INTEGRATED MODELLING FOR COASTAL ALLUVIUM AQUIFER AT KG. TEKEK, TIOMAN ISLAND

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To my beloved parents and family

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ABSTRACT

Sufficient water supply plays an important role in busting the continuous growth of tourism industry for an island. Tioman Island as one of the well-known marine tourism attraction in Malaysia still highly relies on the limited surface water source to supply water for the local residents and tourists. Thus, exploration for the groundwater source is essential as an supplement for the existing water supply system to cater for the increasing water demand in the future. Utilization of surface water and groundwater will prevent the total reliance on a single resource which avoids the water scarcity problem during drought seasons and also occurrence of groundwater overdraft. Groundwater modellings in this study are developed with MODFLOW2000 based on the available data to determine the hydraulic heads and drawdowns of groundwater due to different pumping rates and saline intrusion effects are simulated with the SEAWAT2000 model. The linear optimization problem is solved with GAMS to maximize the rate of pumping for groundwater to fulfill the quantity and quality requirements. The aquifer system would be capable to support withdrawal of groundwater up to 5.8 MLD and cater for water demand till year 2015. The hydraulic drawdown has greater influence for the optimization of pumping rate compared to saline intrusion effects. With additional supply from surface water source of 4 MLD, the combination system could cater for the water demand up to year 2025.

ABSTRAK

Bekalan air yang mencukupi memainkan peranan penting bagi perkembangan industri perlancongan yang berterusan di sebuah pulau. Pulau Tioman sebagai salah satu tumpuan perlancongan marin yang terkenal di Malaysia masih bergantung kepada sumber air permukaan yang terhad untuk membekalkan air kepada penduduk tempatan dan pelancong. Dengan itu, penerokaan sumber air bumi adalah penting sebagai sumber tambahan bagi sistem bekalan air yang sedia ada untuk menampung keperluan air yang semakin meningkat pada masa depan. Penggunaan air permukaan and air bumi akan mengelakkan masalah kekurangan air pada musim kemarau dan berlakunya pengepaman air bumi yang berlebihan. Model MODFLOW2000 telah digunakan dalam kajian ini untuk membentuk model simulasi berdasarkan kepada data yang sedia ada untuk menentukan turus hidraulik air bumi disebabkan oleh pengepaman pada kadar alir yang berbeza. Model SEAWAT2000 pula menganalisa kesan pencerobohan air masin pada setiap kadar pengepaman. Masalah penyelesaian linear diselesaikan dengan GAMS untuk memperolehi kadar pengepaman yang maksimum dan memuaskan syarat kuantiti dan kuality. Hasil kajian menunjukan sistem akuifer mampu mengeluarkan air bumi sebanyak 5.8 MLD dan menampung keperluan air sehingga tahun 2015. Penurunan turus hidraulik menunjukkan pengaruh yang lebih besar berbanding dengan pencerobohan air masin dalam proses mengoptimumkan kadar pengepaman. Dengan bekalan tambahan sebanyak 4 MLD daripada sumber air permukaan, sistem kombinasi dapat menampung bekalan air sehingga tahun 2025.

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INTRODUCTION

1.1 Background of the Study

Tioman Island, as one of the marine tourism destination in Malaysia, is located in the South China Sea, 56 km off Mersing. The island having a total area of about 131 km^2, spanning about 11 km from west to east and 20 km from north to south, is the largest among a group of 64 volcanic islands in the South China Sea. Noted for its crystal clear water and marine life, the island in the vicinity of 2°43'00" to 2°54'00" N latitude and 104°06'00" to 104°12'30" E longitude, have attracted many tourists both local and abroad annually. In addition to fishing activities, tourism has become a very important income generating activity on the island.

Due to the importance of water as the basic criteria for the development of tourism, many studies have been carried out to determine the water availability on the island. Based on this purpose of study, Nazan Awang (1988) had suggested Kg. Tekek and Kg. Juara to be the potential areas for surface water and groundwater extraction on the island. The study also explored into annual water yield from surface as well as groundwater sources in Kg. Tekek by using simulation model based on the site collected data.

Presently, the limited availability of surface water sourced from the river system serves as the main source of water supply in the vicinity for domestic and tourism demands. Groundwater utilization is only available in certain parts of the

area on the island in the form of individual wells. Groundwater system for public water supply is still virtually non-existent. The government's intention to promote Tioman Island as a tax-free tourist based island will further burden the water stress. Thus exploration for new reliable water sources is essential to cater for the increasing water demand due to population and tourist growth.

The extraction of available groundwater will be the best solution for the water crisis problem on Tioman Island other than water transfer from the mainland. The main concern for groundwater aquifer to be developed as public water supply will be the maximum yield available. Pumping of groundwater may cause deleterious side effects if proper management and water conservation aspects are neglected. For coastal aquifer system, water quality degradation due to saline intrusion effects may limit the application of groundwater, therefore careful study should be carried out on groundwater aquifer to ensure a sustainable water supply of the area.

1.2 Objectives of Study

The objectives of this study include:

a. To predict the available yield of the groundwater flow system due to different pumping rate on Tioman Island.

b. To study the saline intrusion effects under different pumping rate.

c. To study the maximum pumping rate of groundwater for optimization.

1.3 Scope of Study

The study on groundwater aquifer system at Tioman Island involves scopes as listed below:

a. The study will focus on the groundwater system in Kg. Tekek, Tioman Island (Figure 1.1).

b. The simulation process involves groundwater numerical models, which include MODFLOW for groundwater flow and SEAWAT for saline intrusion effects.

c. The optimization of pumping rate that involves application of simulated results into linear programming for GAMS.

1.4 Importance of Study

As the basic human need, water is an essential criterion that enables the continuous growth in tourism industry of Tioman Island. The analytical data in 1999 provided by Hassan indicated that the surface runoff is limited and inconsistent, with fluctuating water amount following the annual climatic changes. In order to ensure continuous availability of water supply to local residents and tourists, alternative water sources will be required to supplement or replace diminished surface water supplies. Groundwater resources available in several areas on the island will be a potential option to the solution of the crisis, but extensive studies are still required to determine the advantages and disadvantages of implementation.

Figure 1.1: Location of Tioman Island.

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