CHARPTER 3

DATA GATHERING AND DATA PREPARATION

3.1 Data Gathering

The DRASTIC method was used to obtain seven layers of data from primary and secondary sources: hydrogeological data, collected directly from field investigation methods, such as groundwater levels and groundwater quality; and secondary data, existing data obtained from previous work, e.g. lithological logging data. Rainfall and soil series map data were obtained from the Meteorological Department and Land Development Department, respectively.

3.1.1 Hydrogeological data

Hydrogeological data (Chiang Mai and Lumphun Province) were collected from the Department of Mineral Resources (DMR, 1996) groundwater databases of drilling depths, well logs, and water quality.

Depth to groundwater level, known as static water level (SWL), was measured after the well's development had been completed. Groundwater levels for each well from the years 1974 to 2002 were obtained from the hydrogeological database "Pasutara" of the Department of Groundwater Resources. Data for a total of 5,009 wells situated in Chiang Mai basin were retrieved in the form of Dbase IV format (.dbf extension). Groundwater well data were clarified for integrity; there was no well duplication and groundwater levels at zero were not included. (Table 3.1).

Table 3.1 Groundwater database structure and wells.

Vill_Code	Well No	East	North	Diameter	Depth	SWL	EC	TDS
50151104	DOH	488,932	2,065,801	4.00	0.00	2.10	302	196.30
50120305	DMR	485,300	2,056,836	4.00	0.00	7.30	627	407.55
50120310	PWD8986	484,671	2,060,159	6.00	0.00	2.80	393	255.45
50120102	DOH	488,109	2,060,255	6.00	0.00	4.50	305	198.25
50140203	G0806	503,721	2,080,526	6.00	0.00	3.00	265	172.25

Aquifer data was obtained from digital provincial groundwater availability maps of DGR scale 1:100,000 made in the year 2002. Three provinces, Chiang Mai, Lumphun and Lampang Provinces were included in the Chiang Mai basin map.

Topography of terrain and contour lines were taken from a digital base map of Hydrogeological Information System; Hygis of DGR database.

Impact of vadose zone or unsaturated zones were obtained from well log samples analyzed by a DGR hydrogeologist and stored in coding form inbase IV format. The well logs were interpreted well by well and stored in the well database.

Hydraulic conductivity was determined from well pumping tests during well development and stored in DGR database system.

3.1.2 Secondary data sources

Rainfall and annual rainfall data, including location in the form of coordinates,, was obtained from the Meteorological Department; MD, in spread sheet data format. A total 61 rain gauge stations are located in Chiang Mai basin (Table 3.2), the amount of monthly rainfall intensity (millimeter per year) was also recorded.

Table 3.2 Average rainfall of the year 1999-2002 in Chiang Mai basin (MD, 2002).

LOCATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	EASTING	NORTHING
Fang	15.2	17.9	34.0	73.2	202.7	147.0	228.3	257.9	235.3	96.5	40.7	8.3	1357.0	524426	2198457
Mae Rim	2.8	3.7	2.9	39.0	196.4	125.4	107.1	199.7	166.8	25.1	0.0	0.0	868.9	498244	2084106
Jom Thong	5.9	12.2	21.8	49.7	159.7	67.9	69.7	154.1	182.3	118.0	51.9	12.9	906.1	470071	2032498
Doi Saket	4.9	10.7	19.7	42.5	163.6	109.4	133.9	221.0	197.7	70.4	43.9	9.5	1027.2	517561	2080426
Mae Taeng	8.6	10.1	27.2	32.9	162.5	130.0	208.2	231.9	184.2	75.7	64.0	8.6	1143.9	496493	2106234
Phrao	13.4	12.9	19.8	62.4	180.1	120.0	202.1	222.3	213.9	83.0	68.2	10.5	1208.6	517507	2137591
Mae Jam	0.0	0.0	1.7	4.8	127.2	88.3	127.2	189.5	182.6	44.5	5.2	5.9	776.9	434884	2039961
Omkoi	4.4	16.4	23.5	65.1	185.0	97.0	113.2	140.7	185.6	107.1	44.9	10.7	993.6	434625	1962516
S009 S	6.2	9.3	28.9	50.6	169.7	141.3	186.1	197.1	256.9	101.3	29.4	6.2	1183.0	475414	2080434
Hod	6.9	10.4	25.5	45.0	153.5	87.1	94.1	153.8	194.4	134.3	48.0	20.7	973.7	461212	2004855
Saraphi	4.3	6.2	27.3	40.5	145.0	108.2	105.1	195.8	203.3	105.0	46.9	11.8	961.6	505273	2061978
San Sai	6.3	8.2	22.5	27.0	130.7	95.7	117.5	197.7	162.5	64.7	35.7	6.1	874.6	505269	2078574
Hang Dong	6.1	15.7	20.7	41.8	131.4	121.0	137.8	202.6	148.3	61.7	45.3	8.2	940.6	491207	2052760
San Pa Tong	4.5	7.9	10.5	38.5	126.1	73.2	90.9	137.6	161.3	85.8	62.4	4.5	803.2	489444	2045385
San Kamphaeng	1.3	6.3	15.9	26.6	140.0	72.3	123.0	171.3	160.8	46.6	28.8	11.7	804.6	515817	2065672
Chiang Dao	13.7	9.4	16.5	39.6	204.9	139.0	181.4	230.2	219.7	77.4	44.5	9.4	1185.7	498249	2135739
Mae Ai	18.2	22.6	22.1	73.0	217.4	134.9	253.7	319.3	216.1	111.3	47.7	19.4	1455.7	529648	2205842
T.Ban An A.DoiTao	0.3	22.5	15.0	14.8	140.0	101.4	53.2	83.2	145.3	62.3	22.5	3.4	663.9	473524	1982708

Table 3.2 Average rainfall of the year 1999-2002 in Chiang Mai basin (continued).

LOCATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	EAST	NORTH
Fang Hort agicultural	13.7	20.6	24.5	66.6	219.9	156.1	241.4	306.8	212.0	101.2	49.2	12.4	1424.4	515695	2203928
Doi Suthep-Pui National	11.4	19.6	25.1	67.4	239.2	163.6	200.1	279.3	259.0	143.1	66.3	24.0	1498.1	492972	2078531
Phuphing Ratchaniwet	10.4	16.2	35.8	65.8	260.8	186.0	199.6	312.4	334.2	151.0	78.7	18.3	1669.2	489463	2076685
Bhumibol Dam	10.7	11.4	20.9	38.0	131.3	86.4	77.5	138.7	182.8	119.0	45.6	4.5	866.8	466465	1982675
Northern Petrolium	10.9	17.0	28.1	76.1	212.7	93.7	272.6	199.8	165.8	116.9	44.0	8.2	1245.8	522684	2196566
Sanpatong Rice Research	3.9	13.7	14.5	52.2	153.6	93.0	120.8	161.1	207.7	117.7	66.8	8.0	1013.0	489453	2058253
MaeHoPhra Forest Plantation	6.3	8.8	19.6	24.6	164.1	152.0	220.8	201.4	221.3	105.3	47.2	9.1	1180.5	522795	2108051
Chiang Dao watershed	11.2	3.9	22.6	44.8	214.3	195.9	227.9	277.6	283.6	94.2	50.2	21.1	1447.3	475500	2139398
Bo luang-BoKaew Plant Breeding	4.5	15.8	25.9	77.1	197.3	94.9	115.0	224.6	211.8	102.6	53.7	5.7	1128.9	436544	2006722
Jomthong agricultural	5.6	11.6	15.0	74.6	106.6	63.3	79.3	163.4	178.5	96.4	46.9	8.0	849.2	477133	2049037
Wiang Hang	7.5	9.6	14.3	56.8	206.0	116.4	195.5	231.7	190.3	81.6	30.3	9.4	1149.4	461539	2161551
Mae Jam Forest Plantation	5.5	19.6	19.6	137.0	170.3	103.2	130.4	169.3	202.9	80.5	36.6	11.5	1086.4	434828	2021476
Moving Devt Unit 32	11.6	13.0	14.9	50.2	170.7	111.9	174.5	202.7	195.8	65.2	34.7	9.0	1054.2	496504	2146761
Mae Jo	7.4	13.9	24.8	43.1	173.6	108.0	156.1	184.2	194.8	105.7	46.4	6.8	1064.8	500000	2091482
Chiang Mai	7.6	17.9	21.5	56.3	176.3	111.4	136.5	211.9	205.5	115.7	57.3	14.1	1132.0	498244	2076729
Jae Hom	4.9	12.3	27.0	63.6	193.9	120.3	154.8	215.2	227.7	75.9	46.9	5.1	1147.6	561513	2065766
Mae Tha	0.8	3.3	21.5	49.7	135.9	107.3	94.3	144.8	197.9	86.3	29.4	1.2	872.4	556446	1995679
Ngao	6.9	4.0	53.4	68.0	205.2	130.4	201.1	256.9	190.8	99.7	34.2	3.4	1189.7	605443	2067805
Hang Chat	1.2	4.6	28.0	45.5	131.6	113.1	129.8	176.0	226.9	81.8	33.8	0.8	973.1	540524	2017766
Thoen	3.0	8.9	47.6	86.1	225.8	93.7	88.1	162.6	263.5	152.8	42.5	4.2	1178.8	528296	1943990
Ko Kha	1.0	4.0	52.6	80.7	183.4	132.0	189.7	212.7	261.7	108.4	47.5	2.5	1276.2	544081	2003022
Sop Prap	1.3	9.0	15.9	51.7	77.5	81.5	58.9	122.4	137.0	76.6	34.2	0.0	666.0	537091	1969818
Wang Nua	9.0	9.9	26.5	84.0	205.9	127.4	200.0	246.3	251.1	107.6	36.5	8.9	1304.1	566627	2110042
Mae Phrik	7.8	9.9	42.1	45.5	199.4	141.5	67.5	128.5	240.4	143.2	53.2	2.7	1081.7	515934	1921852

Table 3.2 Average rainfall of the year 1999-2002 in Chiang Mai basin (continued).

LOCATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	EAST	NORTH
Huai Thak Forest Plantation	8.8	4.9	43.8	90.8	180.5	128.0	174.3	263.2	196.9	120.6	39.7	9.7	1261.2	596663	2064030
Thung Kwian Forest Plantation	2.6	8.2	32.2	63.0	200.0	119.4	197.1	224.3	235.4	95.0	44.3	4.6	1226.1	522887	2032442
Mae Mai forest Plantation	6.2	2.1	27.0	51.9	154.3	150.2	141.1	207.1	209.0	64.3	48.7	4.4	1066.3	570362	2047317
Mae Mo Forest Plantation	4.1	4.0	33.6	51.2	169.1	144.3	203.4	213.6	253.1	86.6	36.8	3.7	1203.5	573905	2039951
Mae Chang Forest Plantation	6.4	3.9	37.0	66.2	159.5	97.4	150.2	167.1	230.8	73.8	34.5	2.5	1029.3	577495	2021521
Mae Sai Kham Forest Plantation	5.3	1.8	32.9	59.0	134.8	115.1	172.4	194.1	200.5	79.7	60.5	2.1	1058.2	556288	2045423
Northern Region Sugarcane Center	0.0	7.9	33.2	46.5	103.3	99.3	129.6	152.8	183.9	72.8	39.5	1.6	870.4	543551	2011646
Lampang	1.7	8.1	26.5	65.6	141.8	115.9	133.4	180.7	197.7	83.4	34.0	1.9	989.0	554609	2021489
Lampang Agromet	2.6	9.7	37.8	65.4	171.2	130.7	163.6	195.1	235.0	101.6	35.9	1.2	1147.2	529941	2025122
Lamphun Administration office	1.8	5.4	15.0	34.1	142.4	99.8	93.5	178.5	171.9	68.2	45.7	9.4	865.7	503514	2049024
Mae Tha	2.1	6.0	26.9	62.2	152.9	135.2	149.2	202.1	219.8	108.9	41.4	7.0	1113.7	517604	2034327
Mae Tha	2.1	6.0	26.9	62.2	152.9	135.2	149.2	202.1	219.8	108.9	41.4	7.0	1113.7	517604	2034327
Pa Sang	3.9	8.9	12.8	49.1	169.4	98.4	97.5	218.7	221.5	88.6	59.9	13.8	1016.9	498240	2043538
Li	1.1	12.1	28.8	70.4	191.3	84.9	95.3	189.3	176.0	94.3	29.0	0.0	972.5	496466	1962409
Ban Hong	7.0	7.7	25.4	53.7	182.3	109.1	76.0	173.8	196.4	116.7	40.7	13.9	1002.7	484143	2017730
Ban Goa Jadsan School	1.7	13.3	23.6	69.9	171.5	92.1	95.8	155.4	199.6	121.7	48.0	5.7	998.3	477016	1949472
Mae Li Forest Plantation	3.3	10.0	25.7	72.7	160.2	86.9	85.1	159.6	253.4	122.6	30.2	4.9	1014.6	489411	1982649
Lamphun	3.0	8.8	16.9	37.5	159.5	114.8	122.2	175.5	206.8	86.0	51.9	5.4	988.3	503517	2052758

Soil series and land use maps from the year 1998 from the Department of Land Development; DLD, were used in this research (Figure 3.1). Soil series characterizations were used to classify soil type as described in DRASTIC methods (Table 3.3).

Table 3.3 Soil legends and soil occurrence (DLD, 1998).

SOIL LEGEND				
TRANSPORTED MATERIAL		Soil type		
1	Alluvial Complex (AC)	Sand	FLOOD PLAIN	RECENT ALLUVIUM
2	Tha Muang series (Tm)	Sand		
3	Sanphaya series (Sa)	Sand		
4	Tha Muang / Sanphaya association (Tm / Sa)	Silt		
5	Ratchaburi series (Rb)	Sand		
6	Ratchaburi / Sanphaya association (Rb / Sa)	Clay		
7	Phimai series (Pm)	Silt		
8	Alluvial Soils,poorly drained (A S-p)	Clay		

Table 3.3 Soil legends and soil occurrence (continued).

	SOIL LEGEND	Soil type		
	TRANSPORTED MATERIAL			
9	Alluvial Fan Complex (A FC)	Sand	**ALLUVIAL FANS**	**Semi - recent alluvium**
10	Kamphaeng Saen series (Ks)	Sand	**Semi – recent terrace**	
11	Hang Dong series (Hd)	Silty clay		
12	Hang Dong overwash phase (H d-o)	Silty clay		
13	Mae Sai series (Ms)	Silty clay		
14	Mae Sai / Hang Dong association (Ms / Hd)	Silt		
15	Chiang Rai series (Cr)	Silty loam		
16	Phan series (Ph)	Silt		
17	Lop Buri series (Lb)	Clay		
18	Organic Soils (Os)	Clay		
19	Lampang series (Lp)	Silty loam	**Old alluvium terraces and fans**	**Old alluvium**
20	Lampang,gravelly, basic variant (Lp-gr-b)	Gravel		
21	San Sai series (Sai)	Sandy loam		
22	Lampang / San Sai association (Lp / Sai)	Loam		
23	Ubon series, (Ub)	Sand		
24	San Pa Tong series (Sp)	Sandy loam		
25	Korat series (Kt)	Silt		
26	Korat / San Pa Tong association (Kt / Sp)	Silt		
27	Korat / Renu association (Kt / Rn)	Clay		
28	Nam Pong series (Ng)	Silt		
29	Satuk series (Suk)	Silt		

Table 3.3 Soil legends and soil occurrence (continued).

SOIL LEGEND			
	TRANSPORTED MATERIAL	Soil type	
30	Renu / Satuk association (Rn / Suk)	Clay	
31	Korat / Satuk association (Kt / Suk)	Clay	
32	San Pa Tong / Satuk assocciation (Sp / Suk)	Sandy loam	
33	Hang Chat series, undulating phase (Hc-B)	Sandy loam	
34	Hang Chat, hydromorphie varient (Hc-hd)	Silty loam	
35	Korat / Hang Chat association,undulating phase (Kt / Hc-B)	Sandy loam	
36	San pa Tong / Hang Chat association,undulating phase (Sp / Hc-B)	Sandy loam	
37	Mae Rim series, undulating phase (Mr-B)	Sandy loam	
38	Mae Rim series, rolling phase (Mr-C)	Sandy loam	
39	Mae Rim / Hang Chat association, undulating phase (Mr-B / Hc-B)	Sandy loam	
40	Mae Rim / Hang Chat association, rolling phase (Mr-c / Hc-c)	Silt	
41	Hang Chat / calcareous / Mae Rim association, undulating phase (Hc-ca / Mr-B)	Loam	
42	Mae Taeng series, undulating phase (Mt-B)	Sandy loam	
43	Mae Taeng series, rolling phase (Mt-C)	Silt	
44	Mae Taeng / Hang Chat association, undulating phase (Mt-B / Hc-B)	Silt	

Table 3.3 Soil legends and soil occurrence (continued).

SOIL LEGEND					
	TRANSPORTED MATERIAL	Soil type			
45	Pak Chong series, undulating phase (Pc-B)	Clay	DISSECTED EROSION SURFACES AND HILLS	CLASSTIC ROCKS	RESIDUUM AND COLLUVIUM
46	Pak Chong series, rolling phase (Pc-C)	Clay			
47	Pak Chong series, stony phase (Pc-st)	Sand			
48	Pak Chong series, very stony phase (Pc-vst)	Sand			
49	Li series (Li)	Silty clay			
50	Tha Yang series (Ty)	Clay			
51	Lat Ya series (Ly)	Clay			
52	Tha Yang / Lat Ya association (Ty / Ly)	Clay			
53	Takhli series (Tk)	Clay loam		**LIMESTONE**	
54	Takhli series, eroded phase (Tk-e)	Silt			
55	Tha Ta Ko series (To)	Clay			
56	Sop Prap series (So)	Clay		Basalt	
57	Nong Mot series (Nm)	Loam		**GRANITE**	
58	Chan Tuk series, overwash phase (Cu-o)	Sand			
59	Pong Tong / Loei association (Po / Lo)	Clay loam			
60	Granite derived Soils Complex (Gr SC)	Sand			
61	Doi Pui series, rolling phase (Dp-C)	Sand		**GNEISS AND SCHIST**	
62	Doi Pui series, hilly phase (Dp-D)	Silt			
	MISCELLANEOUS LAND TYPE				
63	Granite Rock Land (Gr RL)	Sand	**HILLS AND MOUNTAINS**	**VARIOUS ROCKS**	
64	Limestone Rock Land (Ls RL)	Clay			
65	Gullied Land (GL)	Clay			
66	Slope Complex (SC)	Colluvium			

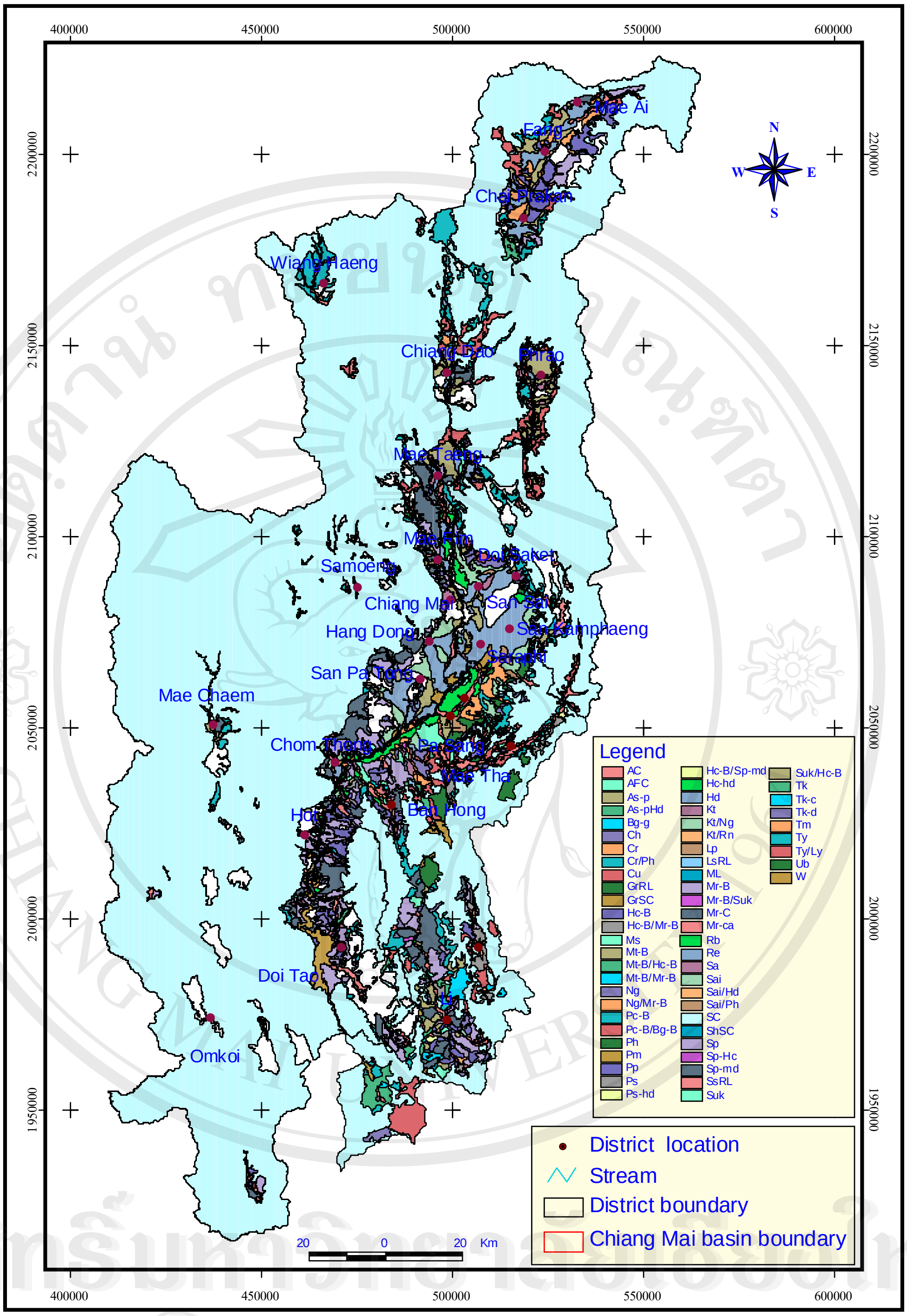

Figure 3.1 Soil series map of Chiang Mai basin (DLD, 1998).

3.1.3 Field investigation

In the year 2004 the project of revising provincial groundwater availability map as part of field groundwater investigation was carried out in the northern region for a total of 11 Provinces including Chiang Mai and Lumphun Provinces (Chiang Mai basin). On site measurement of groundwater levels and groundwater quality were taken in order to update database and compare the results with previous well data. Depth to groundwater level was measured by using electric tape and water level was measured from the ground surface (base of well) to the top of groundwater level in the well. Groundwater quality was measured by using a conductivity meter as well as in-situ measures, and subsequently calculated and converted to the Total Dissolved Solids; TDS.

3.2 Data preparation

3.2.1 Depth to groundwater level

Groundwater level is the most sensitive parameter. The closer groundwater level is to the surface is the easier it can be contaminated. In the year 2004, 3,210 of 5,009 groundwater wells in Chiang Mai basin were measured and recorded in a computer database. The well data was converted or transformed to Universal Transverse Mercator projection system (UTM) of Indian datum as a data field of numeric data. Most of the wells were drilled in the unconsolidated aquifers of flood plain deposits from 50 to 350 meters, although some of them were drilled in consolidated aquifers such as limestone, sandstone, and shale (Figure 3.2).

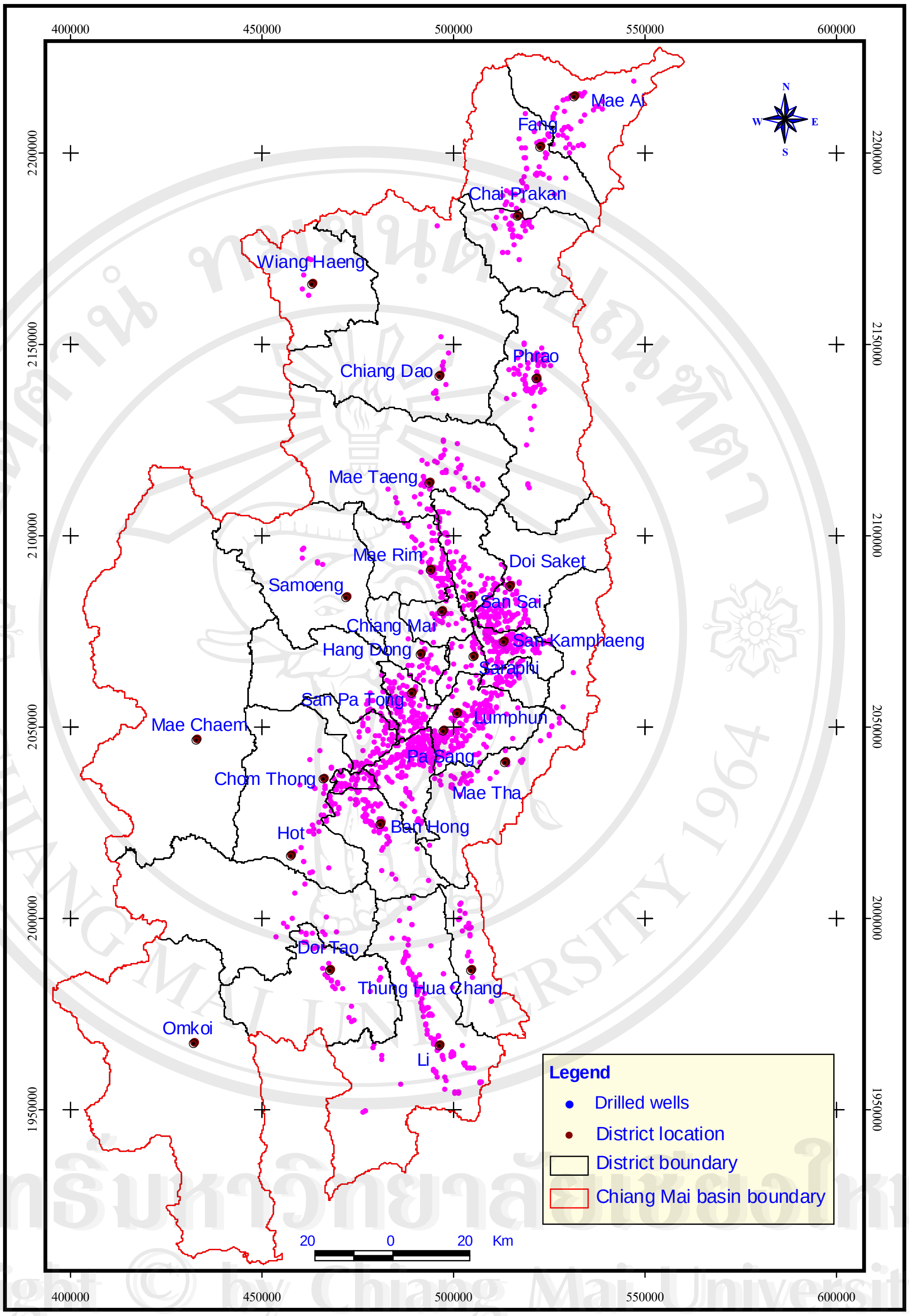

Figure 3.2 Wells location map of Chiang Mai basin (DGR, 2002).

3.2.2 Net recharge

Net recharge, which is determined on the basis of annual rainfall or the amount of rainfall water from precipitate to land surface, plays an important role in dissolving and conducting contaminants from surface to groundwater reservoirs. Large amounts of rainwater can dissolve and conduct huge amounts of contaminants to the groundwater. Annual rainfall data from the year 1999 obtained from the Department of Meteorological from a total 61 meteorological rain gauge stations in Chiang Mai basin, was compiled in Excel data format. Monthly and average annual rainfalls (millimeter) were used to calculate net recharge. The locations of rain gauge stations, in latitudinal and longitudinal coordinates, were converted to the UTM projection system in order to overlay it with the other data in UTM system. The rainfall data was imported to ArcView®program as shape file and average annual rainfall was used to calculate the amount of net recharge rainwater percolated to aquifers (Figure 3.3). High rainfall precipitation, more than 1,000 mm up to 1,669 mm, was distributed in the northern part of the basin from Muang Chiang Mai district in the central to the upper north of Mae Ai district, where high mountain ranges and dense forest are situated. In the southern part less rainfall intensity, ranging from 660 to 1,000 mm, was in evidence.

3.2.3 Aquifer type

Aquifer media type in shape file format from provincial groundwater availability map scale 1:100,000 (Figure 3.4) and hydrogeological map scale 1:500,000 (DGR, 2002) were complied together in a simple form according to aquifer properties of vulnerability to contaminants. Hence, each of aquifers, such as alluvium (flood plain and terrace), igneous rocks, carbonate rocks and metamorphic rocks were grouped individually and assigned an aquifer media range and rating. An edited hydrogeological map was used as aquifer media type and restructured database by adding one more field for rating in the database structure. Moreover, geological maps and structural maps from the Geological Survey Division, Department of Mineral Resources, were also taking into consideration

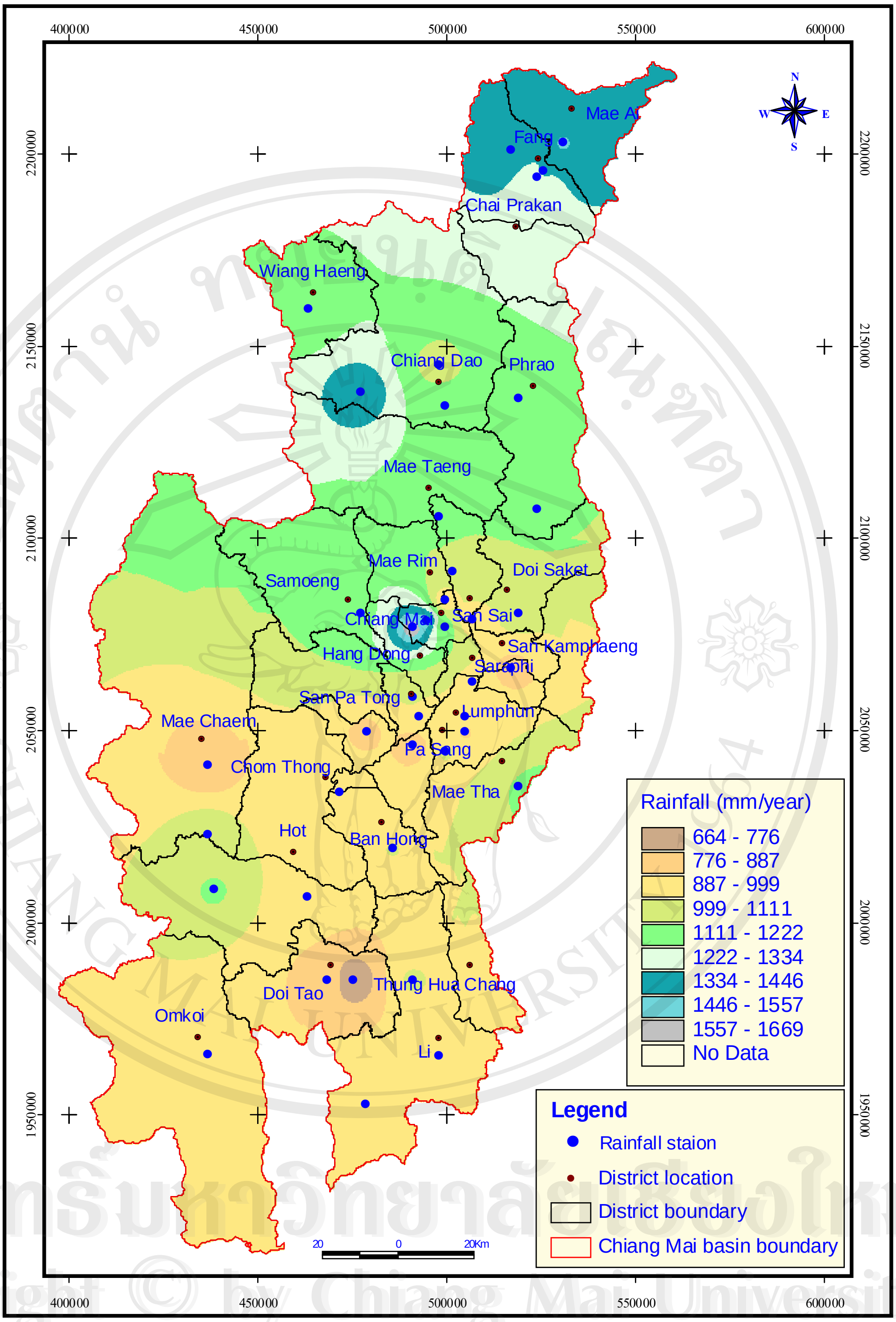

Figure 3.3 Rain gauge stations and distribution of rainfall map (MD, 2002).

3.2.4 Soil map and land use

Digital soil series maps from the Department of Land Development were complied by using soil group, soil taxonomy, and soil classification (Figure 3.5). The upper top horizon of soil sequence from soil series was carefully analyzed for its properties and its mixture for input soil type in the database soil map. A complied soil map was imported to shape file formats of ArcView®program and dissolved into the boundaries by soil type.

3.2.5 Topography

A digital contours map from the Royal Thai Survey Department (RTSD, 1989) series L7017 with its contour lines, contour types and its elevation height for the whole Chiang Mai basin and vicinity areas, were merged together in order to get better slope calculation, especially along the edge of the basin (Figure 3.6).

3.2.6 Impact of vadose zone

The vadose zone is defined as type of soil, or rocks above saturated zone, or unsaturated zone. The unsaturated zone is the zone of the soil or rocks above the groundwater table. The impact of vadose zone media reflects the ability of geologic materials to affect a contaminant moving from the base of the soil to the top of the aquifer. The type of vadose media was obtained from hydrogeological logging of well samples, which was analyzed by a hydrogeologist from the DGR and stored in coded form in the Dbase III plus format. The vadose media types were identified manually, well by well, and put into the attribute database of the well location map. Degree of vulnerability of the vadose zone mainly depended on the thickness, the composition of the material in the vadose zone, and the aquifer type, such as unconfined and confined aquifers. A confined layer is an aquifer that occurs between two impermeable layers, which are normally impervious clay layers that block contaminants to aquifer layers. The rating of contaminants in a confined layer is low compared to gravel, whereas, gravel has a higher porosity and permeability.

3.2.7 Hydraulic conductivity

The hydraulic conductivity (K) is defined as the amount of water percolating to groundwater through the aquifer. The rate at which groundwater seeps into the aquifer also controls the rate that the contaminant moves into the aquifer. Test results from pumping a total of 108 wells from DGR (Figure 3.7) were used to calculate hydraulic conductivity. Various methods were employed; particular the Theis and Jacob Methods, in order to obtain the hydraulic conductivity. Time-drawdown curves are the most suitable method and were used to evaluate vulnerability. Using pumping test data with constant pumping rate (Q), a time-drawdown graph of each well was calculated for transmissivity (T). Thus, hydraulic conductivity (K) is the transmissivity (T) divided by the aquifers thickness (B).

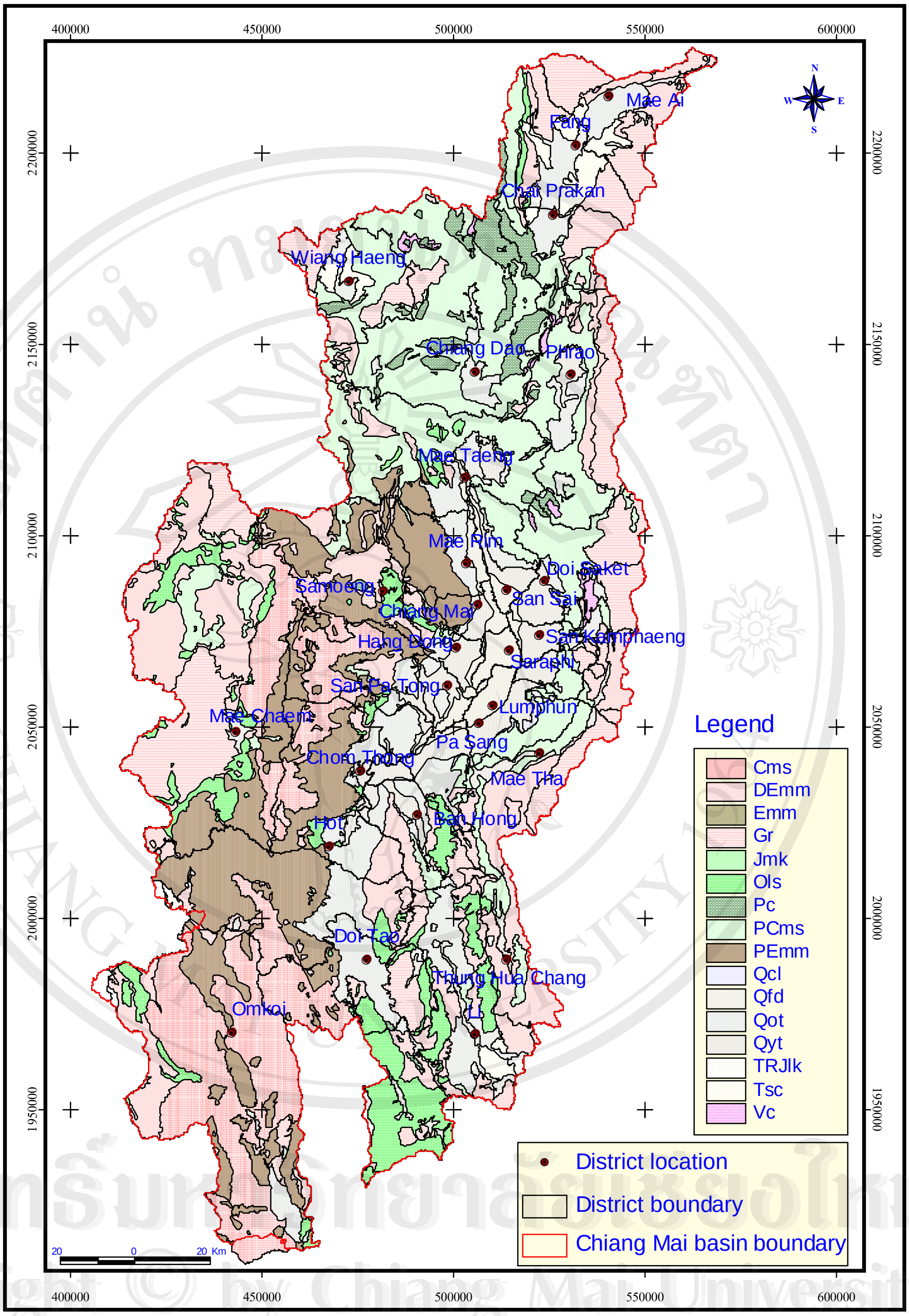

Figure 3.4 Aquifers map of Chiang Mai basin (DGR, 2002).

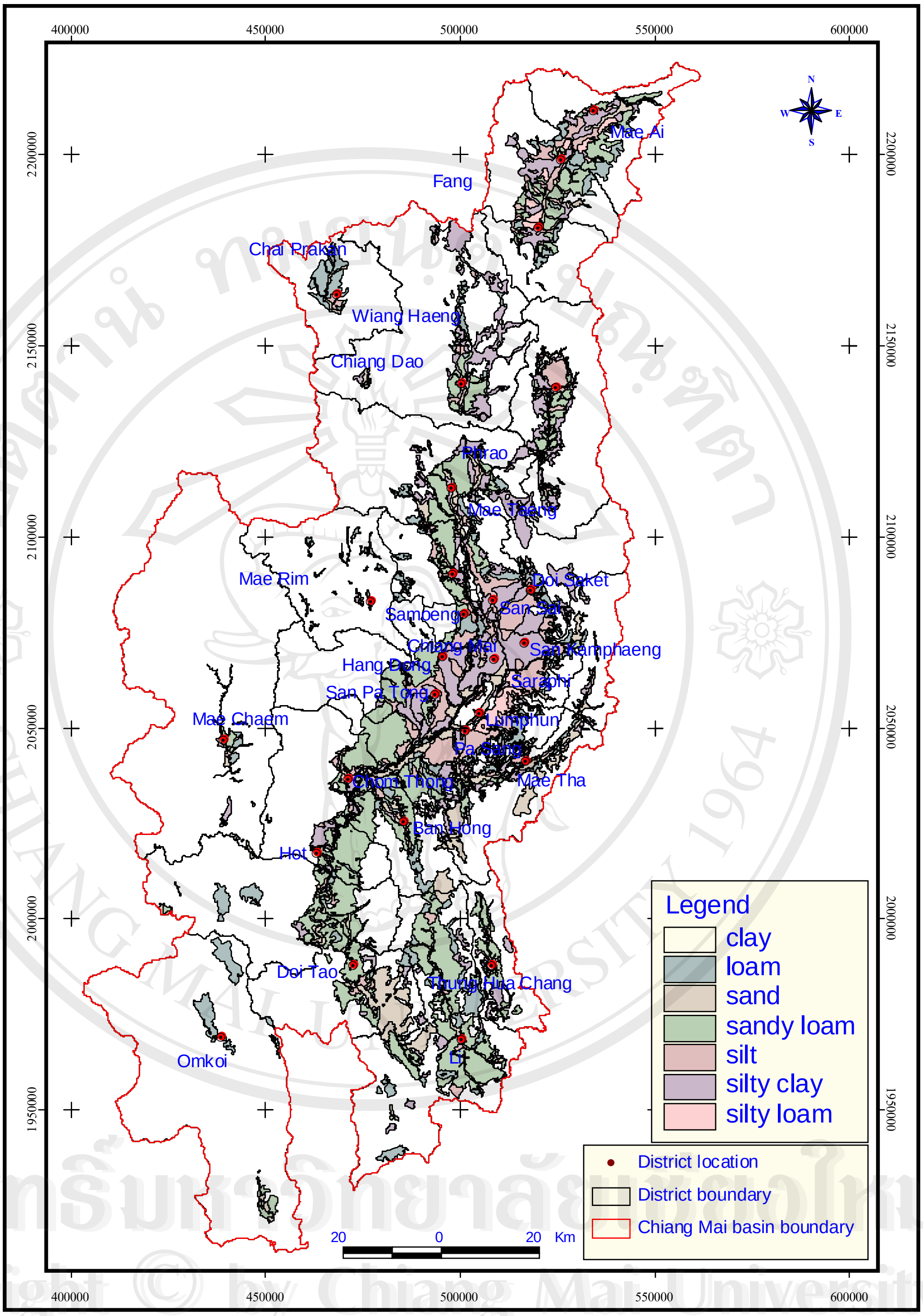

Figure 3.5 Soil classification map of Chiang Mai basin (modified from soil series DLD, 1998).

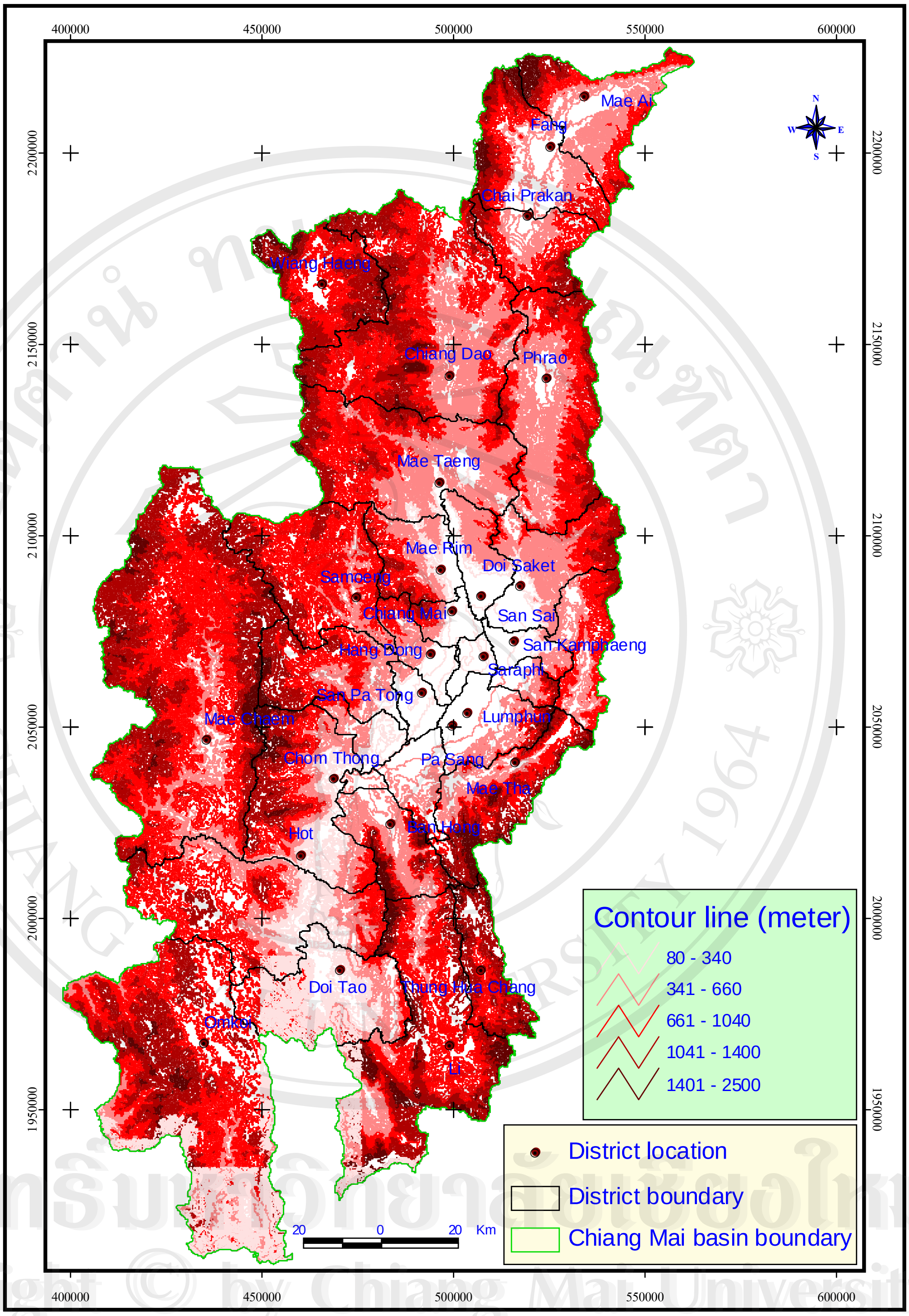

Figure 3.6 Topographic map of Chiang Mai basin (RTSD, 1989).

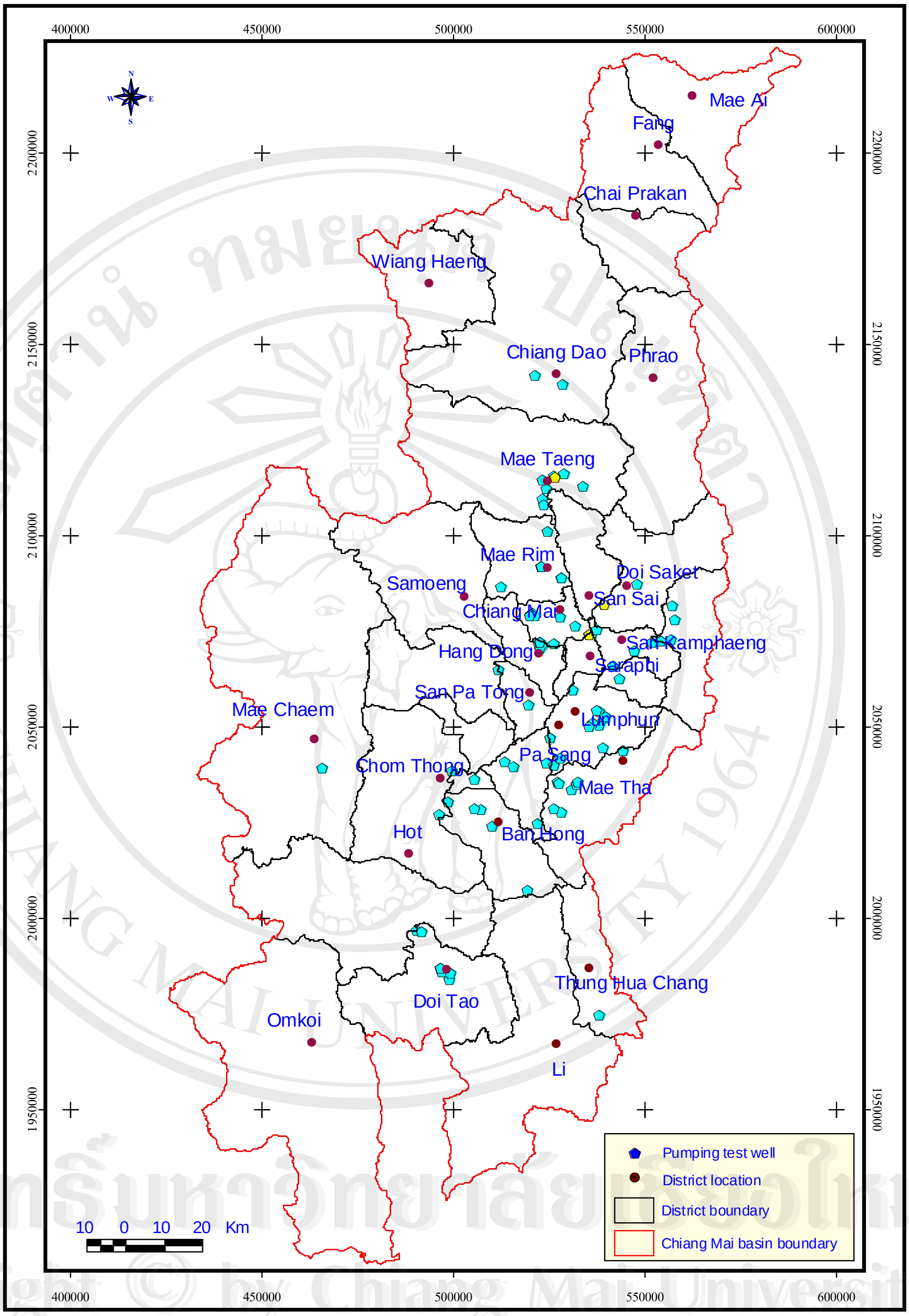

Figure 3.7 Pumping wells location (DGR, 2002).