Hydrogeology of Northwestern Turkey

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Introduction

This article has been prepared as a part of the final volume of the MARMARA Poly-Project and presents hydrogeologic information about Northwestern Turkey obtained from various reports and studies.

The area covered by this report is situated in NW Turkey, around the Marmara sea. The boundaries of the studied region are the Greek and Bulgarian borders and the Aegean sea to the west; the Black sea to the north, the Sakarya river to the east and the line Bakırçay valley-Soma-Sındırgı to the south. The surface area of the region is about 67,000km^2. The main part of the studied area belongs to the Marmara region.

Topography and climate

The region has mountain ranges that are neither very high nor continuous. The hills and mountains of the region are the Yıldız (İstranca) and Samanlı mountains, the Uludağ (2543m a.s.l.), the Kazdağ (1774m a.s.l.) and the Çatalca and Kocaeli hills. The lowlands are the Ergene basin; Adapazarı, Pamukova, Bursa, Gönen, İnegöl and Yenişehir plains; bottom of the Marmara sea; İzmit and Gemlik gulfs; Ulubat, Manyas, İznik and Sapanca lakes.

The Marmara type climate prevails around the Marmara sea, i.e. a transitive climate between the Mediterranean and the Black sea climates. The effect of the Mediterranean climate decreases from south to east. A steppe climate is seen in Bilecik and the Ergene basin. The climate of the Balkans and inner Anatolia prevails from time to time because of the discontinuous mountain ranges. The climate, in general, is hot and dry in the summer and cold and wet in the winter. The annual average snowy days are less than 10, but in Uludağ more than 60. In Sarıyer (İstanbul), the annual average precipitation is 752mm and the average temperature is 13.8°C. In Kırklareli, the annual average precipitation is 576mm and average temperature is 13.2°C. The Mediterranean climate is hot and dry in the summer, warm and wet in the winter. In Bergama, the annual precipitation is 755mm and the average temperature is 16.1°C. The Black sea climate is wet and warm in the summer and wet and cold in the winter. In Bartın (Zonguldak), the annual average precipitation is 1071mm and the average temperature is 13.1°C. Figure 1 shows the average precipitation of the region.

Penman's water budget of Kartal (İstanbul) and Thornthwaite's water budget of Bursa and Bergama are given in Appendices 1, 2 and 3.

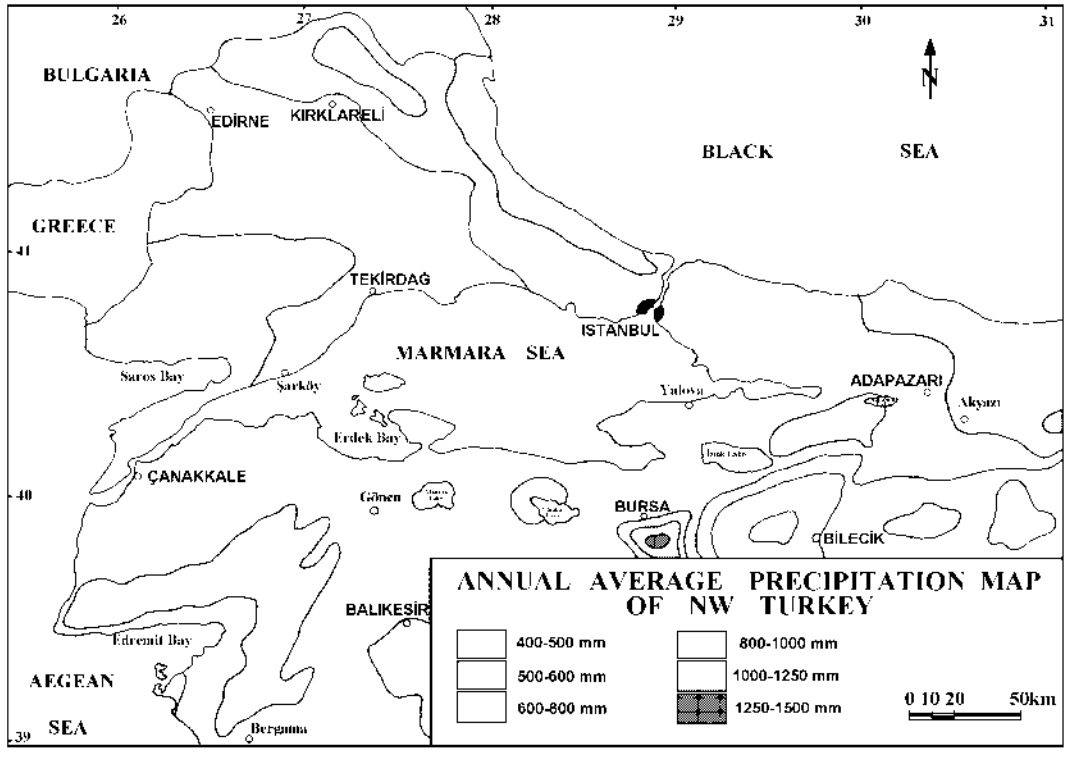

Figure 1: Annual average precipitation map of Northwestern Turkey.

Hydrogeology

The hydrogeological setting of the Marmara region is summarised in this section.

Hydrology

Streams and lakes

The main streams that drain the important plains and lakes in the Marmara region are shown in Appendix A and listed in Appendices 4 and 5. The Ulubat and Manyas lakes are situated in the southern part and the İznik and Sapanca lakes are situated in eastern part of the Marmara region. The Büyük Çekmece and Küçük Çekmece lakes are situated within the boundary of İstanbul.

Wells and springs

The ranges of depth and yield for the drilled wells are given in Appendix 6 and their chemical characteristics are given in Appendix 7. Some cold water springs in the Marmara region, their average yields and their chemical characteristics are listed in Appendix 8. The location of all wells and cold water springs mentioned in Appendices 7 and 8 can be found in Appendix B.

Geological conditions

The Marmara region is covered by a wide variety of igneous, sedimentary and metamorphic rocks ranging in age from Paleozoic to Quaternary.

Paleozoic formations cover a wide area in the Marmara region, such as the Kapıdağ peninsula, Balıkesir, Bursa, İstanbul, the Kocaeli peninsula and Adapazarı-Çamdağ. The Paleozoic formations that are located at both sides of the Bosphorus and Kocaeli peninsula begin with Ordovician and end with Carboniferous. The Ordovician units are composed of some clastic rocks referred to as the Arkose or Kocaeli series. The Silurian units are composed of limestone and shale. The Çarboniferous units are composed of claystone, siltstone and sandstone, which are known as the Trakya (Thrace) series.

The Paleozoic stratification at Çamdağ, that is located between Adapazarı and Düzce, is composed of Ordovician-Silurian age clastic sediments, such as arkose, subarkose and arkosic conglomerates and Devonian age sedimentary oolitic iron deposits. Devonian age rocks overlie the Ordovician-Silurian aged rocks transgressively.

Mesozoic formations are seen from the Triassic to the Upper Cretaceous in the Marmara region. The Paleozoic aged rocks are overlain by the Triassic age rocks unconformably. Also, the Triassic age rocks are overlain by the Cretaceous aged rocks unconformably. The Triassic-Jurassic age rocks begin with a series of red coloured conglomerate-sandstone that is 50-1000m thick at the south of Gebze and Hereke. This series is overlain by yellow coloured clay and fossiliferous limestone. This limestone is overlain by grey coloured and intercalated limestone that has a thickness of 100-300m. Green-grey coloured shales overlie all of these formations.

The Triassic-Jurassic units are transgressively overlain by the Upper Cretaceous age units with an angular unconformity. The Upper Cretaceous age units begin with a 50-100m thick conglomerate and Rudist containing limestone. This unit is overlain by a 150-300m thick white coloured marl intercalated with shale, which in turn is overlain by a 55m thick sandy limestone.

Cenozoic formations are widely seen in the Marmara region, especially in the Thrace basin. The sequence begins with Paleocene that overlies the İstranca massif unconformably. The Paleocene age rocks consist of sandstone, sandy-clay and fossiliferous limestone. Widespread sedimentation is seen in the Eocene. It generally consists of limestone. The Neogene formations are seen in most of the Marmara region which may be seen in continental facies. The thickness of sediments in the Thrace basin reaches up to 6000m.

The *Quaternary age rocks* are mostly seen as alluvium composed of sand, silt and clay.

The *intrusive rocks* of Northwestern Anatolia are generally acidic. They are seen in the İstranca, Uludağ, Çataldağ, Eğrigöz and Kozak massifs, the Kocaeli and Kapıdağ peninsulas and between Balıkesir and Bursa.

The *metamorphic rocks* of the İstranca massif are composed of metagranite, micaschist, marble, calcschist, quartzite and phyllite. The metamorphic rocks seen in Uludağ are gneiss, amphibolite, calcschist and marble overlain by phyllite and recrystallised limestone metamorphosed in greenschist facies The Kazdağ massif is composed of marble, gneiss and amphibolite.

Water bearing properties of rocks

Water bearing properties of the rocks seen in the Marmara region are summarised in the following section and shown on the hydrogeologic map of the region. (Figure 2).

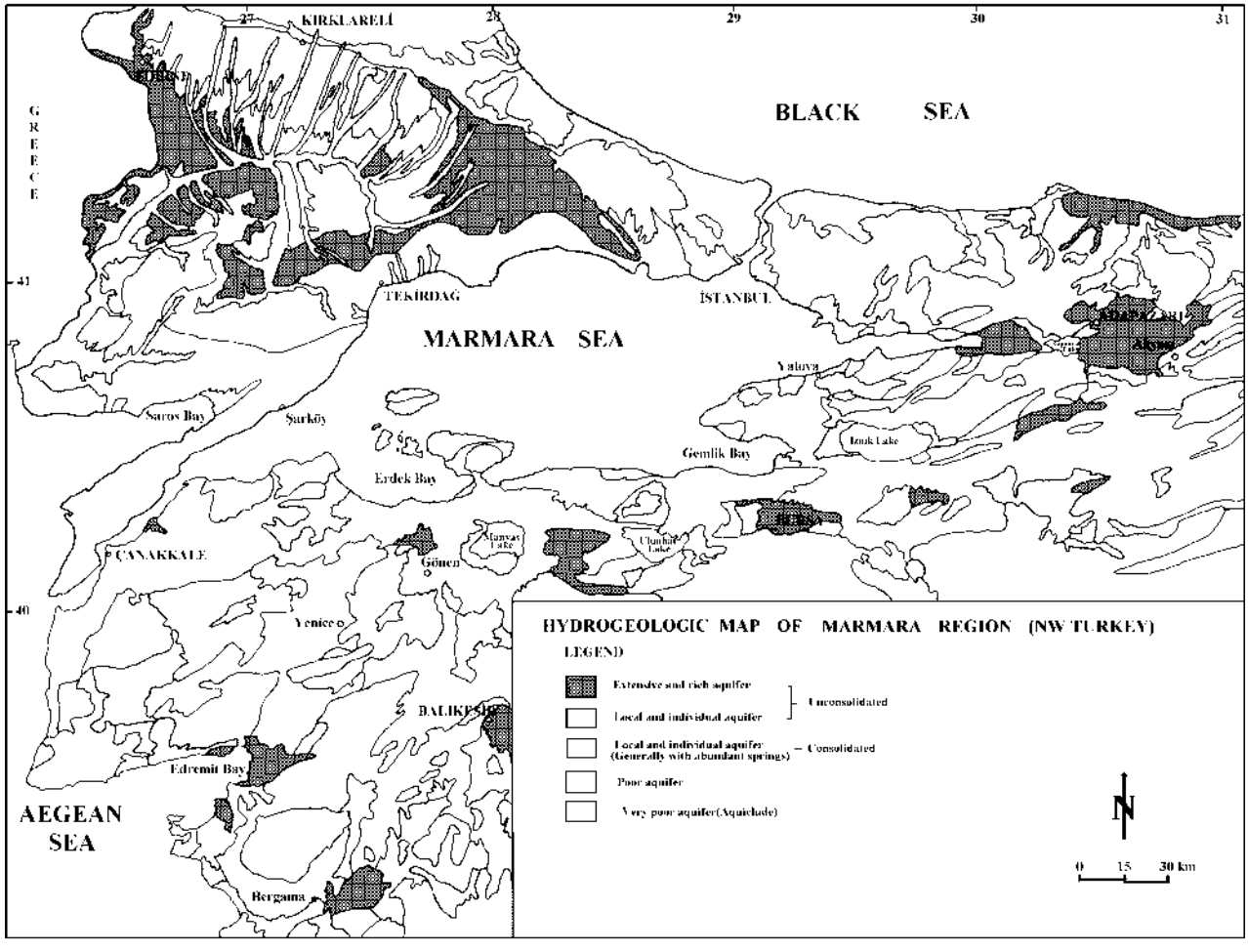

Figure 2: Hydrogeologic map of the Marmara sea region.

Rich and extensive aquifers

Unconsolidated formations (nonindurated sediments), such as Quaternary-Pliocene age alluviums, are generally extensive and rich aquifers. Their groundwater productivities are good. Specific capacities of the wells drilled in these formations are greater than 2l/s/m.

The most important alluvium aquifer of the region is in the Ergene basin. The transmissibility of this aquifer has a range of between 200-2000m/day. Other important alluvium aquifers of the region are seen in Sakarya, Bakırköy (İstanbul), İznik-Orhangazi, Yenişehir, İnegöl, Bursa, Karacabey, Sarıköy-Gönen, Gümüşçay, Yalova, Gemlik and the Kocaeli plains.

Local and individual aquifers

Some Quaternary age alluvia and Neogene age sand-gravel, as unconsolidated formations, and different ages of sandstone, conglomerate, flysch, limestone, marble, tuff, agglomerate, andesite, granite, gabbro, as consolidated formations, are local and individual aquifers. Their groundwater productivities are medium. Specific capacities of the wells drilled in these formations vary between 0.5-2l/s/m.

Poor aquifers

Quaternary, Pliocene-Quaternary and Neogene age clay-sand-gravel as unconsolidated formations, Neogene age sandstone, conglomerate, marl, limestone, tuff and agglomerate, as consolidated formations are poor aquifers. Their groundwater productivities are poor. Specific capacities of the wells drilled in these formations vary between 0.1-0.5l/s/m.

Very poor aquifers

Quaternary, Pliocene-Quaternary age clays and Neogene age clay-sand-gravel as unconsolidated formations, and different ages of well-cemented sandstone and conglomerate, marl, limestone, ophiolitic rocks, schist, quartzite, granite, andesite, peridodite, as consolidated formations are very poor aquifers. Their groundwater productivity is very poor. Specific capacities of the wells drilled in these formations are less than 0.1l/s/m.

Water quality

The electrical conductivity (EC) values of streams and lakes are given in Appendix 9 in order to give information concerning the water quality. The groundwater quality of the pilot wells is given in Appendix 7 and that of the springs in Appendix 8. Groundwater quality is generally suitable for irrigation and domestic use in the Marmara region. But, because of overpumping, groundwater has become salty (saline) in some coastal aquifers such as İstanbul-İzmit, Bakırköy-K.çekmece and the Yalova-Hersek plains. It is also partly contaminated in large cities (such as İstanbul and İzmit) because of leakage from sewers.

In the İznik-Orhangazi-Gemlik plain, the dominant anions are HCO_3-CO_3, hardness is between 13.5-40°fH and EC is 274-1387μS/cm. At the north of Orhangazi the groundwater is corrosive.

In the Silivri-Enez plain, EC is generally between 600-2250μS/cm inland but, at the sea shore and in deep wells, it is greater than 15,000μS/cm. pH values are greater than 7 and hardness is between 3-30°fH. For drinking water, bacteriological analyses are necessary because of high nitrite in some locations.

In the Gölpazarı plain, groundwater quality is sufficient for drinking, domestic use and irrigation.

In the Bursa-Çayırköy plain, the dominant anions are HCO_3-CO_3 and partly incrustative. EC is greater than 1150μS/cm for deep wells.

In the north Ergene plain, the dominant cation and anion are Ca-HCO_3. EC is between 240-700μS/cm, pH 6.8-7.8 and hardness 10-36°fH.

In the Edremit plain, EC is between 250-1500μS/cm, pH 7.5-8.4 and average hardness 20°fH.

Safe yields of the plains

The safe yields of the plains are given in Appendix 10. Because of overpumping, lowering of groundwater level and seawater intrusion are observed in İstanbul-İzmit, Bakırköy-K.çekmece and the Yalova-Hersek plains.

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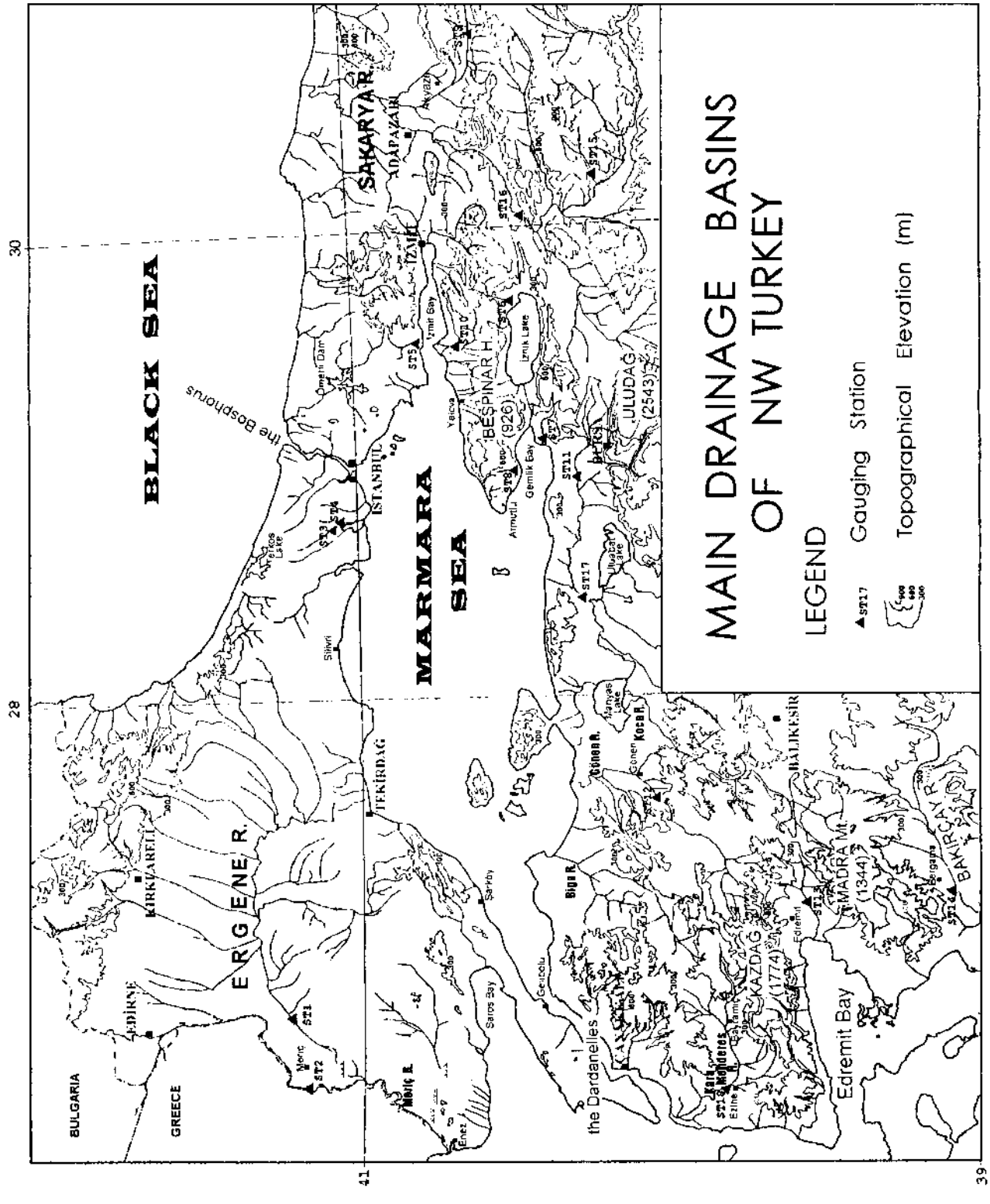
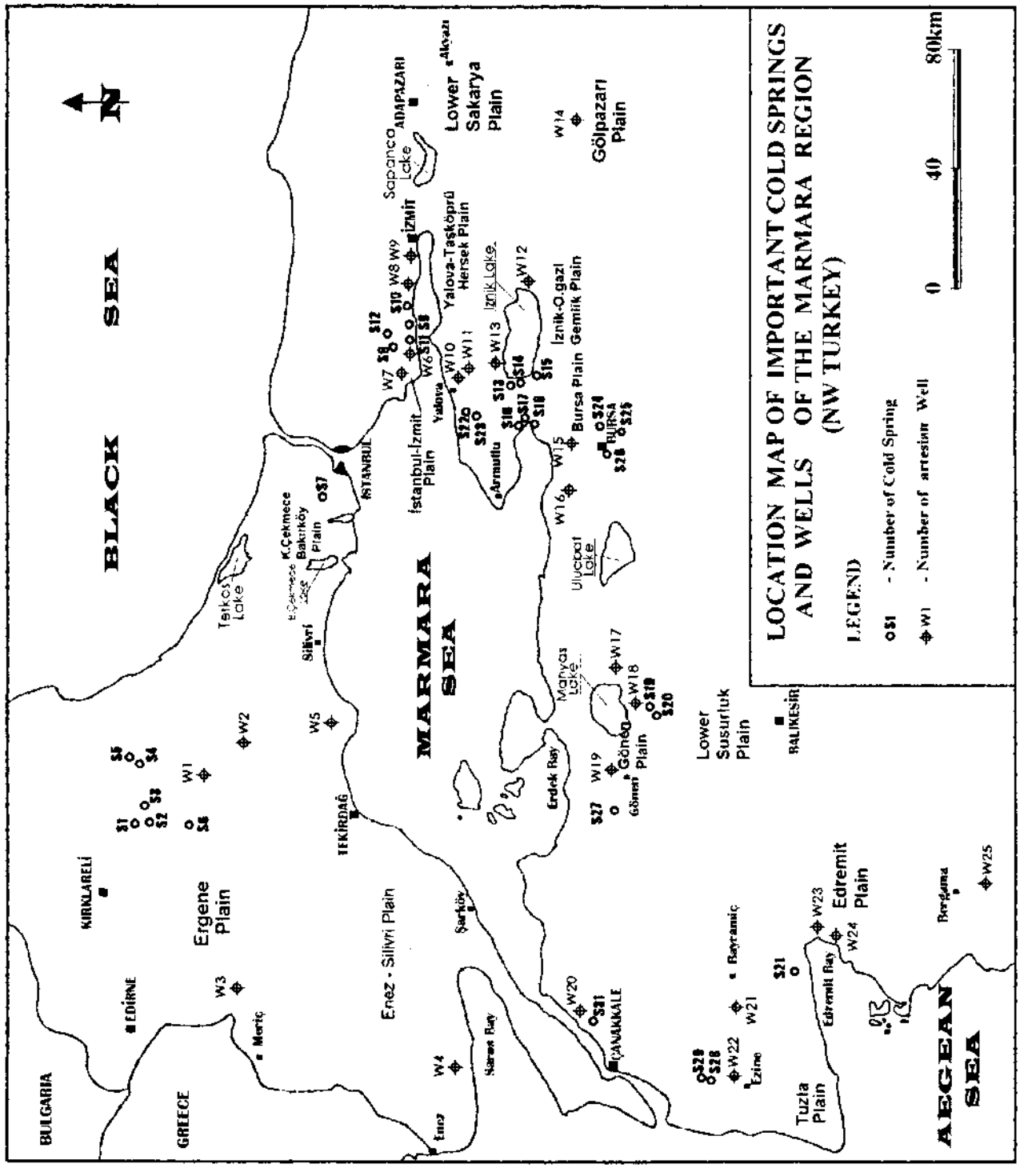
Appendices



Appendix A: Main drainage basins of Northwestern Turkey.



Appendix B: Location map of important cold springs and wells of the Marmara sea region.

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	annual
Temperature, t, (°C)	6.5	7.0	7.8	12.6	17.2	21.6	24.0	24.2	21.1	16.4	12.6	9.0	15.0
Pot. evapotranspiration ,Ep,(mm)	13.1	21.7	36.6	57.7	84.5	114.8	144.3	123.4	73.1	35.8	21.0	13.8	739.8
Precipitation, P,(mm)	96.5	79.0	71.3	47.7	30.5	19.2	19.9	18.7	46.8	59.8	82.0	109.7	678.1
P-Ep (mm)	83.4	57.3	34.7	-13.0	-54.0	-95.6	-124.4	-104.7	-26.3	24.0	61.0	95.9	-61,7
Reserve water	100.0	100.0	100.0	87.0	33.0	0.0	0.0	0.0	0.0	24.0	85.0	100.0	
Real evapotranspiration, Er, (mm)	13.1	21.7	36.6	57.7	84.5	52.2	19.9	18.7	46.8	35.8	21.0	13.8	421.8
Deficient water (mm)	0.0	0.0	0.0	0.0	0.0	62.6	124.4	104.7	26.3	0.0	0.0	0.0	318.0
Excess water (mm)	83.4	57.3	34.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.9	256.3
Flow (mm)	62.0	59.6	47.1	23.6	11.8	5.9	3.0	1.5	0.7	0.4	0.2	40.5	256.3
Deficiency of flow according to the precipitation	34.5	19.4	24.2	21.1	18.7	13.3	16.9	17.2	46.1	59.4	81.8	69.2	421.8

Appendix 1: Penman's water budget of Kartal -Istanbul (Kiliç 1977).

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	annual
Temperature, t, (°C)	5.3	5.9	8.0	12.6	17.3	21.6	24.2	23.9	19.7	15.5	11.4	7.5	14,4
Temperature index	1.1	1.3	2.0	4.0	6.5	9.0	11.0	11.0	8.0	5.4	3.4	1.8	5.0
Gross evapotranspiration (mm)	16	19	28	50	75	100	120	118	90	65	45	25	60
Precipitation (mm)	91	85	72	57	56	30	30	16	42	57	77	97	709
Fluctuation of reserve water (mm)	0	0	0	0	-37	-63	0	0	0	0	+40	+77	
Reserve water (mm)	100.0	100.0	100.0	100.0	63	0	0	0	0	0	40	100	
Real evapotranspiration (mm)	13	16	29	55	93	93	30	16	42	57	37	20	388
Deficient water (mm)	0	0	0	0	0	32	121	123	52	5	0	0	333
Excess water (mm)	78	69	43	2	0	0	0	0	0	0	0	17	209
Flow (mm)	43	56	49	25	12	6	3	2	1	0	0	8	209
Deficiency of flow according to the precipitation	48	29	23	32	44	24	7	14	41	57	77	89	388

Appendix 2: Thornhwaite's water budget of Bursa (Göçmen 1973).

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	annual
Temperature, t, (°C)	7.5	8.3	9.7	13.8	18.5	23.1	25.3	25.0	21.3	16.8	13.2	9.6	16.0
Temperature index	1.85	2.15	2.73	4.65	7.25	10.15	11.64	11.44	8.97	6.26	4.35	2.69	74.13
Gross evapotranspiration (mm)	16	19	25	45	75	108	122	118	94	63	42	25	752
Precipitation (mm)	146	94	72	46	40	17	7	5	14	50	109	150	750
Fluctuation of reserve water (mm)	0	0	0	-4	-52	-44	0	0	0	0	+74	+26	
Reserve water (mm)	100	100	100	96	44	0	0	0	0	0	74	100	
Real evapotranspiration (mm)	14	16	26	50	92	61	7	5	14	50	35	21	391
Deficient water (mm)	0	0	0	0	0	73	147	134	84	10	0	0	448
Excess water (mm)	132	78	46	0	0	0	0	0	0	0	0	103	359
Flow (mm)	92	85	66	33	17	8	4	2	1	0	0	51	359
Deficiency of flow according to the precipitation	54	9	6	13	23	9	3	3	13	50	109	99	391

Appendix 3: Thornthwaite's water budget of Bergama (Koç 1976).

Nr.	Name of Stream	Name of Plain	Catchment Area(km^2)	Average Discharge (m3/sec)	Observation Period (year)
ST1	Ergene (Uzunköprü)	Ergene	10194	25.84	22
ST2	Meriç (Meriç Bridge)	Ergene	27250	150	22
ST3	Sazlıdere	K.Çekmece - Bakırköy	84	0.89	11
ST4	Nakkaş	K.Çekmece - Bakırköy	43	0.25	21
ST5	Tavşanlı	İstanbul - İzmit	125	1.125	1
ST6	Karadere	İznik -Orhangazi - Gemlik	220	1.708	18
ST7	Kocadere	İznik -Orhangazi - Gemlik	77	0.7	24
ST8	Olukdere	İznik -Orhangazi - Gemlik	74	0.674	10
ST9	Mudurnu (Dokurcan)	Lower Sakarya (Akyazı)	1072	7.9	34
ST10	Yalakdere	Yalova-Taşköprü - Hersek	262	2.1	17
ST11	Nilüfer (Geçit)	Bursa	1290	16	32
ST12	Gönen (Kumköy)	Gönen	1192	14.6	19
ST13	Havran	Edremit	534	0.988	22
ST14	Bakırçay (Eğrigöl)	Bergama	2887	16	29
ST15	Akçay	Gölpazarı	37	0.13	2
ST16	Sakarya (Mekece)	Sakarya Basin	52372	170	4
ST17	Kocadere	Lower Susurluk Basin	21611	135	38
ST18	Karamenderes (Ezine)	Çanakkale-Bayramiç	1584	12.845	29

Appendix 4: The main streams of the Marmara region.

Nr.	Name of lake	Area of lake (km^2)
L1	İznik	300
L2	Uluabat	240
L3	Manyas	200
L4	Sapanca	60
L5	B.Çekmece used as reservoir	23

Appendix 5: The lakes of the Marmara region.

Name of plain	Depth range (m)	Yield range (lt/sec)
Ergene	30-450	0-40
Bursa	20-300	24-51
İstanbul-İzmit	32-236	0-10
İznik-Orhangazi-Gemlik	10-237	2-53
Yalova-Taşköprü-Hersek	16-243	0-25
Gönen	10-534	0-15
Edremit	33-102	2.5-60
Lower Sakarya-Adapazarı	80-120	20-22
Tuzla	814-1020	0-10
Gölpazarı	18-294	4-16
Bergama	50-250	0.1-36.8
Çanakkale-Bayramiç	31-159	8.1-39.8
K.Çekmece	10-400	0-40
Çanakkale-Lapseki	73-139	17.3-26.7
İzmit-Sapanca	10-180	1-23
Lower Susurluk	28-300	0-40

Appendix 6: Depth and yield ranges of wells in the Marmara region.

Appendix 7: Chemical characteristics of drilled wells by DSİ (values in mval/l).

Well no	Name of plain	pH	EC (μS/cm)	Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^- + $CO_3^=$	Cl^-	SO_4^{2-}
W1	Ergene (Ahmetbey)	6.7	570	1.5	21.1	4.2		3.3	0.9	1.5
W2	Ergene (Beyazköy)	7.9	470	1.5	0.6	3.2		3.5	0.8	0.5
W3	Ergene (Pehlivanköy)	8.3	700	5.1	0.1	1.1		0.5	4.4	1.4
W4	Enez	8.3	600	1.4	0.06	4.8		3.9	1.2	1.0
W5	Silivri	7.4	2225	13.2	0.25	8.4		5.1	9.4	7.4
W6	İstanbul-İzmit (Çayırova)	7.9	600	1.6		2.8		4.8	1.1	0.1
W7	İstanbul-İzmit (Dilovası)	8.2	700	2.6		4.9		6.1	0.4	0.9
W8	İstanbul-İzmit (Yarımca)	8.2	740	2.5		6.2		4.7	1.8	2.2
W9	İstanbul-İzmit (Derince)	7.9	500	0.7		4.6		2.9	0.7	1.7
W10	Yalova-Taşköprü-Hersek	-	370	1.1		2.8		2.4	0.4	1.0
W11	Yalova-Taşköprü-Hersek	-	1600	13.0		2.4		7.0	7.0	1.6
W12	İznik-Orhangazi-Gemlik (İznik)	-	800	1.3		4.2	2.9	6.9	0.5	1.3
W13	İznik-Orhangazi-Gemlik (Orhangazi)	-	456	2.3		2.9		4.2	0.5	0.5
W14	Gölpazarı	-	620	1.6		3.3	1.1	5.0	0.3	0.4
W15	Bursa-Çayırköy (Bursa)	-	1150	2.5	0.1	8.0		4.5	3.0	4.5
W16	Bursa-Çayırköy (Çayırköy)	-	530	0.7	0.1	5.0		5.0	0.3	0.8
W17	Lower Susurluk (Karacabey)	7.5	560	1.8	0.0	1.7	1.9	4.0	0.5	1.2
W18	Lower Susurluk (Manyas)	8.2	730	4.2	0.0	2.2		5.3	1.3	0.8
W19	Gönen	7.9	400	0.7	0.07	2.3	1.1	3.5	0.3	0.3
W20	Çanakkale-Lapseki	8.2	1800	8.7	0.2	5.7	3.3	4.0	10.6	5.2
W21	Çanakkale-Bayramiç	8.1	700	1.0	0.1	4.7	1.0	5.4	0.9	0.4
W22	Çanakkale-Bayramiç	7.9	680	1.7	0.1	3.7	1.2	4.9	1.1	0.6
W23	Edremit	7.3	860	4.2	0.1	4.1	0.3	2.7	1.1	4.8
W24	Edremit	8.1	1000	3.5	0.1	4.2	2.9	5.8	1.0	4.0
W25	Bergama	7.3	660	1.3		5.5		5.4	0.6	0.8

Appendix 8: Chemical characteristics and average yields of springs (values in mval/l).

Spring no	Name of Spring	Name of plain	Average yield of spring (lt/sec)	pH	EC (μS/cm)	Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^- + $CO_3^=$	Cl^-	SO_4^{2-}
S1	Kaynarca	North Ergene	480	7.5	530	0.70	0.02		5.00	4.10	0.80	0.87
S2	Pınarhisar	North Ergene	65	7.1	530	0.50	0.04		5.00	4.30	0.68	0.56
S3	Poyralı	North Ergene	95	7.3	540	0.60	0.06		4.80	4.20	0.68	0.58
S4	Karpuzkaldıran	North Ergene	80	7.4	550	0.41	0.04		5.10	4.60	0.56	0.39
S5	Balkaya	North Ergene	350	7.5	600	0.36	0.03		5.70	5.40	0.41	0.25
S6	Kocakaynak	Ergene	357-560	8.2	500	0.58	0.11		4.20	3.40	0.68	0.81
S7	Altınşehir	K.Çekmece-Bakırköy	35	7.3	450	0.70	0.00	3.90	0.05	1.00	0.94	1.66
S8	Ovabaşı	İstanbul-İzmit(Dilovası)	24	7.5	670	0.30	0.04		6.60	6.31	0.40	0.23
S9	Küplü	İstanbul-İzmit(Dilovası)	17	7.4	510	0.16	0.04		4.90	4.68	0.24	0.18
S10	Ulupınar	İstanbul-İzmit(Dilovası)	100	7.1	800	0.94	0.02		6.90	5.86	1.08	1.15
S11	Ballıkaya	İstanbul-İzmit(Dilovası)	13	7.8	360	0.31	0.03		3.50	3.06	0.36	0.42
S12	Çayıraçma	İstanbul-İzmit(Dilovası)	28	7.6	630	0.21	0.05		6.40	6.08	0.36	0.22
S13	Nadir	İznik-Orhangazi-Gemlik	100	6.8	380	0.12	0.01	3.98	0.38	4.10	0.11	0.12
S14	Gedelek	İznik-Orhangazi-Gemlik	130	6.8	460	0.13	0.01	4.77	0.39	4.90	0.11	0.12
S15	Karsak	İznik-Orhangazi-Gemlik	2	7.0	595	0.34	0.03	5.70	0.64	5.96	0.44	0.26
S16	Ilıpınar	İznik-Orhangazi-Gemlik	100	6.5	560	0.34	0.04	5.35	0.70	5.19	0.27	0.21
S17	Kumla	İznik-Orhangazi-Gemlik	100	6.3	344	0.15	0.02	3.21	0.47	3.54	0.11	0.13
S18	Cihatlı	İznik-Orhangazi-Gemlik	40	7.2	500	0.23	0.01	5.00	0.60	4.92	0.22	0.38
S19	Hacıyakup	Lower Susurluk	173	7.7	470	0.31	0.04		3.70	3.24	0.40	0.41
S20	Değirmenboğazı	Lower Susurluk	100-150	8.0	350	0.41	0.05		2.70	2.36	0.54	0.26
S21	Güre	Edremit	150	7.5	186	-	-		2.10	1.70	0.40	-
S22	Sellimandıra1	Yalova-Taşköprü-Hersek	20	8.3	480	1.55	0.66		3.50	2.10	0.50	2.50
S23	Sellimandıra2	Yalova-Taşköprü-Hersek	20	-	-	-	-	-	-	-	-	-
S24	Karapınar	Bursa	276-2383	7.2	353	0.09	0.06	3.20	0.66	3.30	0.13	0.52
S25	Pınarbaşı	Bursa	43-582	6.8	502	0.30	0.05	2.65	1.25	3.52	0.21	0.31
S26	İnkaya	Bursa	50	7.4	484	0.22	0.03	3.80	1.66	4.65	0.16	0.73
S27	Hafızhüseyinbey	Gönen	7	7.3	600	0.26	0.04	3.80	1.07	4.50	0.32	0.20
S28	Pınarbaşı	Çanakkale-Bayramiç	600-1500	-	-	-	-	-	-	-	-	-
S29	Kokana	Çanakkale-Bayramiç	50	-	-	-	-	-	-	-	-	-
S30	Akpınar	Çanakkale-Lapseki	10	-	-	-	-	-	-	-	-	-

Nr.	EC(μS/cm)
ST5	540
ST6	400-680
ST10	500
ST11	290-500
ST12	400
ST13	400-480
L1	1150-1300
L2	<1500
L3	<1500

Appendix 9: Electric conductivity (EC) values of some streams and lakes.

Name of plain	**Safe yield ($x10^6$ m^3/year)**
North Ergene	45.5
Ergene	274
İstanbul-İzmit	10
Gönen	29
İznik-Orhangazi-Gemlik	39.5
Yalova-Taşköprü-Hersek	15
Bursa	40
Edremit-Armutova	64.5
Lower Sakarya(Akyazı)	65
Bakırçay-Bergama	45
Gölpazarı	2.45
Lower Susurluk	72.5
Çanakkale-Bayramiç	26
Enez-Silivri	17.5
K.Çekmece-Bakırköy	11
İzmit-Sapanca	37

Appendix 10: The estimated safe yields (by DSİ) of some plains of the Marmara region.