CHPATER V

DISCUSSIONS

In this chapter, all the results together with those of the previous work are synthesized and discussed. Focuses are placed on rate of sedimentation and soil erosion, sources and transportation of heavy metals, and heavy metals contamination.

5.1 Rate of Soil Erosion and Sedimentation

As described in the earlier chapters, the present-day rate of overall sedimentation for the SKL study area is about 0.36 to 0.38 mm per year. It is likely that the rate of sedimentation is slightly lower than that of the erosion. It is interpreted herein that the less in the rate is probably due to the deposition of sediment on the way to bay mouths of the river.

As shown in Figure 5.1 for the world soil erosion, the region of Thailand has the average range of erosional rate between 1.0 and more than 2.0 mm per year. As shown in the earlier section, the author's rate of 1.6 is lower than that reported by Zang (1998). For the South East Asian region, Wen (1993), argued that the erosional rate presently is about 3.33 mm/year which is lower than the author's erosional rate.

It is considered from data of the previous chapters that the higher rate of deposition at the beginning of the Holocene is probably due to the changes of shoreline to become more emergent or the presence of the high-relief terrain, or the changing of world climate, or very low sea-water level at that time. However, much of the lake sediment derived landward. The rate of sedimentation becomes lower in the middle and late Holocene due to slightly higher sea level. However, at present to about 50 years ago, lake shorelines have been governed by more marine action than river action. Therefore one may suggest, as stated earlier, that the erosional shorelines are more prominent than deposition shorelines (Figure 5.1). This may, perhaps, have caused the rate of deposition become higher and given rise to the shallowness of lake floors.

However, it is also interpreted from our result that the higher rate of lake deposition at present (within the 50-year period) has been attributed mainly to the higher acceleration by human activities.

As displayed in Table 5.1, there are two kinds of sample analysis for heavy metal concentrations, one is mainly clay size sediments and the other is sand-size sediment. It is quite clear that apart from the clay with iron oxides, arsenic seems to show no contrast between contents in clayey and sandy material. However, copper and zinc elements show remarkable contrast in concentration. Clayey materials are likely to contain Cu and Zn contents less than sandy material. Pb element displays the different scenario, only for the clay with iron oxides contains very high content whereas the sand contains less Cu than the clay. This may indicate modes of transportation. It is considered that Cu and Zn may be transported in the form of terrigenous clasts whereas As and Pb are likely to be transported in solution and perhaps precipitate when the environments become much more reduced.

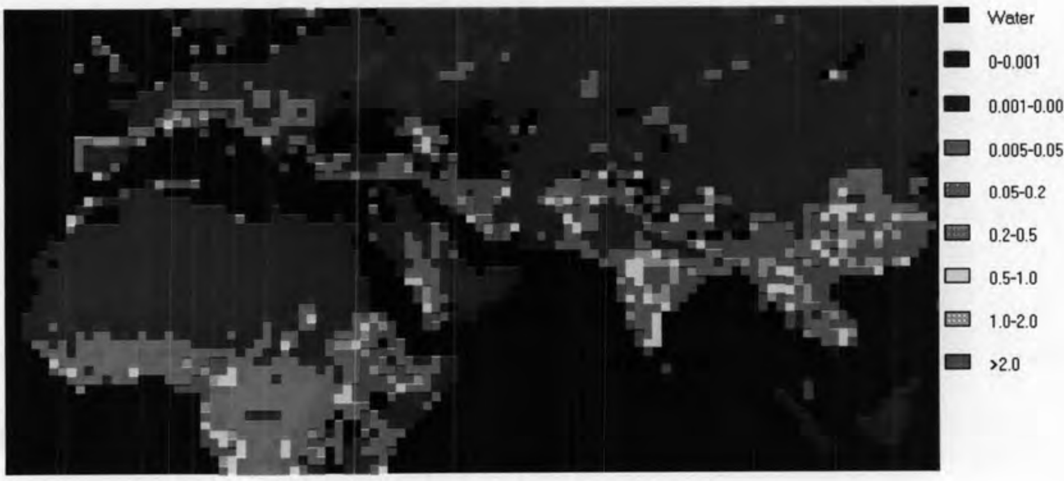

Figure 5.1 Part of soil erosion of the world

5.2 Sources of Heavy-metal Interpretations

This step is to identify locations of heavy metals in the SKL area with respect to landform and geology. There are three elements that are interesting namely arsenic, lead, and zinc.

Arsenic (As) is mainly located in the hilly area and swamp and it also present in the every layer of the lake sediment. Lead (Pb) is located mainly in the high terrace, flood plain and swamp and it also exits in the lower part of the lake sediment. Zinc (Zn) is located in the colluvium, flood plain, and coastal area and it also shows some significant relationship with human activities.

For the preliminary identification of the sources of arsenic, it can be visualized that As can be separated into 2 parts. The first part is located in the mountainous area; this arsenic would be originated from granitic rocks from the granitic terrain that located in the high mountain ranges in the western part of the area. The next part of the As is located in the swampy area. From Table 5.3, it shows the mobility of heavy metal in each environment. It can be concluded that this As originated in the granitic terrain and transported through water with the oxidizing stage and precipitated in the reducing environment as swampy area. There are some relationship with the human activities in this area effected to the As dispersion such as Tin and rock mining, and deforestations.

For the preliminary identification of the sources of lead, it can be concluded that the high concentration of Pb is located in the Tertiary sediment such as Tertiary terrace and Tertiary sediment in the lake. It can be inferred that the lead is deposit during the fluvial process in the Tertiary period. Then the was redistributed and transported by human activities particularly in urbanized area.

For the preliminary identification of the sources of zinc, there are no significance with natural occurrences. At present, it is widely accepted that zinc has been used for several purposes (Office of Pollution Prevention, 2002). Due to the fact that Zn is a raw material, especially, rubber industries materials, so it is common for zinc to be higher in areas dominated by para-rubber plantation. So, at present, it can be concluded that Zn derives from the para rubber industrial.

5.3 Heavy Metals Contamination

5.3.1 Heavy-metal Contamination on Land

Judging from the result on both soil and stream-sediment analyses of the SKL study area for identification of heavy metal contamination on land (see Table 5.1), sources of heavy metals are required. As shown in Figure 5.2, all data of stream sediments analyzed for heavy metals in the SKL study area were compiled, and only the value higher than target (or intervention) values are marked as larger circles (yellow and red, respectively).

The standard of metals levels suggested by the Dutch Ministry of Housing, Spatial Planning and Environmental (VROM, 2001), having target and intervention values for soil/sediment remediation (Table 5.2) was applied for this study. This standard has been long established and the intervention values are based on extensive studies of both human and eco-toxicological effects of soil and sediment contaminants. In addition, they assist in the assessment of contaminated soils/sediments and sites that pose potential concern, as well as providing a means for screening out those soils/sediments that do not warrant additional attention (Macklin et al, 2003).

It is quite likely that the arsenic values are high in the mountainous and hilly regions, which are mainly granitic terrain, of the west. We, therefore, consider that provenance of arsenic is granitic rock. Only the granitic terrain in the south is likely to be the most favorable source. But one high arsenic location shows the other interesting scenario. Since this high arsenic value is found in the swampy area. Such area is somewhat suggestive of reducing environment. Thus this area is interpreted to be contaminated by human activities and eventually affected to arsenic dispersion, such as tin mining rock quarrying, deforestation, etc.

The other high element concentrations i.e., Ni, Pb, and Cu, display the interesting point of view, which are in general in the range of target values. These elements are mainly located either on hill slopes as colluvial deposits. However, they are essentially located along or at the western edge of para rubber and mixed orchard plantation. We therefore interpret that their high potential provenance for stream sediment are likely to be non-point sources, such as human deforestation and severe uses of fertilizers and pesticides.

For the result of geochemical soil analyses, all the reported elemental concentrations are not higher than target values. However as shown in Figure 5.3, there are a few elements, such as, Cu, Ni, Pb, ad Zn, which show high contents in the range of target values. Although these elements geologically occur mainly in alluvial terrace, they are interpreted based on land uses to be non-point sources , having formed as a result of human activities similar to those of the stream sediments. It is interesting to note that none of the analyzed elements in soils are higher than intervention values at present.

Figure 5.4 shows the interesting map for the SKL study area. It illustrates the change in soil erosion for the year 1981 and 2002. it is clear that the relatively very high modification occurs at foots of Nakorn Si Thammarat granite mountain range, whereby there exist high values of deforestation. A few changes are located at the alluvial terraces which are now covered with para rubber and mixed orchard plantation.

Table 5.1 The contamination level of trace elements (maximum permitted levels) in rural soils of the world from various literatures.

Country	As	B	Ba	Cd	Co	Cr	Cu	Hg	Mo	Ni	Pb	Se	Zn
Australia	20			1		100	100	1		60	150	5	200
Australia				2		100	100	2		60	100		1000
Belgium				12		500	750	10		100	600		2500
Mainland	75	150		5		600	250	15		100	300		500
China	75	150		20		1000	500	-		20	1000		1000
Denmark				0.8		100	1000	0.8		30	120		4000
France				2		150	100	1		50	100	10	300
Italy				1.5			100	1		75	100		300
Netherlands	55		625	12	240	380	190	10	200	210	530		720
Norway				1		100	50	1		30	50		150
Norway				4		125	1000	5		80	100		1500
S. Africa	2	10		2	20	80	100	0.5	2.3	15	56	2	185
Sweden				0.4		30	40	0.3		30	40		75
U.K.	50			3		400	100	1	4	60	300	3	250
USA	20			10		1500	750	8	9	210	150	50	1400
USA	41			39		1200	1500	17	18	420	300	36	2800
Canada	20		750	3	40	750	150	0.8	5	150	375	2	600
Germany	50		20	5		500	200	50		200	1000	10	600
Japan	15	-	-	-	-	-	125	05	-	100	400	-	150
Taiwan	20	-	-	4	-	200	150	1	-	120	100	-	300
Thailand	3.9	-	-	37	-	300	-	23	-	1600	-	390	-

(1993), and National Environmental Quality Act, Thailand (1992).

Table 5.2 Dutch standards for soil contamination assessment: Target values and soil remediation intervention values for selected metals have been expressed as concentrations in a standard soil (10% organic matter, 25% clay). From Dutch Ministry of Housing, Spatial Planning and Environment (VROM, 2001).

Element	Target (A) value (mg/kg)	Intervention (C) value (mg/kg)
Arsenic (As)	29	55
Barium (Ba)	200	625
Cadmium (Cd)	0.8	12
Chromium (Cr)	100	380
Cobalt (Co)	20	240
Copper (Cu)	36	190
Mercury (Hg)	0.3	10
Lead (Pb)	85	530
Molybdenum (Mo)	10	200
Nickel (Ni)	35	210
Zinc (Zn)	140	720

Table 5.3 Detailed of heavy metal contents of the SKL study area in comparison with those of the Dutch's standard of heavy metals contamination.

	Element	S1	S2
Stream sediments	As	6	7
	Cr	0	0
	Cu	2	0
	Ni	5	
	Pb	24	7
	Zn	0	720
Soils	As	0	0
	Cr	0	0
	Cu	2	0
	Ni	1	0
	Pb	1	0
	Zn	1	0

Note: S1 = number of sites having values higher than or equivalent to the target values of Dutch standard.

S2 = number of sites having values higher than or equivalent to the intervention values of Dutch standard

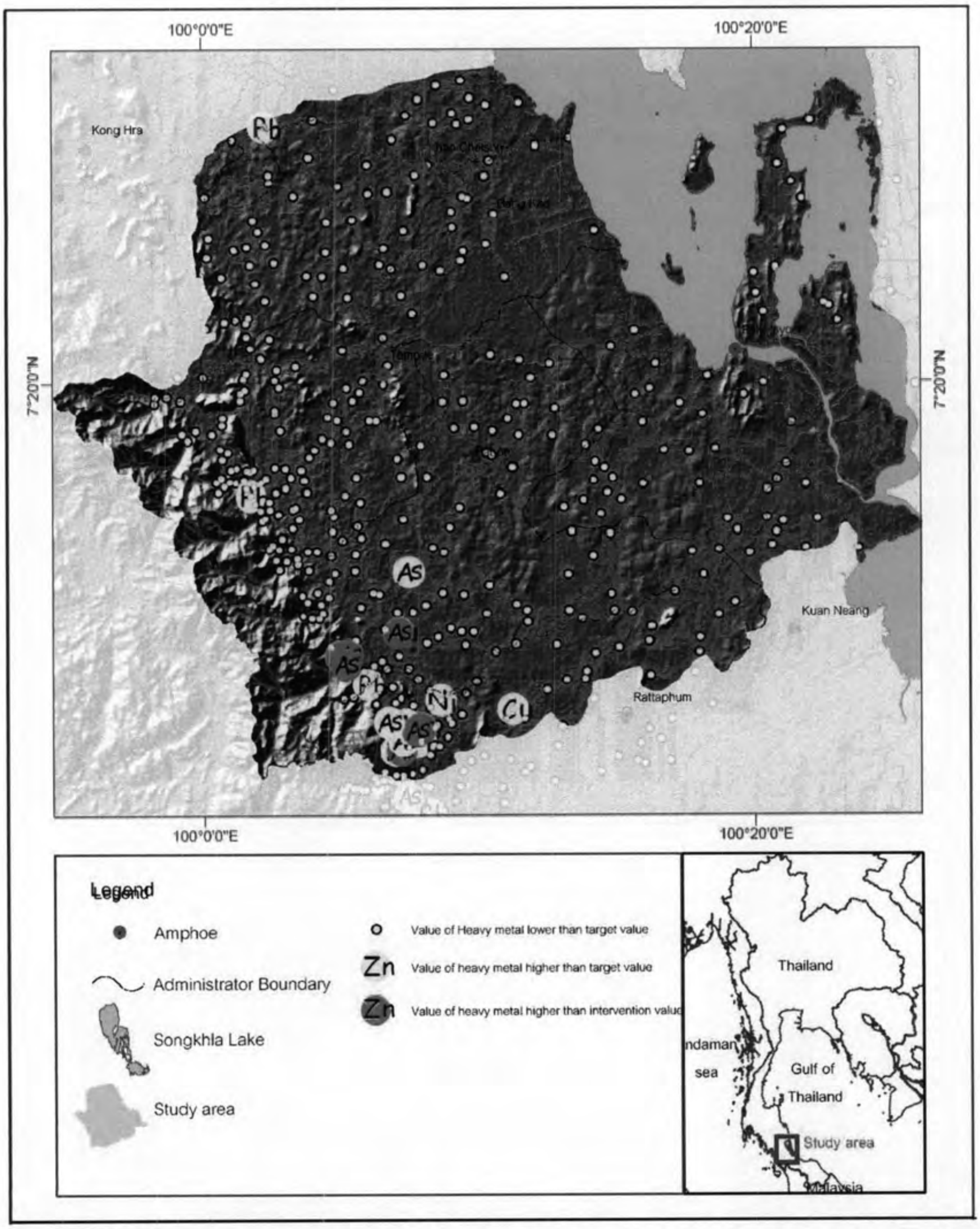

Figure 5.2 Map showing distribution of heavy metal in stream sediments with locations of contents higher than target (yellow) and intervention (orange) values of Dutch standard.

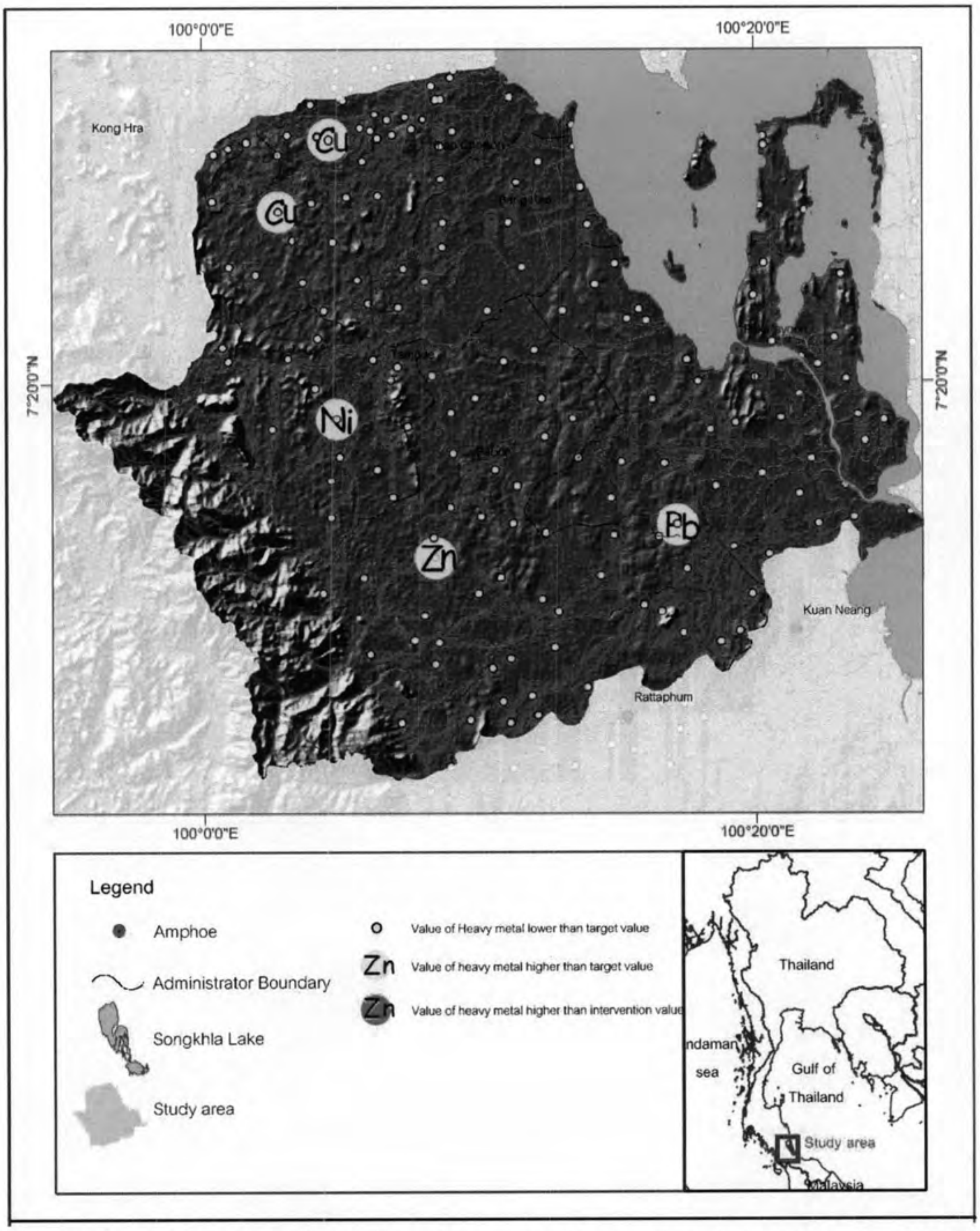

Figure 5.3 Map showing distribution of heavy metal in soils with locations of contents higher than target (yellow) and intervention (orange) values of Dutch standard.

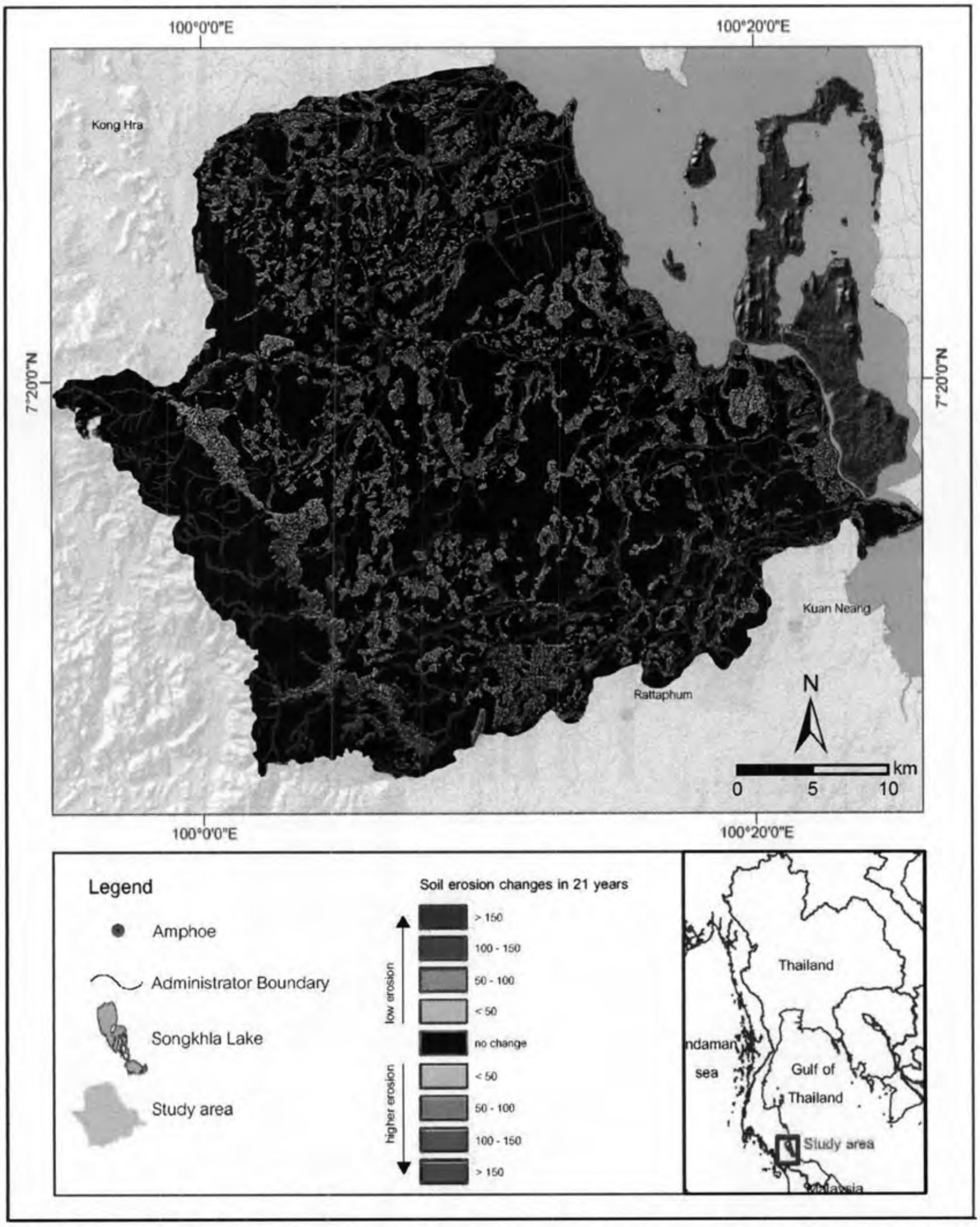

Figure 5.4 Map showing the change in soil erosion for the year 1981 and 2002 of the SKL study area. Note that the highest changes are located at the foot of Nakorn Si Thammarat range: granitic terrain.

5.3.2 Heavy-Metal Contamination in Lake

In the case of heavy-metal concentrations in lake sediments, it is likely that not all sediment layers from drill holes contain values within the range of the target values. It appears that only some sediment layers from drill holes nearby lake shores contain elemental concentrations higher than target values. As shown in Figure 5.5, arsenic contents become higher when lake sediments are close to the near shore side and father away from lake shore the arsenic becomes lower in concentrations. Similar situations occur as well for copper and zinc as illustrated in Figures 5.6, and 5.8, respectively. It is interesting that few lake sediments containing copper contents higher than target values and high in the range of interception values only at near shore environment. For Pb contamination, as seen in Figure 5.7, only two samples of lake sediments contain Pb contents equivalent to target and intervention values. As reported very recently by Department of Mineral Resources (2006), no lake sediments containing heavy-metal concentrations in any individual layers are as high as the target values. It is also quite interesting to note herein that the lake sediments in the uppermost layer from every drill hole have heavy-metal concentrations higher than or within the range of the target values.

As mentioned above, for the SKL study area, it is apparent that sources of heavy metal concentrations are mostly from land. As shown in Table 5.4 for the Hong Kong standard values of heavy metal contents in soils in comparison with those values from Songkhla Lake sediments (Table 5.5). There are some samples which have high metal concentrations equivalent to target and intervention values. No lake sediments in the SKL study area contain high heavy metal contents so as to justify as harmful or dangerous sediments.

Table 5.4 Hong Kong standards for dredged sediment planning: Target values and sediment remediation intervention values for selected metals in sediment have been expressed as concentrations in standard sediment.

Element	Target (A) value (mg/kg)	Intervention (C) value (mg/kg)
Arsenic (As)	8	42
Cadmium (Cd)	1.5	4
Chromium (Cr)	80	160
Copper (Cu)	65	110
Lead (Pb)	75	110
Mercury (Hg)	0.5	1
Zinc (Zn)	200	270

Sources: Environmental Lands Bureau and Works Bureau Joint Technical Circular (1998)

Table 5.5 The heavy metals in stream sediment and soil of SKL study area in comparison with those of the Dutch's standard of heavy metals contamination.

	As	Cr	Cu	Pb	Zn
Target (A) value	39	0	8	1	0
Intervention (C) value	4	0	8	1	3

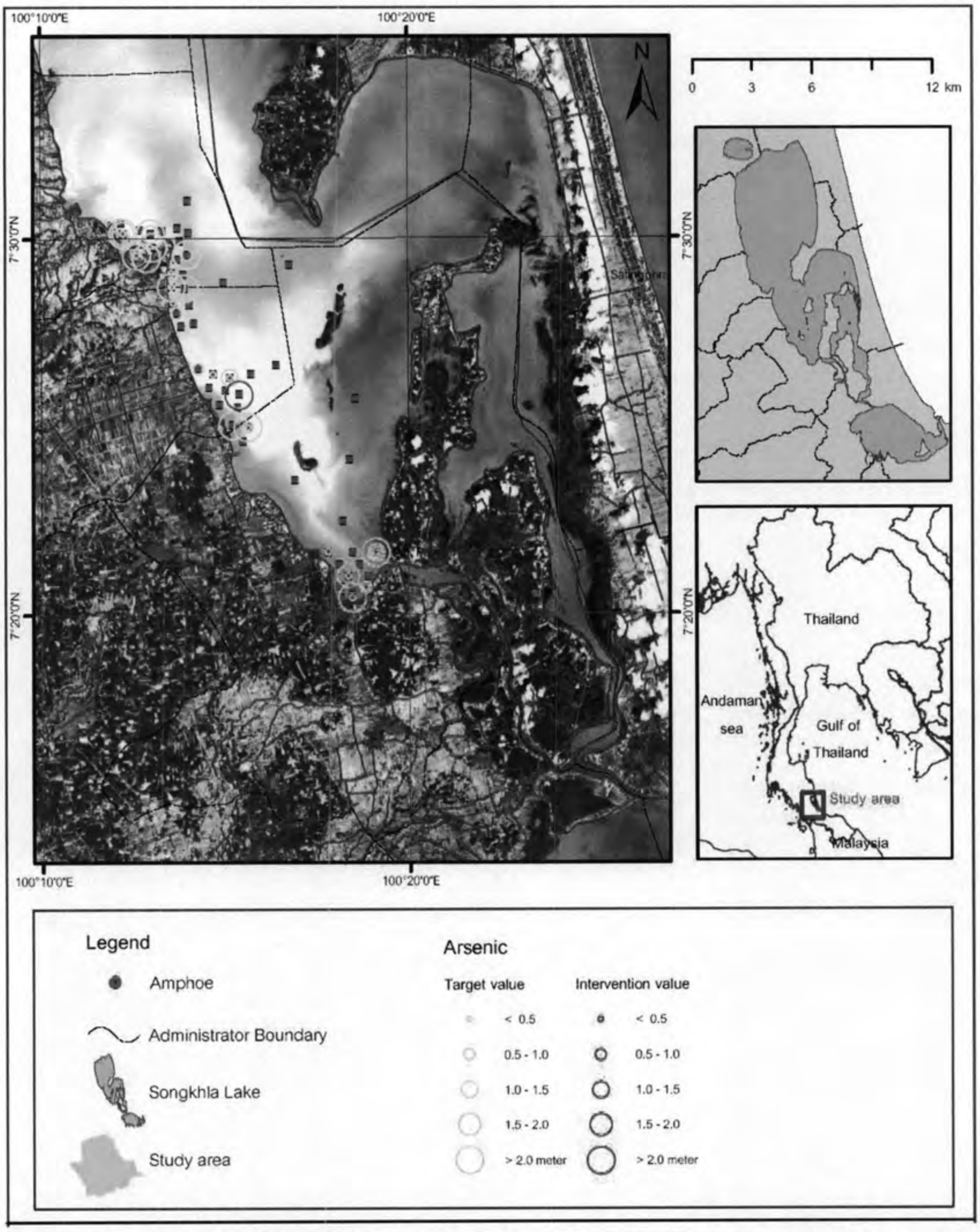

Figure 5.5 Map of the SKL study area showing arsenic concentrations that higher than Target (yellow) and Intervention (red) value of Hong Kong's standard.

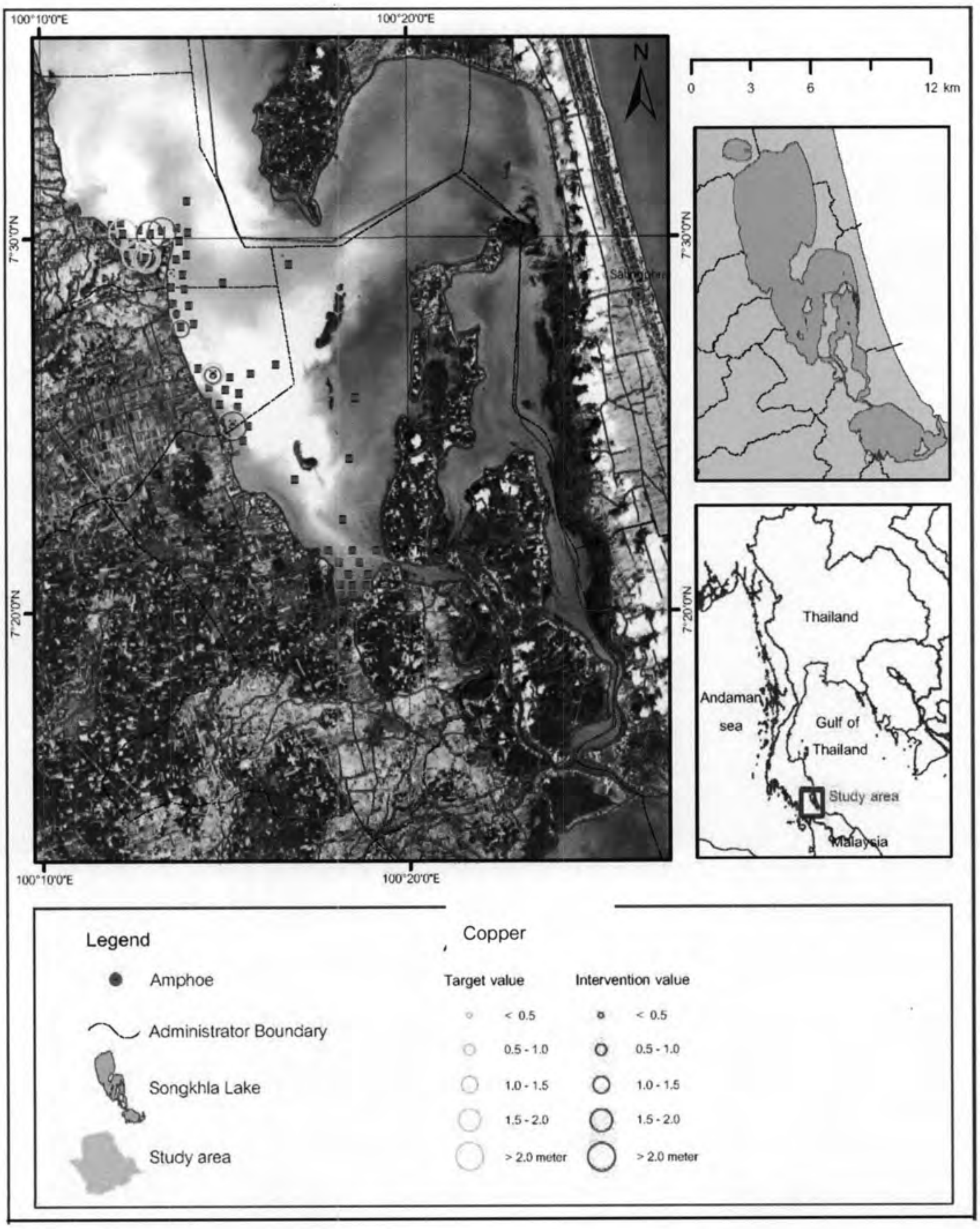

Figure 5.6 Map of the SKL study area showing copper concentrations that higher than Target (yellow) and Intervention (red) value of Hong Kong's standard.

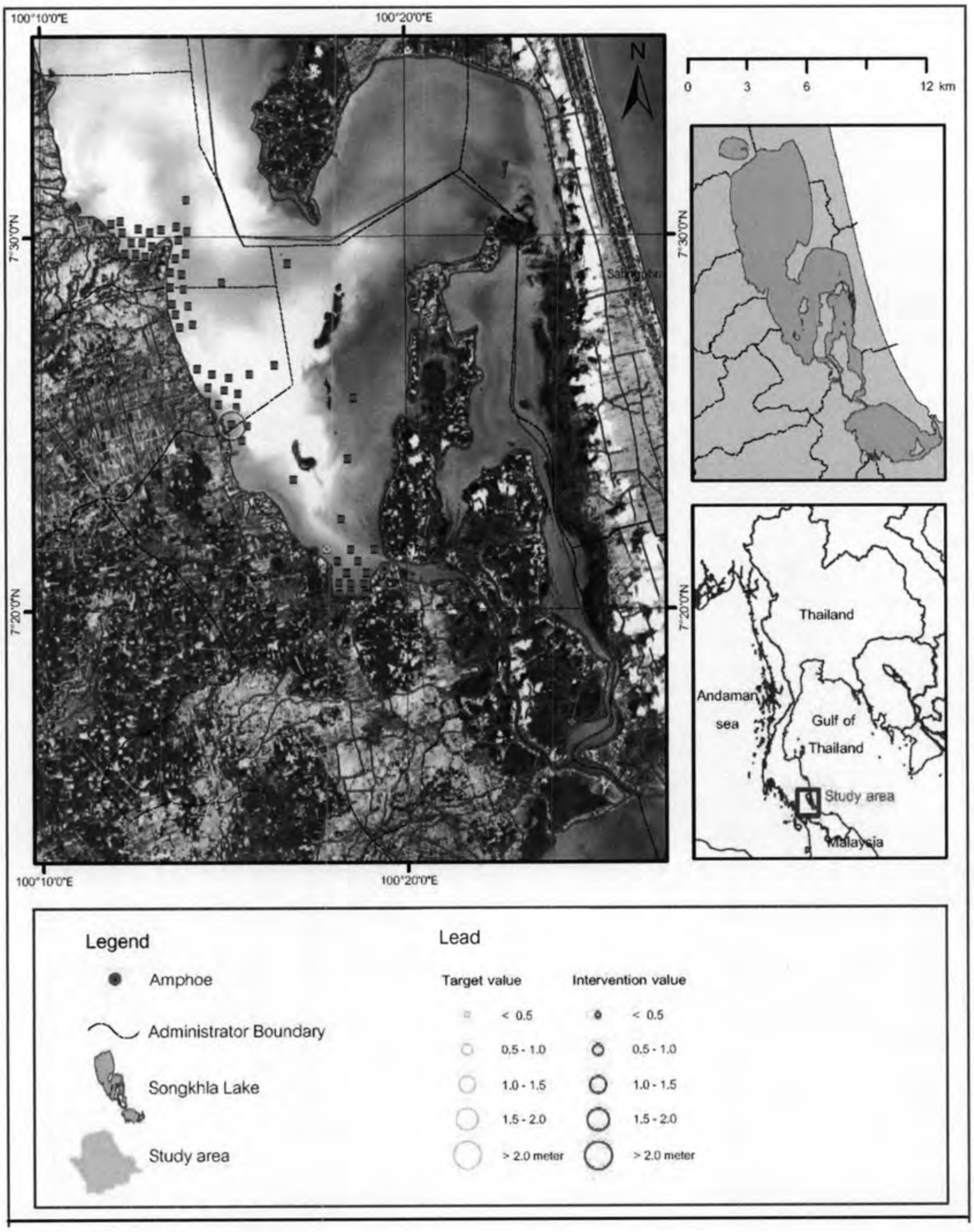

Figure 5.7 Map of the SKL study area showing lead concentrations that higher than Target (yellow) and Intervention (red) value of Hong Kong's standard.

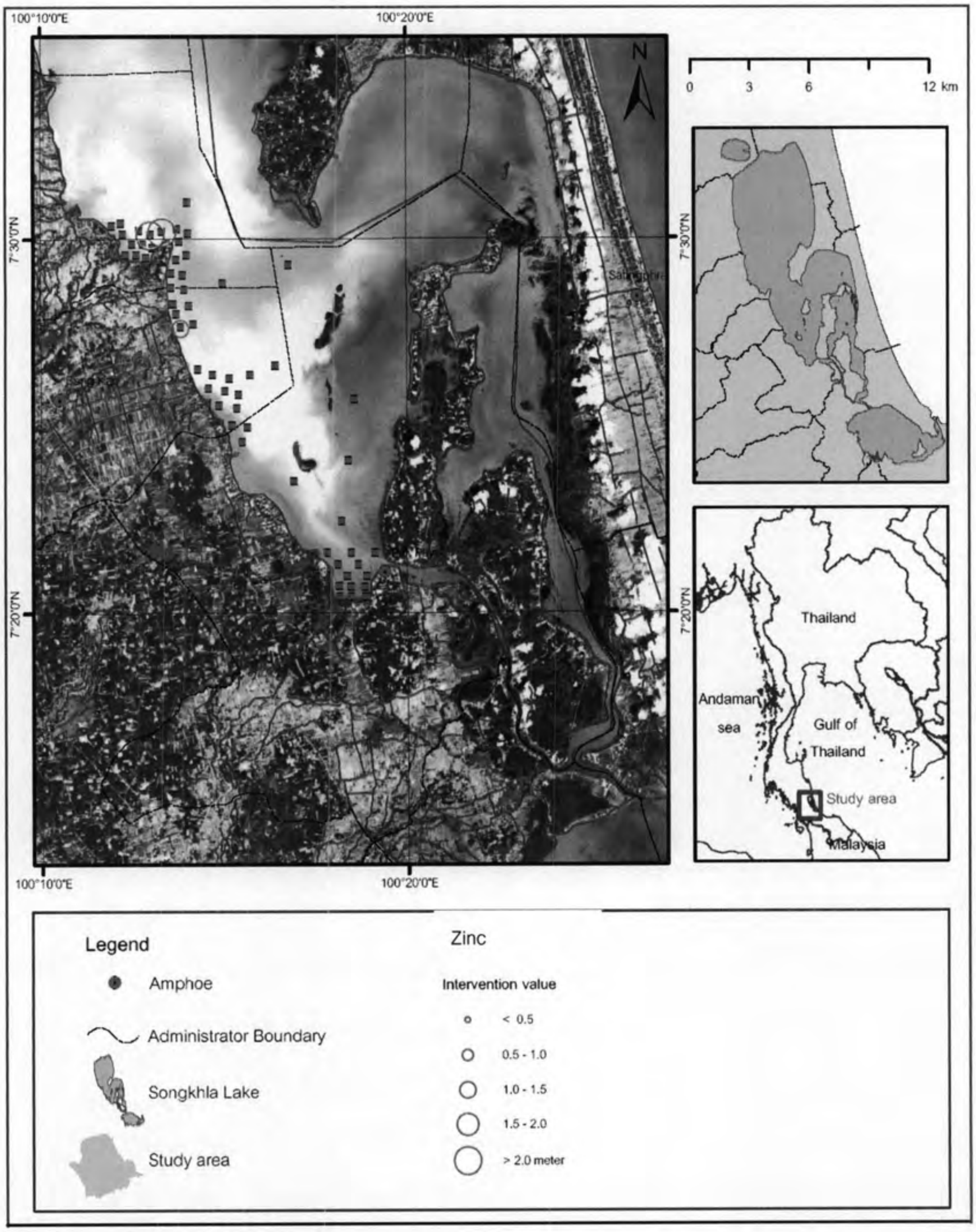

Figure 5.8 Map of the SKL study area showing zinc concentrations that higher than Target (yellow) and Intervention (red) value of Hong Kong's standard.