CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Hydrogeology of the Nakhon Luang Aquifer

1. The Nakhon Luang aquifer is separated from the overlying and underlying aquifer by thick layers of hard and compacted clay. It is situated from 125-180 meters below ground surface. The confining layers are of large areal extent having thickness ranging from 15-75 meters, its averages thickness is 50 meters. It consists mainly of sand with some gravel and clay lens intercalated through out the area. The thickness of the aquifer is thickening westward and northward directions. The thickness of sand-gravel layers within the aquifer ranging from 10-25 meters intercalated with thin clay layers, 2-10 m. thick. The compacted clay and sandy clay which capping the overlying the Nakhon Luang aquifer is approximately 2-15 meters in thickness. These clay layers are thinnest in the central part. The impervious and sandy clay layers underlying the NL aquifer are approximately 4-15 meters thick and quite thin in the southeastern and also in the southwestern parts. Based on the lithologic correlation of the existing wells data indicates that the lateral extent of the clay layer is often discontinuous and the thickness of water bearing layers vary from location to location. Thus, the groundwater regime in the area can be normally characterized by a hydraulically interconnected multiaquifer system rather than a distinctly separate aquifer system. Based on geologic studies, the environment of deposition of sediment in this area is classified into 3 types as follow: the first one is alluvial fan; the gravel is mainly found in the western part of the area that depicted that the sediment was

transported with short distance from the west. The second one is flood plain, point bar and channel deposits. Its characteristics are fine to coarse sand with some gravel, poorly to moderately sorted, subangular to subrounded and fining upward sequence in the SP curves. It is found in the central, northward and eastward of the area. The last one is delta which is shown the relicts structure in coarsening upward sequence in the SP curves. It is observed in the southern part, western part further to the north of the area. The unconsolidated Fluviatile-deltaic deposit in the study area is Middle Pleistocene.

2. Hydraulic properties of aquifer are estimated from the seventeen pumping wells in the eastern part of the study area. Based on the aquifer test data the transmissivity, obtained from the constant rate-pumping test, varies from 26 to 1,300 m^2/day. Whereas the transmissivity, obtained from the recovery test, varies from 40 to 2,200 m^2/day. The transmissivity that observed in the study area indicates the NL aquifer is adequate for industrial, municipal, or an irrigation purpose. It is classed as a good aquifer. The hydraulic conductivity of the aquifer, obtained from the constant rate-pumping test, varies from 2 to 51 m/day. While the hydraulic conductivity, obtained from the recovery test, varies from 3 to 196 m/day. As the hydraulic conductivity is rather low and not corresponding to the transmissivity which is due to the variation of the thickness of the NL aquifer. The smaller values of transmissivity and hydraulic conductivity reflect the thinner and less permeable deposits of the aquifer. The large values reflect much thickness and more permeable deposits. The specific capacity varies from 0.3 to 40 m^3/hr/m. The zone of high specific capacity is concentrated along the west bank of the Tha Chin River except at the central part, Amphoe Muang and Amphoe Nakhon Chai Si, Nakhon Pathom Province as well as

along the east bank of the Chao Phraya River. The hydrogeologic properties of the NL aquifer vary from place to place because of the variation of the thickness and the sedimentary facies and also some damage from compaction and subsidence

3. The groundwater quality is evaluated by using Piper Trilinear Diagram. The hydrochemical facies are generally found in two major types and one minor type. The major types are the Na-K-Cl-SO_4 type (Type IV) and the Na-K- HCO_3-CO_3 type (Type II) whereas the minor type is the mixing water (Type V). Moreover, the water sub facies which supporting to specify the distribution of groundwater quality in the study area is appeared into 4 types. The Na-Cl type (Type A) and Na-HCO_3 type (Type C) are mainly observed in the study area. Type A is concentrated along the Chao Phraya River, southeastern and southwestern parts of the area in, while Type C is distributed in the central part further to the eastern part of the area. The rest are the Ca-Cl type (Type D), which is spreading over the central further to the southern parts of the area. The Na-SO4 type (Type B) is concentrated only in the central part of the area.

The 15 critical parameters analysis including Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Total Iron (Fe), Sulfate (SO_4^{2-}), Chloride (Cl^{-}), Bicarbonate (HCO_3^{-}), Nitrate (NO_3^{-}), Fluoride (F^{-}), Total Dissolved Solids, Total Hardness as CaCO3, Manganese (Mn), the Power of Hydrogen ion (pH), and Specific Electrical Conductivity (EC) are shown in terms of the groundwater quality maps. The concentrations of nitrate, fluoride, and pH values are within the standard drinking water in the whole area whereas the rest are shown the critical contaminated zone. Especially, the concentration of chloride, total dissolved solids, total iron, total hardness, and manganese are concentrated along the Chao Phraya River and the zone

of the southwestern and southeastern parts of the area. It is interesting to note here that the total iron, manganese, total dissolved solid, total hardness contents are conformed to the areas of the excessive quantities of chloride. The causes of this phenomenon are the saltwater intrusion and connate water trapped during deposition. Generally, the groundwater quality on the eastern bank of the Chao Phraya river is relatively better than the western bank according to the GROUNDWATER ACTS B.E. 2520. Due to the saltwater encroachment, many wells in the southwestern part of the Samut Sakhon municipality had been abandoned. Most of the industries, developed around Amphoe Phra Pradaeng, used groundwater supply and some of these wells had to be abandoned due to saltwater intrusion. The abandonment of wells will be continued unless some possible and appropriate solutions are implemented.

4. From the flow net analysis, it is shown that the maximum production of the total Q of the Nakhon Luang aquifer is 1,295,000 m^3/day or 57 % when compare with the total groundwater extracted and the minimum production of the total Q of the Nakhon Luang aquifer is 435,000 m^3/day which covering an area 8,000 square kilometers.

5. The pumping of large quantities of groundwater in the southwestern and southeastern parts may be changed considerably the direction and rate of groundwater movement. The artesian pressure was lowered and cone of depression were produced. At present the potentiometric surface was greatly modified owing to heavy withdrawals of groundwater. Thus, the hydraulic gradients were steeped and the slopes of the potentiometric surface were moving from nearly all directions toward Amphoe Muang, Samut Sakhon Province in the western part. In the southern part at

Amphoe Muang, Amphoe Phra Pradaeng Samut Prakan Provinces toward to Amphoe Lat Krabang and Amphoe Minburi, Bangkok Metropolis in the eastern part of the study area.

6. From the analysis of land subsidence, it reveals that the severe subsidence is concentrated in Amphoe Muang, Samut Sakhon Province, Amphoe Muang and Amphoe Bang Phli, Samut Prakan Province, Amphoe Lat Krabang and Amphoe Minburi, Bangkok Metropolis, Amphoe Lam Luk Ka, Pathum Thani, Amphoe Phutha Monthon and Amphoe Nakhon Chai Si, Nakhon Pathom Province. The maximum decline of potentiometric surface is found in the same area in which large subsidence is taking place, which indicates the close correlation between the declince in potentiometric surface and land subsidence in the area.

The aquifer does not receive any local recharge in the study area from rainfall since the overlying clay layers rule out such possibility. In addition, no hydraulic connection of 150 m deep aquifer with the Chao Phraya River can be inferred from to shape of potentiometric surface contour. Therefore no recharging nodes have been included in the flow domain. Recharge takes place only along the outer periphery of the flow domain.

As indicating in the hydrogoelogic cross section, the aquifer generally extends the full width and length of Lower Central Plain. In addition, there are a lot of reasons to believe that the aquifer may be continue to extent a long way into the Gulf of Thailand due to the large areal extent and confined nature of the aquifer.

5.2 Discussions

1. According to the sedimentary facies variation and the few hydraulic properties data availability in the study area. It is unlikely to indicate the exact hydraulic properties characteristics of the NL aquifer without some variation.

2. Water quality samplings which taken from the observation wells were the stagnant water. Thus, the results in data interpretation might be misleading because the water samples are not good representative for the water quality analysis of the NL aquifer.

3. Water quality sampling were collected from the observation wells, are not consistent and not systematic collection in sequential years. It may affect in misinterpretation.

4. The pumping test calculation from only the production well may get reliable results as a pumping duration is short as well as the recharge and boundary effected which induced the fluctuation of water level in the pumping period. Thus, the obtained hydraulic properties values might be considered carefully.

5.3 Recommendations

1. Extensive abstraction of groundwater has induced the contamination of salt water intrusion from the upper aquifer, the layers of aquifer and aquitard are compacted which this phenomenon might be effected to the hydraulic properties changed decreasing the quantity and quality of the NL aquifer

2. Reduction of the unnecessary use of groundwater through appropriate price cost and also through public information campaigns and use/reuse of groundwater lower quality such as water cooling that are used in industry could receive a lower but adequate quality of supply.

3. To cope the groundwater overexploitation, the MWA, who is responsible the water supply for consumers should accelerate the expansion of the water supply system to cover the whole Bangkok Metropolis and its vicinity which needs to seek the alternative surface water sources to substitute the groundwater used to alleviate the severe problems.

4. To identify the recharge areas of each major aquifer system and formulate a development scheme on land use that benefits both economically to the landowner and promote natural assists groundwater recharge.

5. It would be emphasized here that both surface water and groundwater should be planed or managed as a conjunctive use so as to maximize the utility of natural water resources.