CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to assess the vulnerability of groundwater resources in Phuket island using of a GIS-based DRASTIC method. This study covers an area of about 543 km^2, which includes Muang, Kathu, and Thalang districts of Phuket province. The study focuses on the groundwater vulnerability mapping using a DRASTIC method on the basis of seven parameters: depth to water table, net recharge, aquifer media, soil media, topography, impact of vadose zone, and hydraulic conductivity. These vulnerability factors were reclassified to vulnerability scores using the ArcView GIS software.

In the study area, the hydrogeological setting is characterized by five units: beach sand, floodplain, colluvium, granite, and sediment or meta-sedimentary unit. The main aquifer is the granitic unit, whereby the heavily weathered granite provides an excellent aquifer. From the measurements of groundwater levels in 73 shallow groundwater wells, the average water level is calculated to be 3.52 m. The higher contours reflecting the greater depths to water table are shown in the eastern part. The origin of groundwater was evaluated based on its isotopic characteristics. Analyses of stable isotopes ^{2}H and ^{18}O were done on 31 water samples including four rain water samples, five river water samples, three old tin mine pond water samples, and nineteen groundwater samples, that were collected during June to July, 2004. The oxygen and hydrogen isotopes were plotted on the δD and $\delta^{18}O$ diagram and compared with the Thailand meteoric water line. The trend and isotopic characteristics of groundwater samples show no significant differences from the isotopic trend of water samples from other parts of Thailand. This suggests that the groundwater in the study area has the same recharge water sources. The similarity between the isotopic compositions with the local precipitation indicates that the groundwater in the study area is derived by recharge from the local precipitation.

Several techniques have been developed to assess the groundwater vulnerability potential. The GIS technique is the one that provides user-friendly functions for the analyses. It was used to analyze, identify, and display the regional sensitivity of groundwater to contamination and data were stored in a GIS format and can be retrieved and edited with convenience later. A DRASTIC method is a classic and simple method for vulnerability mapping that can be applied to any area. However, users of this method should be aware and careful in assigning rating and the source of database. The DRASTIC indices vary from user to user. But, the differences are not significant as the indices are considered in relative terms not absolute terms. The source of database is very important as the difference in the database will result in the difference in the final DRASTIC map. The study to determine data uncertainties is useful for verification of the database. Groundwater vulnerability maps involve only with the hydrogeologic setting that tends to make the groundwater susceptible to contamination from surface sources; they do not take into account the chemical nature of the pollutants and land-use. Seven parameters of particular hydrogeologic setting were considered in the analysis and were used for the DRASTIC vulnerability assessment. Each parameter was given a weight reflecting their relative significance, and these vulnerability factors were reclassified to

vulnerability scores to calculate scales, ranges, and ratings. By combining all seven parameters, the potential vulnerability map was generated. Five classes of vulnerability ranking were chosen to describe the relative probability of a groundwater resource of contamination: high, moderately high, moderate, moderately low, and low. The high vulnerability rank is predominantly found in beach sand sediments in the northwest. The moderately high vulnerability is characterized mainly by unconfined and shallow groundwater systems in the lowland areas. The moderate vulnerability rank is the dominant class in colluvial deposits which are the largest in areal extent. The moderately low vulnerability rank comprises the second largest area which includes weathered granite or weathered sedimentary or meta-sedimentary rocks, and mangrove clay in near shore areas. The low vulnerability rank groundwater resources are predominantly found in a few areas of the upland and mangrove area.

Wherever a water resources development project is formulated, the groundwater vulnerability mapping will be a very useful tool to provide important basic information for groundwater development planning, and protection of groundwater contamination. The environmental protection plan can be designed with careful analysis of several factors such as interconnectivity of surface water and groundwater, watershed characteristics, groundwater vulnerability to contamination, existing land-use, current zoning, and existing and available resources.

As for water development planning and protection of groundwater contamination, responsible agencies of the Phuket island should demonstrate remedial action plan and prohibition in high vulnerability areas, especially in the northwestern and the western part of Thalang district that include several communities located on sandy beaches such as Tha Chat Chai, Suan Maphrao, Mai Khao, Nai Yang, Khok Tanot villages and the eastern part of Kathu district in Bang Tong village. The important parameters that have a strong impact in the DRASTIC analysis in this area include the depth to water table and impact of vadose zone (given weight of about 5). Groundwater protection system in moderately high vulnerability areas, such as the alluvium area with urban area, build-up land, industrial land, and perennial lake, should also be planned. Future development of the area should take a precautious step, as these areas are prone to groundwater contamination. The moderate, moderately low, and low vulnerability areas that include agriculture land, urban area, build-up land, hill, and mangrove in the eastern part of the island should be under further investigation together with monitoring and groundwater contamination assessment report.

Groundwater vulnerability map can be applied in various circumstances, for example, as in the case of the Andaman coast tsunami disaster on 26 December 2004 where surface water and groundwater were affected by sea-water intrusion. The groundwater system which was affected by the tsunami is in the areas of high to moderately high vulnerability shown in the groundwater vulnerability map in this study. The strongly affected areas are the sandy beaches in western part of island. Relevant agencies may apply this acquired knowledge as a basis for planning of protection and monitoring system to deal with future disaster.