şekil 3: S yönündeki etkin kabarma uzunluğunun hesaplanması

FIGURE 6.3.3 Computations of Effective Fetch Length in S Direction



YÖN : SSE
DİRECTİON : SSE

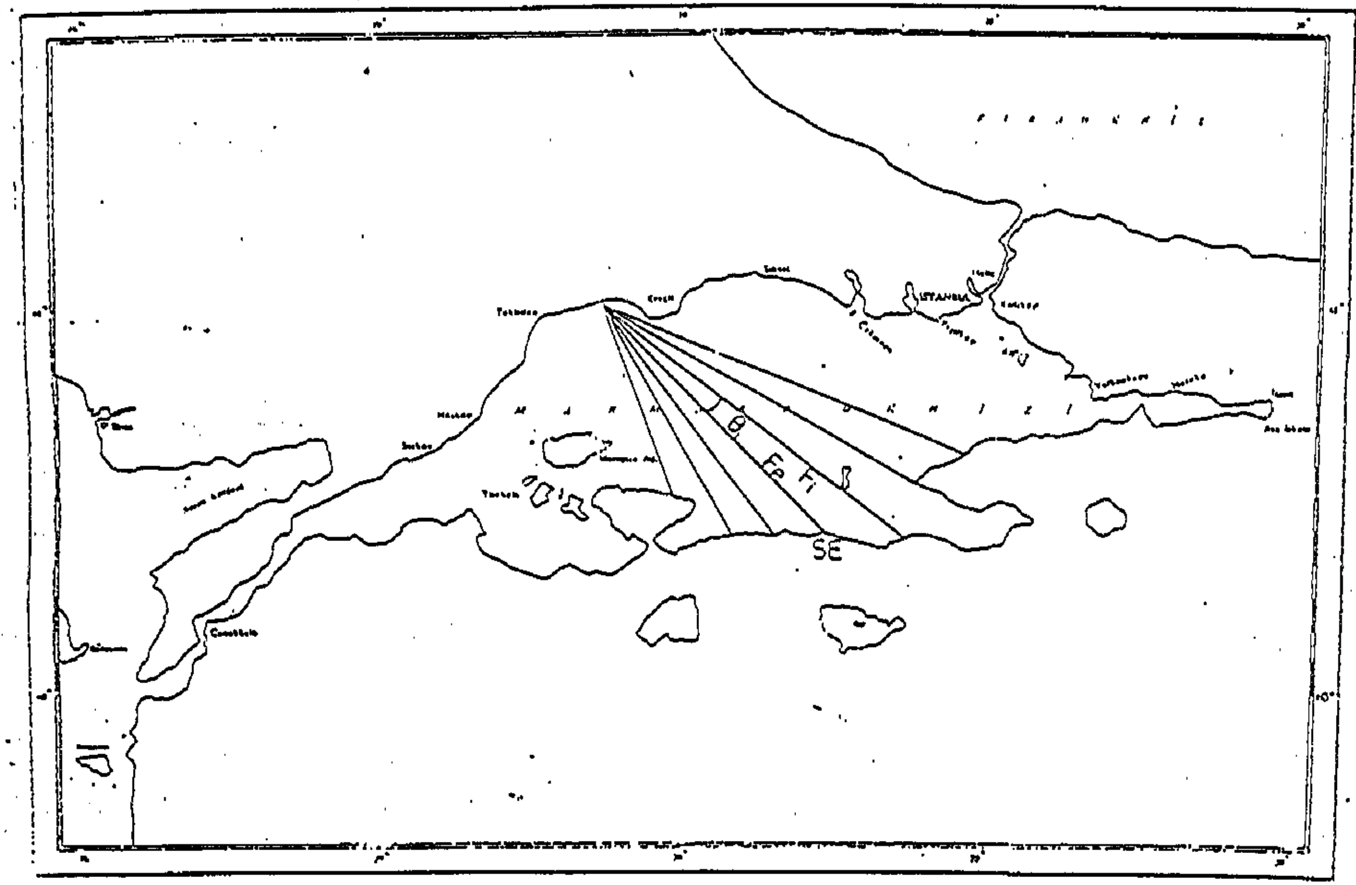
θ_i	F_i(Km)	$F_i Cos\theta_i$
-22.5	53.5	49.427
-15.0	55.0	53.126
-7.5	60.0	59.487
0	77.5	77.500
7.5	80.0	79.315
15.0	87.5	84.518
22.5	102.5	94.698
		$\sum$ 498.071

$$Fe = \frac{F_i Cos\theta_i}{Cos\theta_i} = \frac{498.07}{6.7622}$$

Fe = 73.652 Km.

Şekil ç: SSE yönündeki etkin kabarma uzunluğunun hesaplanması

FIGURE 6.3.4 Computations of Effective Fetch Length in SSE Direction



YÖN : SE
DİRECTİON : SE

θ_i	F_i(Km)	$F_i Cos\theta$
-22.5	63.5	58.666
-15.0	77.5	74.859
-7.5	80.0	79.316
0	87.5	87.500
7.5	102.5	101.623
15.0	112.5	108.667
22.5	103.0	95.160
		$\sum$ 605.791

$$Fe = \frac{F_i Cos\theta_i}{Cos\theta_i} = \frac{605.7}{6.7622}$$

Fe = 90.172 Km.

Şekil 5: SE yönündeki etkin kabarma uzunluğunun hesaplanması

FIGURE 6.3.5 Computations of Effective Fetch Length in SE Direction

θi	Fi_{SW}	$Fi_{SW}\cos\theta i$	Fi_{SSW}	$Fi_{SSW}\cos\theta i$	Fi_{S}	$Fi_{S}\cos\theta i$	Fi_{SSE}	$Fi_{SSE}\cos\theta i$	Fi_{SE}	$Fi_{SE}\cos\theta i$
-22.5	20.0	18.478	90.0	83.149	77.5	71.600	53.5	49.427	63.5	58.666
-15.0	25.0	24.148	76.5	73.893	41.0	39.603	55.0	53.126	77.5	74.859
- 7.5	30.5	30.239	71.0	70.392	40.0	39.658	60.0	59.487	80.0	79.316
0.0	90.0	90.000	77.5	77.500	53.5	53.500	77.5	77.500	87.5	87.500
- 7.5	76.5	75.845	41.5	41.145	55.0	54.529	80.0	79.315	102.5	101.623
-15.0	71.0	68.581	39.0	37.671	56.0	54.092	87.5	84.518	112.5	108.667
-22.5	77.5	71.601	53.5	49.428	65.0	60.052	102.5	94.698	103.0	95.160
	Σ	380.892	Σ	433.178	Σ	373.034	Σ	498.071	Σ	605.791

Using $Fe = \frac{\sum Fi \cos\theta i}{\sum \cos\theta i}$, for $\sum \cos\theta i = 6.7825$

Fe(SW) = 56.028 km , Fe(SSW) = 64.056 km , Fe(S) = 55.162 km , Fe(SSE) = 73.652 km , Fe(SE) = 90.172 km

FIGURE 6.3.6 Computations of Effective Fetch Length in SW-SSW-S-SSE-SE Direction

TABLE 6.3.1 Comparison of Effective Fetch Lengths Marmara Ereglisi and the Site

(km)

Location \ Direction	Wave direction										
	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W
LNG Terminal Marmara Ereglisi	11.0	23.6	63.3	90.1	85.2	73.5	55.8	47.0	65.7	64.6	25.2
Proposed Site (ref.)	-	-	-	-	90.2	73.7	55.2	64.1	56.0	-	-

The number of occurrences of various wave heights by direction and wave periods off the proposed site could be summarized as shown in Table 6.3.6 to 6.3.11. The wave occurrence more than 2.54 m is very rare except for SSE direction, in which the maximum wave height of 3.3 m was hindcast two times. Generally, the wave periods are short, ranging mostly from 2 to 4 seconds.

(2) Wave analysis by Middle East Technical University

Marmara Ereglisi were included in the study points for Wave Hindcasting and Determination of Design Wave Characteristics for 15 Coastal Regions by the Ministry of Public Works and Settlement, Railways, General Directorate of Ports and Airports Construction in 1984.

The wave hindcast were mainly undertaken by use of Pierson-Moskocitz-Kitalgorodski (PMK) spectrum method and summarized as shown in Table 6.3.2and 6.3.3. The results of the wave analysis were further processed into the significant wave heights and periods for 10, 25, 50 and 100 years are turn periods as shown in Table 6.3.4.

In the process of determination of usual direction of the annual highest waves, results of meteorological observatory and synoptic map were combined together.

For Marmara Ereglisi, generally, the annual highest waves occur in the direction of SW. According to meteorological observations as shown in Table 6.3.2 S to SSE direction should also be considered as a secondary direction.

TABLE 6.3.2 Annual greatest definite wave heights of deep sea and Gumbel Probabilities

Meteorological Observatory between 1969 and 1984

Sequence of wave height	Year	$H_{1/3}$ (m)	$P(H_{1/3})$ (%)	Direction
1	1978	1.65	5.88	SSW
2	1983	1.71	11.76	S
3	1984	2.74	17.65	SSE
4	1977	1.82	23.53	SSE
5	1982	1.86	29.41	SW
6	1972	1.92	35.29	SSE
7	1981	1.93	41.18	S
8	1975	1.98	47.06	SSE
9	1980	2.24	52.94	SE
10	1979	2.26	58.82	SSW
11	1970	2.22	64.71	S
12	1971	2.34	70.59	S
13	1973	2.50	76.47	SSW
14	1974	2.52	82.35	SSE
15	1969	2.59	88.24	S
16	1976	3.08	94.12	SSE

TABLE 6.3.3 Annual greatest definite wave heights of deep sea and Gumbel Probabilities

Synoptic Map between 1969 and 1984

Sequence of wave height	Year	$H_{1/3}$ (m)	$P(H_{1/3})$ (%)	Direction
1	1978	1.68	10	E
2	1982	1.80	20	SW
3	1984	2.36	30	SW
4	1983	2.41	40	SW
5	1977	2.54	50	SW
6	1981	2.55	60	S
7	1979	2.66	70	SW
8	1980	2.90	80	SW
9	1976	3.22	90	SW

TABLE 6.3.4 Significant Wave Heights and Periods for Several Return Periods

Return Period (year)	10	25	50	100
Meteorological Observatory				
H 1/3 m.	2.78 ± 0.06	3.13 ± 0.09	3.38 ± 0.11	3.64 ± 0.13
T 1/3 s.	5.99	6.36	6.61	6.86
Synoptic Map				
H 1/3 m.	3.29 ± 0.21	3.73 ± 0.30	4.6 ± 0.37	4.39 ± 0.44
T 1?3 s.	6.52	6.94	7.24	7.53

(3) Wave analysis by General Directorate of Meteorology

The GDM report were prepared for Deployment Harbour (for NATO) as a WINDWAVESAT THE COASTS OFTEKIRDAG by General Directorate of Meteorology of the Republic of Turkey in 1988. The ten years hourly mean wind data (1978 to 1987) at Tekirdag Meteorological Observatory were used to identify the wind forces and directions. The fetch length for the directions of SSW is approximately 80 km and effective fetch length is 64.054 km.

The report considered four (4) methods for predict significant wave heights and periods. These methods are Pierson - Moskowitz (PM), Sverdrup - Munk - Bretschnider(SMB), Wilson and the diagram given in the WMO (World Meteorological Organization) Pat. No.446.

The applied data were the wind velocity of 15 m/sec., duration of 6 hours and the direction of SSW which was taken from the data in February 13 of 1979. The fetch lengths of 64 km and 80 km, the significant wave height and periods were predicted in Table 6.3.5.

TABLE 6.3.5 Significant Wave Heights and Periods by 4 Methods

Applied Methods / Fetch Length	PM	SMB	WILLSON	DIAGRAM
F=64 km				
Hs m.	2.24	2.18	2.19	2.70
Ts sec.	5.3	5.8	5.4	5.6
F=80 km				
Hs m.	2.51	2.38	2.38	3.00
Ts sec.	5.7	6.1	5.7	5.9

In addition, the storm surge was also described in the report as a sum of approximately 0.107 m, which is of low magnitude, so that this particular natural phenomenon has not been considered in our port planning.

6.3.2 Design Wave Heights

The proposed port site is located 19 km West of Marmara Ereglisi which is discussed in 6.3.3.1 for LNG Terminal studied by Delft Hydraulics, and 6.3.1.2 for the Wave Hindcasting and Determination of Design Wave Characteristics covering 15 Coastal Regions.

The effective fetch lengths for the proposed port site is almost similar to those for Marmara Ereglisi as shown in Table 6.3.6, and repeated below.

	Marmara Ereglisi	Proposed Port Site
SSE	73.5 km	73.7 km
S	55.8 km	55.2 km
SSW	47.0 km	64.1 km
SW	65.7 km	56.0 km

For Marmara Ereglisi, generally, the annual highest waves occur in the direction of SSE. However, according to meteorological observations as shown in Table 3.3.7 that S to SW direction should also be considered as a secondary direction in accordance with 6.3.1.2 the report of Middle East Technical University.

The exceeding probability values computed by use of the significant wave heights hindcast for the 10 years period between 1975-1984 have been also tabulated in Table 6.3.13 where the highest waves of 3.71 m occur form SSE direction with a return period of 50 years.

In addition to the exceeding probability by wave direction, the extreme waved heights distribution irrelevant to the wave directions was projected by use of Fisher-Tippett type I (Gumbel) methods. As a result, the wave heights in any direction was hindcast with a return period from 5 to 10 years as shown in Table 6.3.10.

The maximum significant wave heights is any direction with a return period of 50 years was projected at 4.17 m as shown in Table 6.3.13.

The results of synoptic map have been considered in determination of usual direction of the annual highest waves. The analysis are described in 6.3.1.2 and the result are shown in Table 6.3.3 where the Significant Wave Heights of 4.6 m ±0.37 with return period of 50 years.

TABLE 6.3.6 Wave Direction and Period

$H_{1/3}$	WAVE DIRECTION: ESE $T_{1/3}$ [s]								
[m]	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4
0.3	8	32	238	155	-	-	-	-	-
0.6	-	2	16	460	628	59	-	-	-
0.9	-	-	2	22	145	458	-	-	-
1.2	-	-	1	2	13	30	79	-	-
1.5	-	-	-	-	-	6	20	16	-
1.8	-	-	-	-	-	-	-	22	-
2.1	-	-	-	-	-	-	-	-	4
2.4	-	-	-	-	-	-	-	-	1

TABLE 6.3.7 Wave Direction and Period

$H_{1/3}$	WAVE DIRECTION: SE $T_{1/3}$ [s]								
[m]	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4
0.3	9	10	149	64	-	-	-	-	-
0.6	-	1	19	386	567	7	-	-	-
0.9	-	-	2	-	101	390	-	-	-
1.2	-	-	1	1	1	22	47	-	-
1.5	-	-	-	-	-	-	11	2	-
1.8	-	-	-	-	-	-	-	8	-
2.1	-	-	-	-	-	-	-	-	1
2.4	-	-	-	-	-	-	-	-	1

TABLE 6.3.8 Wave Direction and Period

$H_{1/3}$	WAVE DIRECTION: SSE $T_{1/3}$ [s]									
[m]	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0
0.3	23	39	688	279	-	-	-	-	-	
0.6	-	4	57	1289	1498	-	-	-	-	
0.9	-	2	7	107	389	1062	-	-	-	
1.2	-	-	4	2	46	186	366	-	-	
1.5	-	-	-	1	2	1	146	44	-	
1.8	-	-	-	-	-	-	5	48	-	-
2.1	-	-	-	-	-	-	-	3	10	-
2.4	-	-	-	-	-	-	-	-	5	-
2.7	-	-	-	-	-	-	-	-	-	7
3.0	-	-	-	-	-	-	-	-	-	-
3.3	-	-	-	-	-	-	-	-	-	2

TABLE 6.3.9 Wave Direction and Period

$H_{1/3}$ [m]	WAVE DIRECTION: S $T_{1/3}$ [s]								
	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4
0.3	6	14	135	70	-	-	-	-	-
0.6	-	2	132	326	584	-	-	-	-
0.9	-	3	4	53	236	605	-	-	-
1.2	-	1	2	-	29	187	283	-	-
1.5	-	-	-	-	3	-	160	14	-
1.8	-	-	-	-	-	-	-	51	-
2.1	-	-	-	-	-	-	-	4	7
2.4	-	-	-	-	-	-	-	-	1

TABLE 6.3.10 Wave Direction and Period

$H_{1/3}$ [m]	WAVE DIRECTION: SSW $T_{1/3}$ [s]								
	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4
0.3	22	14	135	61	-	-	-	-	-
0.6	-	4	64	211	457	-	-	-	-
0.9	-	1	2	20	173	462	-	-	-
1.2	-	-	-	-	1	211	155	-	-
1.5	-	-	-	-	-	3	103	9	-
1.8	-	-	-	-	-	-	-	23	-
2.1	-	-	-	-	-	-	-	2	5
2.4	-	-	-	-	-	-	-	-	2

TABLE 6.3.11 Number of occurrences of various wave heights and period classes(deep water)

$H_{1/3}$ [m]	WAVE DIRECTION: S $T_{1/3}$ [s]								
	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4
0.3	15	111	104	61	-	-	-	-	-
0.6	-	-	4	153	222	-	-	-	-
0.9	-	-	-	-	100	276	-	-	-
1.2	-	-	-	-	-	68	126	-	-
1.5	-	-	-	-	-	-	73	16	-
1.8	-	-	-	-	-	-	-	8	-
2.1	-	-	-	-	-	-	-	1	1

TABLE 6.3.12 Significant wave height in meters for various return periods(deep water)

DIRECTION	RETURN PERIOD [YEAR] 1	5	10	25	50
SSE	2.45	2.97	3.19	3.49	3.71
SSW	1.92	2.32	2.49	2.72	2.89
SW	1.67	2.02	2.18	2.38	2.53
ESE	1.77	2.15	2.32	2.53	2.76
SE	1.63	2.00	2.16	2.38	2.54
S	1.92	2.27	2.42	2.62	2.77

TABLE 6.3.13 Deep water significant wave heights of various return periods for Marmara Ereglisi

Return Period (RP) [year]	5	10	25	50
H 1/3 [m]	2.70	3.05	3.84	4.17

6.3.3 Wave Height Distribution

The characteristics of extreme waves stated in the previous section would be essential to design the marine structure, while in port planning, particularly in the study of the alignment of breakwaters and the navigation channel, typical wave height distribution all through the year would be more important. To this end, the wave height distribution by directions at the proposed port site has been analyzed and summarized as shown in Table 6.3.14, where the most of the wave heights has derived from the accumulation of wave occurrences summarized in Table 6-3.6~ 6.3.11.

In the process of above analysis, the offshore waves fro S to SSW have been slightly modified taking into account the sheltering effect of the island named "MARMARA ADASI" that is located approximately 39 km of South. This island will partly protect the proposed port area particularly against the waves from SSE to SSW.

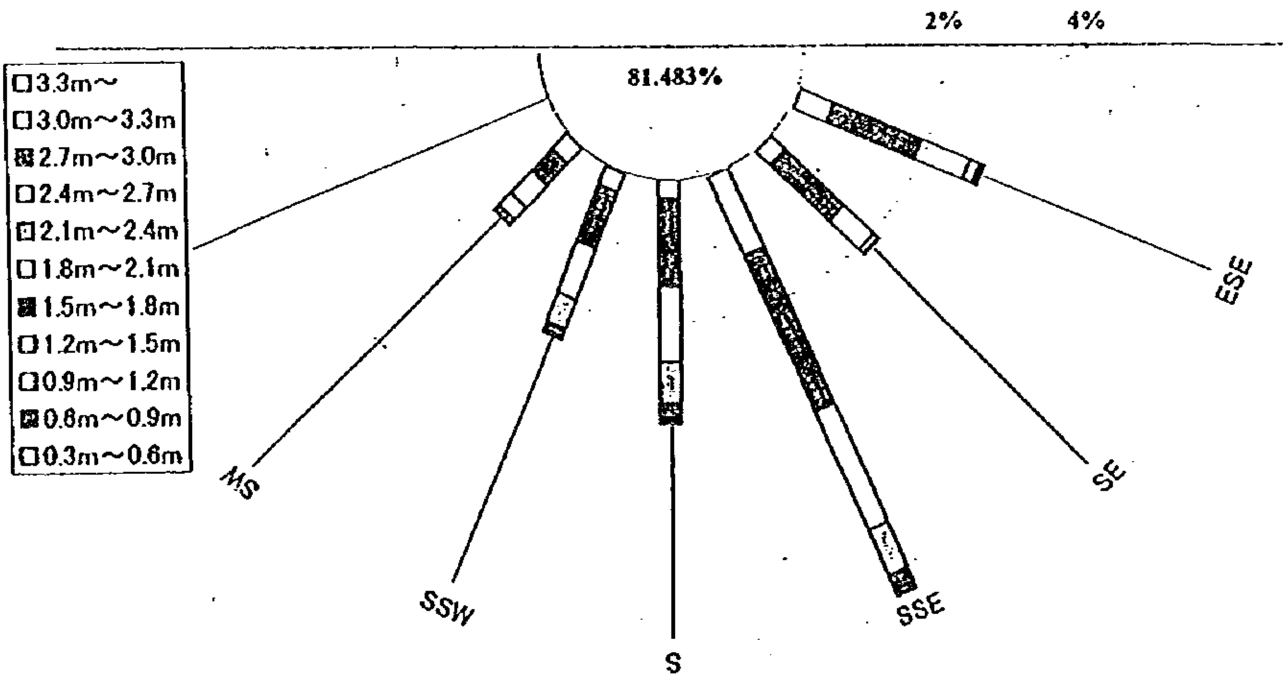
As described before, the effective fetch lengths for Marmara Ereglisi and for the proposed port site are almost similar, so that the part analysis on the wave height distribution can be adopted to the proposed port site.

The wave height corresponding to the exceedance probability value of 95% is estimated at 1.1m, and that of 99% is 1.5m.

TABLE 6.3.14 Wave Height Distribution by Direction at the Site

Wave Height Class	SW	SSW	S	SSE	SE	ESE	Total	(%)
0m~0.3m	70825 81.483						70825	81.483
0.3m~0.6m	252 0.290	232 0.267	225 0.259	1029 1.184	232 0.267	433 0.498	2403	2.765
0.6m~0.9m	379 0.436	736 0.847	1044 1.201	2048 2.356	980 1.127	1165 1.340	6352	7.308
0.9m~1.2m	376 0.433	658 0.757	901 1.037	1569 1.805	493 0.567	627 0.721	4624	5.320
1.2m~1.5m	194 0.223	367 0.422	502 0.578	604 0.695	72 0.083	125 0.144	1864	2.145
1.5m~1.8m	89 0.102	115 0.132	177 0.204	194 0.223	13 0.015	42 0.048	630	0.725
1.8m~2.1m	8 0.009	23 0.026	51 0.059	53 0.061	8 0.009	22 0.025	165	0.190
2.1m~2.4m	2 0.002	7 0.008	11 0.013	13 0.015	1 0.001	4 0.005	38	0.044
2.4m~2.7m		2 0.002	1 0.001	5 0.006	1 0.001	1 0.001	10	0.012
2.7m~3.0m				7 0.008			7	0.008
3.0m~3.3m				0 0.000			0	0.000
3.3m~				2 0.002			2	0.002
Ratio of direcion	1.496	2.461	3.350	6.355	2.071	2.783		

Note:Tentative estimation, Upper figure are frequency, lower are %.



6.4 Currents

The current measurements have been performed at such spots as shown in Figure 6-4.1 during the period between February 1st and March 6th of 1997. The currents have been measured at the water depth of 2.5 m and 5.0 m in two locations for a period of 33 days. The current records have been taken every 30 minutes. The fresh data have been processed into current direction vs. time and current progressive vector plots as presented in Figure 6-4.2 to Figure 6-4.9.

When the current meter data are plotted, it has been noticed that similar changes in current velocity and direction have occurred almost at the same times at the two current measurement stations.

This facts due to the proximity of the two stations, which are located very close and similar in the water depth levels with lower current meters being installed only 2.5 m deeper than the upper current meters.

The current velocities and directions have been quite variable at both current stations and for both depths. While the prevailing current directions are 250 to 300 and 050 to 130, much stronger current have been measured between direction of 250 and 300. The maximum current velocities and directions at current meter station 1 (CM1) at 2.5 m depth level is 41.4 cm/s toward 275 at 5 m depth level is 39.25 cm/s toward 279, at current meter station 2 (CM2) at 2.5m depth level is 55.04 cm/s toward 269 and finally at 5 m depth level is 49.61 cm/s toward 268 (Fig. 6-4.2 to 6-4.9).

Generally, it can be said that the prevailing directions are between West - Northwest and Northeast - East - Southeast. The current velocities are relatively higher in these direction limits.

The sea surface currents in the sea of Marmara are parallel to the shore with a mean velocity of 45 cm/s, minimum velocity of 21 cm/s and maximum velocity of 69 cm/s shown in Fig. 6-4.10.

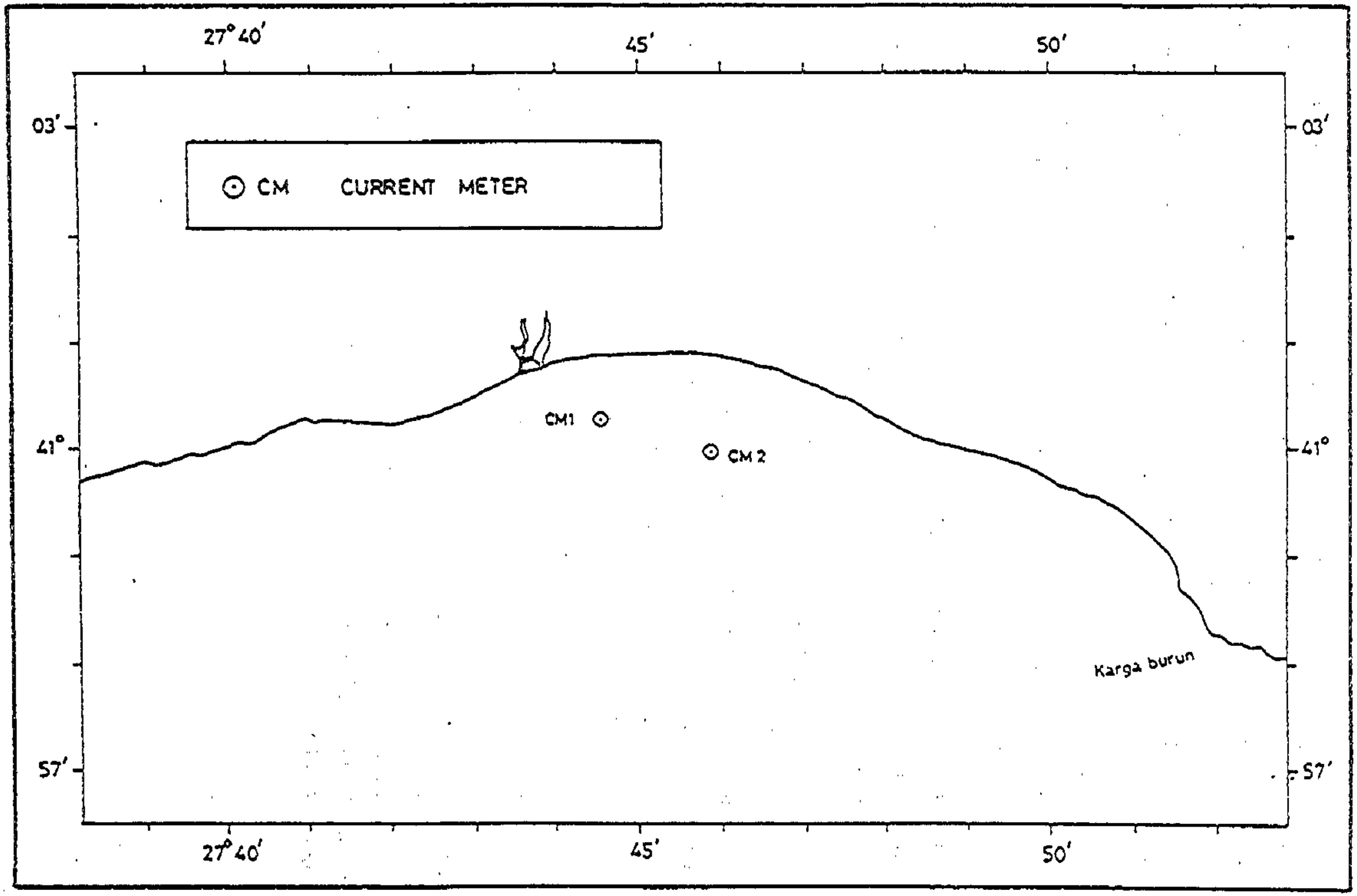


FIGURE 6.4.1 Location Map of Current Meter Stations

STATION NO	LATITUDE	LONGITUDE	STATION DEPTH	MEASUREMENT DEPTH	STARTING		ENDING		FILE NAME
					DATE	HOUR	DATE	HOUR	
CM1	41°00'18"N	027°44'36"E	10 m.	2.5 m.	01.02.1997	18:00	06.03.1997	12:00	CM1.25E
CM1	41°00'18"N	027°44'36"E	10 m.	5.0 m.	01.02.1997	18:00	05.03.1997	20:00	CM1.50E
CM2	40°59'59"N	027°45'51"E	10 m.	2.5 m.	01.02.1997	14:00	06.03.1997	14.30	CM2.25E
CM2	40°59'59"N	027°45'51"E	10 m.	5.0 m.	01.02.1997	14:00	06.03.1997	14.30	CM2.50E

TABLE 6.4.1 Information of the Current Meter Stations

6.5 Tidal Level

6.5.1 Tidal Level Measurement

The tidal levels have been measured at the location shown in Figure 6-5.1. The coordinates of the tidal level measurement site is 41 00'33"N and 027 45'39"E. The tidal level measurement was performed by Aandreaa water level recorder "Model 5" (WLR 5) which has been installed on the sea bed at a water depth of 2.5 m. The recording interval for tidal level measurements has been set at 10 minutes.

6.5.2 Sea-Level Variations for Northern Marmara Sea (Marmara Ereglisi - Tekirdag)

Since the Sea of Marmara is located in between the straits of Istanbul and Canakkale and the Sea of Marmara is continued geographically a water passage system linking between the Black Sea and the Aegean Sea govern the Sea of Marmara. The region of the Sea of Marmara is affected by two distinct seasonal climatic regimes. During the winter, the weather is dominated by an almost continuous passage of climatic regimes. During the winter, the weather is dominated by an almost continuous passage of climatic regimes. During the summer, NE winds, widely known as Meltem, are dominant. When not blowing from the NE, winds are mostly from SW. In general, onshore winds tend to rise, and offshore winds to lower the sea level. The range of sea level movements depends largely upon local conditions, being much more marked in bays and inlets than in more open places, and occasionally as high as 30 cm. Cyclones coming from Aegean Sea to the Black Sea in the winter season changes the meteorological structures of the Sea of Marmara. In a monthly patter, the dominant wind direction is NE-NW except for January when SW winds are more frequent.

6.5.3 Data Acquisition and Processing

The sea level data has been corrected by means of WLR5 tide gauge which was installed between Marmara Ereglisi and Tekirdag. Spectral analysis have been made for 10 minute sea level records. To calculate the power spectral densities, consecutive 50% overlapping segments from each data have been taken when the sea level time series was long enough. Trend and menu have been removed from each segment. Hamming window has been applied to each segment to have an optimum power spectral density. The tapered segments have been then subjected to Fast Fourier Transform (FFT) so as to calculate the power spectra.

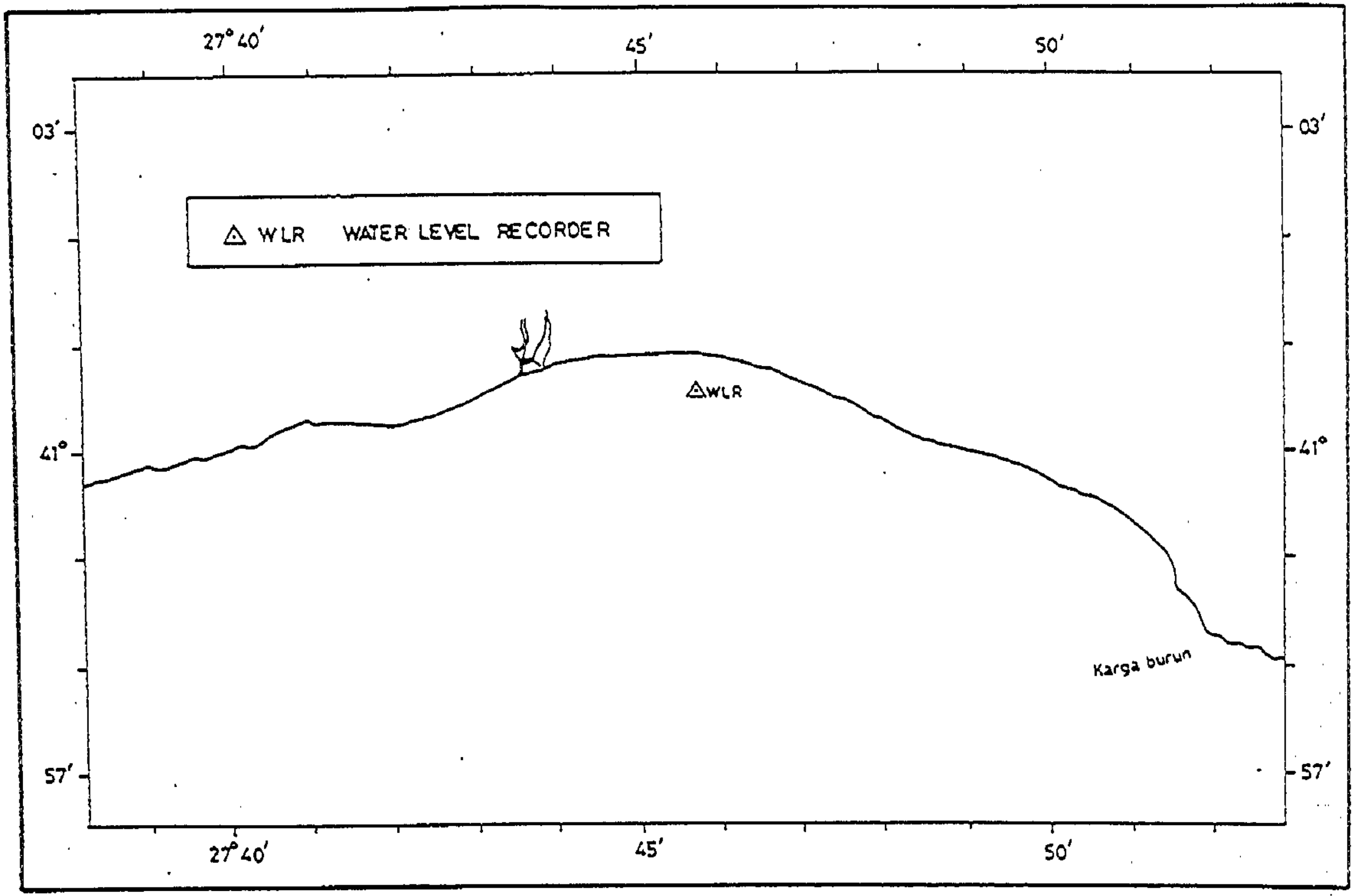


FIGURE 6.5.1 Location Map of Water Level Recorder Station

6.5.4 Results and Discussions

The 10 minute sea level record which has been obtained from the tidal gauge station between January 30 and March 4 of 1997 demonstrates that the proposed area is located at port low tidal amplitudes zone. The tidal data show small tidal range and non-tidal fluctuations superimposed on the long-period oscillations as shown in Figure 6.5.2. The data, in addition, show mixed fluctuations with a minor diurnal inequality. The long-period oscillations in the records may be due to the existence of long-period tidal constituents and the meteorological influences which can be identified by examining the variations in the Mean Sea Level.

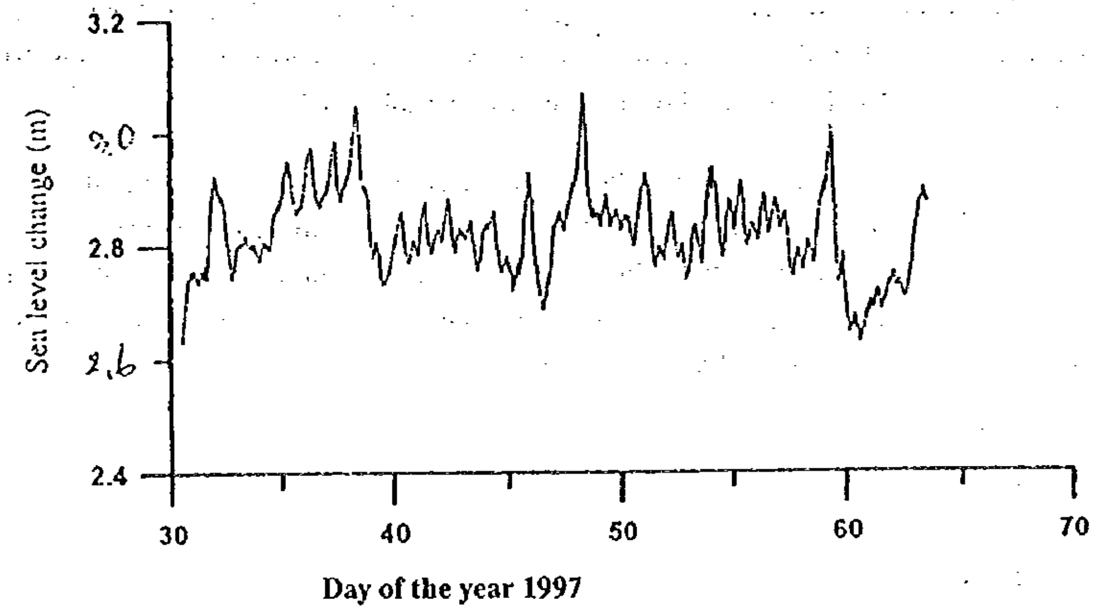


FIGURE 6.5.2 Record of the sea level observed at the site for the period of January 30 to March 4, 1997

Short-term comparative records of the sea level fluctuations for the tide-recording stations at Fenerbahce also demonstrate the existence of similar long period tidal characteristics experienced in the proposed port site.

A numerical analysis of the energy distribution shows the contributions in different frequency bands as shown in Table 6.5.1 and expressed as percentages of the total energy in the hourly records. These ratios confirm quantitatively, that low frequency energy inputs (<0.8 cpd) for the site are more important than at Fenerbahce.

TABLE 6.5.1 Energy distribution percentages in the sea level records over different frequency bands

Frequency band	Fenerbahce	Proposed site
Low	74	79
Diurnal	17	16
Semi diurnal	5	3
Others	4	2
Total	100.0	100.0

(1) Short Period Oscillations

The power spectra analysis on the high frequency band of the sea level records at the port site indicates that short-period oscillations exist with a period of 6 hors for 10 minute records. The detailed sea level data are shown in Table 6.5.2.

There are also some small amplitude periodicity around 3.1 hours (not plotted on Fig. 6.5.3). The oscillation period of a closed rectangular basin and g is the gravitational acceleration (9.81 ms^2). Applying the values of 240 km and 200 m in the Sea of Marmara for the variables L and h respectively, the natural period of oscillation has been estimated at 3.01 hours I which corresponds well to the spectral calculations.

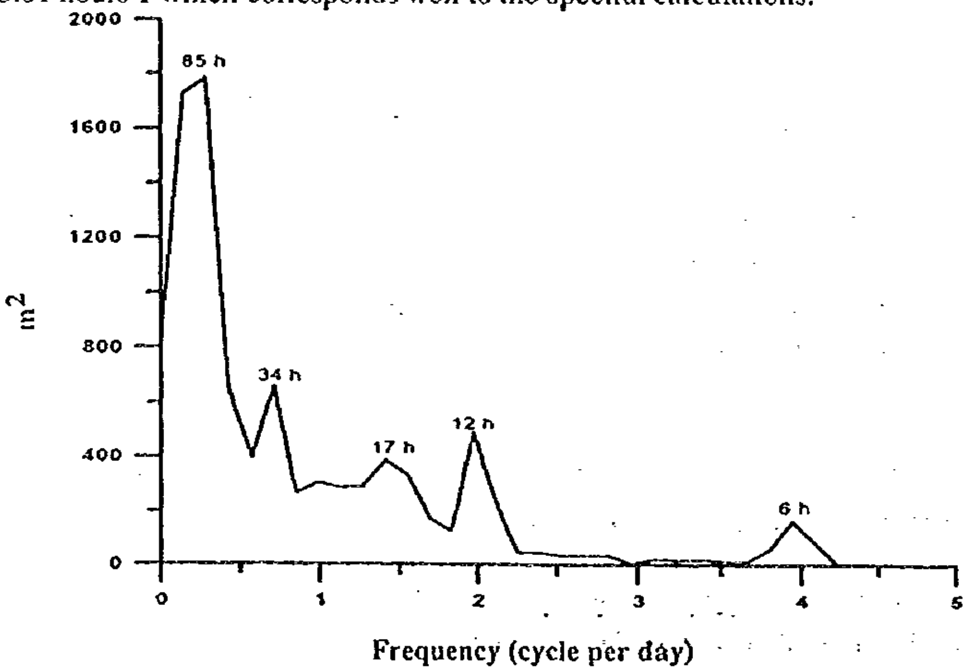


FIGURE 6.5.3 Power Spectra at the Site of 10 Minutes

Figure 6.5.3 shows Power spectra at the site of 10 minute sea level data for the observation period. The 95% confidence factor, for 6 d.o.f., is (Bmin = 0.415, Bmax = 4.849) on 4740 points. Spectrum normalization factor is 1785 for sea level data.

Tides:

The amplitude and phases of the M2, S2, K1 and O1(semi-diurnal lunar, semi-diurnal solar, soli-lunar diurnal and main lunar diurnal), all of them principal tidal components, can develop form number. $F = (K_1 + O_1)/(M_2 + S_2)$, mean spring ranges $2(M_2 + S_2)$('Defant, 1961 as shown in Table 6.5.2.

TABLE 6.5.2 Tidal harmonic constituents for the stations Fenerbahce and the Proposed site

Station name	M_2 amplitude phase	S_2 amplitude phase	K_1 amplitude phase	O_1 amplitude phase	Mean Spring Range	Neap Spring Range	Form Number
Fenerbahce	0.84	0.51	0.96	0.74	3.4	0.4	1.259
Proposed site	0.90	1.51	2.73	1.13	4.8	1.2	1.602

As shown above, tidal amplitudes are small, and the Form number calculated shows that tides are mixed and mainly diurnal in the area.

(2) Long-period(sub tidal) Variations

Even though some interactions are involved in a low-frequency-band for the Sea of Marmara, there are no long-period variations on the observed data. Only 85 hours peak can be observed on the power spectra as shown in Figure 6.5.3.

Actually, dominant sea level fluctuations in the Sea of Marmara occur at the time scale of greater than 6.5 days, and coherently over the whole width of the basin.

6.6 Shoreline

The shoreline runs East to West, facing the Sea of Marmara with slightly bowing shore ward. The shore mostly consist of fine to medium sand.

The actual shape of the shoreline is drawn up in Fig. 6.6.1. On the basis of topographic survey which has been carried out during survey period in February 1997.

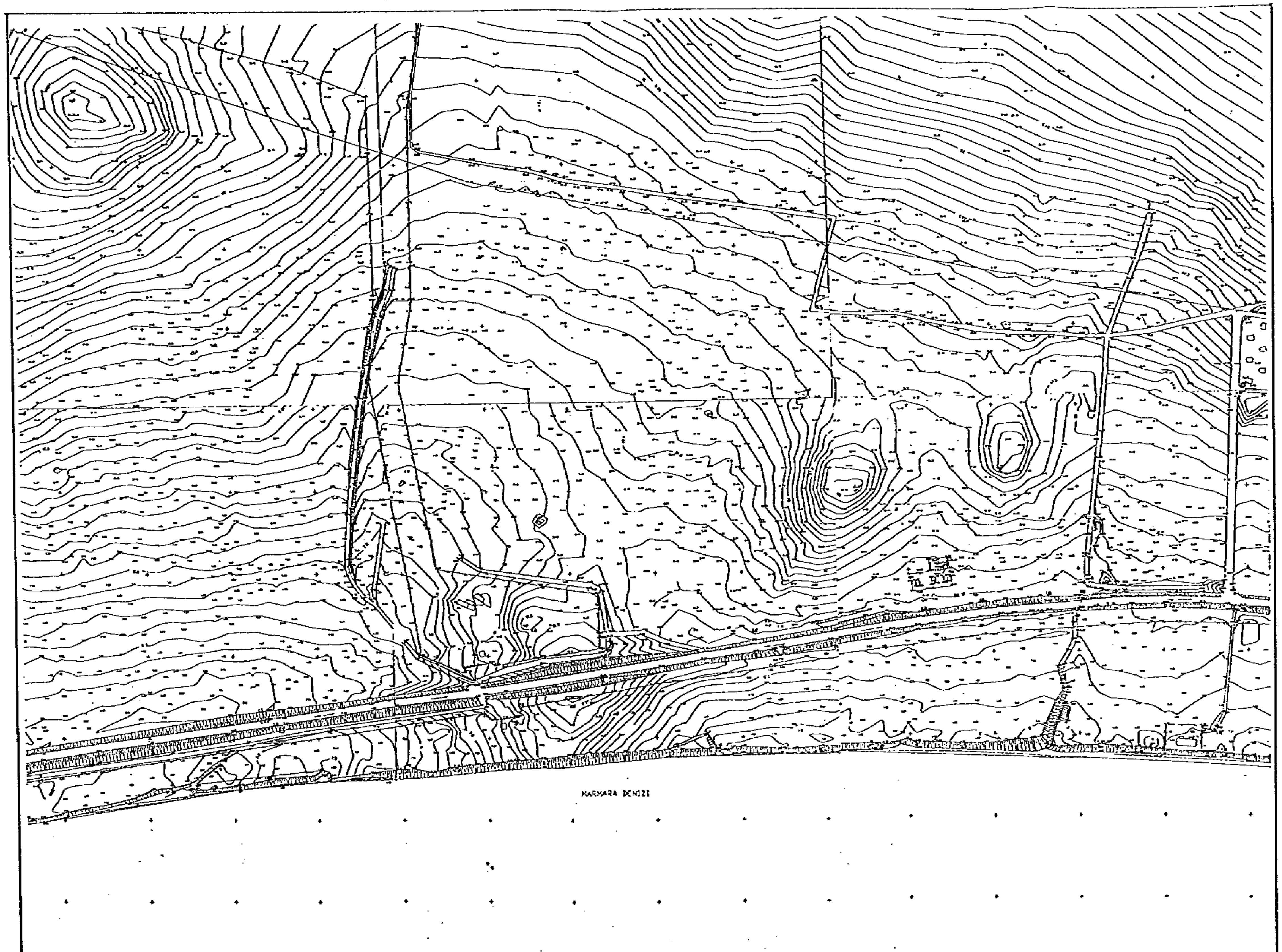


FIGURE 6.6.1 Shoreline of sea of the proposed site Scale : 1 : 5,000

6.7 Soil Conditions

Over the proposed port area, intensive soil investigation has been conducted under the contract with Istanbul based GEOS Geotecnic ve Sondajc Ltd., in February 1997. The geological location map are shown in Fig. 6.7.1. and the bore hole location plan are shown in Fig. 6.7.2.

6.7.1 Topography

The seabed has a slight inclination towards the sea. The water depth of the seabed varies with the distance from shore. The water depth of the seabed is 11.0 m at the location of bore-hole DS1 and 16.3 m at the location of bore-hole DS3. The onshore borings have also been executed, all of them located within 1.0 m difference in elevation.

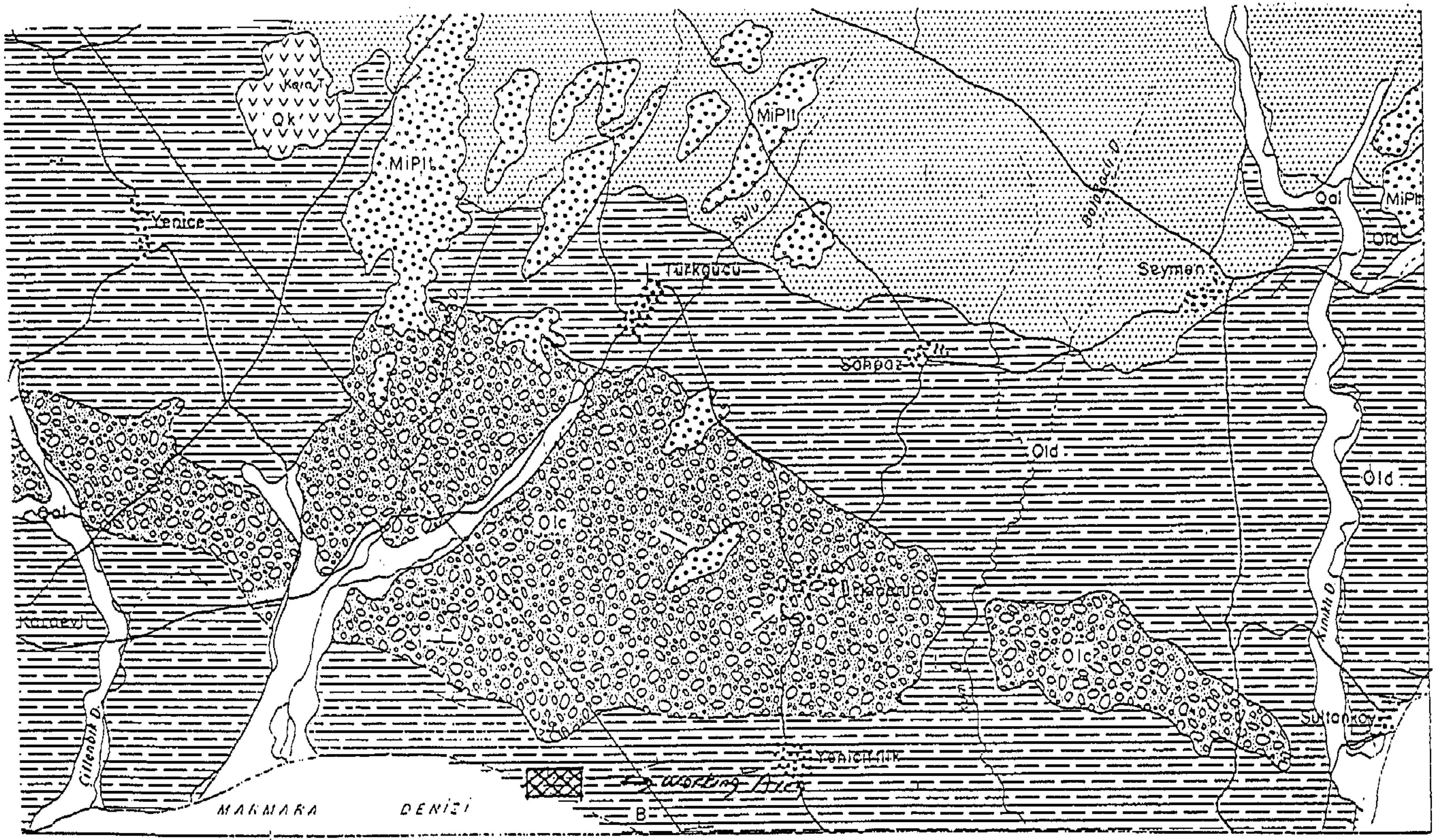
6.7.2 General Geology

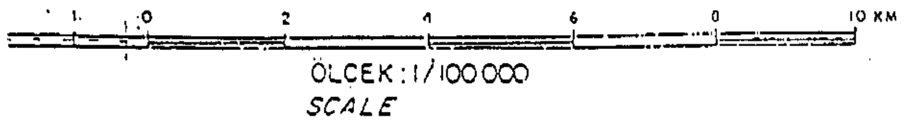
The sub soil formation is mainly composed of yellow, brown, and gray colored layer mixed with medium - thickly bedded sandstone, silt stone and claystone alternations. The soil contains rich lignite and locally tuff inter beds. Cross bedding and ripple marks have been observed in the formation. The presence of lignite deposition in the formation indicates the existence of swamp faces, based on which the soil properties can be classified as delta sediments.

6.7.3 Borings

Bore holes have been drilled in order to define the subsurface profile of the proposed port site. The boreholes consists of 3 offshore borings and 3 onshore borings, accompanied by physical and mechanical laboratory tests.

The number, depth and location of the bore holes are described herein after.





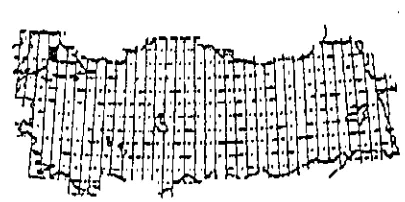


FIGURE 6.7.1 Geological Location Map

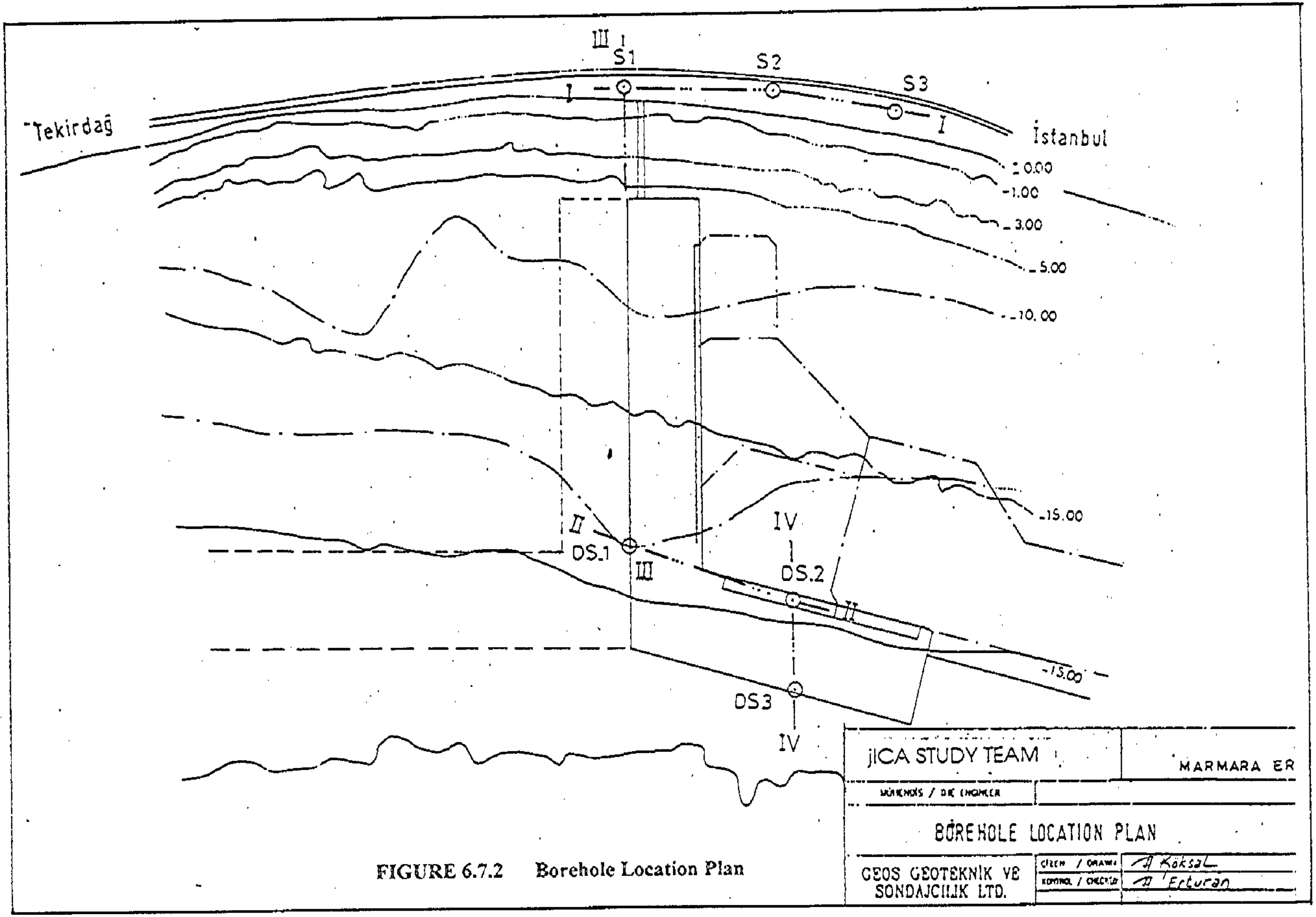


FIGURE 6.7.2 Borehole Location Plan

6.7.4 Standard Penetration Test (SPT)

SPT test has been conducted in each bore hole with a view to assessing the consistency of soil layers. The blow counts for each 15 cm penetration in 3 drives has been recorded. The first 15 cm is named as seating drive and neglected. The summation of last two 15 cm drive has been designated as "N" resistance value.

6.7.5 Groundwater Observation

The groundwater level have been measured in the boring, executed onshore. The static record of groundwater levels are shown in Table 6.7.1.

TABLE 6.7.1 Static Groundwater Level

Bore Hole No.	GWL (m)
S1	5.10
S2	4.20
S3	4.00

6.7.6 Laboratory Testing

The samples taken from the borings have been re-evaluated and classified in such terms ;

Grain Size Distribution, Water Content, Atterberg Limits. Laboratory Vane Tests, Unconfined Compressive Strength tests on selected soil, and core samples has been taken. The tests have been performed in accordance with ASTM standards.

6.7.7 Onshore Borings for Subsurface Profiling

Three onshore borings have been executed at the site. Different soil characteristics have been observed at the investigation area. These soil characteristics are described as follows.

Top Soil;

The upper strata encountered in the bore holes S1, S2 and S3 are 30 cm to 50 cm thick top soil.

Stiff-Very Stiff, brown-green gravely CLAY;

The thickness of this soil formation, which was observed in all bore holes, varies between 1.3 m to 2.80 m. The penetration resistance recorded in SPT could be summarized as below.

N = 18 - 27

Water Content	W=15.2 - 27.2%
Liquid Limit	LL=24.5 - 48.6%
Plastic Limit	PL=12.3%
Plasticity Index	PI= 12.2 - 36.3%

Laboratory vane test	cu = 0.86 kg/cm^2

Very dense, green, silty fine SAND

In the bore holes of S2 and S3, stiff to very stiff, gravely clay layer underlies very dense, green silty fine sand layer. The penetration resistance (N) has been found as follows:

N = 65 - 90

Green, very weak cemented SANDSTONE - CLAYSTONE

Very weak cemented Sandstone - Claystone have been encountered below very dense, silty fine sand at the bore holes of S1 and S2, and below very stiff, gravely clay at the bore hole of S1.

TCR (Total Core Recovery) and RQD (Rock Quality Designation) value of the layer are determined as follows,

Sandstone	TCR = 24 - 76%
Claystone	RQD = 0 - 50%
	TCR = 25 - 39%
	RQD = 16 - 20%
Sandstone-Claystone	TCR = 32 - 67%
	TQD = 12 - 67%

The unconfined compression tests have been carried out only for the selected samples and the compressive strength have been estimated as shown in Table 6.7.2.

TABLE 6.7.2 Compressive Strength

Bore Hole No.	Depth (m)	Unconfined Compressive Strength (kg/cm2)	Rock
S1	13.10-13.50	38.1	SANDSTONE
S1	13.50-14.00	49.2	SANDSTONE
S1	19.00-19.20	36.9	CLAYSTONE
S2	13.50-13.80	35.7	SANDSTONE
S2	15.00-15.20	30.3	SANDSTONE
S2	21.00-21.30	40.4	SANDSTONE
S3	12.00-12.50	30.3	SANDSTONE
S3	16.80-17.00	75.7	CLAYSTONE

6.7.8 Offshore Borings for Subsurface Profiling

All the bore holes has encountered medium dense, green and green sandy shell layers below the seabed with a thickness of 1.3 to 2.15 meters.

The standard penetration number (N) lies in the following range.

$$N = 15 - 18$$

Thin layer is underlain by firm-stiff, green, shelly clay layer. The standard penetration number (N(is in the following range.

$$N = 12 - 20$$

The following results are obtained from the Atterberg Limits and Water Content tests,

Water Content	W = 17.3 - 23.6%
Liquid Limit	LL=41.2 - 50.8%
Plastic Limit	PL=14.5 - 18.5%
Plasticity Index	PI=26.5 - 32.3%

In the bore holes DS1 and DS2 1.0 to 1.7 meters of thick sandy shell layer.

The penetration number (N) values for the layer are as follows.

$$N = 13 - 28$$

In the bore hole DS1, green and sandy Shell which is encountered between 15.1 and 16.8 meters depth is underlain by firm, green and sandy Clay.

The standard penetration number (N) is found as below.

$$N = 9$$

The following results are obtained from the Atterberg Limits and Water Content tests.

Water Content	W = 13.5 - 21.7%
Liquid Limit	LL=38.2 - 52.7%
Plastic Limit	PL=11.7 - 19.1%
Plasticity Index	PI=26.5 - 36.6%

Clay layer in bore hole number DS2 is found as hard consistency which represent penetration number (N) are as follows.

N = 35

The following results are obtained from the Atterberg Limits and Water Content tests.

Water Content	W = 27.2%
Liquid Limit	LL=52.7%
Plastic Limit	PL=19.1%
Plasticity Index	PI= 33.6%

Hard clay layer is overlain medium dense, green, silty sandy Shell layer with the thickness of 2.50 m in bore hole number DS2.

The penetration resistance for this shell layer is found as followings.

N = 24

The medium dense, white-yellow colored and shelly silty Sand layer is observed below firm clay in bore hole number DS3.

The penetration resistance for this shell layer is found as followings.

N = 9 - 15

Green, very weak cemented Claystone-Sandstone layer are encountered below sand layer in DS3, below shell and clay layers in DS1 and DS2 of bore holes. Which one the sediments of the layer formation.

Standard penetration tests gives refusal within these weakly cemented, highly weathered rock layer.

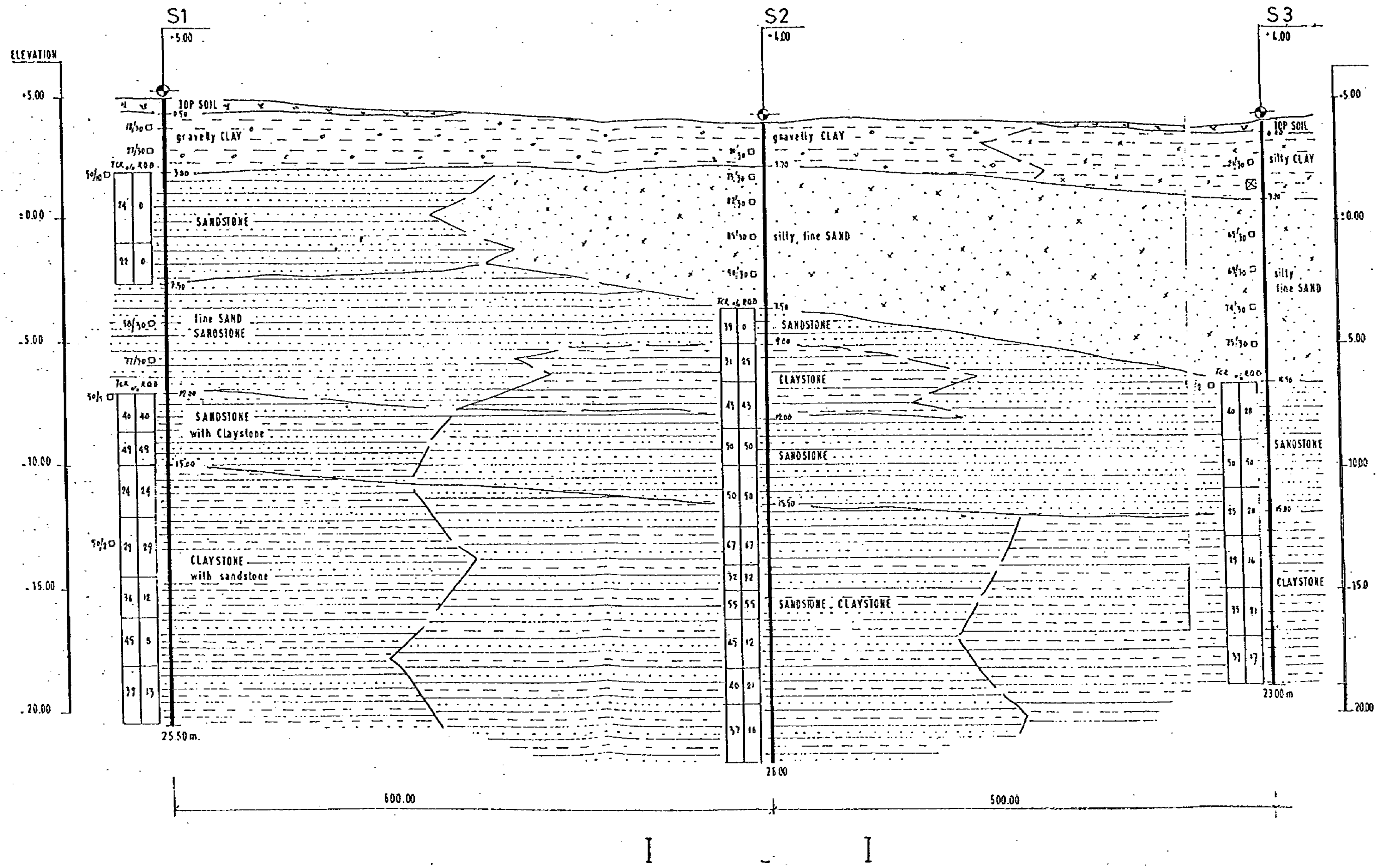


FIGURE 6.7.3 Geological Section-1

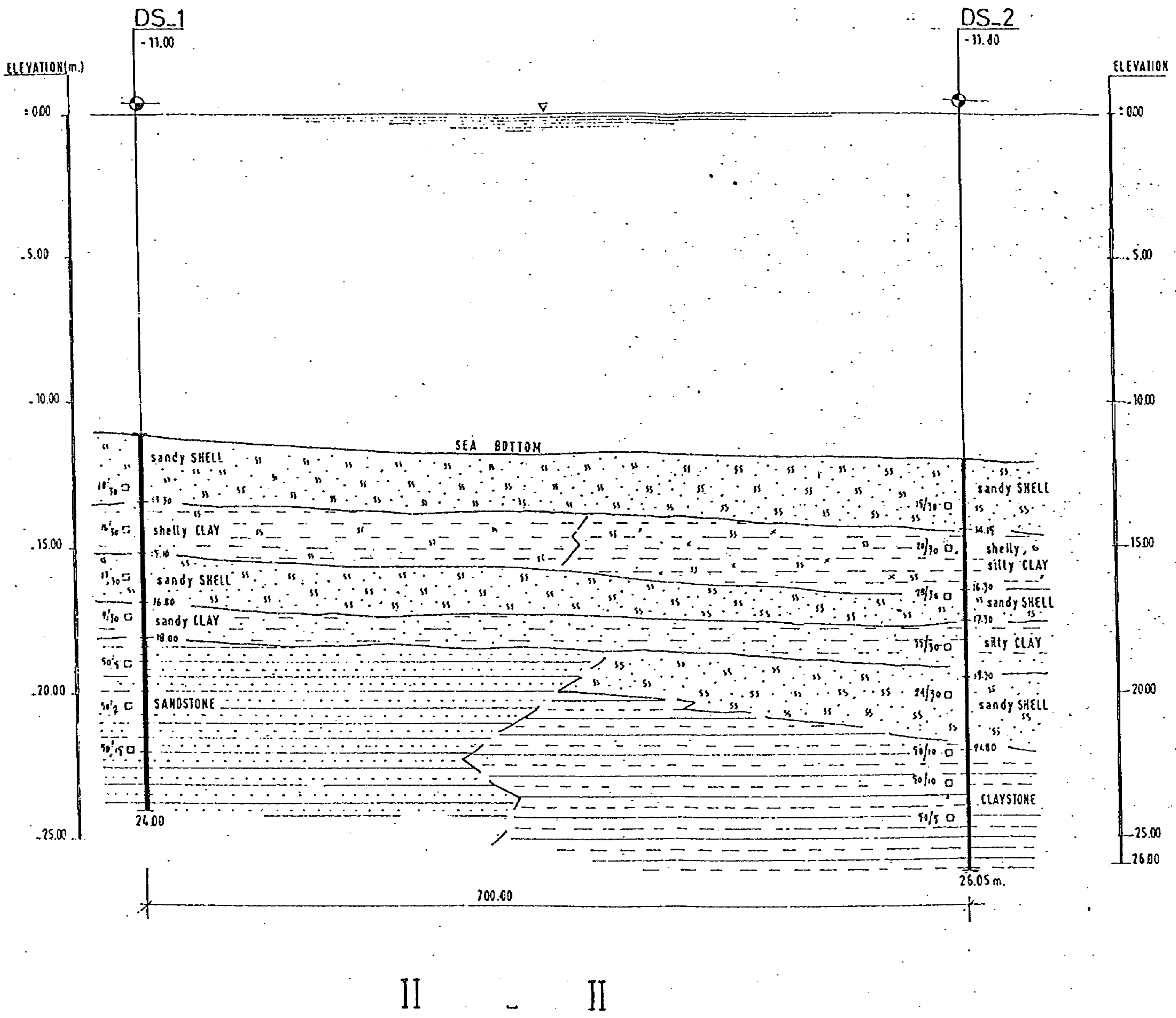


FIGURE 6.7.4 Geological Section-2

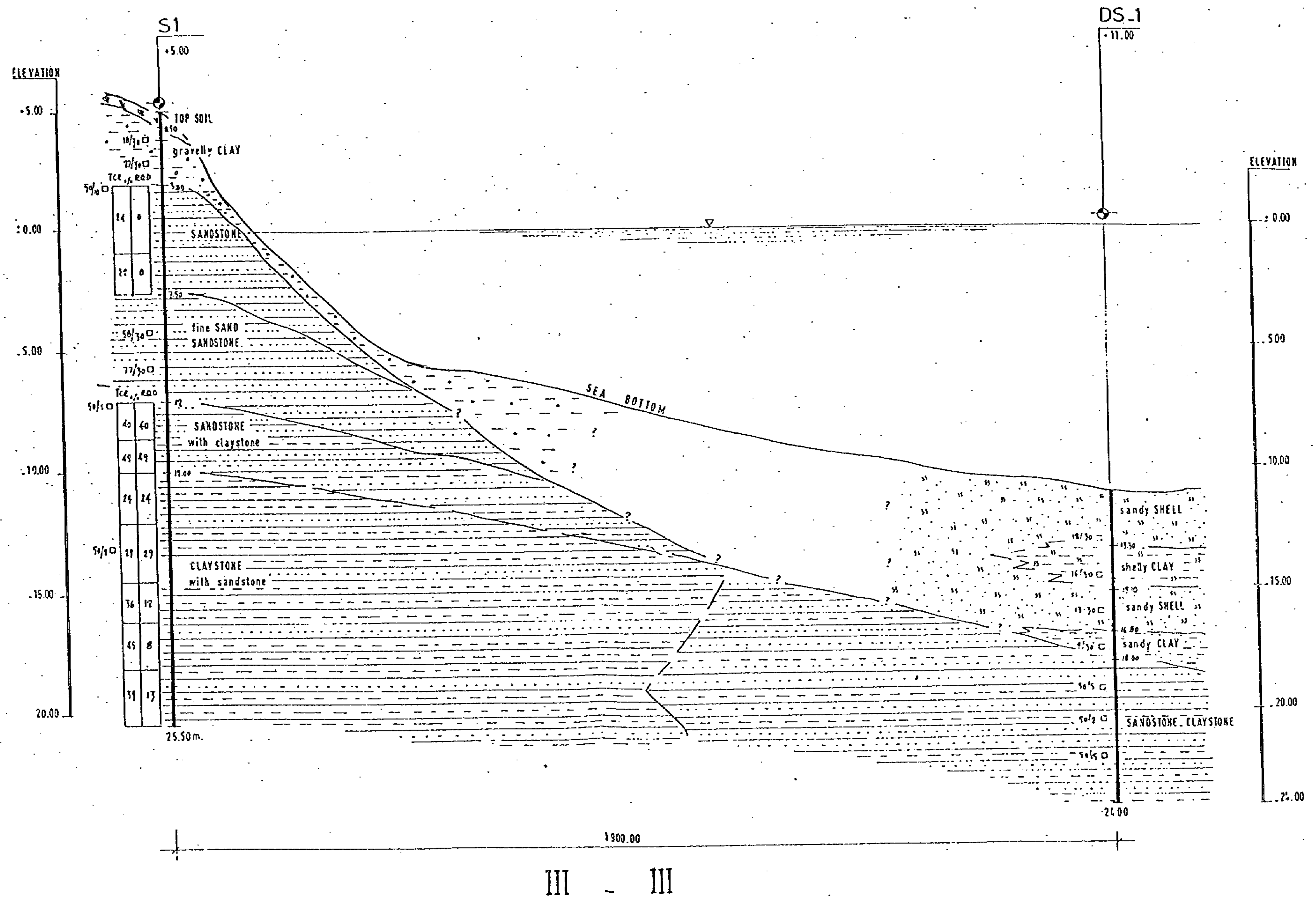


FIGURE 6.7.5 Geological Section-3

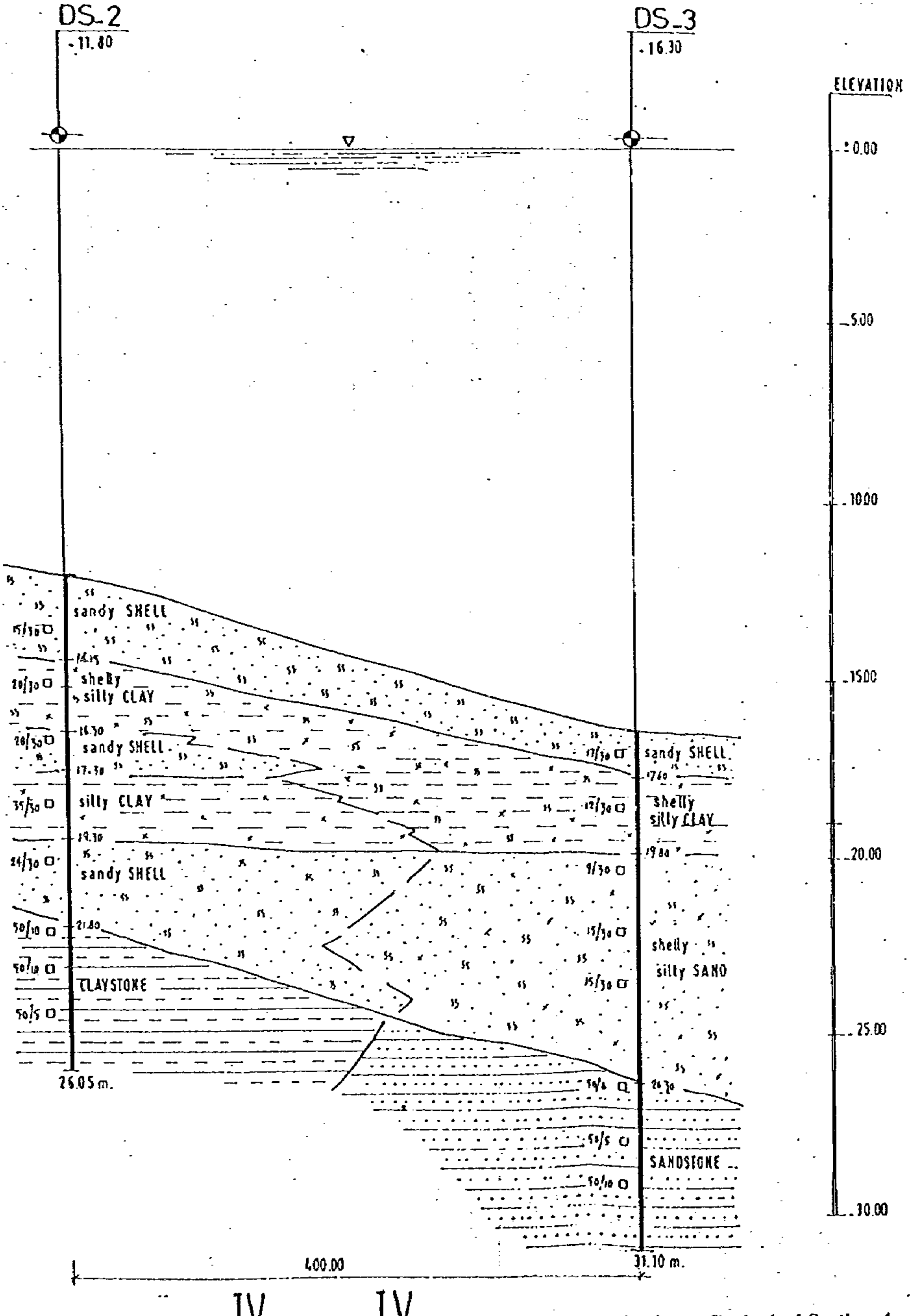


FIGURE 6.7.6 **Geological Section-4**

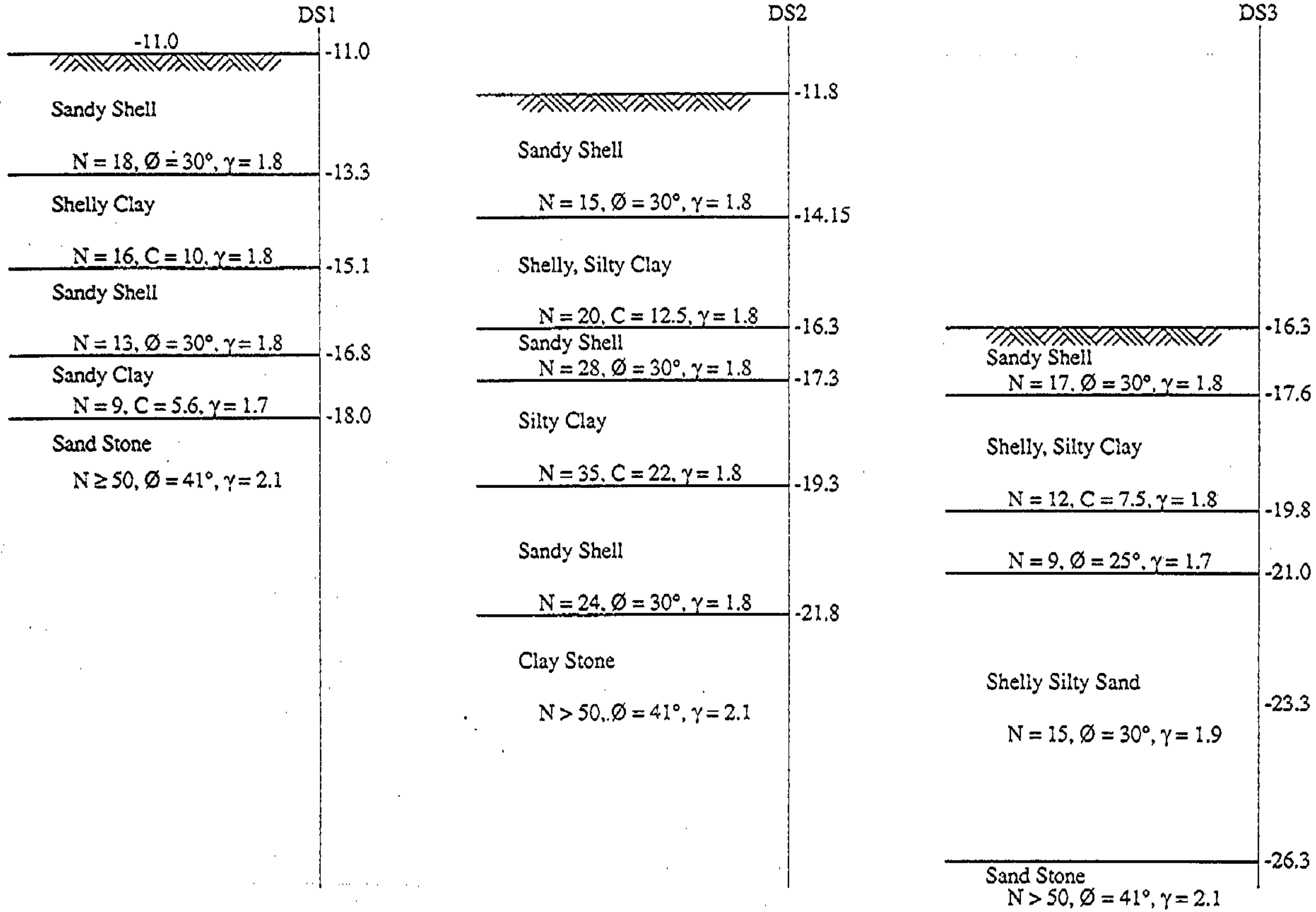


FIGURE 6.7.7 Soil Condition for Design Criteria

7. Present Environmental Situation in Marmara Region

7.1 Air Pollution in Marmara Region

7.1.1 General

Air pollution in this region is caused by the fertilizer, paper and cellulose, sugar, cement, petrochemical and leather industries.

The fertilizer industry is located at Bandýrma, the paper and cellulose industry at Ýzmit, the sugar industry at Susurluk, the cement industry in Istanbul, Balýkesir and Bursa, the petrochemical industry at Ýzmit and the leatber industry in Istanbul. Beside the industrial pollution, household emissions also contribute in Ýstanbul, Ýzmit and Bursa.

TABLE 7.1.1 SO_2 and Particle Concentrations in various Districts of Istanbul (μ/m^3)

		1990	1991	1992	1993	1994	1995
Bakırköy	SO_2	343	474	358	277	252	231
	Particles	159	185	130	112	100	78
Beşiktaş	SO_2	328	345	341	-	221	217
	Particles	164	157	149	-	96	94
Beykoz	SO_2	224	-	307	208	-	-
	Particles	112	-	135	92	-	-
Beyoğlu	SO_2	434	-	568	290	238	239
	Particles	183	-	223	115	96	86
Eminönü	SO_2	355	402	341	359	197	182
	Particles	160	200	110	164	113	97
Fatih	SO_2	362	335	377	326	255	242
	Particles	186	129	129	133	110	81
Gaziosmanpaşa	SO_2	329	417	555	325	295	336
	Particles	198	197	212	170	128	133
Kadıköy	SO_2	358	459	533	205	85	151
	Particles	156	164	120	80	25	64
Kartal	SO_2	214	192	230	133	110	78
	Particles	97	111	97	71	65	50
Şişli	SO_2	445	481	564	359	288	317
	Particles	217	232	226	101	87	83
Ümraniye	SO_2	288	306	393	218	199	198
	Particles	125	157	116	80	72	73
Üsküdar	SO_2	287	383	431	199	171	139
	Particles	123	167	145	68	72	64
Zeytinburnu	SO_2	271	250	304	229	183	171
	Particles	143	125	138	102	82	74

7.1.2. Istanbul

Even though air pollution has been on the agenda for years in Istanbul, experiencing an air pollution emergency in 1995 winter has brought up the subject again. Almost all studies on air pollution in Istanbul show that the primary reason of it is the use of low quality coal, mined around Istanbul, for heating (Alp *et al.*-1993, Ertürk-1993, Anoðlu-1995). Therefore, enforcing the use of better coal would reduce the pollution considerably. Ertürk (1993) found out that the use of coal with sulfur content below 1 %, would reduce the SO_2 concentrations bellow limits.

Sofuoðlu *et al.* (1993), Bereket and Özdemir (1992) and Tekin (1993) studied the effect of exhaust gases in air pollution. With the current increase in the number of cars in traffic, and decreasing concentrations of pollutants as a result of precautions, vehicle effects may become important. Sofuoðlu showed that the CO concentration increases with the increase in the number of vehicles and decrease in the vehicle speed. Bereket and Özdemir (1992) used bioindicators for determining lead accumulations, but found out that lichens are not a good indicator for Pb.

The unique study on rain water of Istanbul has been carried out by Okay and Oraltay (1995), in which they measured the ionic composition of rain and concluded that the rain is not acidic with 5.0 pH value.

7.1.3 Bursa

Bursa is among the most polluted cities according to the Ministry of Health in terms of SO_2 and particle concentrations, but both has a tendency to decline. The most recent study has been carried out by Özer *et al.* (1995), in which results were agreed with the data provided by the Ministry of Health.

7.2 Water Pollution in Marmara Region

7.2.1 Marmara Basin

With a drainage area of 24,100 km^2, the Marmara Basin constitutes 3.09 % of Turkey's entire area. Average annual rainfall has been estimated to be 18.412 billion m^3 and the total annual average output of the rivers in the basin to be 6.619 billion m^3. There are no major rivers in the basin, but the waters of a large number of its short streams drain into the Sea of Marmara. The most important rivers are the Kocabaþ (Biga) and the Gönen in the southwestern part of the basin.

This basin includes the population and industrial centers in the provinces of Istanbul, Tekirdað, Ýzmit, Bursa and Çanakkale - the region with the most dense concentration of population and industry in all of Turkey. The population of Istanbul alone is around 10 million, and in total, approximately one fifth of Turkey's population lives in this region, while there are no purification systems for the wastewater of urban areas.

Some of the biggest industrial installations are in this region, which are also discharcing the wastewaters without any purification any purification process. Therefore, one of the final destination of the wastewaters, Ýzmit bay is one of the two most polluted bays and will be discussed in marine pollution chapter.

TABLE 7.2.1 General Quality Parameters in the Bay of Izmit Recipient Environment (mg/lt)

Sampling Place	BOD	COD	NH_4-N	PO_4-P	Detergent	Phenols	Oil
SEKA Outlet							
7/1982	47	153	0.8	-	4.0	0.5	2
11/1982	330	413	1.7	0.08	3.5	0.5	40
12/1982	27	160	0.3	-	1.2	-	76
Front of Kor. Tarım							
7/1982	40	140	0.6	-	4.2	0.5	16
11/1982	160	318	1.0	0.08	1.2	0.5	37
Gölcük Dockyard							
12/1982	25	104	0.8	0.95	1.8	-	74
Değirmendere Outlet							
12/1982	15	176	0.1	0.08	1.2	-	120
İGSAŞ Outlet							
7/1982	60	196	1.2	-	2.3	0.5	9
11/1982	55	92	1.3	0.10	0.5	0.5	36
PETKİM Outlet							
7/1982	57	127	0.6	-	3.2	0.5	7
11/1982	60	113	1.7	0.10	0.6	0.5	27
Gölcük-K. Mürsel							
7/1982	25	189	0.3	-	2.1	0.5	10
K. Mürsel Outlet							
12/1982	13	176	0.1	0.08	1.3	-	150
Front of Hereke							
11/1982	50	113	0.6	0.14	1.0	0.5	105
Front of Hallaç Str.							
11/1982	220	557	0.9	0.22	0.9	0.5	85
Dilderesi Outlet							
7/1982	18	170	0.6	-	3.7	0.5	31
11/1982	130	299	0.9	0.28	0.7	0.5	90

7.2.2 Susurluk Basin

With a drainage area of 22,399 km^2, Susurluk Basin constitutes 2.87% of Turkey's entire area. Average annual rainfall in the basin has been estimated to be 16.351 billion m^3 and the total average annual output of the basin's rivers to be 5.487 billion m^3. The major water courses of the basin are Simav (Susurluk) Stream and its tributaries, Nilüfer, Mustafakemalpaþa; Orhaneli (Adronas) and Emet (Kiramasti) streams. The basin contains the provincial capitals of Bursa and Balýkesir as well as the counties of Emet, Bandýrna, Karacabey, Mustafakemalpaþa, Orhaneli, Tavþanlý, Sýndýrgý and Manyas. The causes and levels of pollution of the basin's rivers and streams are discussed briefly below.

(1) The Bursa Area and Pollution of Nilüfer Stream

Bursa and its environs are the focus of the worst pollution in the basin. Bursa, whose municipal population was 748,632 in the 1985 census; is the fifth largest city in Turkey, while the population of Bursa province is 1,327,762. The Bursa Plain, previously known for its high yield and farm products, has undergone rapid industrialization over the past 20-25 years with the result that water resources in the area are now threatened by intensive pollution.

Both small and large industrial enterprises of the region, the wastewaters of the Bursa Organized Industrial Zone, and the wastewaters originating from the urban population centers of the area are causes of pollution of Nilüfer Stream. Sewage from the City of Bursa intermixes with this stream through open canals at seven different points. A number of industrial enterprises also discharge their wastes and dump their garbage into these canals, which together with their connected creeks and streams, contain heavy metals as well as organic pollution.

The Bursa Organized Industrial Zone uses 3.5 million m^3 of water per year, all of which is discharged without treatment into Ayvalý Stream, a tributary of the Nilüfer. The water quality of this stream, before it joins up with the Nilüfer, is being monitored giving the following results: BOD 265, COD 475, nitrogen in the form of ammonia 18.5 mg/lt, orthophosphate 3.60 mg/lt and dissolved oxygen 0.00 mg/lt The stream, which dries up in summer, carries nothing but wastewater. The water quality of another stream, Soðanlýdere, also a tributary of the Nilüfer, exhibits similar characteristics. These waters fall within the category known as Class IV (very polluted) water as defined by the Water Pollution Control Regulation.

The quality of Nilüfer Creek, which joins up With Simav Creek at its mouth, is slightly better in terms of parameters like dissolved oxygen and BOD. However, the high COD levels (149 mg/lt) measured here arouse the suspicion that the concentration of organic matter in the water is actually quite high and that low BOD levels are obtained as a result of toxicity.

(2) Simav (Susurluk) Creek

Simav Creek originates in the mountains near Sýndýrgý and flowing through the plains of Sýndýrgý, Kepsut, Susurluk and Karacabey, empties into the Sea of Marmara. The major source of pollution of the Simav is Bigadiç Borax Metal Enterprises, which discharges its wastewater into the creek between the Yörücekler Regulator and the Kaletepe Regulator. As a result of systematic measurements of borax taken on Simav Creek by the SDW, an average of 0.11 mg/lt and a maximum of 0.76 mg/lt were found at the Bigadiç Bridge and an average of 1.48 mg/lt and a maximum of 2.80 mg/lt at the quality observation station at Yahyaköy north of Susurluk (SDW,1987). These values are far in excess of the criterion of 300 µg/lt (=0.3 mg/lt) given in the Water Pollution Control Regulation for the irrigation of borax sensitive plants. It is, therefore, clear that the concentration in the water used for irrigation in the Balýkesir and Susurluk Region is extremely high.

The household and industrial wastewater of the City of Balýkesir, which had a population of 222.336 in the 1985 census, is discharged into Üzümcü Stream, eventually intermixing with Simav Creek. Around 70 industrial enterprises in such branches as mining, chemicals, textiles, metals, foodstuffs, machines and ceramics are active within the Balýkesir municipal limits. The SEKA Paþaköy Paper Factory, also located in this region, discharges its wastewater as well into Simav Creek, which receives only the household wastes of Kepsut between Bahkesir and Susurluk and therefore undergoes a relative degree of natural purification. In the Susurluk segment, however, it becomes loaded with the wastewaters of the slaughterhouse, the small industries, the Tunalýlar Oil Factory, the household wastewaters of the town of Susurluk (population 42,634 in 1985), discharged first into Hatap Stream, seepage waters from the county dump and the wastewaters of the Sugar Factory, where 520,000 tons of beets are processed annually during the 170 day harvesting season between August and December. During this period over 10 million m^3 of water are used. This wastewater, which contains large amounts of organic matter and toxic compounds that decompose slowly in water (saponin and trietilamin) is discharged into Simav Creek without any treatment (Yenigün *et al*,1987).

(3) Mustafakemalpaþa, Orhaneli (Adronas) and Emet Creeks

Mustafakemalpaþa Creek is formed by the confluence of the Orhaneli (Adronas) and Emet creeks near the village of Çamandar. This creek, which absorbs the pollution of Orhaneli and Emet creeks, empties into Lake Apolyont. Orhaneli Creek, which consists of three branches, originates in the north and northeast part of Gediz County. It is 276 km. long. Emet Creek, which is 176 km. long, originates at Kýzýldað in the region of Gediz and flows into the Mustafakemalpaþa Valley where it joins up with Orhaneli Creek 4 km. west of the county seat at Emet. All three creeks are used on a large scale for irrigation of a

20,000 hectare area through a regulator in the County of Mustafakemalpaþa. There is also a plan to use water from Emet Creek at Devecikonaðý to irrigate further 10,000 hectare of land (Torunoðlu, 1986). However, the waters making up this drainage system are becoming polluted by industry in the region and the polluted waters being transported to Lake Apolyont.

The initial pollution of Orhaneli Creek takes place at the T.E.A.Þ. (Turkish Electricity Production and Transmission Corporation) Tunçbilek Thermal Power Plant and the Tunçbilek Garp Lignite Enterprises, whose wastewaters, containing coal dust and ashes, are discharged into it. With the help of the settling tanks put into operation at Garp Lignite in 1984, a certain reduction was achieved in the amount of particulate matter mixing with the creek water. The T.K.I. (Turkish Coal Enterprises) Keles (Marmara) Lignite Enterprises in the region supply fuel to the T.E.A.Þ. Orhaneli Thermal Power Plant, which went into operation in 1987. The particulate matter in the wastewater of this lignite processing plant, however, is largely retained by means of precipitation tanks. Later, Orhaneli Creek, which is polluted by three chrome processing plants in the Orhaneli area, also absorbs the wastewater of the Etibank Borax Enterprises at Kestelek before joining with Emet Creek. The water quality of Orhaneli Creek is continuously monitored at a quality observation station operated by the SDW at the mouth of the Kestelek Bortaþ Mine.

Pollution in Emet Creek stems largely from the wastewater of Etibank Hisarcýk Colemanite Enterprises in the county of Emet, which contain the pollutants arsenic and borax. A semi-closed system of water circulation was implemented in 1984 with the hope of providing at least a temporary solution to this problem. The basis of this system is to let the process waters first rest in basins consisting of two sections and then re-use them and, when their concentration eventually reaches saturation, to discharge them into Emet Creek at periods outside the irrigation season when the creek's output is high.

(4) Kocaçay Stream

The Kocaçay, which originates on the southwest edge of Mt. Madra in the Marmara Region, flows through the counties of Ývrindi, Balya and Manyas and empties into Lake Manyas. Pollution of this stream begins in the County of Ývrindi with the wastewaters of the Bayramoðlu Lead and Antimony Blast Furnaces, which contain heavy metals. The Kocaçay, which absorbs the household wastewaters of the County of Ývrindi, is the target as well of the zinc and lead containing wastes of the Türker Blast Furnace and Refinery in Balya County and of the wastewaters of around twenty settlements and foodstuff industries in the vicinity. The stream empties into Lake Manyas.

TABLE 7.2.2 Measured Concentrations for Meriq and Marmara Basins (mg/lt)

	DO(min)	BOD(max)	NH_3	NO_3	ortho-PO_4
Meriç-Kapıkule	5.3	11.1	0.33	3.35	1.77
Meriç-Edirne	6.6	8.5	1.12	3.65	1.23
Ergene-Uzunköprü	1.8	38.0	0.22	0.49	0.66
Meriç-Enez	8.2	9.2	0.66	2.01	0.96
Biga Creek-Mansap	4.0	-	1.32	0.77	1.09
Gönen Creek-Mansap	4.2	-	0.29	0.43	0.19
Karsak Stream-Köktaş	-	102	17.8	0.26	7.76
Kirazlıdere-Kartonsan	-	597	6.95	0.53	0.68
Kumlu Akarca-Highway Bridge	-	1000	42.4	0.86	0.69

7.2.3 The Sea of Marmara

The topographical and hydrographic characteristics of the Sea of Marmara which is a part of the Turkish straits system, play an important role in this sea's dynamics and health. The two important resourses connecting the Black Sea with the Sea of Marmara and with the Aegean are the Bosphorus and the Dardanelles straits. The thresholds at either end of the Bosphorus exercise a regulatory effect on the straits and consequently on the hydrodynamics of the Marmara. The Dardanelles Strait, which is longer and wider than the Bosphorus, impades the exchange of water between the Marmara and its neighboring seas less than the Bosphorus does (Özsoy et al, 1986). Nevertheless, the narrow, sharp passage in the Nara region is aýý important topographical feature regulating the hydrodynamics of this strait.

With an area of 11,500 km^2 and a volume 3.378 km^3, the Sea of Marmara is bounded by a series of deep depressions of 1,225, 1,335 and 1,097 m. in depth from east to west in its northern portion. Its southern part consists of a broad shelf which is shallow in places. The depressions in the northern part are separated from one another by thresholds at depths of 600-700 m. Because it forms a transitional region between the Black Sea and the Aegean, the oceanographic characteristics of the Sea of Marmara are closely related to the variations caused by tlýe oceanographic characteristics of its adjoining seas.

Waters originating from the Black Sea and the Aegeaýý form two distinct layers in the straits as well as in the Sea of Marmara. In terms of pollution, the coasts of the Marmara are home to Turkey's densest population and industrial ceýýters. Efficient self purificatioýý of the Sea is therefore impossible, owing both to its stratified, structure and to its water discharge potential, which is limited by the straits. The port of Bandýrma in the south and the wastewaters and sludge produced by the borax-sulfuric acid plants, togetlýer wittý the pollutioýý caused by tourism around Erdek-Avþa and the Bay of Gemlik and the olive oil and soap industry in the same region, all affect the Sea of Marmara. At the same time, this Sea is also exposed to pollution from the industries located around the Bay of Ýzmit, which are the most polluting in the entire country, as well as being a receptacle for the wastes of the city of Ýstanbul, which accounts for a sizable fraction of Turkeys total population. Due to their importance, studies concerning pollution in the Bays of Gemlik and Ýzmit will be discussed in detail below.

The studies underway since 1985 by METU-MSE have shown an oxygen saturation of 20-30% in the layer below 25-30 m. (Özsoy *et al*,1986). Considering at oxygen saturation even at a depth of 1,000 m. in the Mediterranean is 70% (Özsoy *et al*,1987; Salihoðlu *et al*,1986), we can get some idea about the degree of oxygen saturation in the lower strata of the Sea of Marmara. The causes of the oxygen deficiency observed in the lower layers of the Marmara and the amount of oxygen input either by vertical mixing or by the lower strata of the Dardanelles have been examined in detail by Ünlüata and Özsoy (1986). The annual rate of oxygen consumption in the lower waters of the Sea of Marmara has been determined to be 0.30-0.40 mg O_2/lt/yr by the same researchers.

The fact that oxygen saturation in the lower strata of the Sea of Marmara never exceeds fifty percent is a clear indication that the amount of oxygen required for the breakdown of the organic particles that precipitate into this layer from the upper layers is not being supplied. The waters in the lower strata of the western basin become more oxygenated in March when the Observable Oxygen Deficiency falls into around 5.6-6.0 mg O_2/lt.

(1) The Bay of Ýzmit

The Bays of Ýzmit, Bandýrma, Gemlik and Erdek are Turkey's four largest bays. Among them, the Bay of Ýzmit is separated from the Sea of Marmara by a threshold 50-55 m. deep. The existence of this threshold signifýcantly affects movements of water masses in the Bay and, especially, the period required for restoration of waters in the lowest layers (Baþtürk *et al*,1985; Oðuz and Sur,1986)

Besides this two-layer structure, since the Bay's exchange of water with the Sea of Marmara is impeded by the threshold and the strait near Dil Burnu, movements of water masses in the Bay are decreasing and have been reduced to a minimum in the eastern region. The hydrodynamics of water movements in the Bay as well as its exchange of water with the Sea of Marmara have been examined in detail by Oðuz and Sur (1986).

Water exchange between the Marmara Sea and the Bay depends on the wind.. Particularly, the surface currents are directly determined by the speed and the direction of the wind. Therefore, the most secluded part, east of bay displays a swamp characteristic with considerably high pollution (Yeÿÿigün *et al.*,1987). Bay sediments is composed of mud containing low level of limestone and high level of shilt. Density and porosity of the sediments have been found as 2.71 atýd 0.77, respectively. Average sedimentation rate is around 25 cm per millennium, while the maximum rate is 70 cm per millennium (Ergin and Yörük, 1990). The bay sediments are poor in terms of heavy metal content.

The household wastes of the City of Ýzmit with its population of 400,000 are discharged into the Bay at various points, with the result that an unpleasant odor pervades the city particularly in summer (Orhon, 1984). This odor; which is compounded by odors from the city's slaughterhouses, originates from the septic conditions and the city dump at the eastern tip of the bay and varies depending on temperature and wind direction. Even if the septic conditions in the area could be rectified and the discharge of wastewaters stopped, this would be an extremely time-consuming project. All the population centers around the Bay also discharge their household wastes into it through various streams. Among the municipalities in the environs, Hereke, Yarýmca, Deðirmendere, Gölcük and Karamürsel all exhibit environmental problems similar in their details to those of Ýzmit itself. None of them has an adequate sewerage network, and their septic tanks either weak or overflow. As in the City of Ýzmit itself, there is a pervasive odor in the environs, and the pollution of the coastal waters deters people from using the area for recreation. The municipalities are awaiting the implementation of the Bay Master Plan (Yenigün *et al.*,1987). .

Over 120 industrial enterprises, most of them located along the Bay's northern shore, discharge their wastewaters into the Bay of Ýzmit. The pollution loads carried b; their wastewaters and the levels to which they could be reduced by treatment are given in detail in two references, one by the Prime Ministry Environment Undersecretariat (1984) and the other by the Prime Ministry Environmental General Directorate (1985). Pollution of the Bay is examined in three sections: the eastern section, the central section and the western section. There are fifteen large industrial enterprises that discharge their wastes into the eastern section of the Bay. These are: SEKA (cellulose, paper and chlor-alkalis), Pakmaya (yeast), Kartonsan (cardboard boxes), Mannesman (metal pipes), Fursan (citric acid), Koruma-Tanm (agricultural pesticides, chlor-alkalis), Pirelli, LASSA and Goodyear (automobile tires), Kazlý Deri (leatlýer), ANS A (pharmaceuticals), Rabak (metal), Çelik Halat (steel wire), Lifli Rulo (paper) and Petrol Ofisi (oil and grease). The main industries discharging wastes into the central section of the Bay are: PETKIM (petroleum products and chlor-alkalis), Tüpraþ (oil refinery), IGSAÞ (ammonia and urea), Yarýmca Gübre (fertilizer), Yarýmca Porselen (fine china), Ýpek Kaðýt (paper), NASAÞ (aluminum), Hereke Sümerbank (woolen fabrics) and Marshall (paint). There are three industrial enterprises making discharges into the western section of the Bay: Arçelik (white goods), Türk Otomotiv Endüstrileri (truck, tractors, agricultural machinery), and Fenis (aluminum).

Research has shown that 82% of the total BOD load, 66% of the suspended solids load and 60% of the oil load is discharged into the eastern section of the Bay. Meanwhile, 57% of the phosphorus and 64% of the ammonia are also discharged into this section. Approximately 58% of the close to 180,000 m^3/day industrial wastewater discharge comes from SEKA, PETKIM and IPRAÞ and almost 50% of the organic load introduced into the Bay's surface waters originates from the SEKA plants. Furthermore, the BOD load of six industrial enterprises constitutes 92% of the total load reaching the Bay. Eighty percent of the total nitrogen load originating from industry stems from the two fertilizer factories alone.

Another study of household and industrial wastewater discharges into the Bay of Ýzmit, done by Baþtürk *et al.* (19851. disagrees slightly with the one just described above in terms of some parameters. In the study, which points out that around 150,000 m^3/day of the area's 190,000 m^3/day output of household wastewater is discharged along the bay's northern shores, the population of the bay environs is estimated to be around 900,000 persons.

Therefore, the main principle of measures to be taken to avoid pollution in Ýzmit Bay is purification of household and industrial wastes separately. Even though the purification became mandatory for industrial installations, only a few of them complied with this. .

(2) Gemlik Bay

Gemlik, which had a population of 57,703 in 1985, is a county seat on the coast of the bay of the same name. The major watercourse emptying into the Bay is Gölayaðý Stream, which originates at Lake Ýznik and picks up the industrial and household wastes of the Town of Orhangazi. The hydrographic and hydrodynamic structure of Gemlik Bay, a breakdown of the industries discharging wastewater into it, and the water quality of the bay have all been examined in detail (Curi, 1982). Household wastes and a few large industrial enterprises in Gemlik County have caused a significant degree of pollution in the Bay waters.

Like the Sea of Marmara, Gemlik Bay is again characterized by a two-layered current structure, exhibiting properties of the Black Sea in the upper layer and of the Mediterranean in the lower. Measurements of heavy metals in the Bay water showed three times as much zinc, four times as much manganese and 100 times a much cadmium as the concentrations observed in clean sea water. Although the mercury concentration was not analyzed in the waters, which had normal concentrations of copper, nickel and lead, 0.34 mg/kg of mercury was determined to be present in mussels collected from the Bay (Carden and Özbal,1976).

Compared with other bays, the largest number of nitrogen compounds was encountered in Gemlik Bay in field studies done by METU-MSI. In view of the fact that Turkey's nitrogen-based fertilizer industry is located along this Bay, it is obvious that the high nitrate levels detected stem from these plants. Gemlik Bay is also the body of water most affected by discharges from Susurluk River.

7.3 Soil Pollution in Marmara Region

7.3.1 General

The most important problem in this region is water erosion: Stoniness ranks second, and all the other problems are also observed. Barrenness takes the form of slightly saline-alkaline to saline-alkaline soil. Gypsum fields are not observed.

Barenness characterizes 44,942 hectares or 1.03% of the region, which consists of 18,152 hectares of second, third and fourth class, 7,092 hectares of fifth .class, and 19,698 hectares of sixth and seventh class soil.

Stoniness affects an area of 534,299 hectares or 12.22% of the total, which consists of 17,733 hectares of second, third and fourth class, and 516,566 hectares of sixth and seventh class soil.

Excessive moisture is a problem on 270,337 hectares (6.12%) of the region's land. 225,408 hectares consist of second, third and fourth class, 10,794 hectares of fifth class, and 516,566 hectares of sixth and seventh class soil.

7.3.2 Erosion

Slightly to moderately severe water erosion is taking place in Thrace, particularly in the cultivated areas on the high slopes of mountains.

The impact of erosion is from slight to moderate on the highlands between Lalapaþa county of Edirne province and the Bulgarian border, around the Kýrcasalih subdistrict of Uzunköprü and between the counties of Uzunköprü and Keþan in the sloping terrain between Kýrklareli and Pýnarhisar where the forest cover has been destroyed, and on the slopes of the Koru Mountains where forest degradation has occurred.

Only a small amount of land, a large part of which consists of heath and pasture, has been set aside for field farming on the Kocaeli peninsula. For this reason, tlýe degree of erosion is not more than would be expected from such a topographical structure. Owing to destruction of the plant cover, however, the tendency to erosion has increased in overgrazed pastures and around the industrial area and supply routes, and flash floods have begun to cause loss of lives and property every year in the settled parts of the region.

7.3.3 Urbanization and Iudustry

Industrialization in Turkey first began in the Istanbul area. Because of its location as a key transportation point and its special geographical position, rapid, unplanned and haphazard urbanization and industrial development have taken place in this area, and. natural resources have been largely destroyed. At tlýe same time, Turkey's worst levels of water pollution are also found in Istanbul. Land suitable for cultivation in the province constitutes 150;632 hectares and that unsuitable 19,159 hectares.

Fertile land all along the London Asphalt, which runs between Istanbul and Edirne, is being taken over for industrial development even though equally appropriate alternate sites exist between Kýrklareli and Istanbul, along the old Istanbul road. Within Istanbul province, a total of 100,000 decares of good agricultural land has thus been destroyed in the last seven years alone.

The large organized industries and their secondary branches are undergoing steady development in the Bursa area. The textile industry and other small branches of industry are also widespread. The spread of industrial growth in this region is centered in three different directions around the transportation network. The first area includes tlýe Bursa-Gemlik highway and the areas of Fethiye and Ýhsaniye. The other industrial centers are located on the Bursa-Mudanya and Bursa-Ýzmir highways.

According to a 1975 analysis of land taken over for heavy and light industry, a total of 5,142 decares had already been appropriated at that time, and figures were expected to reach 8,320 decares by 1985 and 11,220 decares by 1995. Such industrial expansion, even when planned, paves the way to tlýe occupation of a large part of the agricultural plains with factories. Experts report that the extent of industrial growth falling outside existing plans and of illegal and entirely unplanned growth is unknown. They also express concern that a part of the first, second, third and fourth class land in the region, which should be protected by advance planning, has been appropriated by industry due to political influence and loopholes in the law.

For the past twenty years, the province of Kocaeli has been the scene of dense industrial growth. A large part of the generally high quality farmland through which tlýe Istanbul-Ankara highway runs has thus been, and continues to be, taken over for factories even though alternative sites are available on the highlands nearby.

In the province of Edirne, particularly following the period of planning, various branches of industry have been developing, primarily the textile industry. Here again factories generally cover good agricultural land alongside roads, such as the London Asphalt and the Ýstanbul-Tekirdað-Çanakkale highway.

7.4 Wetland, Flora and Fauna

According to international criteria, more than 25,000 aquatic birds regularly visit and inhabit Class-A wetlands. On the other hand, wetlands inhabited by 10,000-25,000 birds are classified as Class-B. Out of a total of 18 Class-A wetlands, three are in the Marmara Region; namely, Estuary of Meriç River in thrase, Manyas Birds Paradise and Lake Ulubat. Out of a total of 45 Class-B wetlands, six are in the Marmara Region (Ýðneada Longoz Ormaný, Büyük Çekmece Lake, Terkos Lake, Saros Bay, Ýznik Lake).

Even though Turkey is one of the richest countries of the world in terms of endemism, the Marmara Region is one of the poorest parts of the country in that aspect. It should, however, be noted that endemic Sand Lily species are recorded in the coastal area in the southern Marmara between Karabiga and Gemlik. Further, Marmara Region is the poorest region of Turkey in terms of pastures and grasslands.

7.5 Forestry

In terms of forested land, Marmara Region has a total of 1,346,145 ha out of a national total of 20,159,296 ha. In terms of coverage, 6.7% of the land is forested in the Marmara Region and only 5.9% of the population lives in or near forest.

7.6 National Parks

There are three national parks in the Marmara Region; namely, Birds Paradise at Lake Manyas, Uludað Mountain in Bursa and Gelibolu Peninsula. In terms of natural reserves, one can only mention two sites within Ýstanbul provincial boundaries; the fir communities in Alemdað Region and the forest ecosystem of Sakagölü near Demirköy. There is only one nature park in Marmara Region; namely, Polonezköy in Alemdað, Ýstanbul.

Further, there are 15 wildlife protection areas in the Marmara Region. The names of these areas and the protected fauna species are given in the attached table in the attached table.

TABLE 7.6.1 Wild Life Protection Area in MARMARA Region

NAME	LOCATION	SPECIES
Kapýdað-Erdek	Bandýrma	deer and roe
Alaçam-Dursunbey	Dursunbey	roe
Manyas	Bandýrma	aquatic birds
Yosunlu Mountain	Gönen	game animals
Ovakorusu	Karacabey	roe and pheasant
Paþalar	Kemalpaþa	roe and pheasant
Boðazova	Ýnegöl	deer
Korudað	Çanakkale	roe
Gökçeada	Çanakkale	game animals
Bayramiç	Çanakkale	roe
Yalýköy	Çatalca-Ýstanbul	deer and roe
Longoz	Ýstanbul	deer and roe
Çýnarcýk	Hasanbaba-Ýstanbul	deer
Feneryolu	Sarýyer-Ýstanbul	roe and pheasant
Þamlar	Arnavutköy-Ýstanbul	pheasant

APPENDIX

Present Situation of Industrial Characteristics in Marmara Area

FIGURE A.1 Share of Production by Type of Industry in Marmara Area

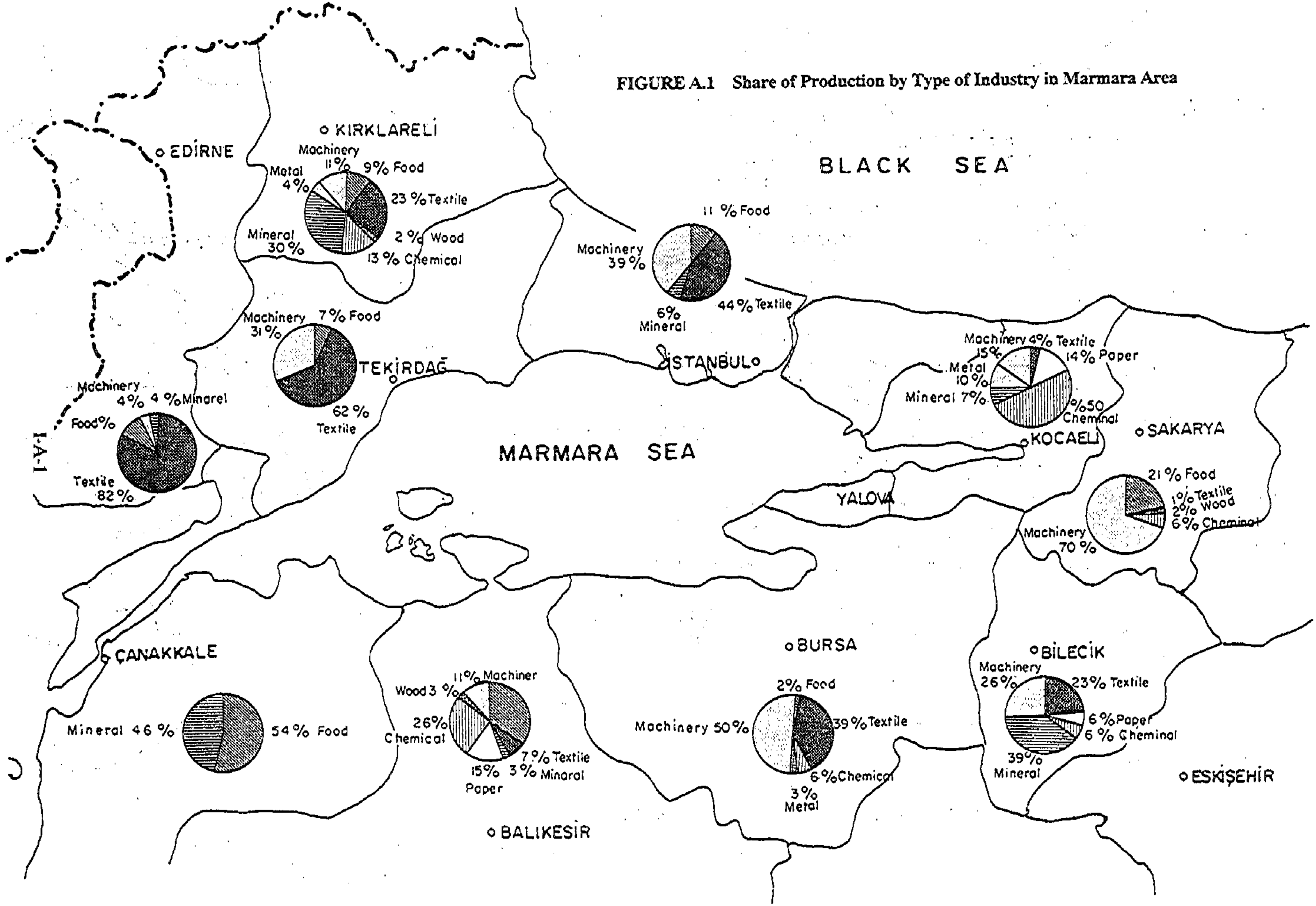


FIGURE A.2 Distribution Map of Machinery Manufacturing Enterprises

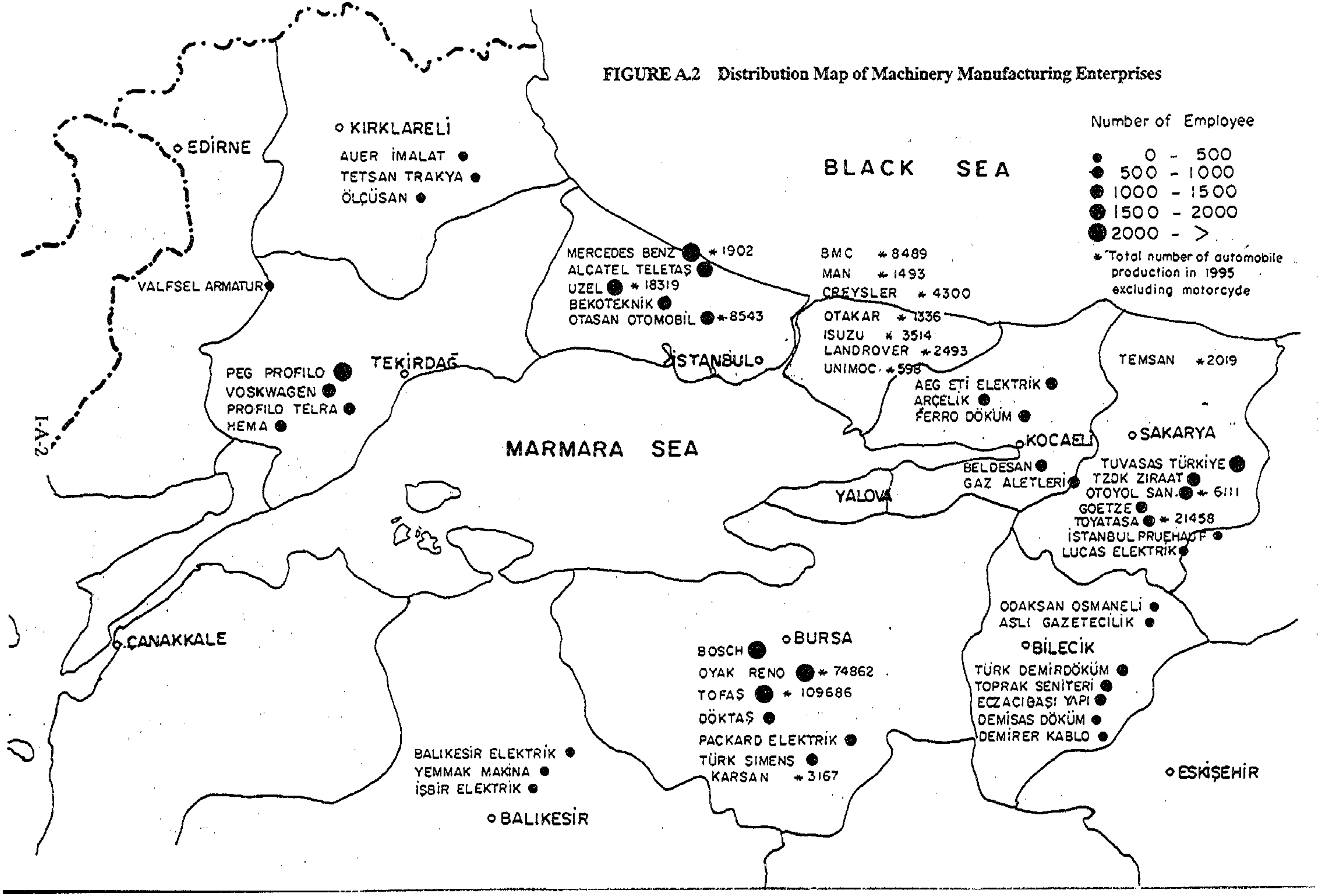


FIGURE A.3 Distribution Map of Wood Manufacturing Enterprises

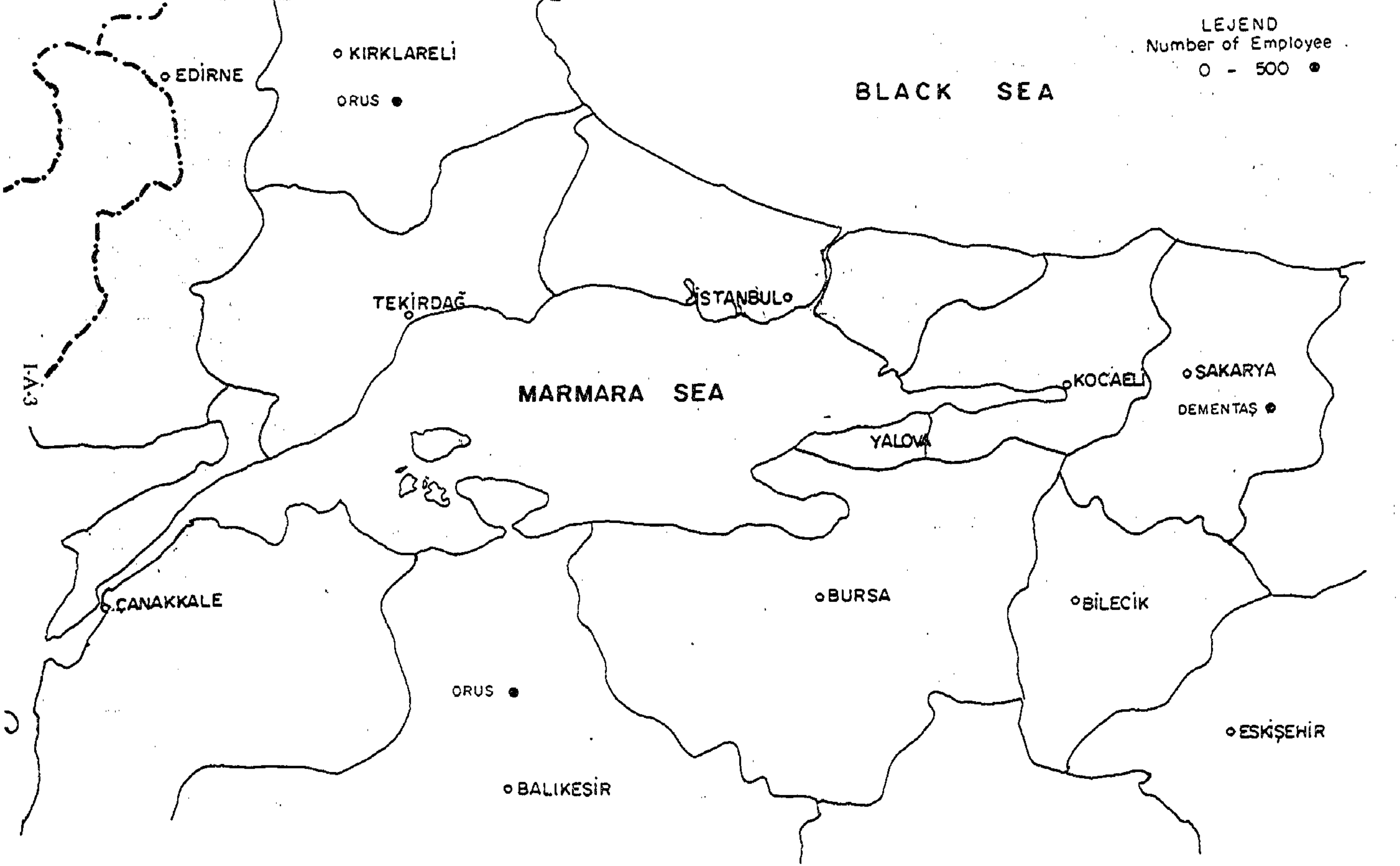


FIGURE A.4 Distribution Map of Food Manufacturing Enterprises

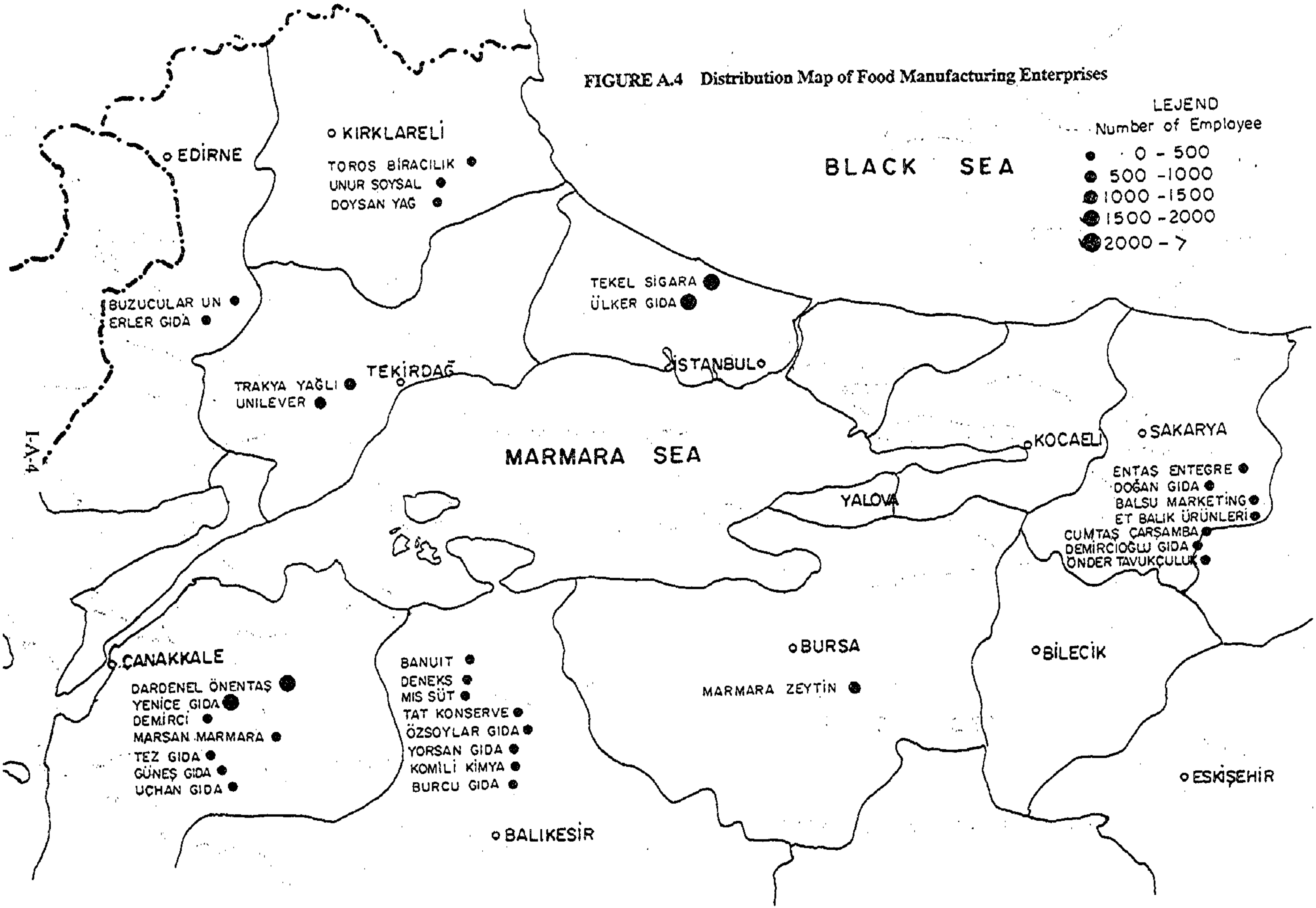


FIGURE A.5 Distribution Map of Textile Manufacturing Enterprises

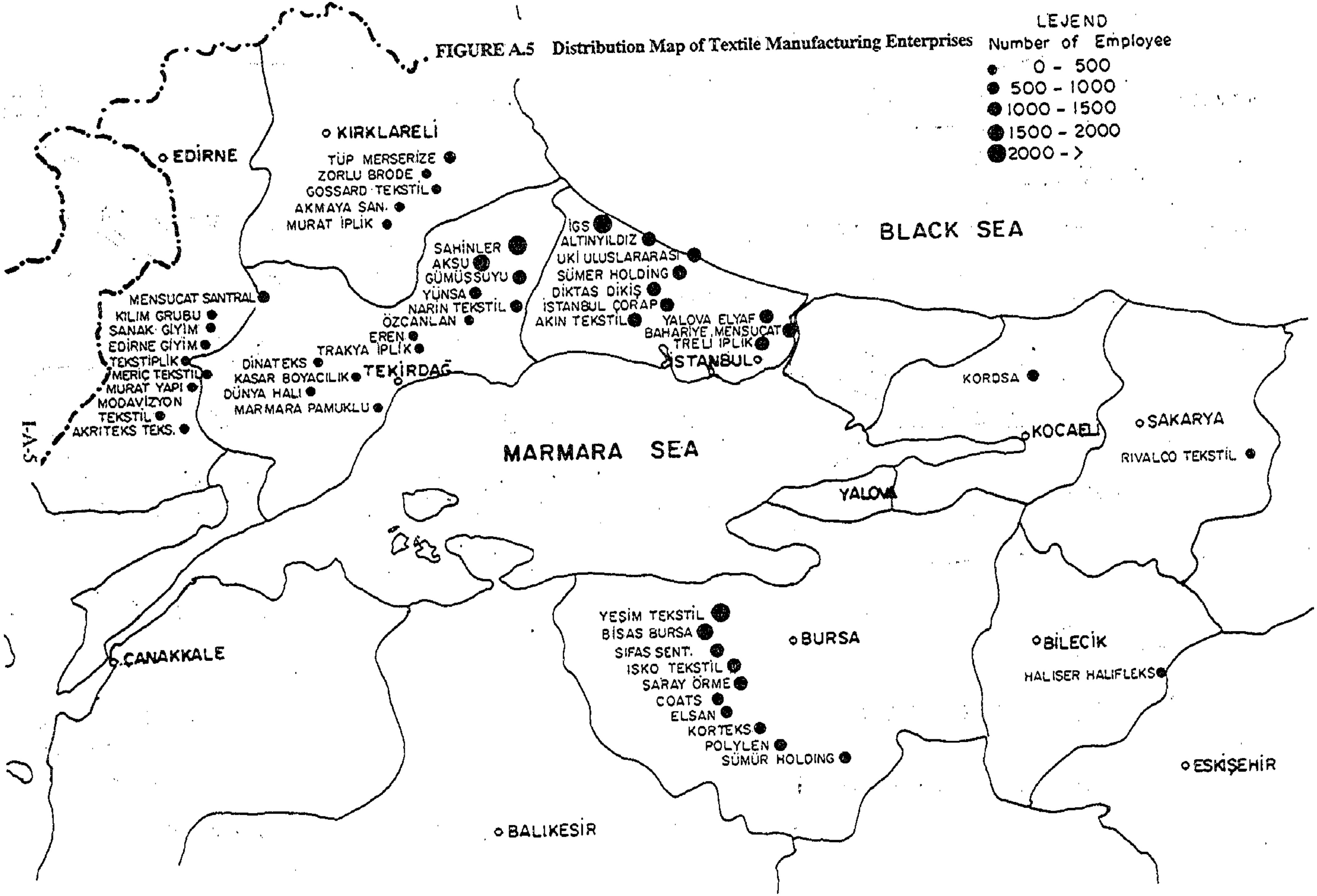


FIGURE A.6 Distribution Map of Paper Manufacturing Enterprises

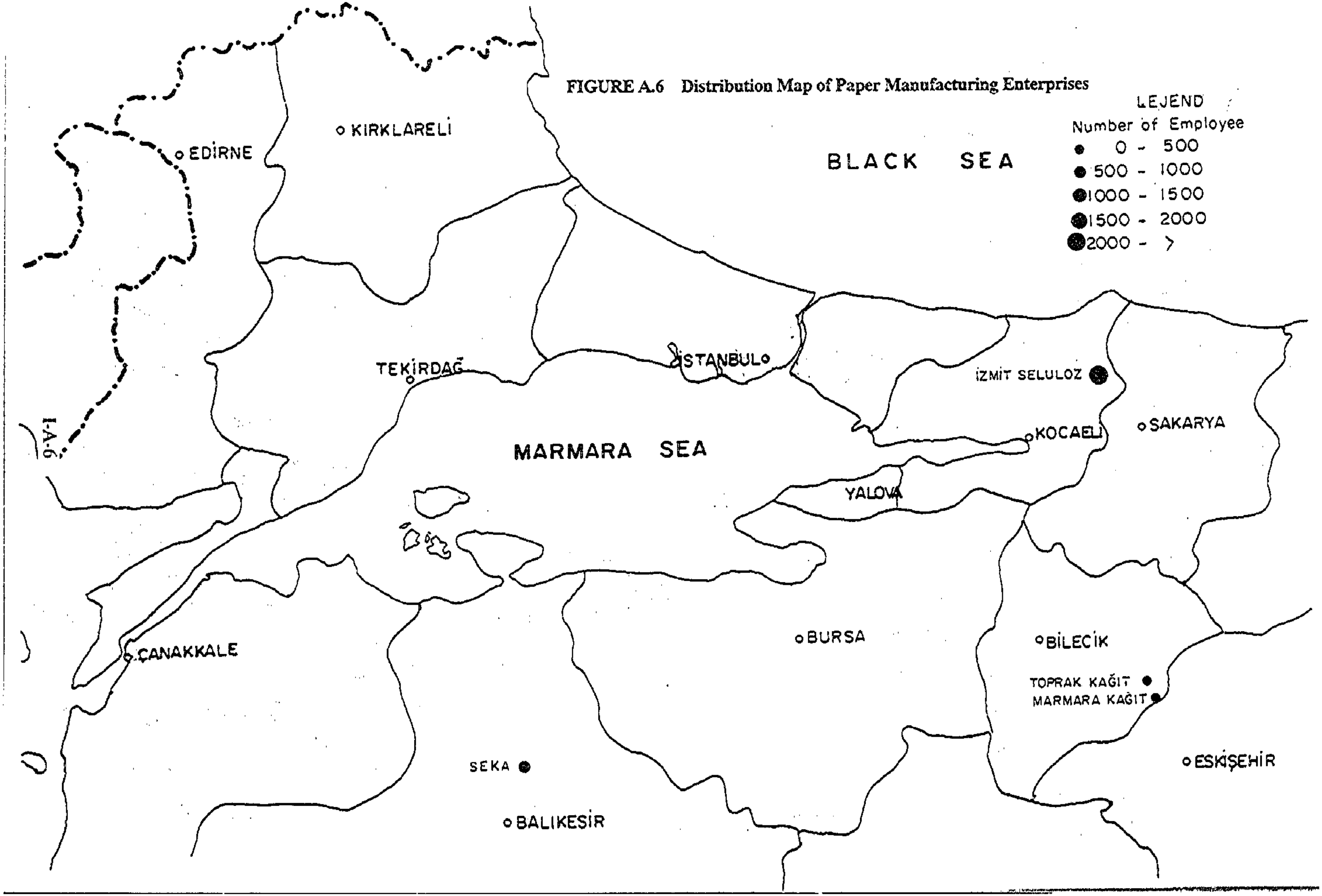


FIGURE A.7 Distribution Map of Chemical Manufacturing Enterprises

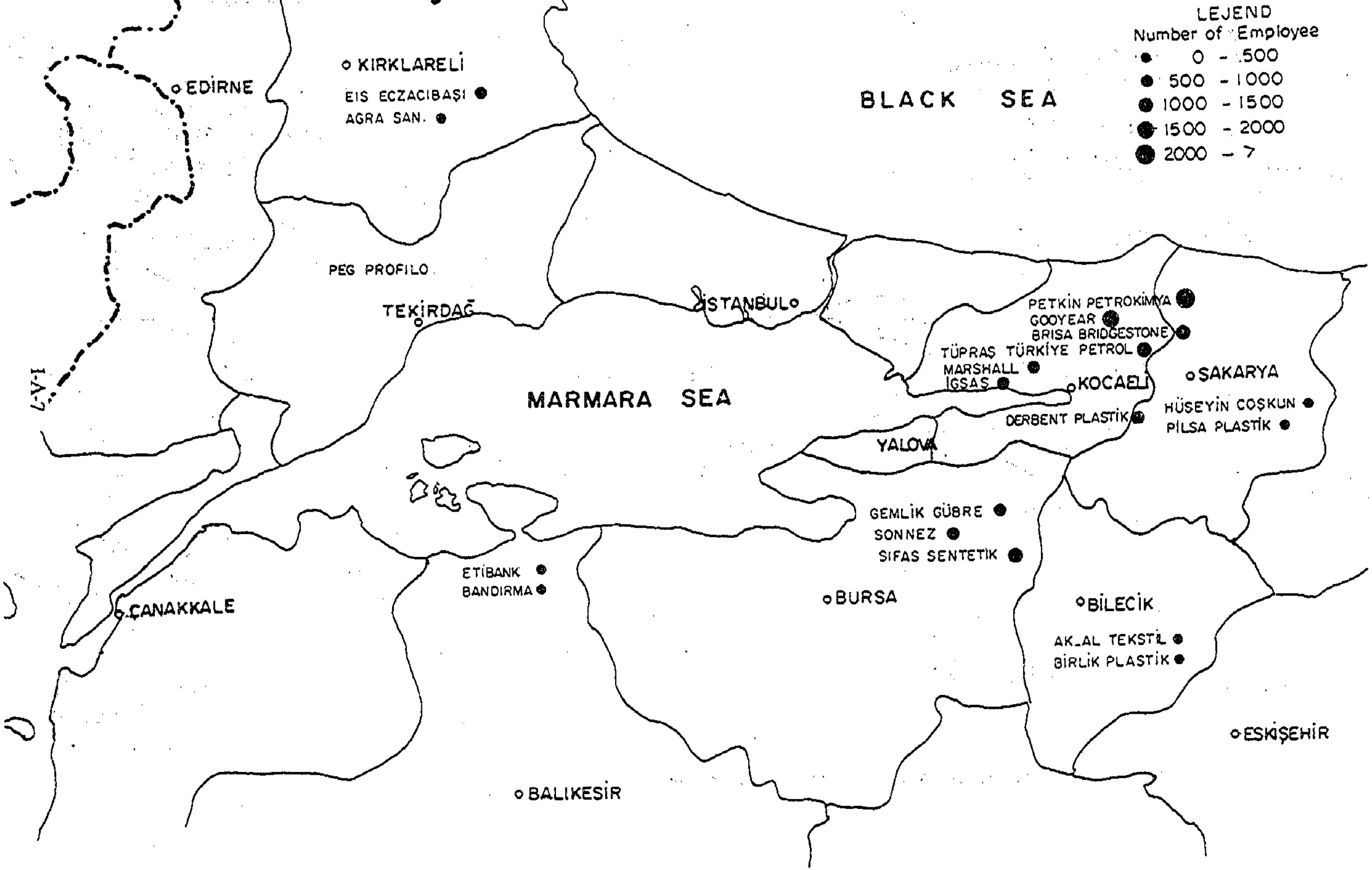


FIGURE A.8 Distribution Map of Mineral Manufacturing Enterprises

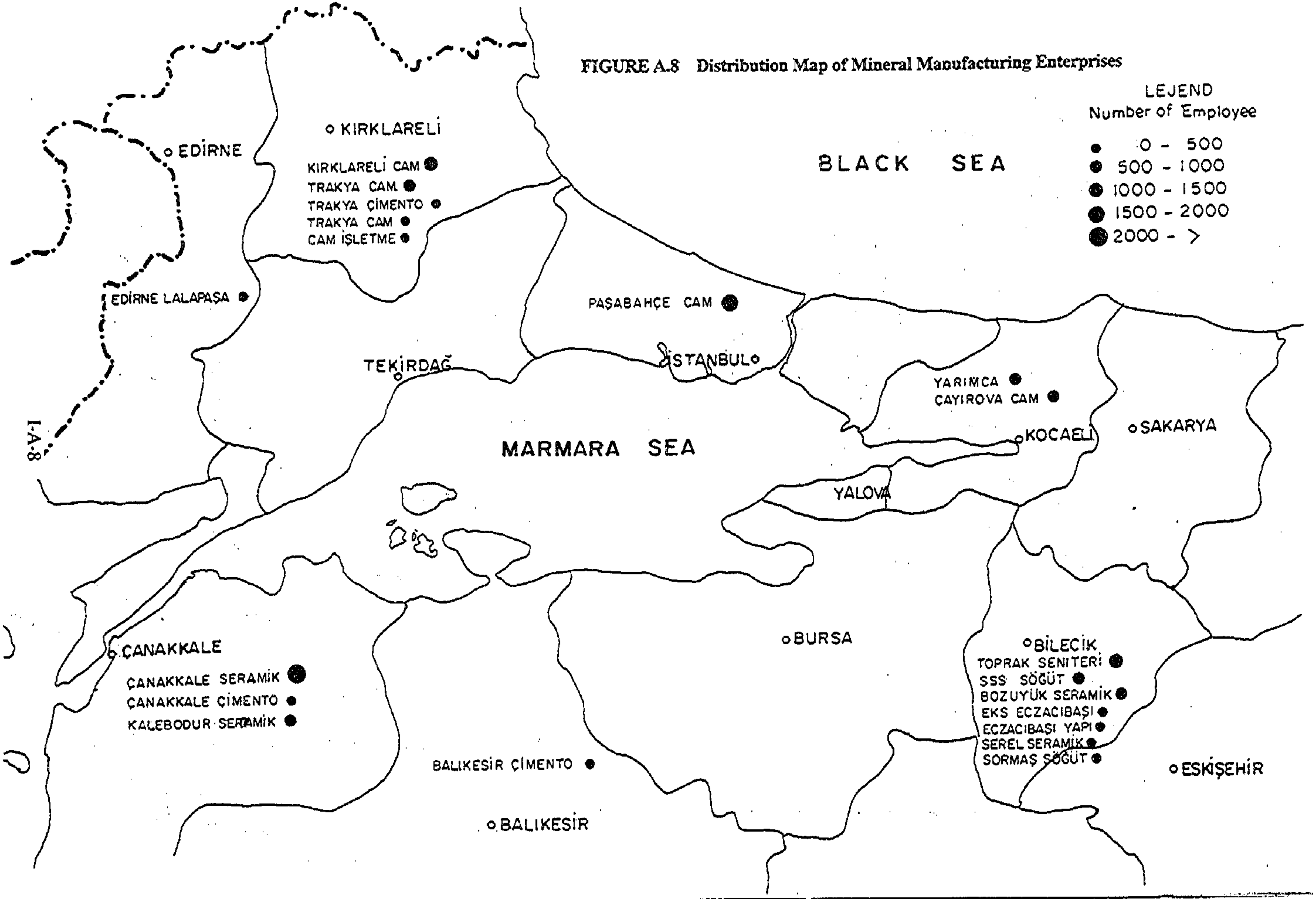
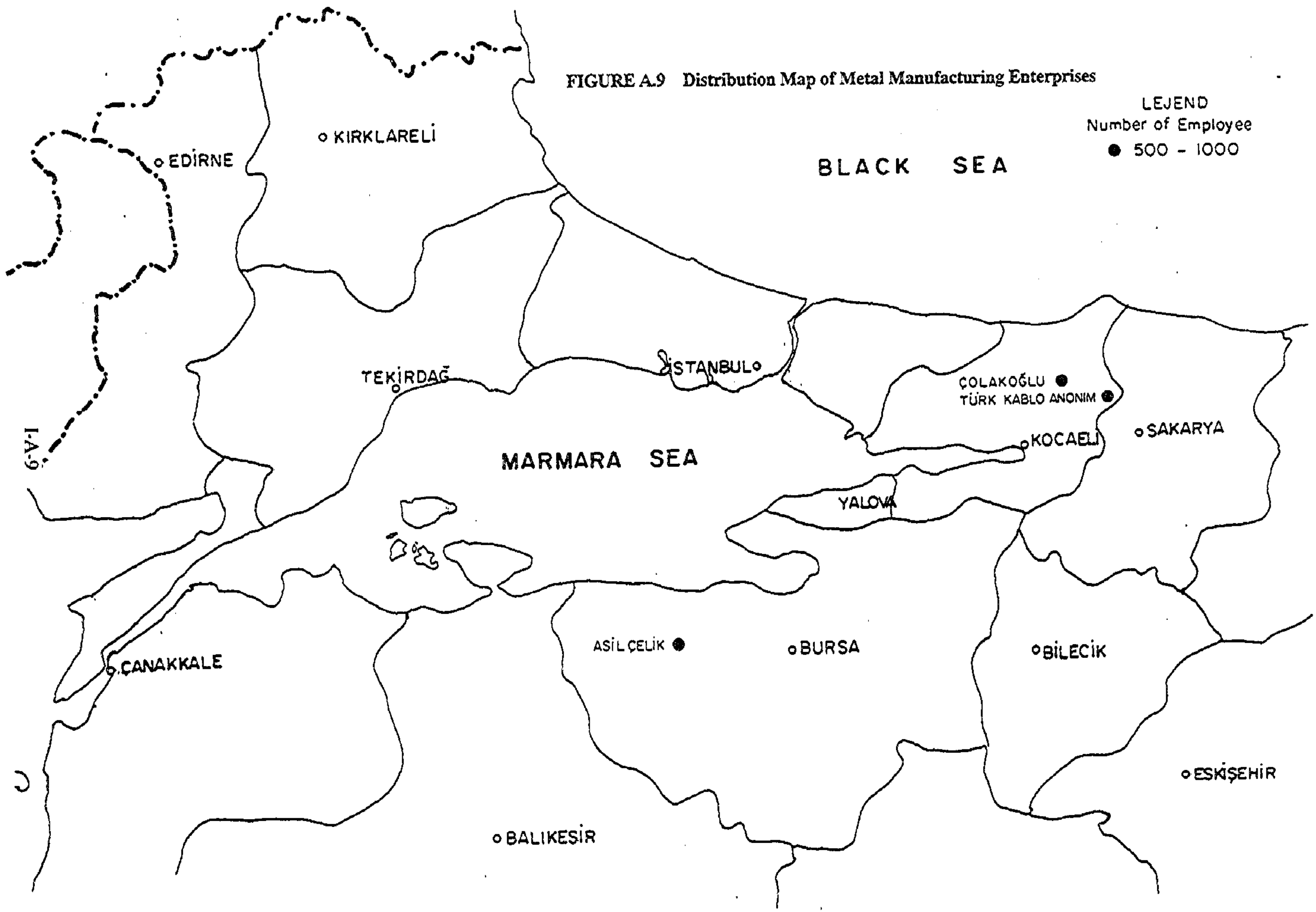


FIGURE A.9 Distribution Map of Metal Manufacturing Enterprises



JICA