Chapter 3

STUDY SITE

3.1. LOCATION

Mae Moh Mine and Power Plant is located in Mae Moh Basin, Mae Moh District, Lampang Province, north of Thailand. It is about 26 kilometers east of Lampang City, 126 kilometers south of Chiang Mai City, and approximately 631 kilometers north of Bangkok. It is situated at 18°18'21" north latitude and 99°44'02" east longitude, and is 17 kilometers long, 9 kilometers wide, covering an area of 16 x 6.5 square kilometers (Ratanasthien and Kandharosa, 1996; Figure 3.1).

3.2. GEOGRAPHICAL DESCRIPTION

3.2.1. Topography

The topography of the Mae Moh basin is flat and low lying with the ground surface throughout the basin ranging from 300 to 350 meters above mean sea level. The northern boundary is Doi Kew-lom, the east and west are bordered by the limestone and mudrock hills of Doi Chang and Doi Luang, and the basalt and limestone of Doi Pha Hob is the southern boundary (Institute of Environment Research, Chulalongkorn University, 1981; Figure 3.2.1)

3.2.2. Drainage system

The water requirements at Mae Moh are about 46 million cubic meters a year for the cooling system and other services. Huai Luang Dam, with a storage capacity of 13.13 million cubic meters, was constructed in 1974. Mae Chang Rockfill Dam, with

128 million cubic meters, was constructed in 1982. The Mae Moh Water Supply Management Project constructed 3 storage dams, one weir, two diversion canals and a conveyance system. This was completed in 1992 and increased the water storage capacity by 39 million cubic meters. Figures 3.2.2a and 3.2.2b show the drainage and waste management systems at Mae Moh Mine (EGAT, 1994).

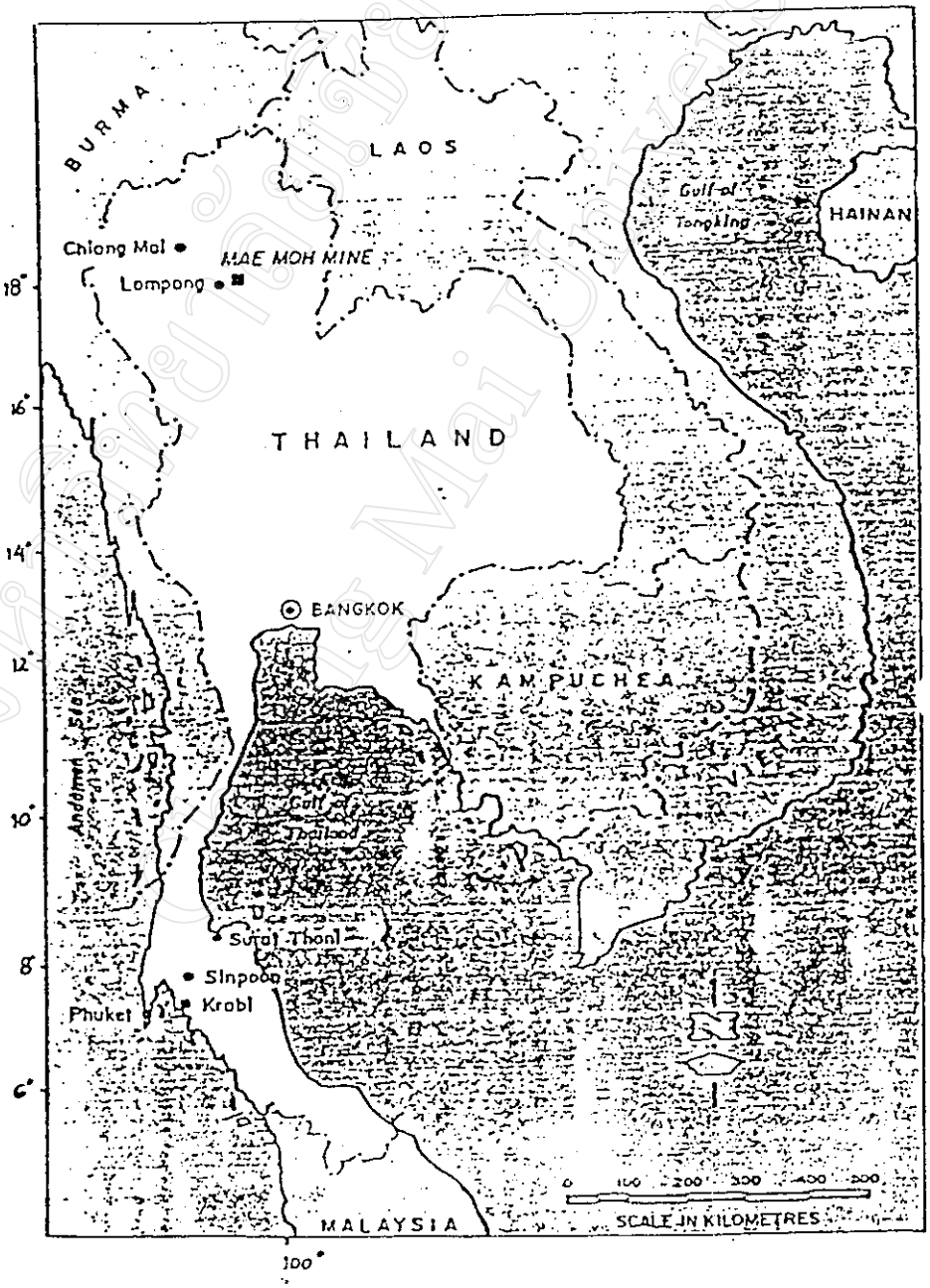

Figure 3.1: Map of the location of Mae Moh Mine and Power Plant
(Source: EGAT, 1991)

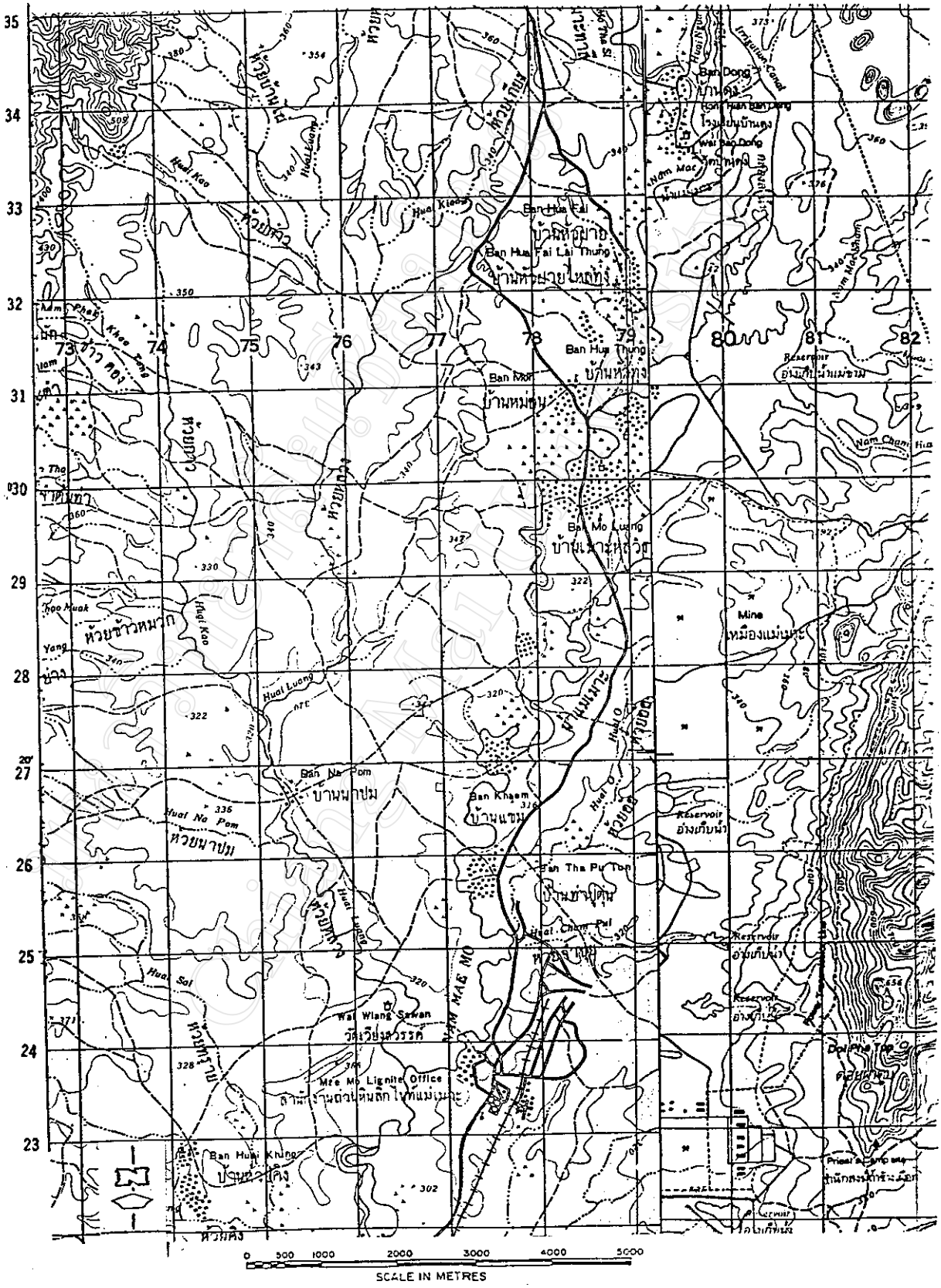

Figure 3.2.1: Topographic map of Mae Moh Mine

(Source: Royal Survey Department, Bangkok Thailand, 1992)

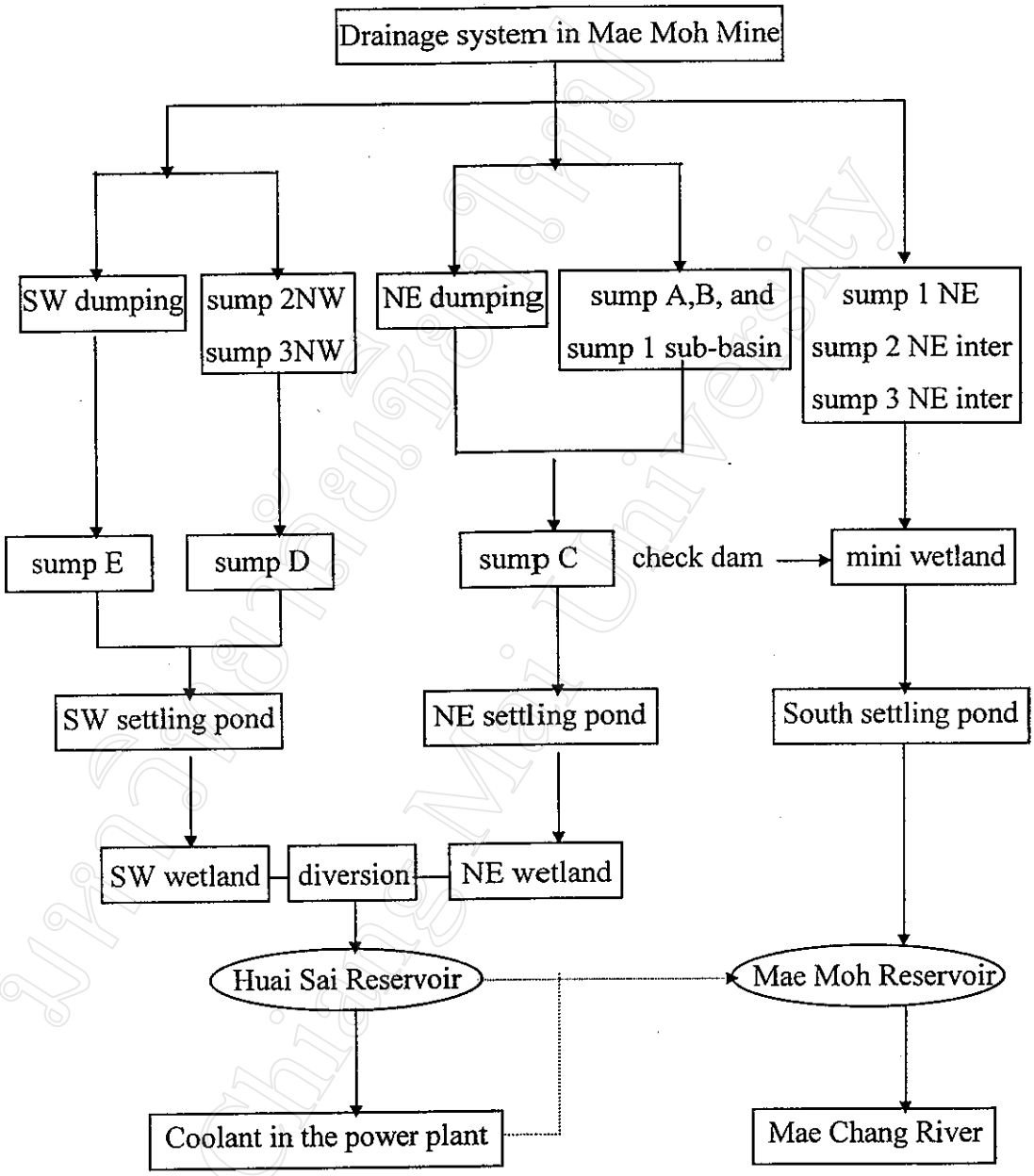

Figure 3.2.2a: Drainage and Waste Management System at Mae Moh Mine

(Source: Mine Environmental Operation Section, EGAT Mae Moh)

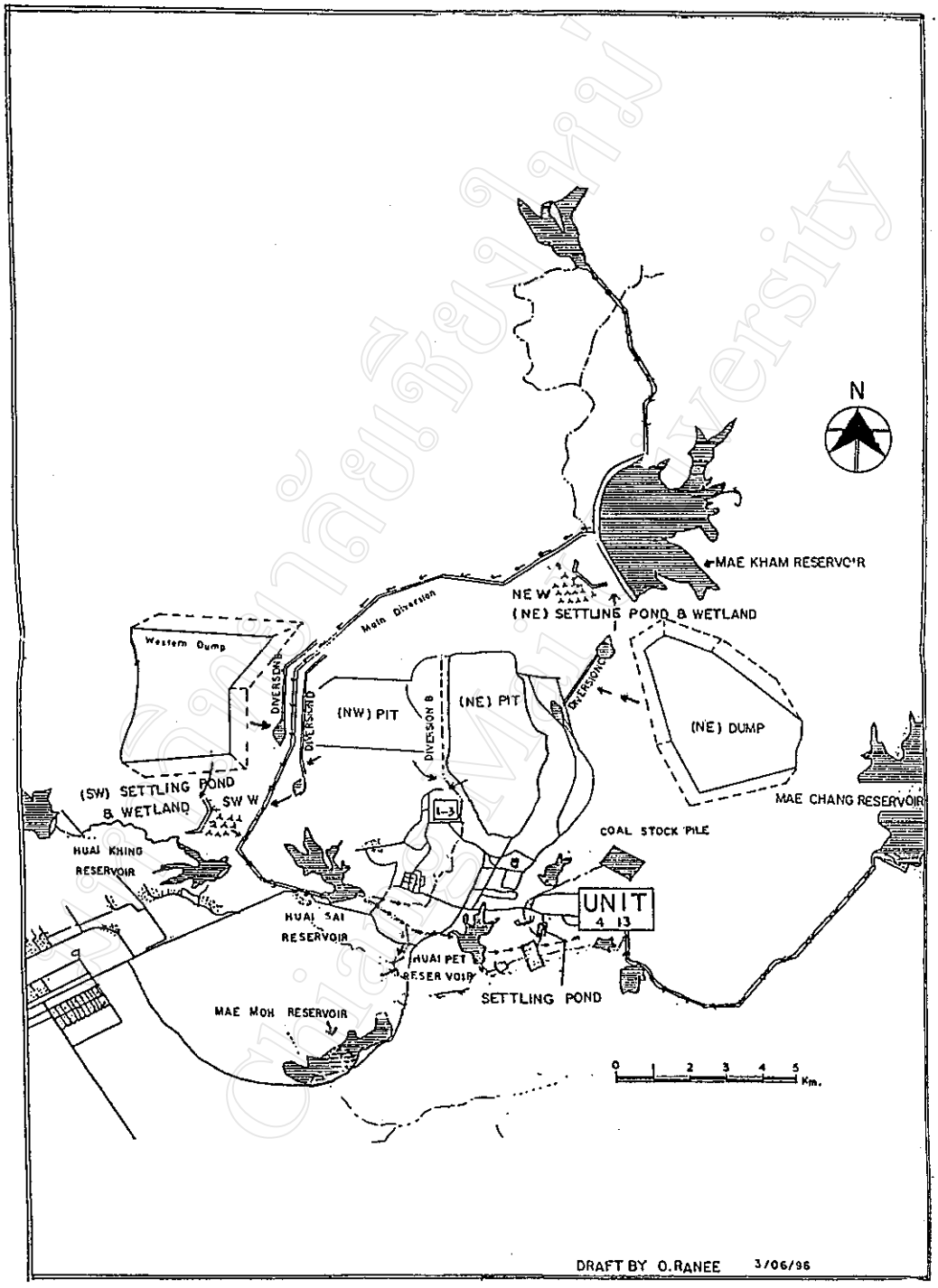

Figure 3.2.2b: Water Supply System at Mae Moh Mine and Power Plant

(Source: Mine Environmental Operation Section, Mae Moh)

3.2.3. Geological conditions

Mae Moh Basin was mainly formed of marine Triassic rocks (Figure 3.2.3). It consists of limestone, shale, and sandstone, with Quaternary basalt in the southern part of the basin (Ratanasthien and Kandharosa, 1996).

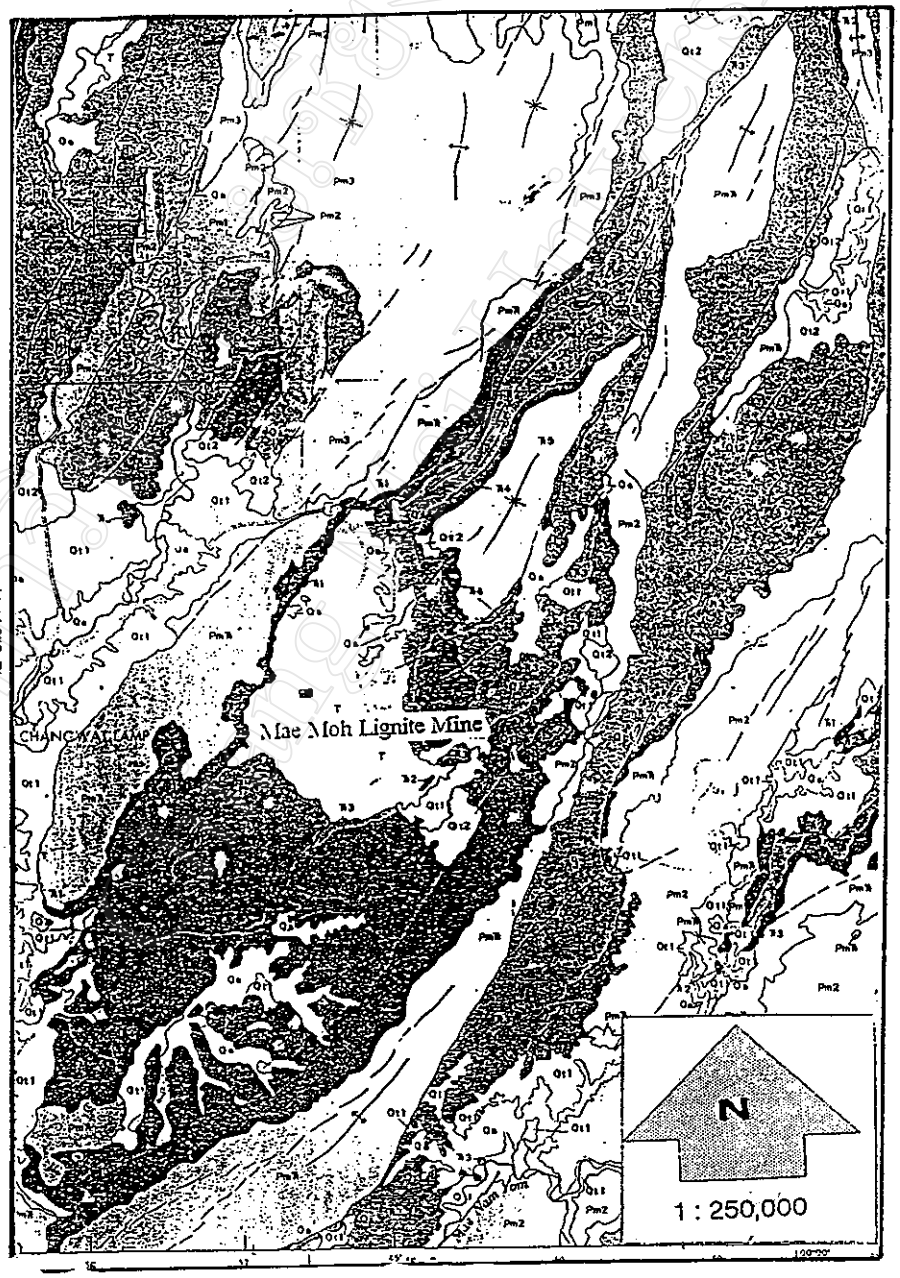

Figure 3.2.3: Geological Map of Mae Moh Lignite Mine
(Source: Department of Mineral Resources)

Explanation:

Qa Riverine gravel, sand, clay, and mud

Qt1 Lower terrace, gravel, sand and silt, clay

Qt2 Higher terrace, gravel, sand, silt, and clay (Mae Taeng group)

T Freshwater sandstone, shale, carbonaceous shale limestone, viviporous beds, lignite (Mae Moh Group)

T_R5 Reddish-brown sandstone, shale, conglomerate, greenish-gray siltstone, shale, sandstone (Pha Daeng Formation group).

T_R4 Limestone, limestone conglomerate, medium gray to pinkish gray with fossils of gastropod, brachiopods (Doi Chang Formation, Lampang group).

T_R3 Greenish gray shale, sandstone, tuffaceous sandstone, laminated shale, conglomerate with fossil of *Halobia, Daonella, Posidonia, Trachyceras, Paratrachyceras, Jaonnites, ets.* (Hong Hoi Formation, Lampang Group)

T_R2 Limestone, massive or banded, dark gray to medium gray: shale, sandstone, calcareous, gray to grayish brown, well stratified, with fossils of brachipoids, *Claria, Halibia, Daonella, Posidonia, Ammonites* (Pha Kan Formation, Lampang Group)

T_R1 Basal conglomerate, redish brown sandstone, shale, agglomerate, tuff Pm3 shale, calcareous shale, carbonaceous shale, tuffaceous shale, tuffaceous shale and sandstone, laminated shale with fossils of *Dielasma, Leptodus, Orthotichia, Echinochus, Neospirifera, Schizopoira, Aviculopecten, etc.* (Huai Thak formation, Ranburi Group) and Bs basalt, vessicular, amygdaloidal.

The sediments deposited in the basin are mainly semi-consolidated with diversified lithology. Within the uppermost 10 meters of the basin, clay, lateritic soil, and terrace gravels are most common. Below 10 meters depth, mustones and lignite are found. The depth from the ground surface to the lignite deposit varies from very shallow, along marginal areas, to deeper in the central part of the basin (more than 300 meters)

Lignite occurs in layers or beds along with other sedimentary rocks which are mostly shale, sandstone, mudstone, and claystone. The lignite consists of bits of fossil wood, bark, leaves, roots and other parts of land plants which have been chemically altered. Although lignite is interbedded with organic sediments, it is not usually mixed with them. Most lignite layer are 1.6 to 8 meters (2-10 feet) thick, some of thickness may reach 80 meters (100 feet) (Institute of Environment Research, 1981).

3.2.4. Lithostratigraphic succession

According to Ratanasthien and Kandharosa (1996), the lithology in Mae Moh Basin can be divided into 3 formations (figure 3.2.4).

Huai Luang Formation or "red bed" consists of semi-consolidated and unconsolidated sediments. Claystone, siltstone and mudstone are dominant in the central part of basin and vary from under 5 meters to 350 meters thick.

Na Khaem Formation consists of semi-consolidated mudrock and 5 zones of lignite. It's thickness ranges from 250 to 400 meters. Na Khaem Formation is separated into 3 members. The first member (J Zone) is gray and greenish-gray claystone and mudstone with occasional siltstone in some parts. The upper part of this

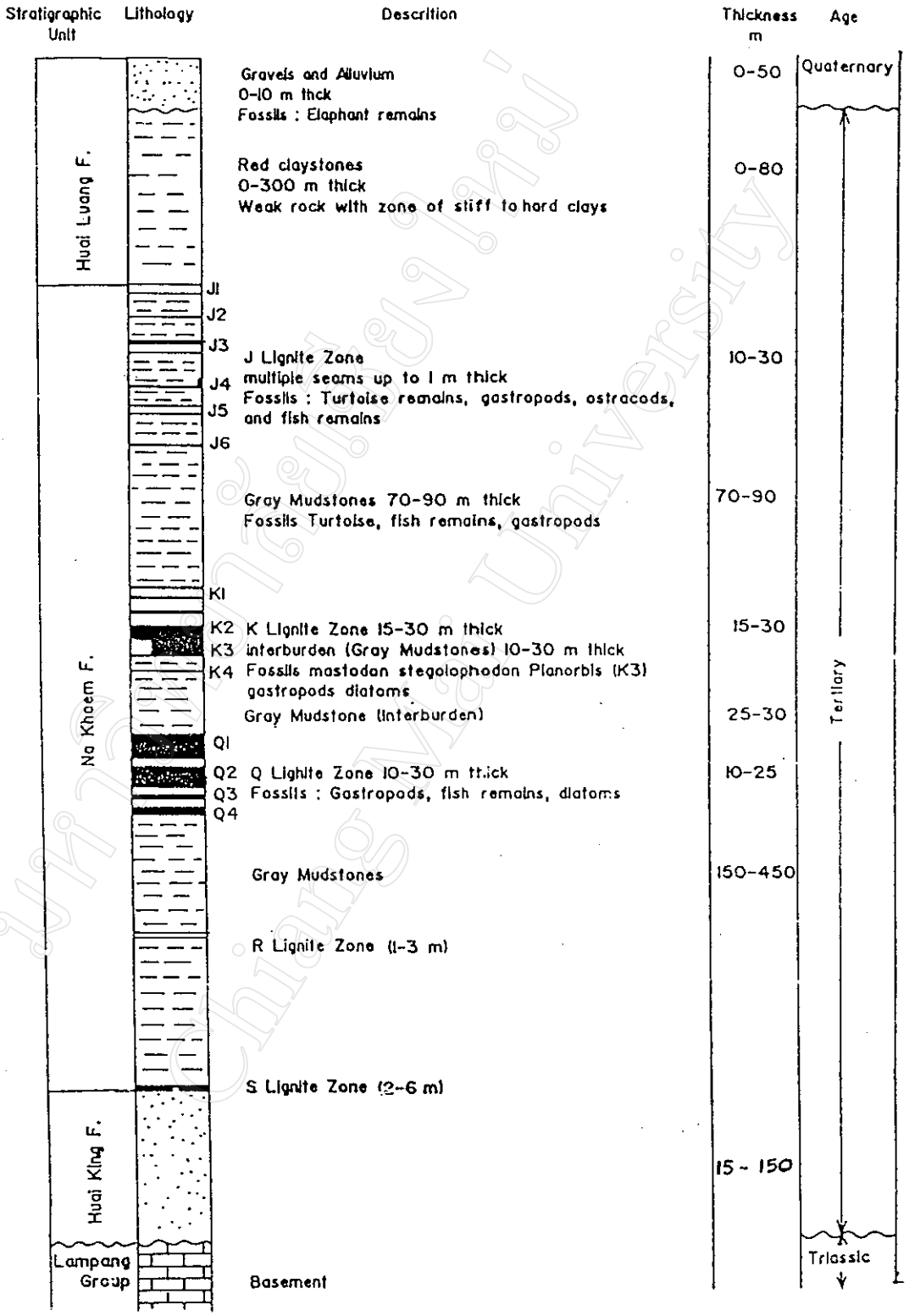

Figure 3.2.4: Lithostratigraphic Sequences of Mae Moh Mine

(Source: Ratanasthien and Kandharosa, 1996)

zone consists of two thin argillaceous layers, less than 2 meters thick and 13 thin seams of lignite which are named J1 to J6. The second member is the most economic lignite sequence and is divided into 3 zones: K-zone is a sequence of lignite in the upper part. Thickness ranges from 10 to 30 meters. The lignite series are named from K1 to K4. The interburden zone is a succession of brown, brownish-gray, gray, green and greenish-gray claystone. It lies between two major lignite seams which are thicker to the east and thinner to the west flanks of the main basin. Lastly, the Q-zone is a succession of lignite and is interbedded with soft lignite and partings of light brown claystone/silty claystone.

The seams are separated into Q1 to Q4 with a total thickness vary from 25 to 30 meters. The last member (underburden) is a sequence of gray to greenish-gray claystone and mudstone. Two thin seams of lignite (1 to 6 meters thick) interbedded in the middle and lower portions, are called R-zone and S-zone with a thickness vary from 150 to 230 meters.

Huai King Formation is the lower-most formation of the Tertiary succession, consisting of semi-consolidated mudstone, siltstone, sandstone, conglomeratic sandstone, conglomerate and some claystone. Thickness varies from under 15 meters on the border to 150 meters in the central part of the basin (Figure 3.2.4).

3.3. CLIMATIC CONDITIONS

The climate in Mae Moh basin is typical of northern Thailand. Being situated in a typical monsoon zone, it is mainly influenced by the southwest and the northeast monsoons, and secondarily by cyclonic storms and inter-tropical fronts. The rainy

season occurs from May to October, with a rainfall peak usually from August to September. A cool dry season occurs from mid-October to mid-March. During mid-March to mid-May weather is hot and dry (Badulis, 1998). In 1998 the average monthly rainfall was high in the beginning of the rainy season with a peak of 459 mm in May while the lowest value was 226 mm in August (Figure 3.3). Generally, wind direction depends on the season. According to Hastuti (1998), from January to September the wind direction is to the south and to the north during October to December. Wind varies in all directions during the transition period of the northeast monsoon to the southeast monsoon (Institute of Environment Research, 1981).

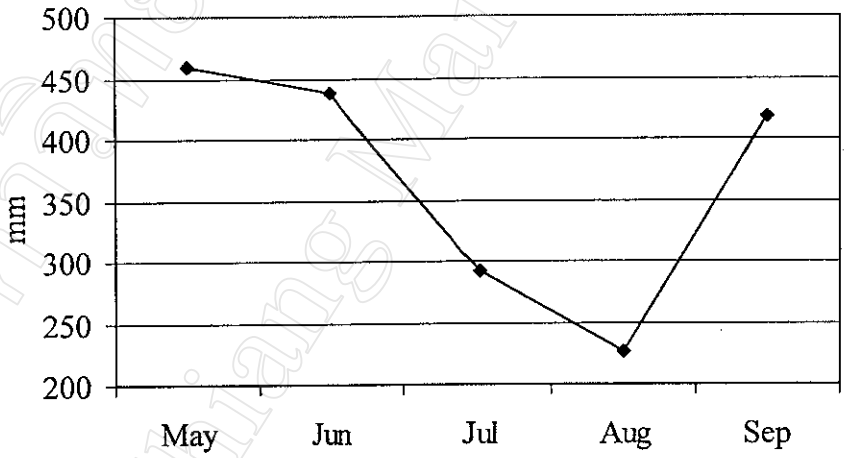

Figure 3.3: Average monthly rainfall from May to September, 1998

(Source: Mae Moh Meteorological station, 1998)

3.4. STUDY SITE DESCRIPTION

Two Reservoirs and 13 ground water points were chosen in the Mae Moh Mine and Power Plant area while one Reservoir and 3 wells, which are located near

Chiang Mai University, Chiang Mai Province, were chosen as control sites. Their positions were recorded using a Geographical Position System (GPS).

No	Sites	North (UTM unit)	East (UTM unit)	Depth (m)	Altitude (m*)
	Surface water				
	Mae Kham Reservoir (MKR)				
1	MKR1 (Dumping side)	2029877	580577		331
2	MKR2 (Outlet)	2031081	579306		379
3	MKR3 (Inlet)	2032778	550467		331
	Mae Moh Reservoir (MMR)				
4	MMR1 (Inlet)	2020577	576183		151
5	MMR2 (Dumping side)	2019017	575100		358
6	MMR3 (Outlet)	2018632	574607		187
	Ang Kaset (AR)				
7	AR1 (Outlet)	2077723	7494578		339
8	AR2 (Restaurant side)	2077696	7494458		343
9	AR3 (Opposite site AR2)	2077718	7494668		341
	Ground water sites				
1	Northern well (N1)	2037557	580737	U	412
2	Northern well (N2)	2032300	579009	12	283
3	Seepage (SP1)	2024170	573025		302
4	Seepage (SP2)	2026172	578250		287
5	Seepage (SP3)	2029189	577949		254
6	Well RH86 (M1)	2025869	577949	> 200	200
7	Well OA67 (M2)	2027694	577710	> 200	266
8	Well PA12 (M3)	2027942	577663	> 200	218
9	Southern well (S1)	2023252	574113	<25	320
10	Southern well (S2)	2018930	574772	U	244
11	Southern well (S3)	2018320	569437	25	420
12	Southern well (S4)	2018137	570114	U	361
13	Controlled well (CT1)	2077466	7495356	15	305
14	Controlled well (CT2)	2077573	7495293	15	303
15	Controlled well (CT3)	2077686	7495311	15	305

*: height above mean sea level; U: Unkown

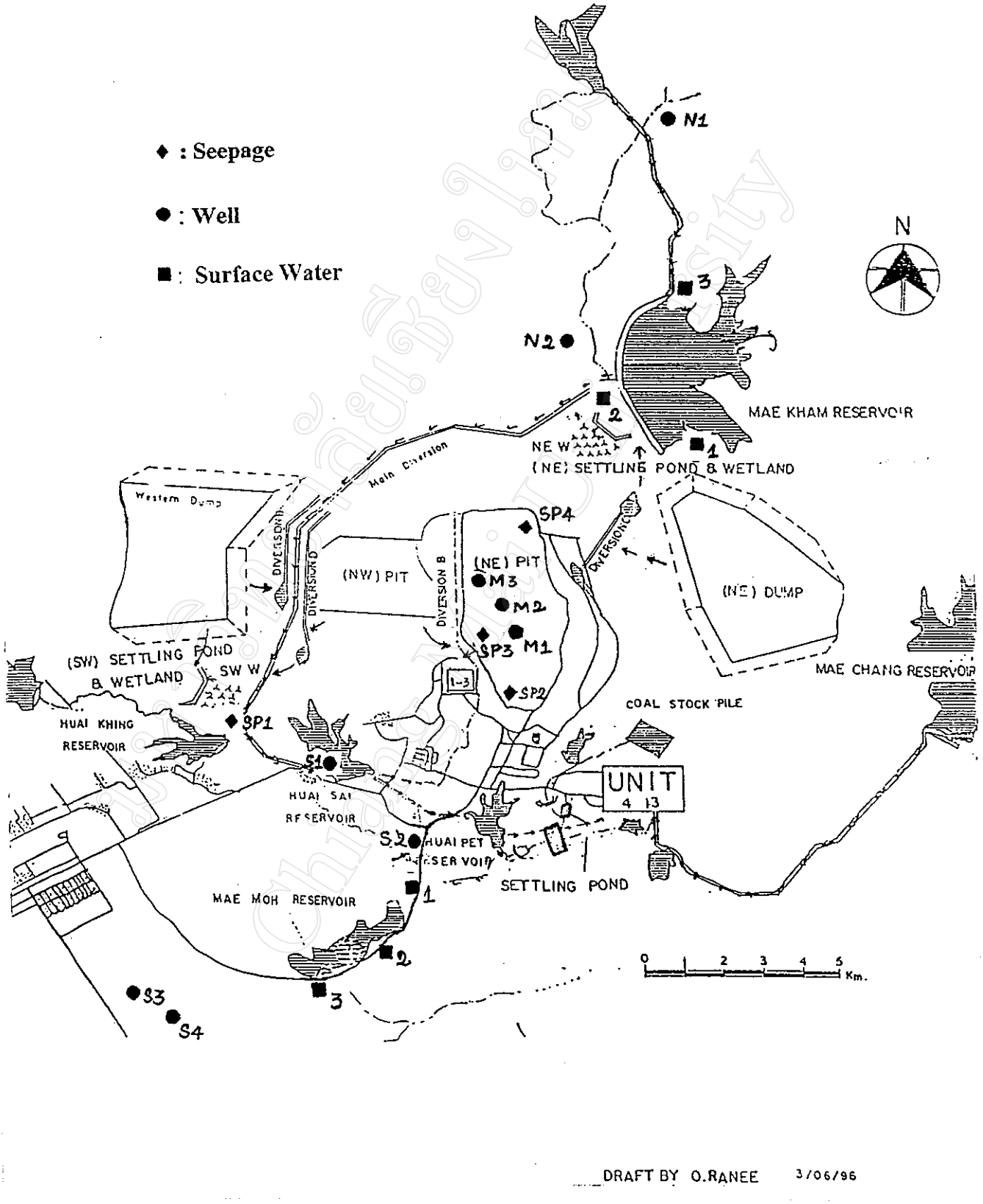

Figure 3.4: Map of Sampling Sites at Mae Moh

3.4.1. Mae Kham Reservoir (MKR)

Mae Kham Reservoir is located in the northern part of the mining and power plant area, about 2 kilometers north of the power plant (units 1-3) and the mining area (Figure 3.4). The water supply for the MKR is mainly from one Reservoir, which is located in Ban Tha Si village. The northeastern dumping site, in which overburden and other wastes from mining activities are dumped, is situated near the Reservoir and releases wastewater into the Reservoir during the rainy season via water runoff and leaching. Water from the MKR is mainly supplied to the thermal generator system via the main diversion system. Three sub-sites, MKR1, MKR2, and MKR3, were chosen. MKR1 is located in the northeastern dump side, MKR2 is the outlet of the Reservoir, and MKR3 is the inlet (Figure 3.4.1a and 3.4.1b).

Figure 3.4.1a. Mae Kham Reservoir, site MKR1

Figure 3.4.1b. Mae Kham Reservoir – site MKR2

3.4.2. Mae Moh Reservoir (MMR)

Mae Moh Reservoir (MMR) is located in the southwestern part of the mining and power plant area, about 5 kilometers southwest of the power plant and 6 kilometers southwest of the mining area. Water discharged into the Reservoir is mainly from Huai Pet and Huai Sai Reservoirs, which is mixed together with wastewater from the power plant after treatment in setting ponds and wetlands. According to Hastuti (1998), aquatic plants in the MMR are mainly *Eichhornia crassipes,(Mart.) Solms (Pomtederaiceae) Impomoea aquatica Forssk.* (Convolvulaceae), *Typha angustifolia L.* (Typhaceae), *Nymphea pubescens Willd.* (Nymphaeaceae), *Ludwigia hyssopifolia (G. Don)* Exell (Onagraceae), *Pistia stratiotes L.* (Araceae), and *Nymphoides indica* (L.) O.K. (Gentianaceae/Menyanthaceae). It is estimated that aquatic plants cover about 10-15

percent of the surface area in the MMR. Water from the MMR is discharged into the Mae Chiang River. Three sub-sites, the inlet (MMR1), the outlet (MMR3) of the MMR and a place in front of the Mae Moh railway station (MMR2), were chosen (Figure 3.4.2).

Figure 3.4.2. Mae Moh Reservoir, site MMR3

3.4.3. Ang Kaset (AR)

This Reservoir is located at the base of Doi Suthep on the western boundary of Chiang Mai University. The Reservoir is also used to culture fish for recreation. One restaurant, which may have an impact on the water quality of the Reservoir, is situated along the Reservoir. AR1 is the outlet of the Reservoir, AR2 is at the restaurant side, and AR3 is opposite the restaurant side.

3.4.4. Groundwater sites in the northern part of Mae Moh basin

Two wells, N_1, and N_2, which are situated in the northern part of Mae Moh Mine and Power Plant, were chosen. The N_1, iron pipe-well, is located in Ban Tha Si village, about 10 kilometers north of the mining and the power plant area while N_2, a shallow well less than 12 meters deep, is situated in Ban Hua Fai village. It is about 6 kilometers from the mining and the power plant operation area. Groundwater in these 2 villages is mostly used for domestic consumption, *e.g.* washing and bathing (Figure 3.4.4).

3.4.5. Groundwater sites inside the mining operation area

Three deep wells (M_1, M_2, and M_3) were drilled for de-watering purposes through the gravel beds of the Huai King formation, which are the lowest deposits of the Mae Moh Tertiary sequences. They are considered to be most affected from mining activities and are more than 200 meters deep. These three wells are used for groundwater monitoring by the Mae Moh Environmental Mining Section (Figure 3.4.5a).

Four seepages, which release water from highland areas, were selected. SP1 is located along the main division canal from Huai Pet and Huai Sai Reservoir to MMR. It is about 4 kilometers west of the mining and power plant area. SP2 is located in the southern mine pit, SP3 is in the southwest, and SP4 is in the northern mine pit (Figure 3.4.5b).

Figure 3.4.4. Iron pipe well, site N1

Figure 3.4.5a. Iron pipe well RH86, site M1

Figure 3.4.5b. Seepage SP1

3.4.6. Groundwater sites in the southern part of Mae Moh Mine and Power Plant

Four wells were chosen as representative of the southern part of the Mae Moh Mine and Power Plant. These wells are about 5 kilometers southwest of the mining and the power plant area. One is a shallow well (S1) and the other is iron pipe-well (S2). Two PPC pipe-wells (S3, and S4) are located in Huai Rak Mai village about 8 kilometers southwest of the mining and power plant area (Figure 3.4.6). Groundwater in that area was also used for cooking, bathing, washing, and sometimes for drinking. All of them are less than 25 meters deep.

Figure 3.4.6. Southern shallow well, site S1

3.4.7. Groundwater in the control sites

Three shallow wells CT_1, CT_2, and CT_3, which are less than 15 meters deep, were chosen in Chiang Mai City for control sites. They are located near Umong Temple, Suthep Road. The groundwater is used for bathing, washing, cooking and sometimes for drinking.