THE DESIGN OF MANMADE WATER STREAM AND LANDSCAPE FOR WATER CONSERVATION AND COMMUNITY PROJECT DEVELOPMENT

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THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SAFETY, HEALTH AND ENVIRONMENT ENGINEERING

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THE DESIGN OF MANMADE WATER STREAM AND LANDSCAPE FOR WATER CONSERVATION AND COMMUNITY PROJECT DEVELOPMENT

ABSTRACT

This study is for the water conservation and community development project in Rumah Hutan Jeram. In this project, we had proposed a design of the manmade water stream and the landscape design of the Rumah Hutan Jeram. To come out with the design plan and idea, we will first need to determine the water source for the manmade water stream. We had identified the groundwater potential ranking using the GIS methods and estimate the groundwater recharge rate. From the geological data and the remote sensing data, it had shown that the Rumah Hutan Jeram area is high groundwater potential. On the other hand, the groundwater recharge rate is in between 247mm - 265 mm. These data had shown that the existing borewell is sufficient to support the water stream. This project analysed the designed and planned of the manmade water stream and the surrounding landscape with the aid of Geographical Informative System (GIS) and Remote Sensing. Rumah Hutan Jeram was designed according to the theme of natural and sustainable concept. This research project has some important criteria and adheres to the concept of water and energy conservation. In this research, the risk assessment and control measure were also included, and it is suggested according to the landscaping construction activities.

Keywords: GIS; Manmade Water Stream; Landscape Design; Wetlands; Community Project Development

REKA BENTUK LANGKAH AIR MANUSIA DAN LANDSCAPE UNTUK PERKEMBANGAN AIR DAN PEMBANGUNAN PROJEK MASYARAKAT

ABSTRAK

Kajian ini adalah untuk projek pemuliharaan air dan pembangunan masyarakat di Rumah Hutan Jeram. Dalam projek ini, kami telah mencadangkan reka bentuk aliran air buatan manusia dan reka bentuk landskap Rumah Hutan Jeram. Untuk keluar dengan rancangan dan idea reka bentuk, pertama kita perlu menentukan sumber air untuk aliran air buatan manusia. Kami telah mengenal pasti kedudukan potensi air bawah tanah menggunakan kaedah GIS dan menganggarkan kadar pengisian semula air bawah tanah. Dari data geologi dan data penginderaan jauh, itu menunjukkan bahwa kawasan Rumah Hutan Jeram berpotensi air tanah tinggi. Sebaliknya, kadar pengisian semula air bawah tanah adalah antara 247 mm – 265 mm. Data ini menunjukkan bahwa borewell yang ada cukup untuk mendukung aliran air. Projek ini menganalisis reka bentuk dan perancangan aliran air buatan manusia dan pemandangan sekitarnya dengan bantuan Sistem Maklumat Geografi (GIS) dan Penginderaan Jauh. Rumah Hutan Jeram dirancang mengikut tema konsep semula jadi dan lestari. Projek penyelidikan ini mempunyai beberapa kriteria penting dan mematuhi konsep pemuliharaan air dan tenaga. Dalam penyelidikan ini, penilaian risiko dan ukuran kawalan juga disertakan dan disarankan mengikut aktiviti pembinaan landskap.

Kata kunci: GIS; Aliran Air Buatan Manusia; Reka Bentuk Landskap; Tanah Lembap; Pembangunan Projek Komuniti

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LIST OF SYMBOLS AND ABBREVIATIONS

GIS	:	Geological Informative System
RS	:	Remote Sensing
GWPZ	:	Groundwater Potential Zone
AHP	:	Analytical Hierarchical Process
DID	:	Department of Irrigation and Drainage
LULC	:	Land Use Land Cover
m	:	Meters
km	:	Kilometres
mm	:	Millimetres
RL	:	Risk Level
L	:	Likelihood
S	:	Severity
PPE	:	Personal protective equipment
HAVS	:	Hand-arm vibration syndrome
MSD	:	Musculoskeletal disorders

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CHAPTER 1: INTRODUCTION

1.1 Background

The manmade water stream is known as "artificial river" or "artificial canal", it is an important water sources in many countries and is an essential water supplies for the natural environment cycle. Water bodies provides mankind with a variety of valuable services. It is considered ecological, cultural, and economically important to the ecosystems. As climate change and human activities escalated, the water bodies are facing various challenges, especially in terms of water quantity, water quality, ecosystem health, and facilities (Wang et al., 2019).

Water stream is a vital natural feature for the growth of plants, animals, and even humans, and it also plays a role in agricultural activity. In general, agriculture necessitates the preservation of soil water sources as well as the flow of water through landscapes. They are also connected by their vulnerability to extreme weather events, including droughts and heavy rains and the need for rivers to transport goods.

Water conservation is the practice of minimizing water usage and using the water efficiently. This can refer to the development, preservation, and control of the water resources in both groundwater and surface, and to prevent pollution. Understanding water resources conservation and environmental is part of the water and environmental management. Despite the major advance of the water management science over the past decades, many problems still need to be focused by the scientific community.

Landscape design is the science and art of planning and creating the landscape for human use and natural resource protection. Landscape science has been used in recent years to refer to research that aims to better understand the relationship between people and their environment, with an emphasis on land use change and data on land resources at the landscape scale (Robinson & Carson, 2013).

Landscape design considers the natural resource as a composite of lands social, ecological, and visual resources. It combines the discipline of biophysical sciences, engineering, and social-political sciences to create holistic site and landscape scale designs. According to Pretty (2004), there are evidence that suggests natural landscape ought to be seen as an essential human wellbeing fundamental. Physical movement is presently known to be a co-determinant of health. However there has been a sensational drop in physical action in later decades, with extreme health results. Combining work out within the nearness of nature thus has important public and environmental health consequences.

Malaysia is a tropical country with abundant of water on the surface. Most of the states in Malaysian are dependent on surface water to meet the different water needs (Mohammed & Ghazali, 2009). Malaysia has traditionally relied on surface water supply for domestic, irrigation, and industrial needs. This reliance has resulted in an imbalance in water availability at various times of the year. There is plenty of water during the monsoon, which frequently causes flooding, and there is little water during the dry season.

In this study we will focus on Kinta Valley, Perak which is famous with the karst landscape and geomorphology. Kinta Valley is a V-shaped valley open to the south and bounded by the granitic massive of the Main Range and of the Western or Kledang Range. Formation of sinkholes at Kinta valley are due to climate change. This situation is linked to the process of groundwater level change and formation of wetland. The summer and rain changes that occur play a role in controlling the fluctuations in groundwater levels (Termizi et al., 2018).

1.2 Study Area

This study focused at the Jeram, Gopeng district in Perak. The location of the site is known as Rumah Hutan Jeram (Figure 1.1 and 1.2). Geographically, Rumah Hutan Jeram is located at 4°24'18.0"N 101°09'35.3"E. The total area of the land is approximately 0.9 hectares (65m x 50m). The surrounding of the study area is a wetland and forest plantation which are unmanaged understory and lower vegetation stratification.

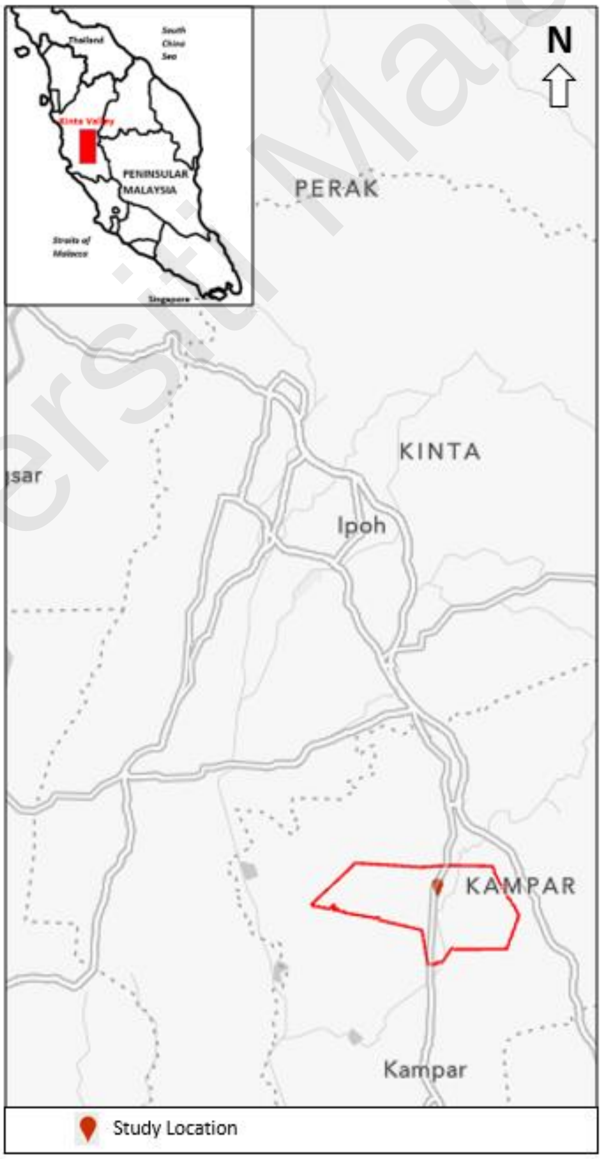

Figure 1.1: The location of Rumah Hutan Jeram at Kampar.

Figure 1.2: The satellite image view of Rumah Hutan Jeram.

1.3 Scope of Study

The study location of this research project is located at Jeram, Gopeng District, Perak State. The project is about the water conservation and community development and this study will focused on the design of water stream and surrounding landscape. This project will help the local community in terms of economical and sociological. In order to determine the morphology and direction of the water stream, it is important to first identify the potential groundwater in the study area. This study will apply Remote Sensing (RS) and Geographical Informative System (GIS) techniques to determine the groundwater potential zones and calculate groundwater recharge rate.

Besides, this research also uses the GIS and Remote Sensing to design a landscape plan for a manmade water stream and the stream connection with the fishpond to make sure the water flow is smooth and natural. The landscape design and elements need to be designed and cannot destroy all the existing feature and tress in the study area. The plan needs to include the pre-construction site investigation, landscape site plan drawing and the landscape element that could be included.

1.4 Problem Statement

According to Shanmugam et al. (2020), the research had proven that Covid 19 pandemic has effect on mental health in the Malaysian population. The researchers explained that Malaysian are expecting to see an upsurge in anxiety disorders, posttraumatic stress disorders, obsessive-compulsive disorders, and aversive social effects of isolation. In the literature on the Covid 19 impacts to human mental health, it proved that age, gender, scholarly specialization, and living condition were essentially related with the mental health condition. In research from Thoma et al. (2018), found that listening to water sounds can prevent the major stress situation. The study proposes that listening to nature sounds may be a basic and easily available mediation that is competent of emphatically influencing the major human stress system.

Besides that, there are lots of people that losses jobs during this pandemic. The unemployment rate had increased although the Malaysia government has spent billions of Ringgits Malaysia to support the local businesses and middle – low class salary citizens. But however, these are not sufficient for the citizens and to continue maintain their life and family, peoples are trying to be self-employed and entrepreneurship in the rural area or their own hometown. Currently in Kinta valley, there are some tin tailings areas are utilized for productive purposes, such as aquaculture, recreation, settlement, and agriculture (Awang, 1994). Therefore, in terms of geographical and hydrological, the study area is suitable for the aquaculture businesses.

1.5 Objectives

1. To determine the potential water source by identifying the groundwater potential and recharge rate.
2. To design the water stream and landscape at Rumah Hutan Jeram using GIS and Remote Sensing.
3. To identify the important measures in designing Rumah Hutan Jeram and assess the risk of the project development.

1.6 Significant of Study

The purpose of this research project will redound to human's health especially in terms of mentally health. The stress of an unfavourable environment can lead to worry, depress, or helpless feel in human being. As a result, blood pressure, heart rate, and muscular tension rise, while the immune system is suppressed. Green natural landscape with pleasing environments can reduce human stress, which in turn impacts the body health. Water stream and green landscape can help the mental health people to have a place relax and the water stream can act as a treatment. The fishpond can bring some career opportunity for the locals as the locals will be able to make some food products using the fisheries.

Besides, this water conservation project is an important part of the practise of conserving water and reducing waste. Water conservation is critical since fresh, clean water is both a finite and expensive resource. Additionally, conserving water resources it is also act as a protection towards the environment.

1.7 Thesis Chapters Outline

This report begins with an abstract, followed by five chapters, covering different aspects of the current research, and ends with references and appendices.

Chapter 1: Introduction

This chapter gives a detail information about the background of this manmade water stream and landscape design. It also includes the importance of the project and why this study is important for the community development. The significant of this research are not only for the economy development but also contributes to the health of the community. There are 3 main objectives that need to be fulfilled in this study and these are done and explain in the following chapter.

Chapter 2: Literature Review

This chapter includes the results of the researching process before and after confirming the title. This chapter will generally breakdown into few parts, staring from understanding the study area in terms of regional and locally. Then we proceed with the water source selection and identify the methods to identifying the groundwater potential and methods for estimating the recharge rate. The water conservation strategies and techniques were also included in this chapter as this is essential in designing the water stream and the landscaping of our study area.

Chapter 3: Methodology

This chapter we describe in detail on how the research project is going to carry out. In this chapter, we start with explaining on the preliminary and site studies then continue with the data collection. After collecting all the necessary data, the analysis and thematic map will be generated using the GIS software. For the groundwater recharge estimation, we will substitute the data into the existing equation. The last part of this report is the design of the water stream and landscape with all the information.

Chapter 4: Results and Discussion

In this chapter, it includes the results of the thematic maps, groundwater potential zone map, groundwater recharge. All these details were explained and analysed in this chapter. After collecting all these information, the water stream will have all the detail slope and depth information, the starting and ending end of the water stream. For landscape design, it includes the water and energy conservation ideas. The illustration were also included in the in this chapter.

Chapter 5: Conclusion and Recommendations

This is the last chapter of this thesis, and it includes the overall background, objectives, and the findings of this study. All the objectives must be fulfilled and mentioned in the conclusion. Besides that, some future recommendation for the future studies will be suggested in this chapter. More researchers can take the suggestion to further improve this study in the future.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Review of the literature is to make sure that the selected method reflects recommended practices and is useful at the regional level. This chapter provides an overview of the regional geology of the study area Jeram, Kinta Wetlands formation, water sources, groundwater potential methodology, recharge rate, water conservation strategies and technologies, GIS in landscape design and risk. All these information will then act as an important reference for the research project and taken into the consideration for any decision making. Finally, a summary is included to conclude the key information of the whole chapter.

2.2 Kinta Valley Geology

Peninsular Malaysia tectonic evolution has shown that it is made up of three terranes juxtaposed to form a single terrane, but two major separate blocks, the Sibumasu and the Indochina blocks. The centre and eastern belts have different stratigraphy than the Western Belt, which is related to their tectonic origin. The Block of Sibumasu includes the Western Belt. Carbonates are typically found in the Western Stratigraphic Belt on the peninsular. (Metcalfe, 2000).

The Kinta Valley is in the Western Belt, located in Perak state of Malaysia. The Kinta Valley located in the middle of western Stratigraphic belt, is bounded by 4˚15' N - 4˚50' N and 100˚55' E - 101˚20' E. It is bounded on the east and west by two Triassic granitic intrusions, the Main Range, and the Kledang Range, which formed a V-shaped topography. The Kinta Valley is surrounded by the mountain ranges to the east and west and widens to the south (Choong et al., 2014). The Kinta Valley stretches for around 50 kilometers in a N-S direction, with a width of 30 kilometers at the south and narrow downs to 10 kilometers at the north.

Regarding structural evolution, early extension is established, followed by compression and late extension. Early expansion formed in the carbonate sediments, which began to harden through diagenesis during the basin filling process, and then cracked overburden, which was reflected in the small fragile conjugate cracks of the Paleozoic shelf. This is followed by a regional compression mechanism, leading to the formation of conjugate slip faults and a series of thrust faults in the carbonate formations. (Choong and Pubellier, 2014).

2.2.1 Lithologies

The geological map drawn by Ingham and Bradford in 1960 classified the near threshing as a series of sedimentary rocks with ages ranging from the Silurian to the Permian. The deformation near threshing has been analyzed using multi-scale analysis, which focuses on the main crops, granite and limestone, despite the fact that most valleys are full of alluvial layers.

Previous study has grouped the Kinta Valley lithologies into a few geological successions. There are argillaceous rocks, calcareous rocks, arenaceous rocks, granitoids and alluvium (Rajah, 1976). The two lakes near the threshing valley are supported by large and homogeneous igneous granite, forming a terrain with an altitude of more than 700 m. The 400-kilometer-long main mountain range surrounds the eastern lakes of the valley, stretching from the Malaysian-Thai border in the north to Malacca in the south.

2.2.1.1 Clastic Sedimentary Rocks

In the southern section of the Kinta Valley, particularly in the Seri Iskandar district, the clastic sedimentary rocks such as sandstone and mudstone are commonly be found. The interbedded sandstone and mudstone have very steep dip angles and strike almost from north to south. The DEM contains ridges with a North to South layout, it was in response to the tectonic movement. The production of a wide array of fractures in the rocks is caused by brittle deformation of the rocks. The ridges are relics of sandstone beds that are resistant. Ridge's remnants of sandstone beds that are weather resistant have narrow, small, and steep lanes, which are characteristic of high angle dips.

2.2.1.2 Karstic Limestone

Along the eastern slope of the Kinta Valley and next to the foot of the Main Range Granite, numerous small karstic hills with steep slopes stand out from the level alluvial plain. The drainage on the limestone hills is easy, and generally develops along the steep hillsides, with some cutting deep into the hillsides, but some may vanish after a short time. The vanishing irrigation channels signify the absorption of the surface drainage by the groundwater subsurface grid. And frequently, the subsurface flow passes along the base of the limestone slope.

2.2.1.3 Alluvium

The Kinta Valley's base is alluvium, which is essentially smooth and low relief. As a result, satellite images can only detect a few or no geographical characteristics. Most areas of the Kinta Valley are underpinned by alluvium, which is rich in pleasure cassiterite, which has been extracted either by the new dredging process or by the traditional graft pump system. What remains of this mining industry are now vast stretches of tailing sand and thousands of mining ponds occupying nearly the entire valley floor.

2.3 Kinta Wetlands

Wetlands, like rain forests and coral reefs, are some of the most valuable habitats on the planet. They too are a source of considerable biodiversity in supporting various species from all the major bunches of life forms – from organisms to well evolved creatures. Physical and chemical highlights such as climate, geology (scene shape), topography, supplements, and hydrology (the amount and development of water) aid decide the plants and creatures that occupy different wetlands.

In Malaysia and other developing nations, the wetlands are getting to be an undermined scene particularly due to improvement. Based on this situation of the draining wetland of the world, a ponder was carried out to explore the frame and work of common wetland in controlling floodwaters and supplements input and yield (Ismail & Ali, 2002). Daerah Kinta, Ipoh, the capital city of Perak state in Malaysia covers a region of 88 sections of land, and the range can by and large be partitioned into a few categories which incorporate open spaces, lakes, soil channels and wetland or swampy zone (Chang et al., 2008). The occurrence of Perak Kinta wetlands is due to the large abandon tin mining area (UNEP, 2008).

2.4 Water Source Selection

Both surface water and groundwater are key water sources in the community. For single residences and small towns, groundwater is a frequent source, whereas rivers and reservoirs are the most common sources for large cities. While groundwater comprises nearly all of the liquid fresh water on the planet, the majority of it is found at tremendous depths. Pumping becomes prohibitively costly as a result, preventing the complete production and use of all groundwater resources.

When evaluating a conceivable source of water supply to guarantee that the resources are in a satisfactory amount so that a dependable supply is guaranteed. The supply of groundwater and springs is subordinate to surface waters as a source. the supply quantity and quality of surface water and the new groundwater are being utilized downstream. There is regularly an impressive time lag between changes in surface water and groundwater.

2.4.1 Stream Interaction

Stream systems can capture groundwater baseflow as well as discharge land surface runoff. Water or solute flows across stream beds in stream–aquifer interactions, regulating the hydrological connection between stream water and groundwater. Hydraulic conductivity of the streambed is an important metric in the research of aquifer-stream interactions. In regions where groundwater-induced stream-flow loss is a water-management issue, knowledge of stream-bed hydraulic conductivity is necessary in the development of integrated stream and groundwater-use plans. (Chen et al., 2013).

2.4.1.1 Gaining Stream

Gaining stream also known as effluent stream. It is a stream that happens in a discharge area and receives the groundwater flow because its discharge increases downstream. The water table along the gaining streams is usually at or near the stream level, and the ground water generally flows in and out of the stream, with a thin seepage face between the two surfaces (Dingman, 2008).

2.4.1.2 Losing Stream

Losing stream also known as influent stream. Losing stream discharge decreases downstream; such a stream may occur in a recharge zone and could be link to or "perched" above the general ground water flow. The water table is below stream elevation. Unlike sinkholes, the loss of streams does not generally lead all the water running in them to the subsurface.

2.4.2 Groundwater Potential

Groundwater resources are an important natural resource because they can be used for domestic, agricultural, and industrial purposes. The demand for groundwater has skyrocketed because of increased population, advanced irrigation practises, and industrial applications. In most types of landscapes, surface-water bodies are interconnected to groundwater. Groundwater and surface water mingle in almost all habitats, from little streams, lakes, and wetlands to vast river valleys and seacoasts (Winter, 1999).

The current groundwater potential zone (GWPZ) map offers decision makers with information for optimal groundwater development and preparation for urban and agricultural applications. The study will aid in the improvement of irrigation systems and agricultural productivity (Arulbalaji et al., 2019). GIS is a useful tool for assessing groundwater potential.

2.4.3 Analytical hierarchical process (AHP)

Analytical hierarchical process (AHP) techniques used to solve complex problems of management to make its implementation easier. High-potential locations with average vegetation and high rainfall are found in the southeast and adjacent forest areas, according to the statistics (Zeinolabedini & Esmaeily, 2015). The AHP approach uses pair-wise comparisons of the importance of the criteria and sub-criteria inside the judgement matrix to divide multi-criterion decision issues into hierarchies. When identifying probable recharging zones from competing sets of characteristics, the hierarchy will allow the analysis to analyse the individual attributes independently.

In the first steps of the AHP technique, each element that determines recharging was assigned a score between 1 and 9, based on its relevance in pairwise comparisons with other factors. Table 2.1 shows a standard scale of relative influence of the parameters can be described using Saaty's 1-9 scale, where score 1 reflects equal influence of the parameters and score 9 represents the excessive influence of a parameter on groundwater recharge compared to the other factors.

Table 2.1: The Analytic Hierarchy Process (AHP) relative class rate scale (Saaty, 1980)

Importance and Scale								
Equal	Weak	Moderate	Moderate Plus	Stro ng	Strong Plus	Very Strong	Very, Very Strong	Extreme
1	2	3	4	5	6	7	8	9
1/9 1/8	1/7 1/6	1/5 1/4	1/3 1/2	1 2	3 4	5 6	7 8	9
← Less important				More important →				

2.5 Aquifer Recharge

When rainfall inputs to the soil exceed evapotranspiration losses, groundwater recharge rates are maximum. The aquifer's water may be exceptionally old when the water table lies deep underground, potentially due to a past climate regime. The transfer of water from the earth surface or unsaturated zone into the saturated zone is known as aquifer recharge. The quantitative measurement of recharge rate aids in the understanding of large-scale hydrologic processes. It's useful for gauging groundwater sources' long-term viability, but it doesn't suggest a long-term extraction rate.

The water balance of any watershed is dependent on groundwater recharge. However, because direct measurement is practically impossible, a variety of approaches have been used to estimate recharge, ranging in complexity and cost (Lerner et al., 1990; Scanlon et al., 2002).

2.5.1 Empirical Relationship

The most important source of groundwater recharge is precipitation. Estimating groundwater recharge from precipitation is a crucial part of hydrology for water resource evaluation and planning (Chen et al., 2008). Despite the fact that precipitation is the most important source of groundwater recharge, the precision of current recharge measurement techniques is insufficient (Sumioka & Bauer 2003).

Seasonal groundwater balance studies can also be utilised to establish empirical groundwater recharge precipitation connections. Using non-linear regression techniques, an empirical connection for estimating ground water recharge was presented to fit the predicted values of precipitation recharge and the corresponding values of precipitation in the country's monsoon season.

In research from Kumar and Seethapathi (2002), it was determined that as the amount of rainfall grows, so does the amount of recharge, but the increase is not linear. The recharge coefficients for the research period's monsoon seasons were determined and expressed as a recharge/rainfall ratio. The objectives of the study, available data, and opportunities to get supplemental data should all influence the method used to estimate natural ground water recharge.

2.6 Water Resources Conservation

The significance of conservation in water resource planning and management has gotten a lot of attention in recent years. Water conservation has been recognised as an essential component of water resource planning and management by major sectors of the water supply community (Baumann et al., 1984).

The demand for water resources has been rapidly increasing, with the most significant challenge being the provision of adequate water to meet social needs. In Malaysia, treated water from reservoirs is used for daily consumption. (Ashraf et al., 2018). Individuals, communities, and countries must make water conservation as a priority. Finding ways to facilitate rainfall percolation into the soil rather than allowing it to run off into streams and rivers is an important approach.

2.6.1 Water Conservation Strategies

The most underestimated parts of a whole-building design plan are water conservation technology and techniques. Planning for varied water needs within a structure, on the other hand, is increasingly becoming a top issue. The methodical management of water resources to reduce waste, overuse, and exploitation is known as water efficiency. The goal of water conservation planning is to "do more with less" while retaining comfort and performance. Water efficiency strategy is a resource management technique that involves analysing water costs and usage, specifying water-saving solutions, implementing water-saving measures, and confirming savings in order to make the most cost-effective use of water resources possible (Bourg, 2016).

Freshwater resource management should also include water conservation and loss reduction, and it should be emphasised in freshwater resource planning. There are several methods for reducing the amount of water consumed in a site. Generally, these methods include:

- Water conservation techniques
- Water reuse/recycling systems
- System optimization (i.e., efficient water system architecture design, leakage detection, and repair).

More specifically, each of these solutions can make use of different of technologies and techniques to reduce water and energy use.

2.6.2 Water Conservation Technologies

Water management technologies include all methods of conserving water by increasing water use quality, increasing runoff retention potential, and eliminating water pollution. Water quality is primarily determined by the availability and usage of water-saving devices, as well as consumers' willingness to minimise overall water consumption volumes.

2.6.2.1 Rainwater Harvesting

Rainwater harvesting (RWH) may be the best long-term solution for implementing into the city's water management system. It can help relieve the water crisis, reduce the strain on traditional water supplies, reduce nonpoint source pollution, monitor water logging issues, mitigate flooding, contribute to climate change mitigation, and help with storm water management, among other factors. RWH is an easily available resource due to water scarcity and the limited capacity of traditional sources in metropolitan areas. The technique might be utilised to meet water demand in water-scarce areas around the world on a local and cost-effective basis. If the water-quality criteria meet the essential requirements, harvested rainwater could be optimized and used as a source of supply water (Tsai et al., 2011).

The presence of chemical and microbiological contaminants makes the monitoring of collected rainwater a major concern because it poses a health risk. As a result, prior to usage, a quality assessment of the collected water is required. The presence of chemical and microbiological pollutants makes the monitoring of collected rainwater a major concern because it poses a health risk. As a result, quality testing of collected water is needed prior to usage (Rahman et al., 2014).

2.6.2.2 Water Biofilter

Biofiltration is an discuss contamination administration strategy in which microorganisms metabolize poisons in a gas stream and turn them to water, carbon dioxide, and biomass (Devinny et al., 1999). It produces no auxiliary contaminants and does not have tall working and support costs. In any case, one of its disadvantages is the trouble in controlling water substance, which can result in destitute biofiltration productivity (Badilla et al., 2011).

Outdoors's bio-filters have been utilized effectively in incubation centres, nurseries, decorative angle refined, and to a few degrees in product angle refined for a long time. These frameworks are operational, well-tested, and demonstrated, and they are accessible for buy. They are, be that as it may, exceptionally costly, both in terms of use and in terms of movement. The fast evacuation of bolster build-ups is another imperative include of the "biofilter" approach. In comparison to in-pond frameworks, which flourish to reuse non-utilized nourish as much as conceivable, conventional biofilter plan parameters dispose of any un-used bolster or bolster build-up as rapidly as conceivable (Avnimelech, 2006).

2.7 GIS in Landscape Design

Based on Nijius (2016), the impacts of GIS usage were largely determined by individual users who have a particular interest in the technology and combine it with landscape architecture expertise. Although according to the surveys, the software's complexity, and breadth of capabilities, as well as access to and availability of data, are all major factors in the GIS's neglect in the landscape. GIS technology is clearly required at all stages of the landscape design operations, including database creation, analysis, scenario evaluation for future development and alternative solutions, decision-making, and visualization of outcomes. The rapid production of alternative solutions and stimulation is a significant benefit of GIS tools in the design (Dora et al., 2017).

Each of these process shapes a major choice point for the proprietor. The user must be given sufficient data to permit choices, counting the elective to not continue. The plan prepare is iterative. Each process requires revaluation of the plan suspicions made in past steps, the capacity of the plan to meet the plan criteria, the compatibility of forms, and integration of the forms. At key choice focuses, the financial reasonability of the venture must be reassessed (Davis, 2019).

2.7.1 Study and Conceptual Design

Choices are examined during the conceptual design process, and appropriate plan criteria are developed. The options for office development are examined at this stage of the project. Obtaining water from a nearby town, storing water within the corporation, or having individual clients supply their own water via a private well are all options for water system businesses. The design methodology is approved for use in the first stages of the project. This method is designed to allow for a more in-depth examination of the alternatives that appear to meet the client's objectives. A work schedule and plan are generated by the construction. These give the client realistic timeframe goals while also guaranteeing that the amount of effort and level of detail put into the construction are adequate for financial decision making about the extension's viability.

The concept is given approval to finish the first steps of the plan before moving on to the final design. This method is designed to allow for a more in-depth examination of the alternatives that appear to meet the client's objectives. A work schedule and plan are generated by the construction. These give the client realistic timeline goals while also guaranteeing that the amount of effort and level of detail put into the construction are adequate for financial planning about the extension's viability (WEF, 1991).

2.8 Project Risk Assessment

Risk management is a systematic way to applying management rules, procedures, and methods to risk-related processes in order for firms to effectively avoid losses while maximising opportunities. Risk management is a relatively recent notion, having been established only around 50 years ago (Aven, 2016). However, in recent years, extensive research involving risk management has been undertaken, and individuals are beginning to recognise the relevance of risk assessment, particularly in the project management profession. (Pekkinen & Aaltonen, 2015).

In research from Dziubiński and Marcinkowski (2006), the basic reason of the failure and possibility of the consequences that will happens on an individual. In addition, the author considers social risk and proposes a risk assessment approach for hazards. Researchers conducted a Hazard and Operability Study (HAZOP), in which potential hazards are identified, as well as the nature and scale of hazardous substances, by instantaneously viewing the design; safe facility operation, control of serious deviations that can result in serious accidents, and on-site emergency response (Qureshi, 1988).

Project risk management should begin with writing the project background; This means the active participation of stakeholders, clearly determining the goals, expected results, management constraints and threats of a given project, and determining the interface with other constraints or organizational / strategic projects. Risk management includes continuous processes that must be updated throughout the project. The goal of risk management is to increase the impact and probability of positive events and reduce the probability and impact of adverse events on the project. The basic plan of Hazard Risk Identification Assessment (HIRA) was explained in figure 2.1.

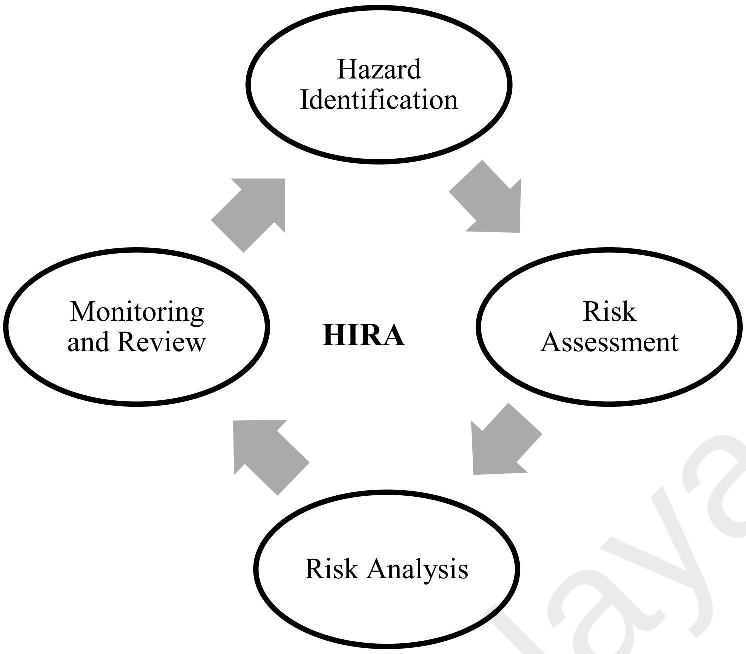

Figure 2.1: The HIRA process.

2.9 Summary

Kinta Valley is formed by the narrow-deformed strip in between the Late Triassic geological history. It is located at the middle of Perak state and the Jeram, our study location is situated at the middle of the Kinta Valley. The lithology of the Kinta Valley is divided by several units, for example, the calcareous and areanaceous series, the alluvium and granite series. Getting to know the geological setting and history of the study area is the most initial and essential process to continue this study. This is because it acts as the first indicator for the decision maker to proceed with the resources.

The main purpose of this study is to identify the potential water resources source and therefore getting to know that the water source is basically either from the surface runoff or the groundwater. In some cases, both of is will be equally important and can be used both. In this study we will focus on the groundwater as the main source for the water tream and therefore it is important for us to know the groundwater potential and its recharge rate. The groundwater potential is good to use the Geographical Informatic System (GIS) and Remote Sensing to identify because of the cheaper cost and time taken. For the recharge rate, we will be considering using the empirical equation.

The next part of the study is to identify the water conservation technologies and strategies. For the water conservation strategies, it is best for use to access all the control measures and risk in order to come out with the most suitable strategies and implement the strategies. Biofiltration is one of the most effective technologies to be used in this case as it is more environmentally friendly, sustainable, and cheaper budget required. Rainwater harvesting also can be one of the techniques to collect water and we don't need to 100% relies on the groundwater source.

The last part of this study is to design the water stream and the landscape. This step is important as it illustrate the whole of our research study and important for the decision maker. In this project, we will use the GIS to design out the water stream system and combined with the drawing application to illustrate the whole landscape and the cross-section design. The design will generally be divided into preliminary design and final design drawing.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The collection of the data for this study was carried out through the collection of required data, for examples, Landsat images, rainfall precipitation data, and site photos. All the data that acquired was interpreted with the aids of ArcGIS Pro and CorelDRAW. The data will be processed, analysed, and explained in chapter 4 and chapter 5. The research flow chart in Figure 3.9 gives the whole idea for the whole research stage.

The methodology outlines the procedure and methods that will be carried out throughout the whole process. The preliminary site location investigations must be done first, followed by site visits. After all the data has been collected, processed, data analysed and interpretated, the research project was completed after finished the report writing.

3.2 Preliminary Studies

The preliminary investigation was carried out to gain additional understanding and information about the research area. Preliminary research was carried out by consulting a journal, a thesis, an existing geological map, a hydrological map, and a previous report. Remote sensing Landsat imageries for the Jeram, Perak had been analysed and observed. There are a lot of informative details about the location that had been recorded and displayed in the software.

The groundwater potential in the research area was also determined using the available geological and hydrological maps of Perak state. ArcGIS Pro was used to construct a groundwater potential zone map and assess the accessibility of Rumah Hutan Jeram. The site reconnaissance was completed before to the site visit in order to gain a better understanding of the study area and to make the research methodology go more smoothly.

At this site reconnaissance, the location topology, accessibility, traffic, and the geographical information were collected and analyse. The information shows that Jeram was located and surrounded by the karst formation and Gua Tempurung is located not far away from the study area. This had given an information that there is high possibility an underground water stream underneath.

Using the existing open-source map like Google Map can clearly identify the route and the accessibility to the study area. Rumah Hutan Jeram is located besides the Jalan Ipoh-Kampar, and it is 10km away from Kampar city. By doing this preliminary study, we can also locate the best and comfortable area to stay and good place to visit during the site visit.

3.3 Site Visit

The purpose of site visit is done to verify and supplement information in the research project. The site visit to Rumah Hutan Jeram was carried out to do a background study, observe the existing facilities and the landscape. This site visit was carried out in a sunny weekend in April 2021. We went to the site location, and visited the owner, her families and a few workers that manage the area.

During the site visit, we were welcome by the owner, and she brings us visit and walk around the site. The owner also shares the idea of how she wanted to manage the area and what is her main purpose of having all the natural features. Interview session with the owner and workers in the Rumah Hutan Jeram had successfully gain more information about this project. The owner is a counsellor, and she would like to create a recreational therapy theme park. These is an existing fishpond in the area and the owner would like to have a manmade water stream connected to the fishpond so that it can act as part of the filtration system.

Few site pictures were also taken for further analysis and recorded in the report. Figures 3.1 and 3.2 are the landscape view of Rumah Hutan Jeram to and from the North direction. From the pictures, we can see that the fishpond is at the Northern part of the land, and it is approximately 50m length and 8m width. The depth of the fishpond is approximately 2m. According to the owner, this fishpond was dig in year 2019 and the purpose of this fishpond serve for local economy activity.

Figure 3.1: Rumah Hutan Jeram landscape view to North.

Figure 3.2: Rumah Hutan Jeram landscape view from the North.

Figures 3.3 and 3.4 showed that the building of Rumah Hutan Jeram. This building was built by the previous owner, and it is currently used a resting area for the visitors. The owner is planning to beautify the surrounding of the building and welcome the visitor stay overnight.

Figure 3.3: The front view of the building.

Figure 3.4: The back view of the building and this land is going to become the route of the water stream.

Figures 3.5 and 3.6 showed the existing borewell that still able to use and they frequently monitor the groundwater level. According to the owner, this borewell was available before they rented the land.

Figure 3.5: The borewell is inside the cottage.

Figure 3.6: The existing borewell in the Rumah Hutan Jeram.

3.4 Data acquisition

The process of sampling signals that measure physical conditions in the real world and transforming the samples into digital values that may be controlled by a computer is known as data acquisition. To conduct the groundwater potential analysis, we used data from the Shuttle Radar Topography Mission (SRTM) and Landsat 8. The satellite pictures were used to create a few thematic maps. On the other hand, rain precipitation data were collected from the official Malaysia government website. The groundwater recharge rate was estimated using the rain precipitation data.

3.4.1 Satellite dataset

The Perak satellite image was acquired from the USGS Earth Explorer. It is an open source to obtain geospatial dataset and there are a lot of different types of satellite data can be obtained. For this project, we used two different types of satellite imagery. STRM data were used to generate the geomorphology, slope, lineament, and drainage thematic maps. The Landsat data was used to generate the Land Use Land Cover (LULC) thematic map. All these maps will then be combined with different weightages and come out with Groundwater Potential Zone map.

3.4.2 Geological Data

The study took into account geomorphology, drainage density, lineament density, slope, elevation, geology, land use and land cover, and soil. These data were gathered from multiple sources and analysed in a GIS context in order to create the database. In this project, we used some existing published map to proceed with the groundwater potential analysis.

Geological map was obtained from Geology of Peninsular Malaysia Toposheet 1:50,000 scale. The DEM was extracted from SRTM imagery, which was used to prepare slope, elevation, drainage density layers. The generalize soil map was obtained from in 1:50,000 scale.

3.4.3 Rain Precipitation

The rainfall data for this study were obtained from The Official Web of Public Info Banjir which is managed by the Department of Irrigation and Drainage (DID). The data collected is from the Gua Tempurung station (4°25'56.7"N, 101°11'09.5"E), Kg Sahom weather station (4°23'10.9"N, 101°12'50.7"E), and Sg Kinta Tanjung Tualang (4°19'21.3"N, 101°04'21.4"E) which showed the rainfall trend in millimeters (mm) occurred. From figure 3.7, we can clearly see that the displacement distance of the Gua Tempurung station is approximate 5 km from the Rumah Hutan Jeram, the Kg Sahom weather station is approximate 8 km, and lastly the Tanjung Tualang is around 15 km away from Rumah Hutan Jeram. The data collected are the monthly precipitation data in 2020. The rainfall stations pictures that we collected the information from were shown in figures 3.8, 3.9, and 3.10.

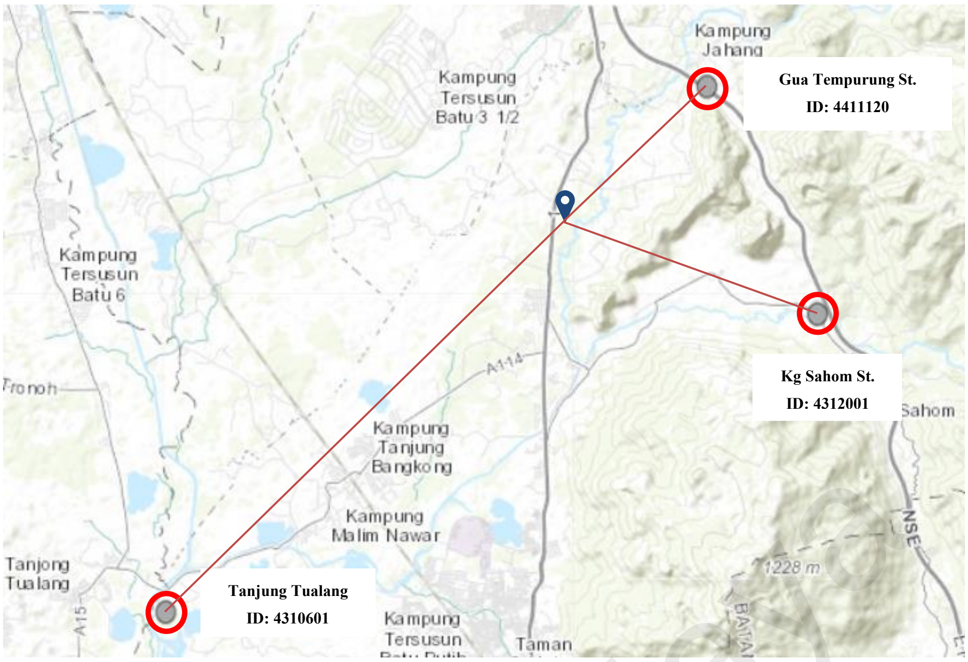

Figure 3.7: The rainfall stations at Gua Tempurung, Kg Sahom and Tanjung Tualang

Figure 3.8: The Gua Tempurung Weather Station (Source: Public Infobanjir)

Figure 3.9: The Kg Sahom weather station (Source: Public Infobanjir)

Figure 3.70: The Sg Kinta at Tanjung Tualang weather station. (Source: Public Infobanjir)

3.5 Data Analysis

In this project we analysed the groundwater potential zone and the groundwater recharge rate of the study area. These are to make sure that a water stream is suitable in the area and identify the potential water source for the water stream.

Geographic Informative System (GIS) is a powerful tool for managing, storing, and displaying the spatial data. GIS methods and technology is often used in the water resources management. The usage of GIS in water supplies has become very common and famous and the applications that related to GIS are addressed and evaluated for efficient future research and development to emphasize the importance of GIS in water resources management (Tsihrintzis, Hamid, & Fuentes, 1996). GIS applications applied on the surface hydrologic and groundwater modelling, source pollution in urban area and agricultural field, and other related application.

In this study, we used the ArcGIS Pro software to analyse the satellite imageries that were acquired from the open source datastore. The Analytical Hierarchy Process (AHP) was used to determine the groundwater potential. This method is commonly used as an offsite method to determine the groundwater potential. There doesn't need much effort or cost to carry out the method, therefore the decision maker will prefer to carry out this method before making further plan. On the other hand, groundwater recharge is another requirement for this project. An equation was used to determine recharge rate.

3.5.1 Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) is a structured decision-making technique that involves creating an empirical comparison matrix and using expert knowledge to establish rankings and weights. The nine thematic classes were prepared using ArcGIS

Pro software. Hierarchical analysis is used to assign weights to georeferenced maps. The normalized weights for the classes are generated by satisfying the consistency index of the generated pairwise matrix and the consistent scale value.

The construction of the pair-wise comparison matrix including all the thematic layers according to the Saaty 1-9 scale in Table 2.1. The determination of the weight coefficient by calculating the consistency ratio (CR) for the consistency check. The CR is calculated by first identify the consistency index (CI), using the following equation:

$$I=C(\lambda \max - n) / (n-1) \tag{3.1}$$

The λ max is the largest maximum eigenvalue of the comparative matrix and N is the matric rank. Then the CR is calculated as the ratio between the CI and the random index (RI). This stage ensures that the analysis and judgement of the scale are consistent. The CR is calculated using the following equation:

$$CR=CI/RI \tag{3.2}$$

Figure 3.10 showed the whole workflow of this methods to determine the groundwater potential zone. Existing geological map and soil map were acquired, digitized, and rectified to generate a local geology and soil thematic maps. The remote sensing data were obtained, and few analytic steps were taken in the ArcGIS Pro software. Geomorphology, slope, lineament, drainage and LULC thematic maps were generated. All the 7 maps were then assigned with the ranking according to the themes and classes. The individual weightage is assigned to each of the sub-criteria and finally combined generated a groundwater potential zonation map.

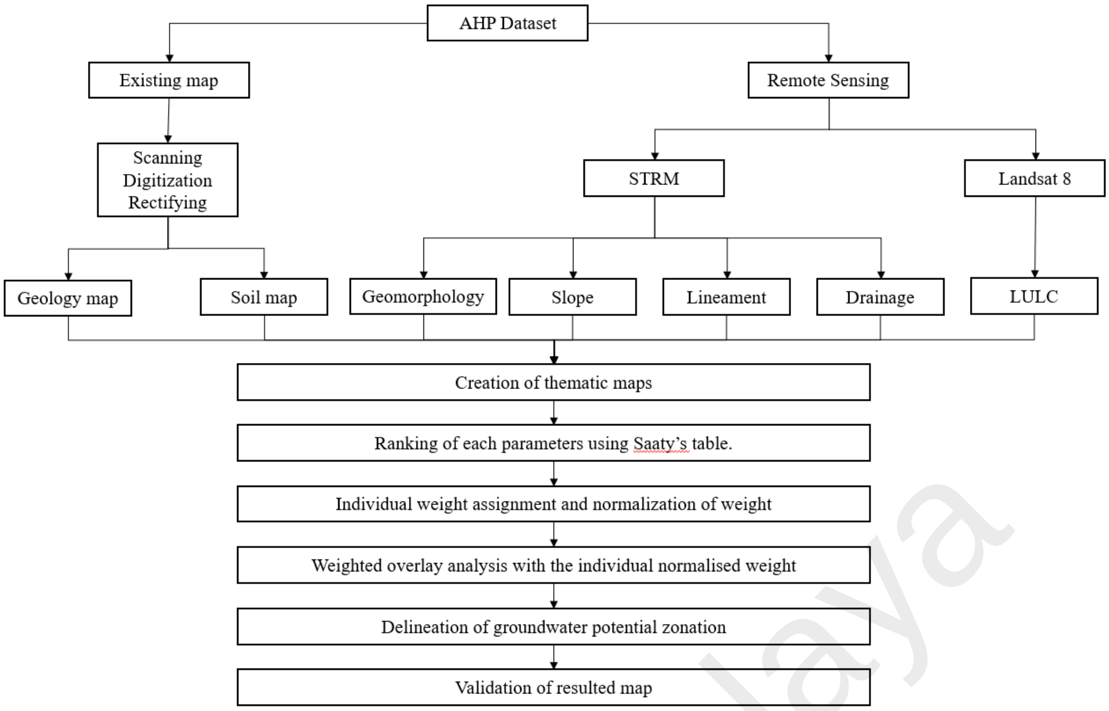

Figure 3.8: The AHP process workflow.

3.5.2 Groundwater Recharge Estimation

Chaturvedi's formula has been widely used to give a rough estimate of the amount of groundwater replenishment due to precipitation. The calculation of the recharge rate in the study area was made by a modified version of Chaturvedi (1973) for the tropics based on the variation of water level and precipitation elevation as follows:

$$R = 0.63\ (P - 15.28)^{0.76} \quad (3.3)$$

where, R is the net recharge due to precipitation during the year and P is the annual precipitation, both in mm. In this stage, we used the collected rain precipitation data and substitute the values in the equation.

3.6 Water Stream and Landscape Design

Water stream and landscape design was drawn by using the CorelDRAW software. All the data that were analysed were used to make determination and selection of the landscape features and the water stream flow. For this design we generally divided into the water stream design and the landscaping design.

For the water stream, we will need to come out with a water stream detailed drawing plan. The total length and depth of the water stream were illustrated and each section that were designed with mini waterfalls were clearly plotted in the drawing plan. Additionally, each small section and certain distance were designed, and additional depth of the slope were added in the design plan. For the landscape design were drawn using the software and all the feature placements were determined by combining the results and criterion. Besides that, the control measures for the water stream project were identified.

3.7 Landscape Risk Assessment

Each design plan was designed based on all the collected information and following the control measures, risk, and requirement. Design risk assessments prepare design teams to identify and manage risk throughout and upon completion of the design project. Design risk assessment provides a design team with a framework to perform risk assessment. When performing a design, we will need to identify what possible hazard and precaution that might take place including the preliminary and final design, the design process, and the project environment. These risk assessment aspects were important for the team and decision maker when carrying out investigation and come out with suitable control measures.

Hazard Identification and Risk Assessment (HIRA) is carried out to identify the unwanted situation that can caused hazard. In this risk assessment we will identify the factors that may be contributing hazard and risk. We will review the safety information and health that are from the authoritative and reliable source. Besides, how severe the damage can cause is important and including information like harm, damage, illness, and number of people that will affected in these incidents. Suggestion or recommendation can be given to analyse the risk, then the final is to monitor and review the implemented suggestions.

3.7.1 Likelihood of an occurrence

Likelihood is an event of incident occurrence and is access based on the experiences, measurement, and analysis. The level of likelihood is from very unlikely to almost certain. Table 3.1 explained the indicators of event likelihood using the value 1 to 5.

Table 3.1: The likelihood, description, and rating.

Likelihood (L)	**Effect example**	**Rating**
Almost Certain	The almost certain results of the event and hazard being happened or realized.	5
Quite Possible	Has a good chance of happening and is not unusual.	4
Unusual but Possible	Might be happening at sometime in the future.	3
Unlikely	Has not been known to occur after so many years.	2
Very Unlikely	Is practically impossible and has never occurred.	1

3.7.2 Severity of Hazard

The severity can be explained by the highest level of the hazard damage when the accident occurs. In another way of explaining is when a hazard is not mitigated what is the severity of the issue or problem that will occurs. Table 3.2 showed the severity rating.

Table 3.2: The severity, description, and rating.

Severity (S)	**Effect example**	**Rating**
Catastrophic	Numbers of fatality, irrecoverable property damage.	5
Fatal	Approximately one single fatality and major property damage.	4
Serious	Non-fatality, permanent disability	3
Minor	Disabling but not permanent injuries	2
Negligible	Major cuts, bruises, first aid type injuries.	1

3.7.3 Risk Assessment

Risk can be presented in in different ways and the result of the analysis is used to make decision on risk controls. The risk level can be determined by using the formula below:

$$L \times S = \text{Risk Level} \qquad \text{(eqn. 4)}$$

where L is the likelihood and S is the severity. The risk analysis uses the likelihood and severity on the qualitative methods, and it presented in the matrix below (Table 3.3).

Table 3.3: The risk analysis matrix chart.

	Severity (S)				
Likelihood (L)	**Negligible 1**	**Minor 2**	**Serious 3**	**Fatal 4**	**Catastrophic 5**
Almost certain 5	5	10	15	20	25
Quite Possible 4	4	8	12	16	20
Unusual but possible 3	3	6	9	12	15
Unlikely 2	2	4	6	8	10
Very Unlikely 1	1	2	3	4	5

High Risk

Medium Risk

Low Risk

3.7.4 Control Measures

After the risk assessment completed, the next steps are to come out with some control measures to eliminate and inactivate the hazard occurrence. All the hazards can be controlled at where the problem is created. The closer to the source, the easier to handle the hazard better. Control measure includes all the actions that can reduce the hazards, and, in this case, we will refer to the hierarchy of control measure. Figure 3.11 shows the hierarchy of control measure and starting from the top is the most preferred and bottom is the least preferred.

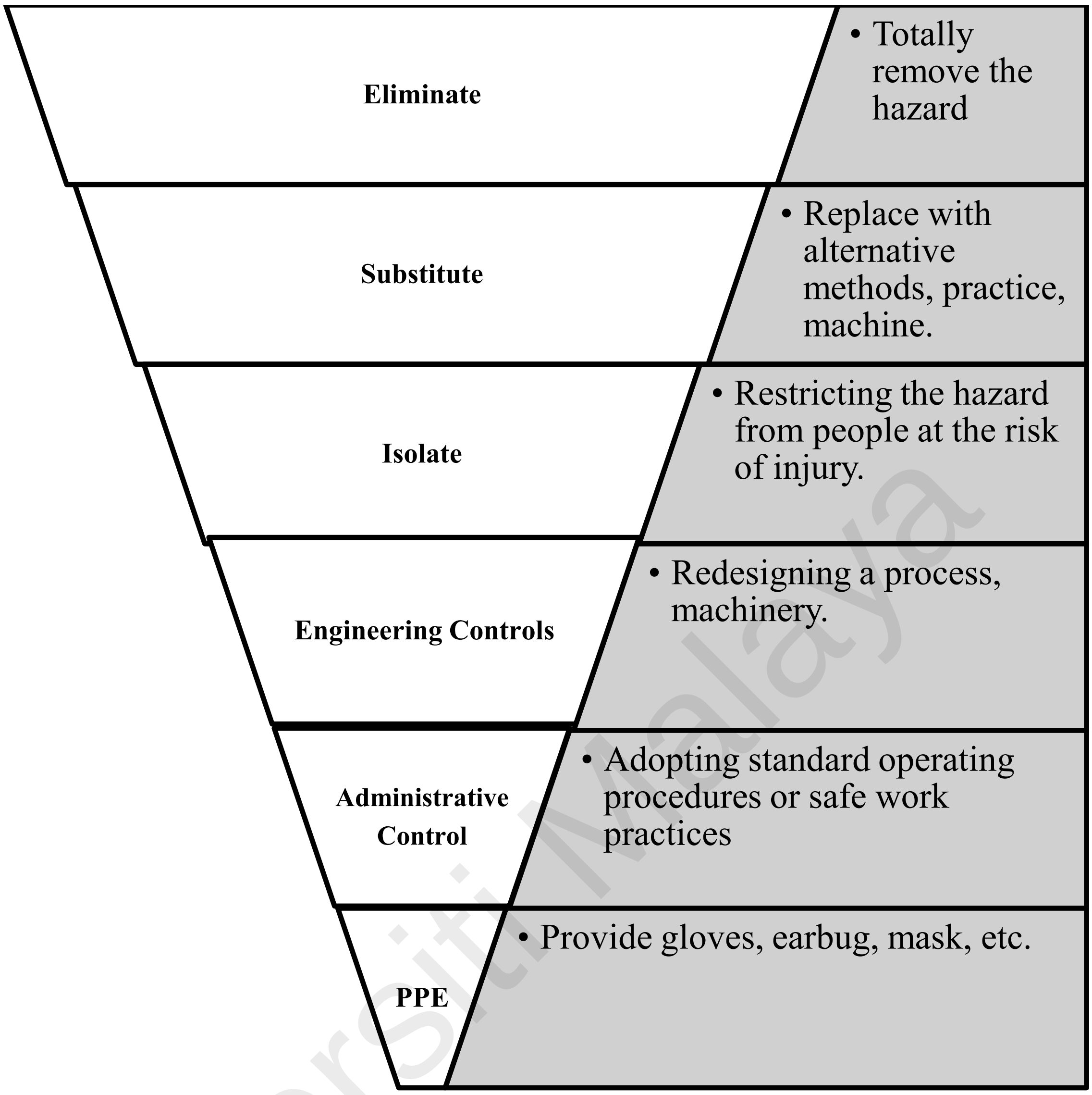

Figure 3.9 The hierarchy of risk control.

3.8 Summary

Research flow was scheduled at the beginning of the research project. In this project, we had gone through four main research methodology steps. We started with the preliminary study and drafted a proposal. The proposal was presented to the audience and had been approved to continue with the research.

Next, the research flow continues with the data acquisition. This step was very important, all the required data were collected, for example the geological data, satellite imageries and rain precipitation were collected from reliable sources. All the data were then analysed and interpretated accordingly. Next, the water stream and landscape were designed according to all the information in this project and the report written.

In this chapter, we also included the Risk Assessment (RA) and the control measures. The risk assessment technique that applied in this study was the Hazard Identification and Risk Assessment (HIRA) method. All the activities in the landscaping project were listed and possible hazards were evaluated and provide initial risk. The control measure were also suggested by following the hierarchy of control measure. Methods of this research project is shown in figure 3.12 showed the full research flow that were carried out in this study.

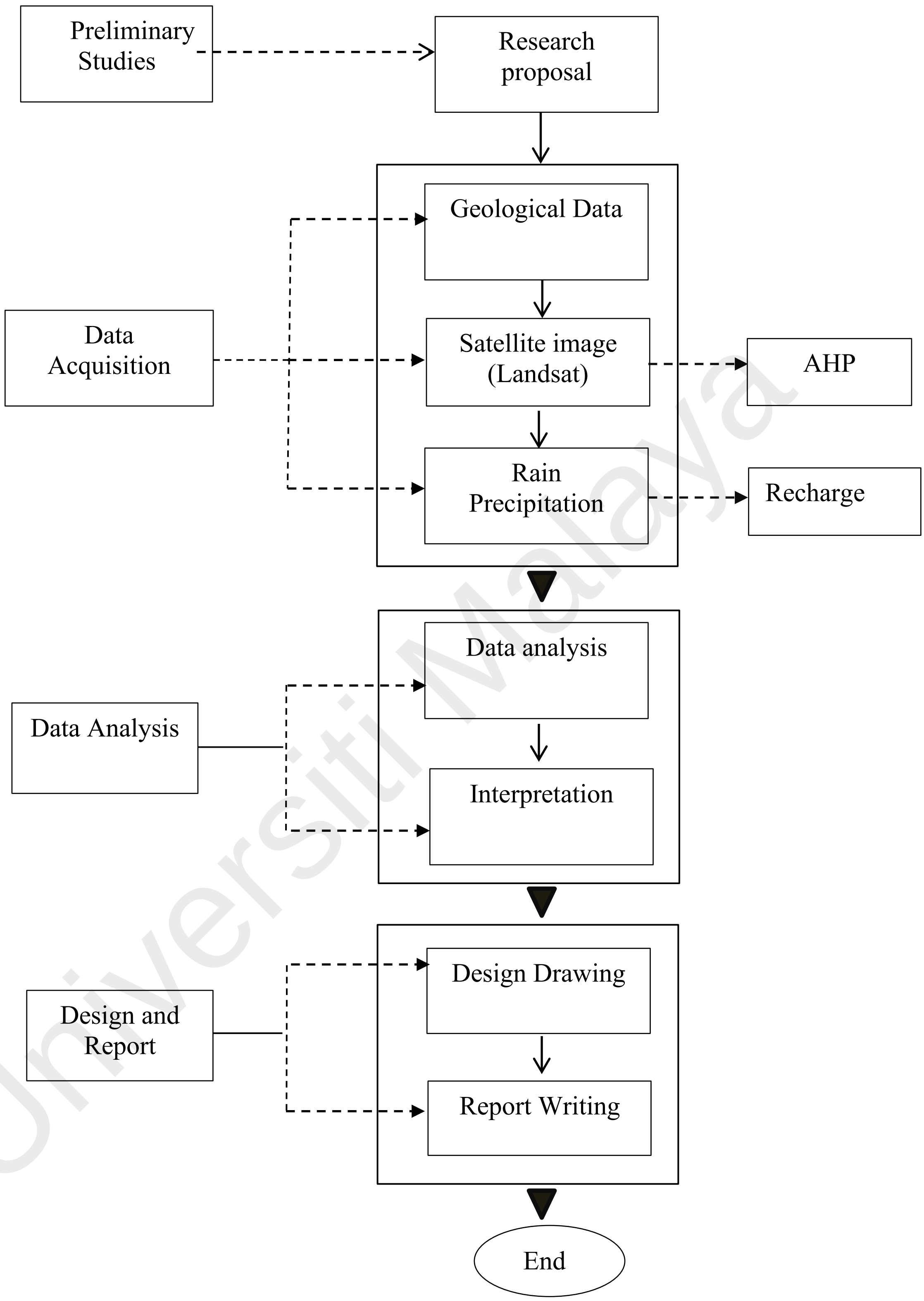

Figure 3.10 The research flow diagram of the overall methodology.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

This chapter discussed the result obtained in this study. The flow of the chapter follows the sequence of the objectives. The first part of this chapter discussed the different thematic maps that had been generated using the GIS software. All the thematic maps were then be combined following the weightage of each parameter and then the groundwater potential map was generated. Next, the rain precipitation data that were collected then substitute in the empirical equation to determine the recharge rate. The last part of this chapter is mainly focusing on the water stream and landscape designing and some control measure that needs to be taken throughout the designing process.

4.2 Classified Map Generation

Thematic maps were generated in this study to determine the groundwater potential of the study area by using the ArcGIS Pro software. Seven criteria related to the occurrence of groundwater in an area such as geomorphology, slope, land use and cover, drainage density, road density, soil and lithology were carefully assessed. on the map of the different potential groundwater zones of Jeram, Gopeng.

The Rumah Hutan Jeram location was located at the middle of the Jeram map. It was plotted in the thematic maps so that the decision maker and readers can clearly identified where is the Rumah Hutan Jeram located and what is the characteristic of the area for each criterion.

4.2.1 Geomorphology Map

Geomorphology is the study of land structure, and it also helps to express the inheritance process related to the potential area and structure of groundwater (Swain 2015). Geomorphology surveying and mapping involves the identification and characterization of various geomorphology and structural features, water movement, and freezing and thawing (Arulbalaji et al. 2019). Many of these characteristics favour the emergence of groundwater and are classified according to the potential of the groundwater.

A geomorphic map portrays surficial features or landforms that record geologic processes on the earth's surface. Figure 4.1 is the Jeram geomorphology, it had shown that most of the area were consider the wetland, followed by the flat area. The wetland located at the western part of Jeram previously was part of the mining industry. Currently this area is mostly act as the agriculture and aquaculture economy activities.

The hillside is marked as red colour and it is the Gua Tempurung and the Hutan Simpanan, Kampar. The yellow colour is the flood plain which normally indicates the surface water stream location. From the map, Rumah Hutan Jeram is located at the flat area, which also very near to the flood plain.

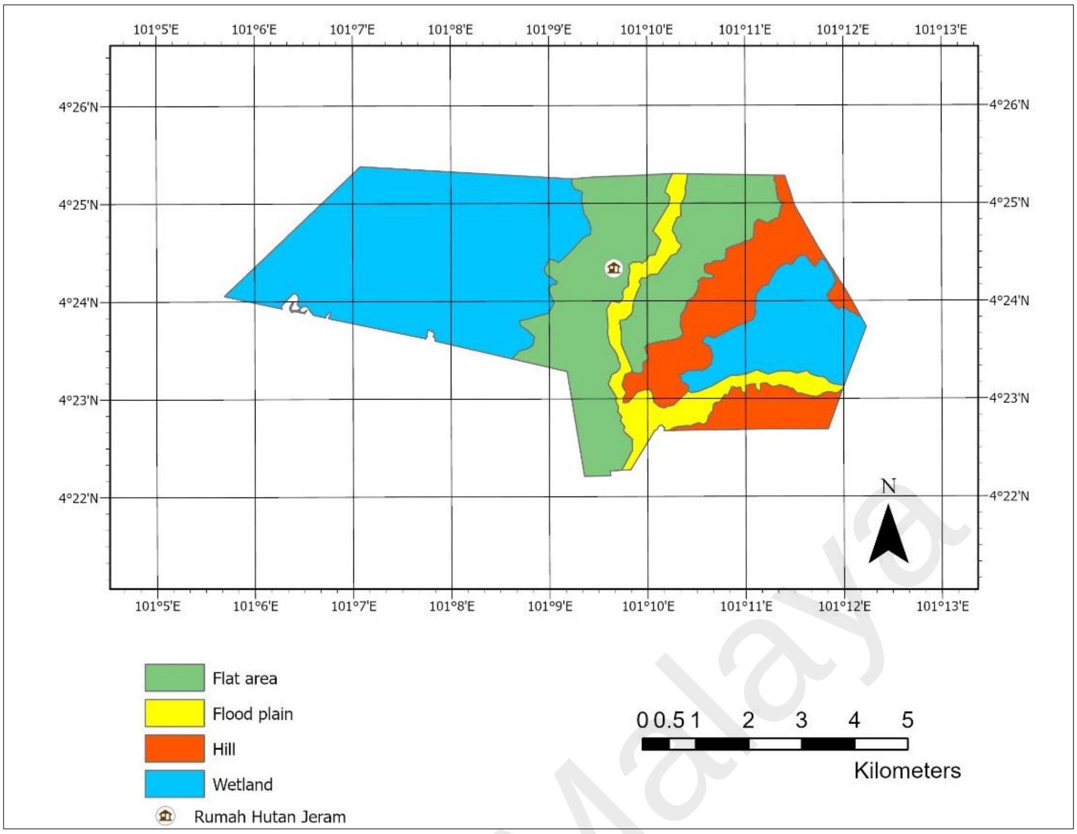

Figure 4.1: The geomorphology map of the Jeram, Perak.

4.2.2 Lineament Density Map

The lineament is the existence of joints, faults and cracks, which provide paths for water seepage and are also indirect indicators of potential areas (Pinto et al. 2017). Lineaments are fundamentally controlled straight or curvilinear highlights, which are distinguished from the disciple symbolism by their moderately direct arrangements. These highlights express the surface geology of the basic auxiliary highlights.

The lineaments for Jeram area are mostly at the North and North-East directions and it is shown in figure 4.2. Very high lineament density was observed at the middle of the map where the natural river stream located. From the map, Rumah Hutan Jeram is surrounded by the high and very high lineament density, and this can be interpreted as it is located at the structural area.

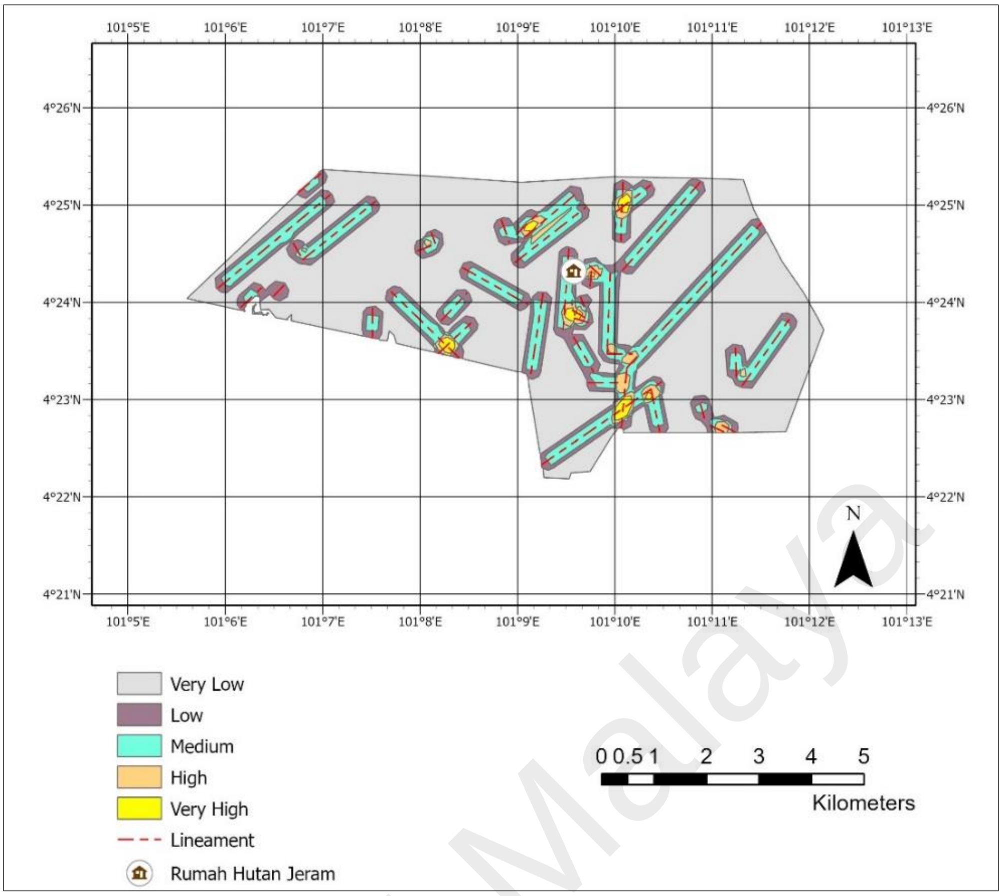

Figure 4.2: The lineament density map of the Jeram, Perak.

4.2.3 Lithological Map

The characteristics of different aquifers play an important role in the presence and movement of groundwater (Arkoprovo et al. 2012). The petrography of a rock unit is the description of its physical characteristics which can be seen on an overhang, in the hand or in a core, or with a low magnification microscope. Petrology is the basis of the subdivision of rock sequences into individual stratigraphic units for the purposes of mapping and interrelationships between regions.

In the Jeram lithology map shown in figure 4.3, there are 90% of the area is covered by the limestone (Karst Formation) and only 10% of it is covered by the granite. The Karst formation in the study area is very well known and a lot of publication and research studies were done in the surrounding area. Besides that, limestone is also famous in the porosity and sinkhole, therefore, the underground stream potential considering very high potential in the study area.

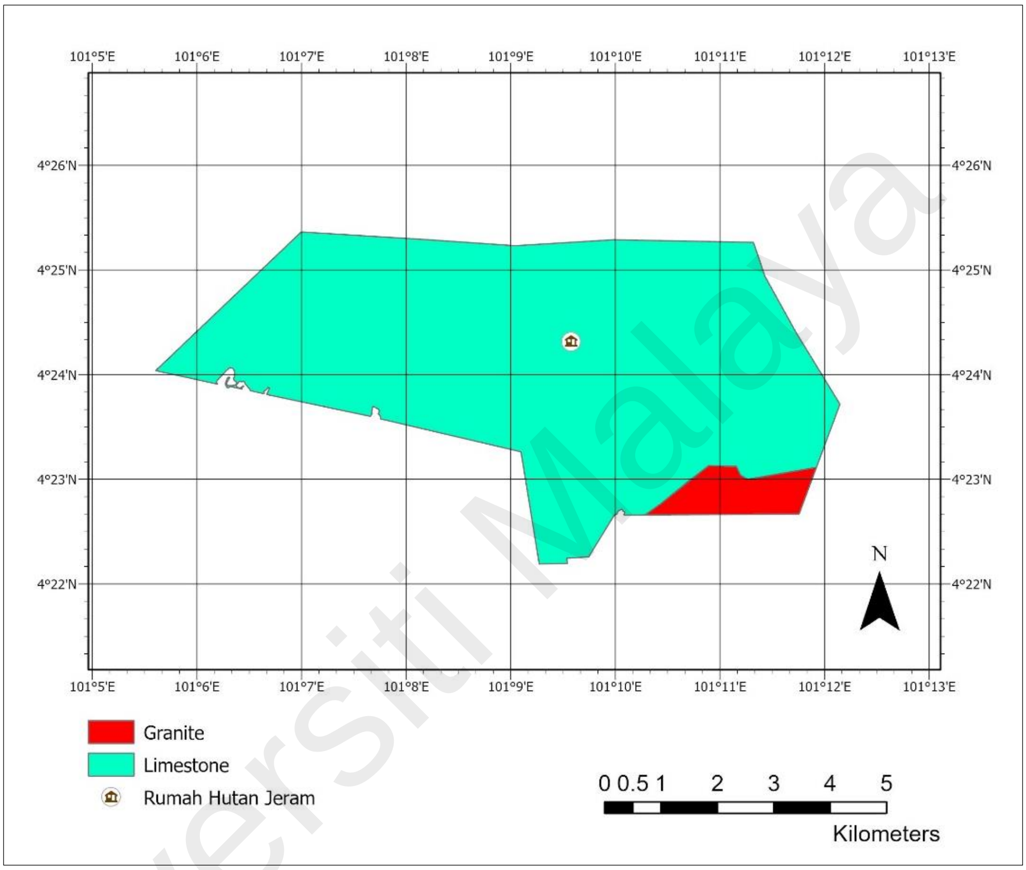

Figure 4.3: The lithology map of the Jeram, Perak.

4.2.4 Slope Map

A slope map is a topographic map showing changes in elevation on a highly detailed level. Slope map is considered very important in this study as it is part of the groundwater potential criterion and used in the landscaping and water stream design. The slope of the area is a factor that affects runoff and infiltration. The steeper the slope, the greater the runoff. (Gupta et al. 2018).

From the figure 4.4, it showed that most of the Jeram area slope is only between 0-5 degree. This is considering a very flat area. The area with slope 15 degree and above are located at the eastern part of Jeram. From the map, we can observe that the local landslide hazard potential for the study area, Rumah Hutan Jeram, is relatively low. This also indicates that the water stream needs to be designed with a different depth in order to create a natural water flow.

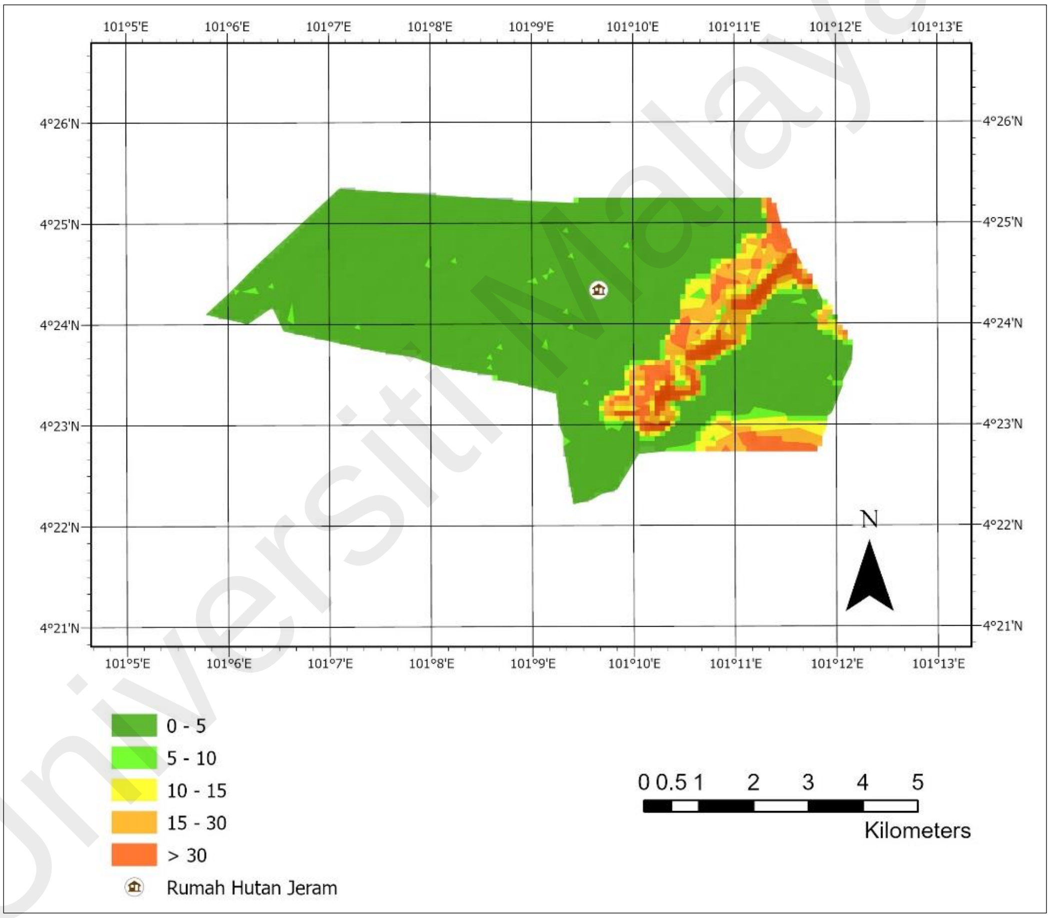

Figure 4.4: The slope map of the Jeram, Perak.

4.2.5 Soil Map

The top layer on earth as a medium permeable to water is the soil. Permeability depends on the permeability and water holding capacity of the soil (Gupta et al. 2018).

Soil map is a geographical representation showing diversity of soil types in the area of interest. Figure 4.5 shows that the soil map of Jeram, Perak is consisting of the alluvial Soil, mined land and sedentary soil.

Alluvium is river-deposited sediment. It is normally most developed in the bottom portion of a river's course, generating floodplains and deltas, although it can be deposited anywhere where a river overflows its banks or if the river's velocity is reduced, such as where it flows into a lake. Alluvium is made up of silt, sand, clay, and gravel, and it frequently contains biological stuff. In comparison to other soils, alluvial soil has the highest productivity. It is found primarily beside rivers and is carried by their streams during rock weathering (Dwevedi et al., 2017). In Jeram, alluvium soil is generally located near the river.

In the early 1900s, Perak was famous for its tin-mining industry, notably in Lembah Kinta. There for we can see that the mined land indicated that previously the area was a mining site. Former mine in Perak mostly has been converted into a lake garden, agriculture, or aquaculture. Sedentary soil is the soil that remains on the rock from which it has developed. Sedentary soil is located at the high land area, Gua Tempurung and Hutan Lipur Sungai Salu. These areas are naturally persevered, therefore covered by the sedentary soil.

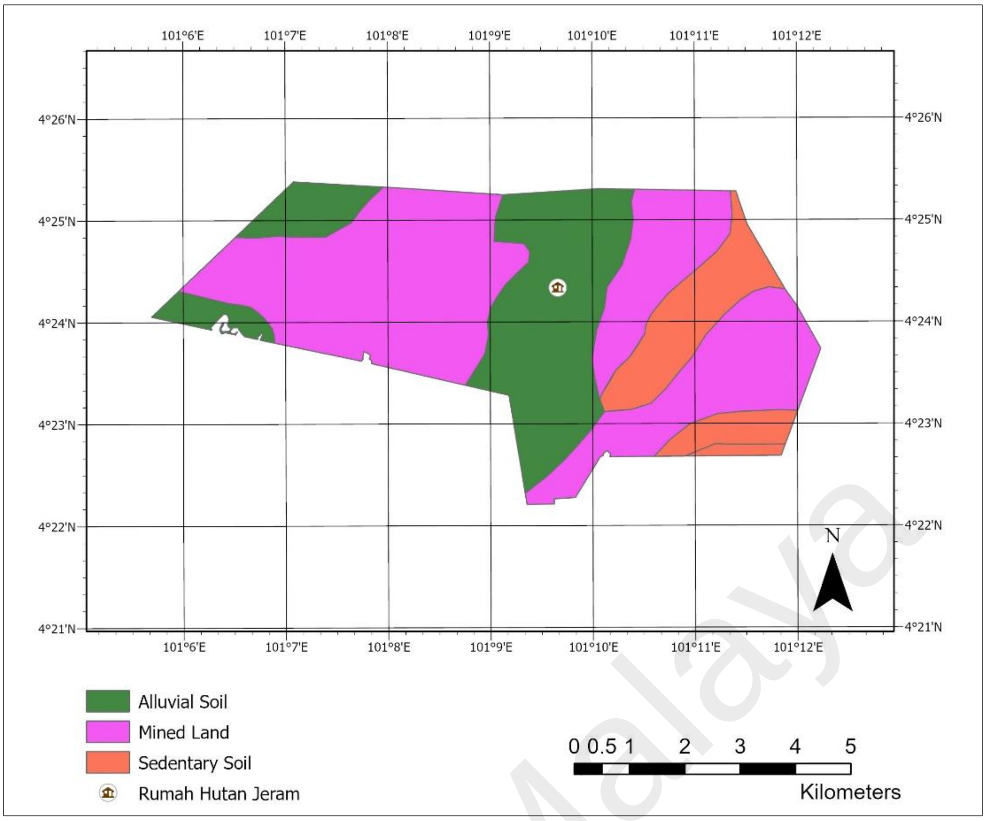

Figure 4.5: The soil map of the Jeram, Perak.

4.2.6 Land Use Land Cover (LULC) Map

Information such as soil moisture, permeability, runoff and water infiltration were determined by type of land use in the study area (IbrahimBathis and Ahmed 2016). The surface cover of the soil, such as vegetation, urban infrastructure, water, bare land, etc., is called land cover. The definition of land use forms the basis of tasks such as thematic mapping and analysis to detect changes. Land use refers to the purpose for which the land is used, for example, for recreation, wildlife habitat, or agriculture.

Land Use Land Cover (LULC) maps of an area provide information to help people to understand the current landscape. From figure 4.6, it showed that Jeram, Perak land was generally categorized in 4 types, which are, development, vegetation, water bodies and forest.

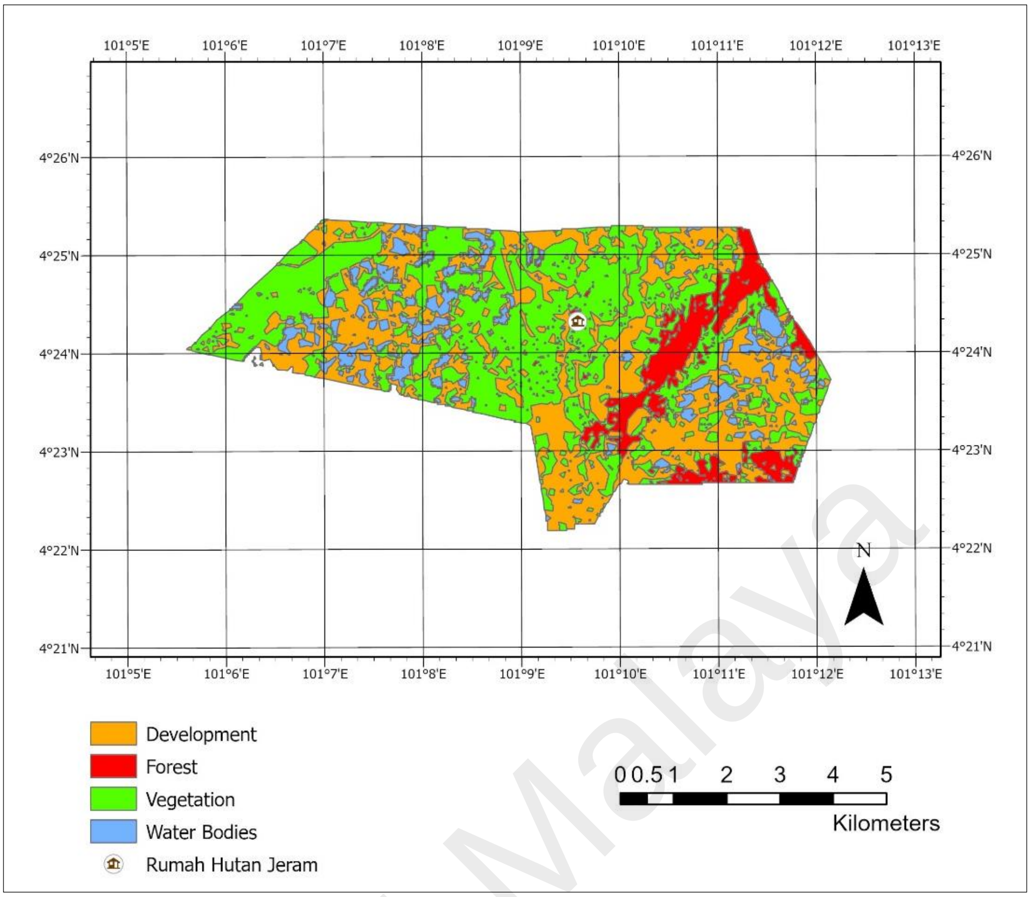

Figure 4.6: The land use land cover map of the Jeram, Perak.

4.2.7 Drainage Density Map

Drainage map showed the drainage patterns formed by the streams, rivers, and lakes in a particular drainage basin. Drainage density is a quantity used to describe the physical parameters of a watershed. It depends on both the climate and the physical characteristics of the basin.

Drainage density is the key indicator; it is a measure of the network's texture and reveals the balance between overland flow's erosive force and the resistance of surface soils and rocks. From figure 4.7, it shows that Rumah Hutan Jeram is located at the medium density and from the map, the nearest river is approximately 300 m distance.

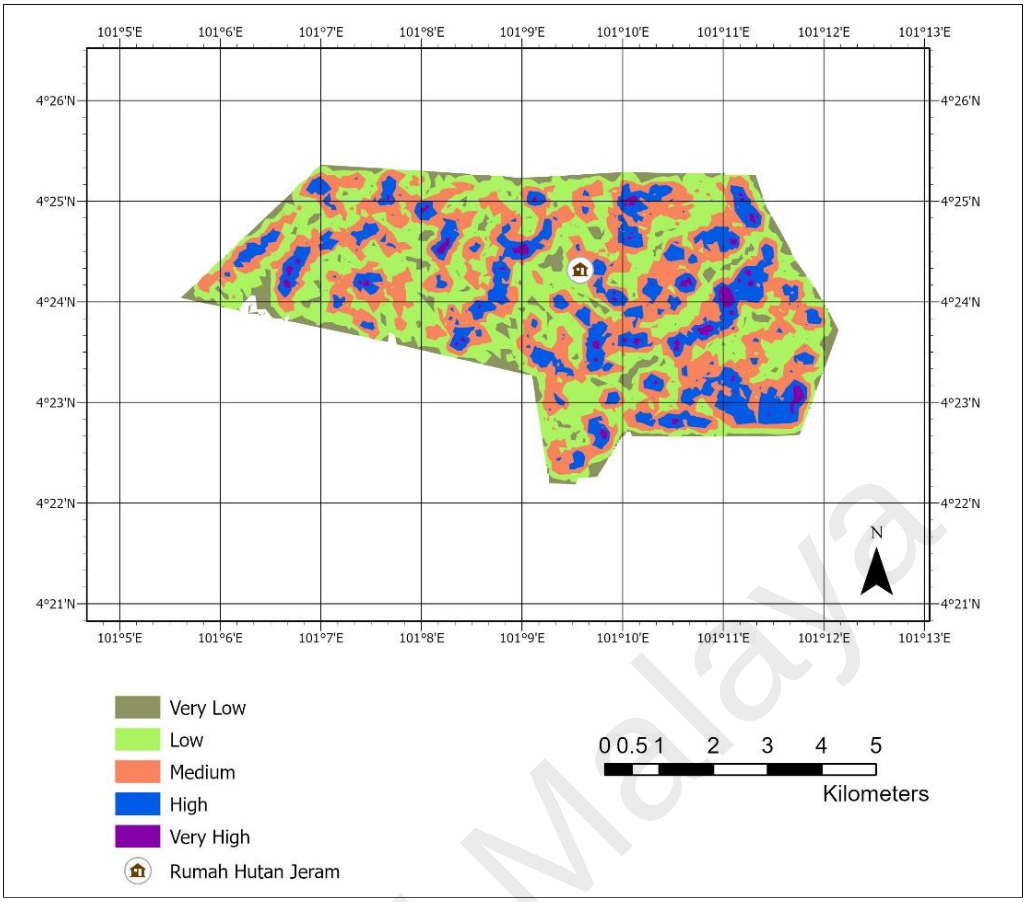

Figure 4.7: The drainage density map of the Jeram, Perak.

4.3 Groundwater Potential Weighting and Layers

Geospatial techniques were applied in this study to delineate the groundwater potential zones of the Jeram, Perak (as part of the Kinta Valley basin) using knowledge-based factor analysis of a total of 7 layers of information of the area such as geology, geomorphology, land use/land cover (LULC), drainage density, lineaments, soil, slope.

The groundwater potential zone, directly and indirectly, depends on all the seven parametric layers considered in this study. The influence of each layer on the other and to itself was determined and the appropriate weights were assigned to them for the overlay process. Analytic Hierarchical Process (AHP) is the most common and well-known method for zoning groundwater potential based on GIS. The correlation of these influencing factors is weighted according to the response to the presence of groundwater. This method is commonly used as an offsite method to determine the groundwater potential (Pinto et al., 2015; Al-Djazouli et al., 2020).

Table 4.1 showed the classification, weights are assigned to the thematic layers based on their importance and water holding capacity. Accordingly, all the thematic layers have been compared with each other in a pair - wise comparison matrix. From the table, geomorphology was selected as the first parameter of the matrix greater influence on recharge potential compared to other standards. Thus, geomorphology was given value 7. Select lineament density as the second most important parameter affecting recharge, followed by lithology, slope, soil, land use/land cover and drainage density parameters, in descending order of impact. Each selected parameter is assigned a Saaty score based on its impact on replenishment related to geomorphological parameters.

Table 4.1: Pair-wise comparison matrix table of 7 thematic layers chosen.

Factors	**GM**	**LD**	**L**	**Slope**	**Soil**	**LULC**	**DD**	**Weight**
GM	7	6	5	4	3	2	1	0.38
LD	7/2	6/2	5/2	4/2	3/2	2/2	1/2	0.19
L	7/3	6/3	5/3	4/3	3/3	2/3	1/3	0.12
Slope	7/4	6/4	5/4	4/4	¾	2/4	1/4	0.10
Soil	7/4	6/5	5/5	4/5	3/5	2/5	1/5	0.08
LULC	7/6	6/6	5/6	4/6	3/6	2/6	1/6	0.066
DD	7/7	6/7	5/7	4/7	3/7	2/7	1/7	0.064
							Total	**1**

Note GM: Geomorphology, LD: Lineament density, L: Lithology, LULC: Land Use/Land Cover, DD: Drainage Density*

Table 4.2 illustrates the assigned rank and weights of thematic layers. It showed the results of weighting each parameter and according to weighting method, criterion and sub-criterion weights calculated. The weightage and the influence rate were then calculated based on the Saaty score provided. The sub-criterion influencing factors were weighted according to their reaction for groundwater occurrence and expert opinion.

A parameter with a high weight indicates a layer with a greater impact, and a parameter with a low weight indicates a small impact on the potential of groundwater. The weight of each parameter is allocated in the range of 5-1 according to the range of groundwater potential. Score 5 will be the highest score and it is the highest groundwater potential. The final score for each sub-criteria was determined by multiplying the rant value with the influence value.

Table 4.2: The weights and scores of the criteria and their sub-criteria.

Criteria (value)	Weight	Influence (%)	Sub-criteria	Rank	Score
Geomorphology (7)	0.38	38	Flat Area	3	114
			Flood Plain	4	152
			Hill	2	76
			Wetland	5	190
Lineament Density (6)	0.19	19	Very Low	1	19
			Low	2	38
			Medium	3	57
			High	4	76
			Very High	5	95
Lithology (5)	0.12	12	Limestone	4	48
			Granite	2	24
Slope (4)	0.10	10	➢ 5	1	10
			3 - 5	2	20
			2 - 3	3	30
			1 - 2	4	40
			0 - 1	5	50

Table 4.2: continued

Soil (3)	0.08	8.0	Holyrood Lunas (Alluvial Soil)	4	32
			Mined Land	3	24
			Rengam Bukit Temiang (Sedentary Soil)	2	16
			Steep Land	1	8
LULC (2)	0.066	6.6	Development	3	19.8
			Forest	2	13.2
			Vegetation	4	26.4
			Water Bodies	5	33
Drainage Density (1)	0.064	6.4	Very Low	5	32
			Low	4	25.6
			Medium	3	19.2
			High	2	12.8
			Very High	1	6.4

4.4 Groundwater Potential Zone (GWPZ)

The identification of the Groundwater Potential zones (GWPZ) was accomplished based on the rates and weights of the 7 thematic layers. The results of the GWPZ mapping are shown in figure 4.8.

Groundwater is a replenishable resources and it is a good water source for agriculture and aquaculture. For planning and long-term development of an area, a greater understanding of the groundwater potential is critical. This knowledge is critical for the design and execution of structures that will improve groundwater recharge processes (Arulbalaji et al., 2019).

The availability of groundwater is not uniform in space and time. Therefore, an accurate and detailed assessment of groundwater resources is required. From the results, the groundwater potential in Jeram area is very high. The left site of the box is a wet land and very high in groundwater resources. At the Rumah Hutan Jeram, it is approximately 300m from the main river. Therefore, it is also a potential groundwater zone. One steps towards that the design of the Rumah Hutan Jetram landscape design the groundwater could be the source of the manmade river stream.

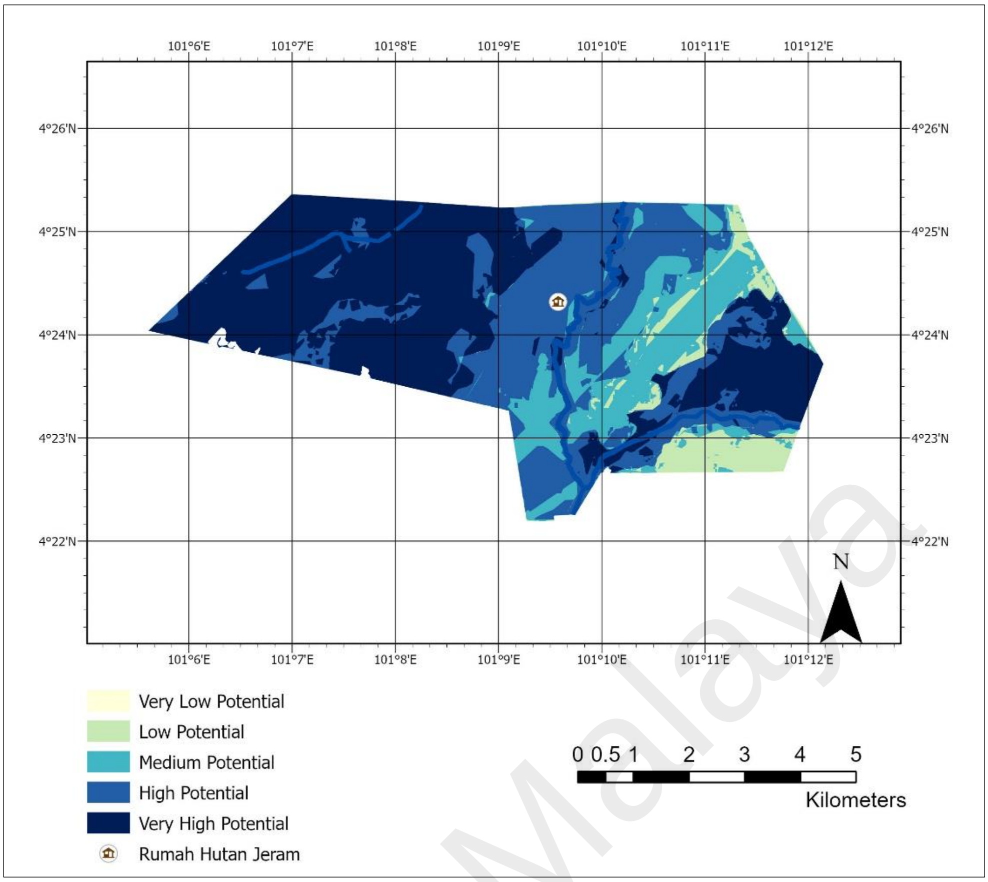

Figure 4.8: The Groundwater Potential Zone map of Jeram, Perak.

4.5 Rainfall Stations Data

The table 4.3 recorded the rainfall data from two different rainfall station nearby the study area, Rumah Hutan Jeram. The annual rainfall of the of the study area is between 2600 mm to 2900 mm. The higher the rainfall, the more the volume available for percolating the soil. Hence, the groundwater recharge rate will be higher. According to the equation 1, the Gua Tempurung, Kg. Sahom and Tanjung Tualang estimated groundwater recharge rate are 247.23 mm, 270.84 mm, and 337.8 mm respectively. These data were then brought into the interpolation analysis to generate the groundwater recharge map of Jeram.

Table 4.3: The rainfall data from Gua Tempurung and Kg Sahom Stations.

Month (2020)	Gua Tempurung St (mm)	Kg Sahom St (mm)	Tanjung Tualang (mm)
January	214	83.5	403
February	71	73.5	295.55
March	94	157.5	296
April	135.5	360.5	554
May	34	310.5	291
June	192.5	202	168
July	327.5	307.5	424.5
August	85	117.5	25.5
September	467	288.5	592
October	412.5	333	254
November	327	379	450
December	242.5	319.5	163
Total	**2602.5**	**2932.5**	**3916.55**

4.5.1 Groundwater Recharge

Groundwater recharge always increased with precipitation which means these two variables have reciprocal effect on each other (Saghravani et al., 2013). Figure 4.9 indicates the relationship of the precipitation and groundwater recharge rate. If looking at the monthly data, the rainfall in February to May is relatively low and the groundwater recharge will be low as well. During this period, it is suggested that the manmade water stream to be dried during the dry season in a year. The groundwater recharge results also indicates that the existing groundwater well is sufficient. The water should be able to supply the 80m x 2m manmade water stream at Rumah Hutan Jeram.

The groundwater recharge rate at the three locations were then used to carry out the interpolation methods using the GIS software and produced a groundwater recharge rate map at Jeram (Figure 4.10). From the date, it showed that the recharge rate at the Rumah Hutan Jeram is in between 247mm – 265mm.

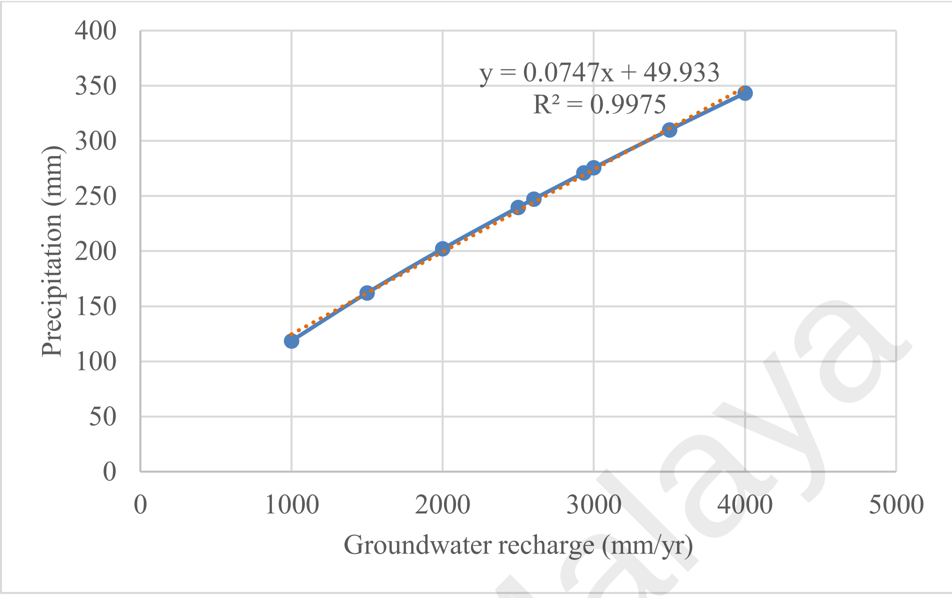

Figure 4.9: The relationship of precipitation and groundwater recharge.

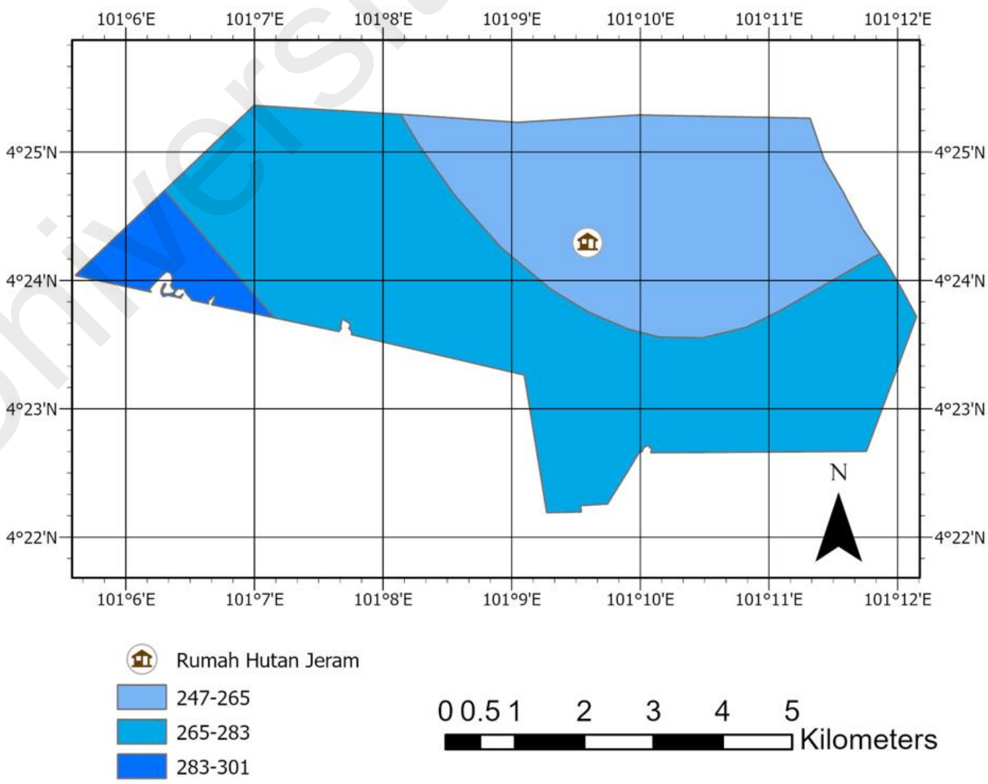

Figure 4.10: The groundwater recharge map of Jeram

4.6 Rumah Hutan Jeram Design

After visiting the site and analysing all the groundwater potential and recharge rate data, the Rumah Hutan Jeram water stream was design using the GIS software. There are a few designs plan that had been drawn for this project. The location and flow of water stream, the slope of the water stream to allow a natural water gradient flow, the length and width of the water stream, and the biofilter at the starting and ending point of the water stream needs to be consider carefully.

4.6.1 Water Stream Design

There are a few criteria that needs to be followed when designing the water stream and landscape. The owner of the site wanted to remain all the natural feature in the area and therefore the designed water stream and landscape needs to conserve all the existing plant in the area and avoid damaging them. The designed stream also connected to the existing fishpond, and it will allow the water flow in the fishpond. The water source of the water stream will be from the existing groundwater borewell. The topology of Rumah Hutan Jeram is flat and in order to create a smooth water flow, the starting point of the water stream needs to be backfilled and few slops and water were designed.

Figure 4.11 showed the design of water stream placement at the study area. It is drawn in the ArcGIS Pro software, and this can make sure we identify the exact coordinate, length, and position in the real world. From the figure, we only include few core features including the water stream, building, existing tree, existing borewell and the fishpond.

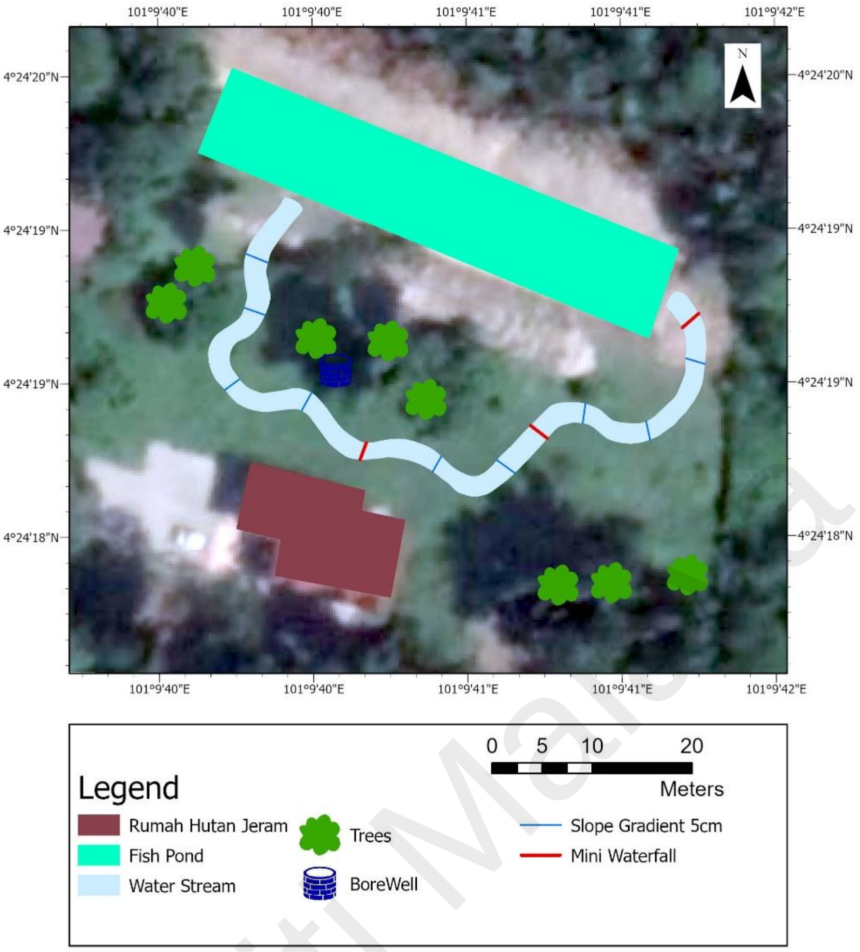

Figure 4.11: The water stream site plan of Rumah Hutan Jeram.

4.6.1.1 Water Stream Cross-Section

The cross section of the water stream is included in the report (Appendix 1). From the water stream cross section plan design, there are 3 mini waterfalls (Wf1, Wf2, and Wf3) were added in the manmade water stream. Each mini waterfall will be approximately 0.25 m – 0.3 m. The mini waterfalls are to add on the overall landscape visual enhancement. There are also 9 slopes gradient that was designed and approximately every 7 m – 8 m for each slope. This is to make sure that the water can flow naturally and smoothly.

The water stream was designed connecting to the fishpond. Starting point is the area that the water from the fishpond flow to the water stream was illustrate in figure 4.12. In this start point, we had included a water pump. The water pump is needed because the water level, and the fishpond and water stream elevation. There is also a biofilter placed at the starting point to filter the fishpond water.

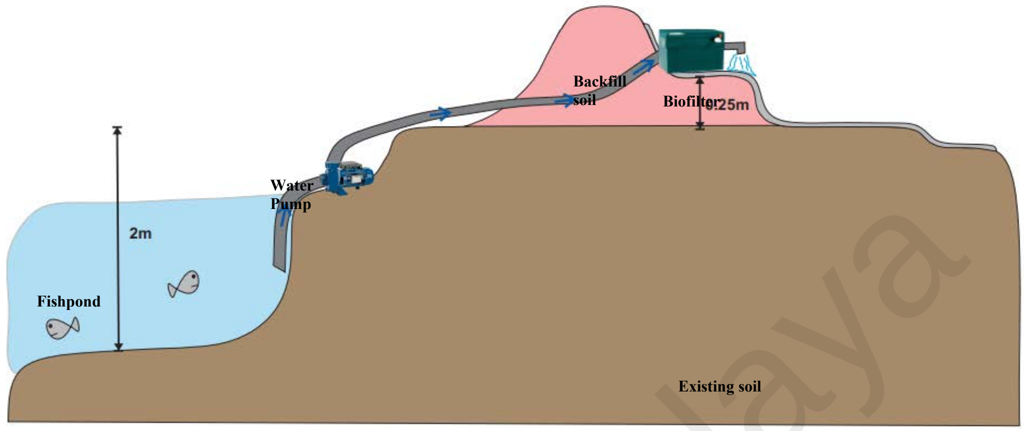

Figure 4.12 The illustration of the water flow from fishpond to the water stream.

On the other side of the water stream, the ending part is where the water in the stream flows back to the fishpond. At this point, the water stream was designed without the biofilter and water pump. A trench was designed in between the fishpond and the water stream. This trench will act as the natural filter and to allow the water flow back to the fishpond by following the water gradient. Figure 4.13 illustrate the water stream ending part that connected to the fishpond.

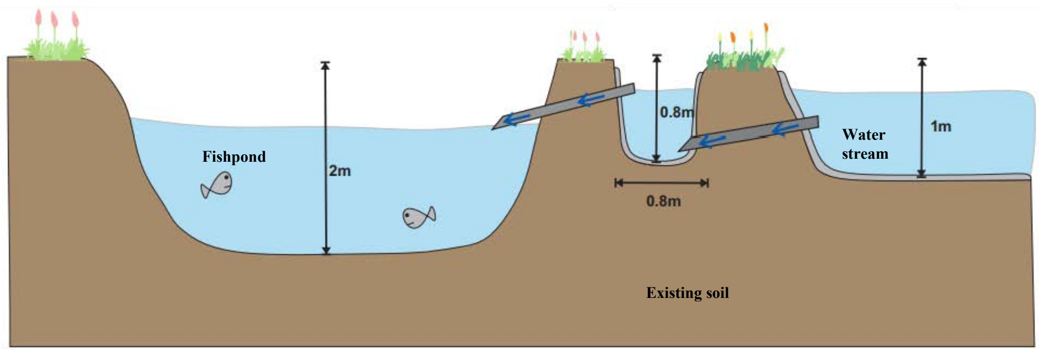

Figure 4.13 The illustration of water flow from water stream to fishpond.

4.6.1.2 Water Stream Functionality

Water stream in Rumah Hutan Jeram can make gentle sound to further enhancing the ambiance. The water stream act as the place to store water during monsoon season. The water stream will also act as a water source for the fishery possibilities, and it can increase the potential of sustainable agriculture irrigation. Besides that, according to the rainfall data collected, February-March and June-July will be the driest and sunny months in a year. At that time of period, the water stream will function as a dry river stream. A dry stream bed will only has running water during wet weather, and this can make sure that the soil could retain at the area and direct rainfall will not erode the soils bed. This water stream also acts as a rainwater harvesting system. The water stream will be covered with a layer of cement, to prevent excessive of rainwater infiltrate back to the ground.

4.6.2 Landscape Design

Rumah Hutan Jeram landscape was designed with numbers of new features, for example, foot reflexology path, solar panel, wood bridges, manmade water stream, plants, flower, and recreation area (Figure 4.14). Reflexology foot path is designed to massage and activate the feet acupressure points. These points are linked and connected to various body meridians. Smooth river rocks or cobblestone are used to construct the reflexology foot path, which stimulates neurological reflex zones on the foot to promote health and happiness.

This landscape design will use the solar energy to support the lights and water pump energy. Solar energy is a renewable energy that is available every day and it can produce energy even in cloudy or rainy season. Besides, solar energy is pollution free, and it will not emit greenhouse gases after installation.

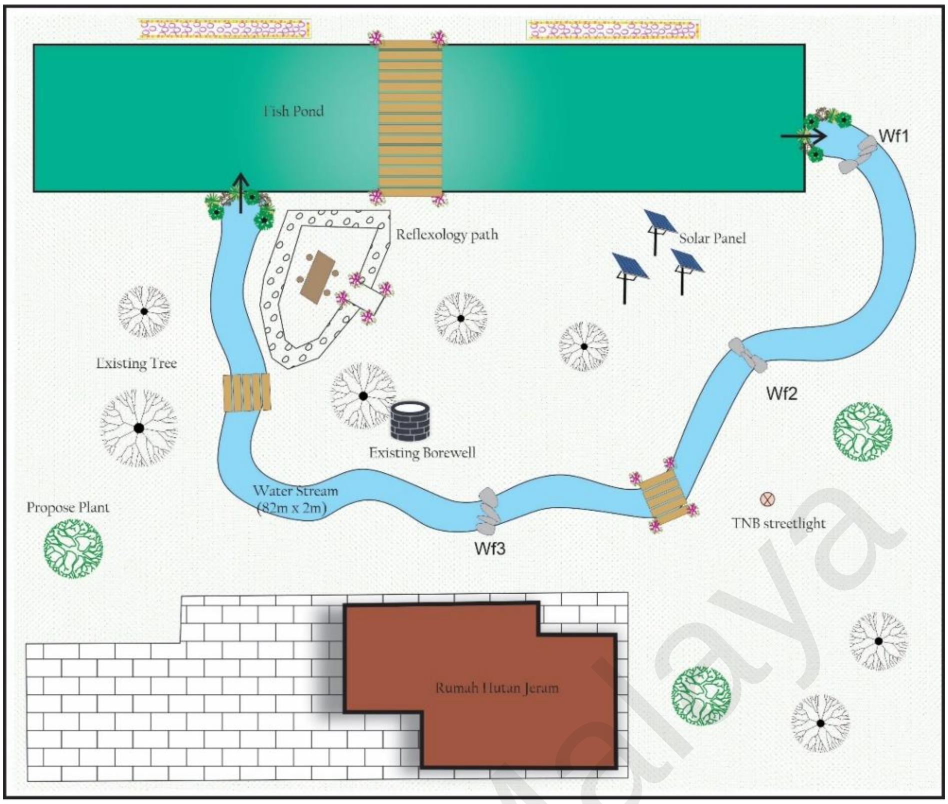

Figure 4.14: Landscape design of Rumah Hutan Jeram

4.6.2.1 Green Plants

The plants that planted surrounded the water stream are an important factor that constitute the overall environment. It is necessary to evaluate not only the qualities of the plants themselves, but also the soil conditions and the impact of the plants on the environment. In comparison to other green space, the green space made by plants around the river channel not only has rich river species richness, but also produces a landscape experience that is more hydrophilic and comfortable.

Plants need to be select based on the landscape area and provide the desired wildlife habitat and aesthetics. Wetland species that need to be continually flooded like water lilies are not suitable in this landscape because the water stream was designed as a seasonal stream, it will only contain water during raining season. Plant native shrubs, ornamental grass or flowers along the water stream banks and disguise the "headwaters" with large boulders or plants. Trees and shrubs can be used in the landscape design because stormwater runoff can be prevented from washing the bank by the strong root system.

Plant placement should consider the overall sense of space and layering. It is impossible to choose just one tree species. It's important to evaluate the landscape's diversity so that the panorama can change over time and there's something to see in all seasons. Pay attention to the colour variations as well, as they will help to showcase the water body's intrinsic beauty.

4.6.2.2 Sustainable Concept

Sustainable landscape is a category of sustainable design, involving the planning and design of buildings and natural environments. Sustainable landscape design includes three pillars of sustainable development: economic well-being, social justice and environmental protection. In designing the Rumah Hutan Jeram landscape, we had focused on the water conservation, and energy conservation.

In this project, the main water resources that will be used is groundwater. Therefore, water conservation is very essential to conserve and prevent wasting. Biofiltration and rainwater harvesting is the main technologies that will be taken in the design. Biological filtration is the removal of biodegradable organic carbon, but the various possible filter configurations, as well as various water types and pre-treatment methods, contribute to the extremely diverse biological filtration performance results reported in the literature. The biofilter is located at the starting point of the water stream because it is important to filter the unwanted particles and to prevent the pollution of the water stream.

On the other hand, energy conservation is another important sustainable consideration that has been taken in this landscaping design. In this design there are few items that will consume energy, for example, the water pump, biofilter, borewell pump, streetlights, and the building. All these will consume a huge amount of energy and installing solar panels is one of the best options.

4.6.2.3 Design Criteria

There are several precautions and items that we need to take note in this design and during the construction. These are the few measures that had been taken:

i. Create slope gradient in the water stream design and make sure it backhoes according to the depth. This is to create a smooth gradient for the water flow.
ii. Besides that, the slope gradient is designed to make sure the water flow in one direction. It is important to prevent backflow of water in the water stream design.
iii. All the plants and natural features needs to be conserved. The existing landscapes will be enhanced, and some protecting measures needs to be taken to protect the landscape trees from construction damage. For example, the backhoe stream needs to have at least 1m from the existing tree. This is to prevent the roots of the tree will not be destroyed.
iv. The designed water stream is not to over 1m depth, this is to avoid touches the water table underground. The water stream is a seasonal stream, and it will be cemented to prevent infiltration of the water into the underground.

4.7 HIRA and Control Measures

Table 4.4 showed the Hazard Identification and Risk Assessment (HIRA) form for this Rumah Hutan Jeram landscape project plan. The HIRA was carried out for the Rumah

Hutan Jeram landscape design project by identified the activity of this project that will be carried out in general. Once all the activities listed and the possible hazard description and consequences were identified. For this landscape project we generally divided into 8 processes or activities and the initial risk, recommendation for control measures and final risk were evaluate:

i. Digging and trench excavation.
ii. Manual handling of tools.
iii. Tree treatment works.
iv. Soil and waste removal.
v. Concreating.
vi. Lying paving.
vii. Pipping in the trench.
viii. Unloading rocks and pebbles.

Table 4.4: The HIRA for landscaping construction

No	Activities (Hazard Descriptions)	Hazard Consequences	Initial Risk			Further Recommendation (Control Measure)	Risidual Risk		
			L	S	RL		L	S	RL
1.	Digging and Trench Excavation (Trench collapse, flooding,	Injuries, Diseases (leptospirosis)	4	3	MR 12	i. Do not nearby the trench unless it is supported. ii. PPE provided and safety sign available. iii. Site assistance and supervisor monitor. iv. Experience and qualified operator v. No entry to the trench if the weather is not allowed.	2	2	LR 4
2.	Manual handling of tools (cut, falling object, collisions, slips, trips, and falls)	MSD, Injuries, Death	4	4	HR 16	i. Correct manual handling techniques. ii. Good housekeeping. iii. Suitable PPE (gloves) iv. Site assistance and supervisor monitor. v. Briefing before operation. vi. Restrict non-essential personnel access. vii. Covered all exposed blades.	2	2	LR 4
3.	Tree treatment works. (Cut, fall from heights, manual handling, using power tools, Flying debris.	Injuries, Death, MSD, Burns.	3	3	MR 9	i. Correct manual handling techniques (only qualified personnel). ii. Good housekeeping. iii. Suitable PPE (gloves, googles) iv. Site assistance and supervisor monitor. v. Ensure all protocols is followed. vi. Restrict non-essential personnel access. vii. Supervisor ensures that working area is kept clear.	2	1	LR 2

Table 4.4: continued

No	Activities (Hazard Descriptions)	Hazard Consequences	Initial Risk			Further Recommendation (Control Measure)	Residual Risk		
			L	S	RL		L	S	RL
4.	Soil and waste removal (slip, trip, fall, cuts, collision, falling object)	Injuries, Death, MSD, Trip over debris.	3	3	MR 9	i. Correct manual handling methods. ii. PPE provided and safety sign available. iii. Site assistance and supervisor monitor. iv. Experience and qualified operator. v. Good housekeeping (Proper waste management) vi. Briefing before operation. vii. Restrict non-essential personnel access. vi. No reversed the vehicle without a banksman.	2	2	LR 4
5.	Concreting (Trench collapse, manual mishandling, burns)	Injuries, Respiratory issue, low back strained	3	3	MR 9	i. No one should be nearby the trench unless it is supported or covered. ii. Qualified operator. iii. Correct PPE (goggles, gloves, face mask) iv. Avoid enter the trench. v. Supervisor arranges mechanical aids.	2	2	LR 4
6.	Laying paving (Crush, vibration, noise, collision, manual mishandling)	Injuries, MSD, HAVS, Hearing issue	4	3	MR 12	i. Qualified operator. ii. Correct PPE (gloves, ear protection) iii. Supervisor provides rotational timetable. iv. Use mechanical aids. v. Non-essential personnel not allowed.	2	2	LR 2

Table 4.4: continued

No	Activities (Hazard Descriptions)	Hazard Consequences	Initial Risk			Further Recommendation (Control Measure)	Residual Risk		
			L	S	RL		L	S	RL
7.	Pipping in the trench (Cuts, Manual mishandling, flying debris, contact with adhesives, grouts, falls)	Injuries, MSD, Dermatitis.	3	3	MR 9	i. No one should be nearby the trench unless it is supported. ii. Correct PPE iii. Site assistance and supervisor monitor. iv. Experience and qualified operator. v. Avoid broken pipes. Avoid entering or near the trench. vi. Briefing before operation. vii. Ensure all the operator and workers are aware of the hazards.	2	2	LR 4
8.	Unloading Rocks and Pebbles. (Manual mishandling, cuts, falls from heights)	MSD, Injuries, Death	4	4	HR 16	i. Correct manual handling techniques. ii. Good housekeeping. iii. Suitable PPE (gloves, hard hats) iv. Site assistance and supervisor monitor. Briefing before operation. v. Restrict non-essential personnel access.	3	2	MR 6

4.8 Summary

This chapter includes all the data collection, results, analysis and discussion of the project. All the results and discussion were explained according to the objective order. The 7 thematic maps that were generated by the remote sensing data and existing geological map were combined with certain weightage and produced the groundwater potential zone map (GWPZ). From the results, it showed that the Rumah Hutan Jeram is located at a high potential area. The groundwater recharge rate was also determined by using the empirical equation. From all the results, it indicates that the existing borewell in Rumah Hutan Jeram is sufficient to serves as the water source for the water stream.

The water stream and landscape were designed using the GIS and remote Sensing. The water stream is approximately 80 m long and 2 m width. The cross section of the water stream is provided in this report. The landscaping design had followed the sustainable rules to make sure that the water and energy were conserved in this project. In this chapter, we also include a HIRA form that listed out all the activities, possible hazard, risk level and the control measures for each event.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The development of the Rumah Hutan Jeram water stream and landscape will help to promote the development of local economy, and it also acts as a recreational park for the locals. This development is planned without ignoring the protection of the ecological environment.

This project analysed the designed and planned of the manmade water stream and the surrounding landscape with the aid of Geographical Informative System (GIS) and Remote Sensing. Rumah Hutan Jeram was designed according to the theme of natural and sustainable concept. Additionally, according to the results and data collected, the area in Rumah Hutan Jeram is high potential for groundwater source and the recharge rate is high. Lastly, we had identified the risk and suggested the control measures for each of the activities that will be carried out during the landscaping construction.

To support the growth of human health and local economy, we must adhere to the notion of ecology and employ ecological theories and approaches. With all the elements and beautiful landscape designed, the locals can generate more income and make sure the fisheries products are at the good quality and standard. We can only create a better living environment and meet the elements of human sustainable development by integrating all areas of detail when designing the water stream and landscape at Rumah Hutan Jeram.

5.2 Recommendation for Future Studies

This research had combined the application of Geographical Informative System (GIS) in the landscape designing and groundwater potential. It is noted that there are few other aspects that not included in this study due the limitations of time, cost, and travel restriction during the pandemic. Therefore, there are several parts of this study can be suggested and be improved in the future studies.

For identifying the groundwater potential, in this study we just use the application of GIS to identify the groundwater potential. This method had some limitation for example the structure underneath the earth could not be identify. Geophysical methods can be added to the study and from geophysical method, we can clearly identify the potential of water and know whether if there is some structure available underneath the land. Although geophysical method is more accurate, but the budget is high.

In additional, one of the good recommendations for future study is by using a 3D-software to illustrate the landscape design. 3D is a great tool to demonstrate the landscape design and presenting the design in 3D will make the whole drawing more presentable and more convincing to the decision maker.

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LIST OF PUBLICATIONS AND PAPERS PRESENTED

No	Articles	Status
1	Fong Mei Yong, Fathiah binti Mohd Zuki (2021) Groundwater potential zone using GIS and Analytical Hierarchy Process (AHP) for Water Conservation and Community Development Project in Jeram, Perak. ISI-indexed	Submitted