INTEGRATED DESIGN PROJECT 1 REPORT - GROUP 3

SEAA3022-01

UNIVERSITI TEKNOLOGI MALAYSIA

FACULTY OF ENGINEERING

SCHOOL OF CIVIL ENGINEERING

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1.0 Company Profile

1.1 Company Background:

KitaBina Consultancy was established in 2023 by a group of highly knowledgeable engineers with a variety of experiences. It is one of the most promising consulting firms in the fields of civil engineering design, project management, supervision, quality assurance, and consulting services in Malaysia.

KitaBina Consultancy is a pioneer in offering value-added services to our clients by developing a strong collaboration with our clients throughout the construction process. The business possesses the necessary expertise, enthusiasm, and self-assurance to take on difficult tasks and deliver the best services.

1.2 Mission, Vision & Motto:

Mission:
To use our knowledge, experience, and technology to offer our clients high-quality construction consulting services while upholding the strictest standards of morality, safety, and sustainability.

Vision:
To be the most reputable and dependable construction consulting company in the market, renowned for providing creative and affordable solutions that aid in clients' goal-achieving and support the growth of resilient, sustainable communities.

Motto: Building success together with KitaBina

1.3 Organizational Chart

2.0 Project Profile

2.1 Project Description:

The objective of this project is to create a high-end yet reasonably priced residential and business district in Nusajaya. The development aim is to build a planned community that offers top-notch neighborhoods with a range of facilities and infrastructure. The project site will cover 61.144 acres and feature office buildings, food courts, gas stations and commercial lots in addition to four residential dwelling types, including bungalow, single-story bungalow, double-story semi-D and double-story terrace housing. On an additional 3.741 acres, public facilities such Surau, Hall, and Kindergarten will be available. The project will also reserve 51.361 acres of land for various public facilities and utilities, such as road reserves, drain reserves, and detention ponds. The project will be constructed in tandem with Nusajaya's transformation into the Johor State New Administrative Centre, and completion is anticipated in 4 years.

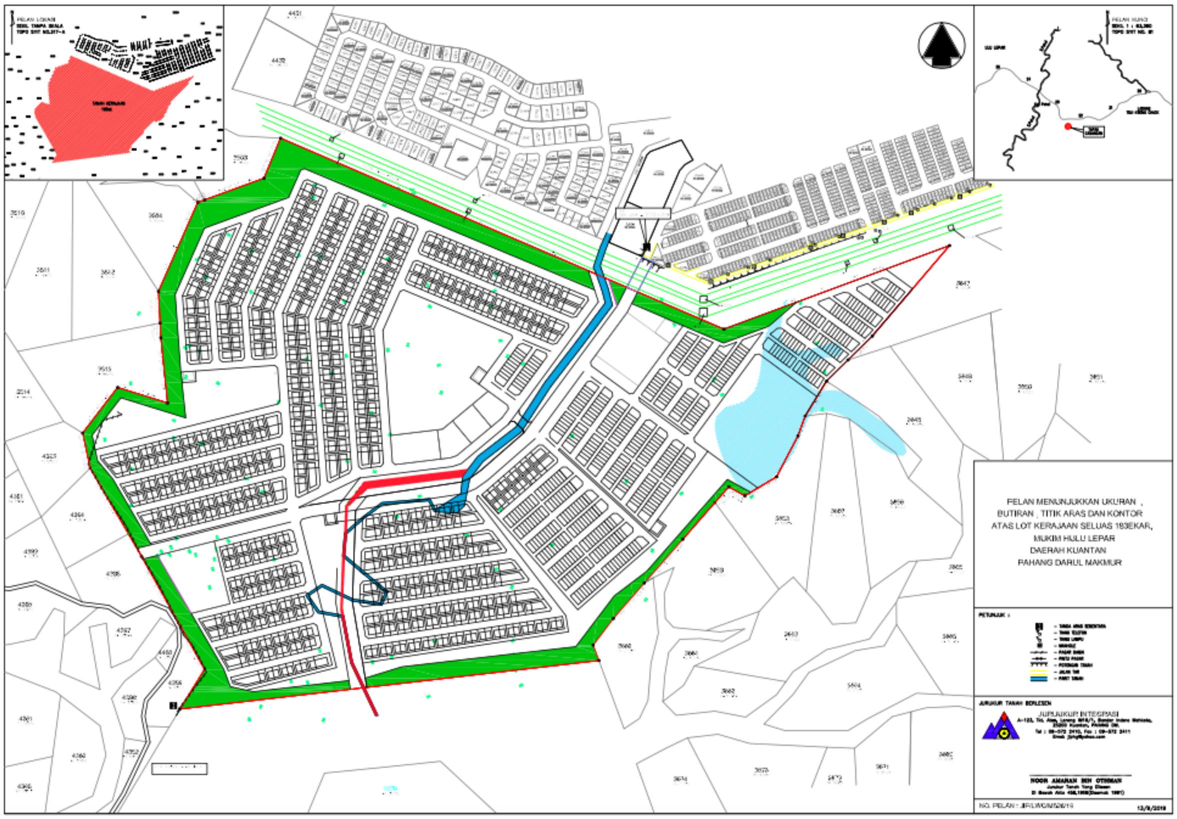
The goal of this project is to create a high-end neighborhood with a variety of infrastructure and amenities in Nusajaya that is both exclusive and reasonably priced. In keeping with Nusajaya's transformation into the Johor State New Administrative Centre, the project's objectives include the creation of a planned community and the provision of housing alternatives for citizens and government workers. The project not only aims to set aside land for a range of public utilities and facilities, including detention ponds, road reserves, and drain reserves but also provide public amnesties necessary for the community. The overarching objective is to build a flourishing and sustainable community that caters to potential inhabitants' needs and aids in Nusajaya's expansion and development.

2.2 Overall Development Detail

The project is divided into several components based on units and acres : housing is 82.17%, commercial 14.62%. 0.53% public amenities and 0.53%

The types of housing available are
Bungalow Lot: 14 units, with a size of 100' x 120', occupying 2.50% of the project area.
Single Storey Bungalow: 239 units, with a size of 70' x 100', occupying 42.60% of the project area.
Double Storey Semi-D: 96 units, with a size of 40' x 80', occupying 17.11% of the project area.
Double Storey Terrace: 112 units, with a size of 22' x 70' (Type A&B), occupying 82.17% of the project area.

2.3 Project Layout:



2.4 Scope of Work:

Earthwork

- Do a site investigation and analyze the proposed site (Site inventory).
- Plan and design the structure and location for buildings, roads, embankments, and canals. (Proposed level).
- Calculate the volume of Cut and fill (grid method).
- Produce cross-section for cut and fill of the site.

Erosion & Sedimentation Control

- Manage the design of the catchment area in Zone A construction plan.
- Propose BMPs to prevent or control stormwater runoff and the discharge of pollutants (including sediments) into local water bodies.
- Stabilize the landform and control erosion, minimizing the environmental impact of runoff.

- Enhance the urban landscape and ecology.

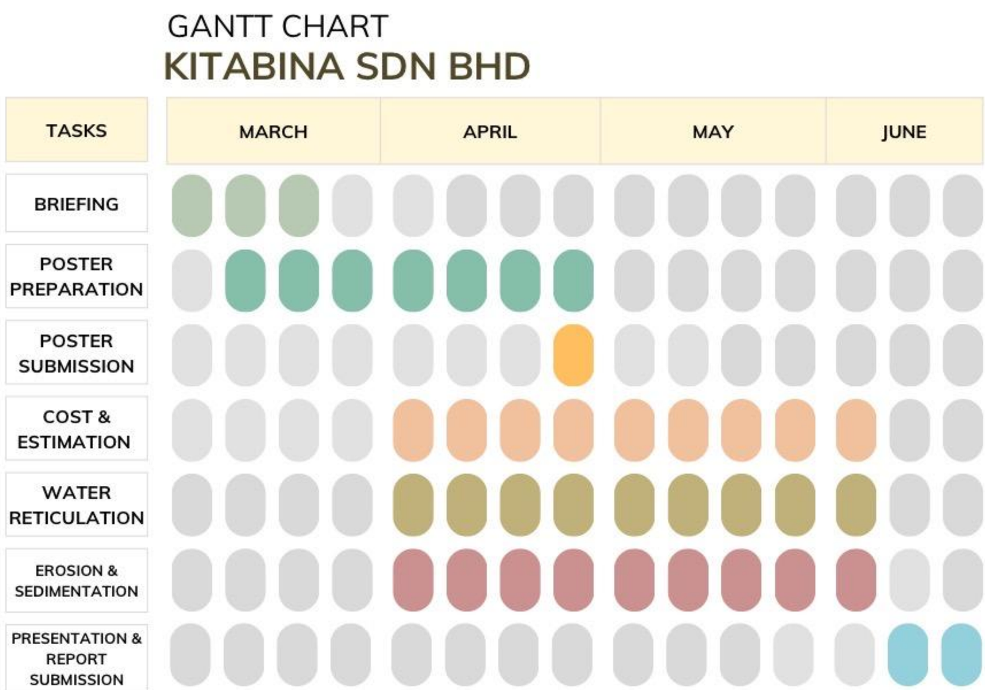
Water Reticulation

- Proposed suitable location for water tank
- Decide the type of water tank and design the size of the water tank.
- Proposed suitable pipe network.
- Decide the type of pipe and its size.

Cost & Estimating

- Estimate the cost for cut and fill and site clearance for the project site.
- Preparing Bill of Quantity (BOQ).
- Provide the fare rates for the equipment and manpower.

2.5 Work Schedule:



3.0 Earthwork

Name	Matric	Department
Imran Shahriar (L)	**A19EA3010**	**Earthwork**
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Annisa Shafa Aulia	**A20EA0223**	

3.1 Introduction

Earthwork is a fundamental aspects of construction and civil engineering, encompasses a wide range of activities involving the movement, excavation, and placement of soil, rocks and other materials. It forms the basis for numerous infrastructure projects, providing stability, support, and the necessary groundwork for successful construction endeavors.

We will delve into the significance of earthwork in construction projects. From preparing construction sites to shaping the terrain, earthwork plays a crucial role in ensuring the stability and functionality of structures. We will explore how earthwork activities, such as excavation, grading, and compaction, contribute to the creation of a solid foundation and enable the implementation of various architectural and engineering designs.

Furthermore, this report will examine the factors that influence earthwork projects. Site evaluation and surveying, soil characteristics and analysis, as well as geotechnical considerations, all play vital roles in determining the appropriate techniques and approaches for earthwork. By understanding these factors, engineers and construction professionals can make informed decisions and optimize project outcomes. Environmental considerations will be addressed, emphasizing the importance of sustainable practices in earthwork projects. Minimizing soil erosion, implementing erosion control measures, and promoting proper waste management are crucial for mitigating environmental impact and preserving natural resources.

This project focuses on establishing an oil palm plant in the vicnity of Mukim Hulu Leper, Daerah Kuantan, Pahang Darul Makmur, Pahang, Malaysia. The coordinates for the location are latitude 3°41'20.46" N and longitude 103°02'29.74" E, and the area of the project site is 770,000 square meters.

3.2 Objective

The primary objective of earthwork is to prepare, shape, and modify the natural terrain to meet the specific requirements of construction projects. Earthwork serves as the foundation for various infrastructure developments, providing a stable base upon which structures can be built. The key objectives of earthwork can be summarized as follows:

Site Preparation: Earthwork aims to prepare construction sites by clearing vegetation, removing obstacles, and creating a level or suitably graded surface. This objective ensures that the site is ready for subsequent construction activities and facilitates efficient construction operations.

Soil Stabilization: Earthwork involves stabilizing the soil to enhance its load-bearing capacity and resistance to settlement. By compacting the soil and implementing appropriate geotechnical techniques, earthwork aims to create a stable platform that can support the weight and stresses imposed by structures.

Foundation Establishment: Earthwork plays a crucial role in establishing the foundation of structures. It involves excavating the soil to the required depth and dimensions, ensuring proper bearing capacity, and providing a level and stable base for the construction of foundations, footings, and underground utilities.

Grading and Drainage: Earthwork aims to achieve proper grading and drainage on construction sites. Through the reshaping of the land, earthwork ensures the correct slope, contour, and elevation, allowing for effective surface water runoff and preventing water accumulation, which can cause erosion, flooding, or structural damage.

Material Handling and Placement: Earthwork involves the efficient handling, transportation, and placement of materials such as soil, rock, gravel, and fill. The objective is to optimize the use of available materials, minimize waste, and ensure their appropriate distribution to achieve the desired site contours and structural requirements.

Safety and Compliance: Earthwork endeavors to prioritize safety throughout the construction process. This objective involves adherence to safety regulations, implementing proper slope stability measures, ensuring proper compaction and stability of embankments, and maintaining site safety for workers and equipment.

By achieving these objectives, earthwork contributes to the successful implementation of construction projects, providing a solid foundation, optimal site conditions, and proper drainage. It ensures the structural integrity, stability, and functionality of built environments while considering environmental sustainability and safety.

3.3 Earthwork Common Requirements

Common Earthwork Requirements include:

1. Site preparation: Before excavation can start, the site must be cleaned of all vegetation and other obstacles
2. Excavation: The action of taking soil or rock out of the ground to make a level surface for building
3. Grading: To obtain the desired slope and levelness, the soil must be shaped and smoothed throughout the grading process
4. Compaction: The process of pressing soil firmly together to give it more solidity and stability
5. Soil stabilization: treating the soil to increase its tensile strength and stability
6. Drainage: To stop water from building up and harming the site, adequate drainage must be offered
7. Erosion Controlling: Preventing soil erosion and topsoil loss requires an action effect on the environment
8. Site restoration: To reduce the influence on the environment, the site must be returned to its original state after the earthwork is finished

3.4 Site Inventory

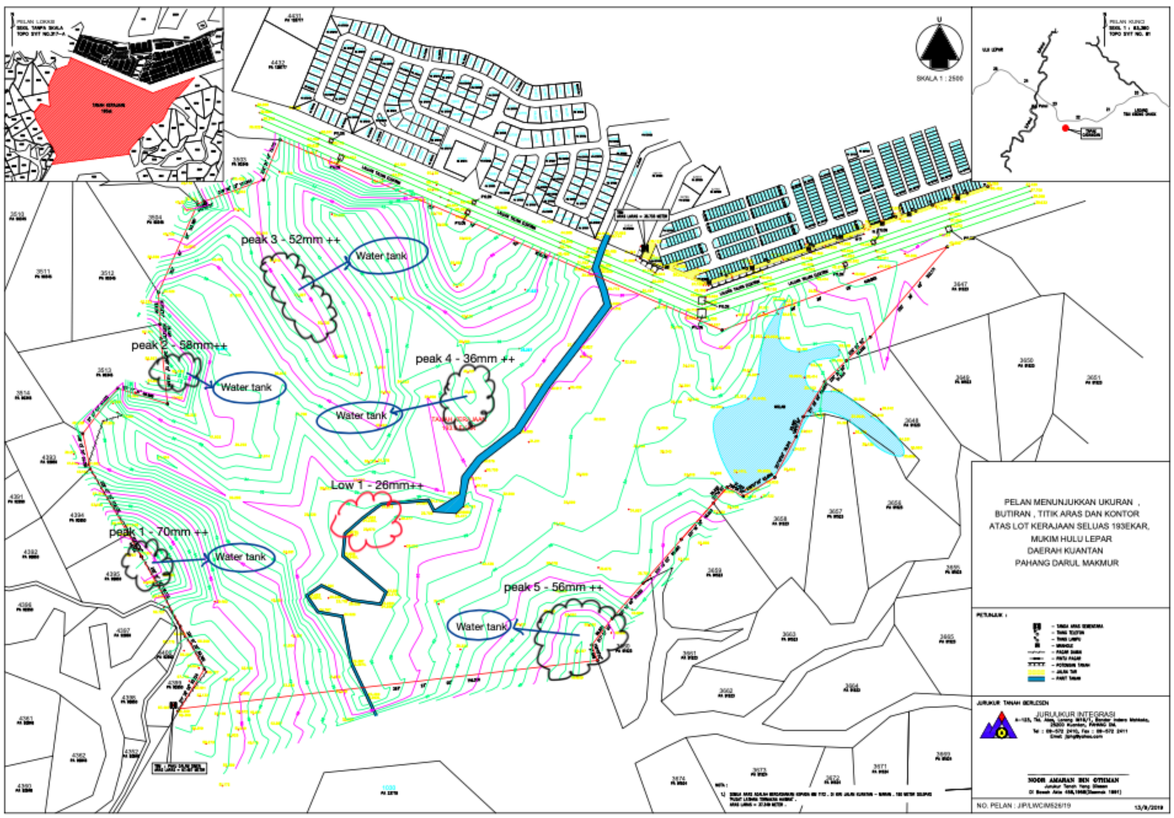
Site inventory is a straightforward listing of all aspects of the property as they stand right now. Real conditions must be taken into account in the design process at the proposed development site since they have a significant impact on existing elements. Engineers would use sound judgment and intelligent conclusions as a result of these lists and observations. The surroundings and current conditions of the construction site need to be reviewed because they can help detect any issues or potential dangers. This is so that if any issues arise later, it won't disrupt the construction schedule. We have dispatched a representative in the form of the head of each department to conduct a survey and tour the potential location

Site inventory is an essential component of site analysis in landscape architecture and urban planning. It entails a methodical procedure for gathering, compiling, and analyzing information about a site's cultural and ecological aspects. A site inventory informs design decisions by assisting designers and planners in understanding the current circumstances and potential site limitations.

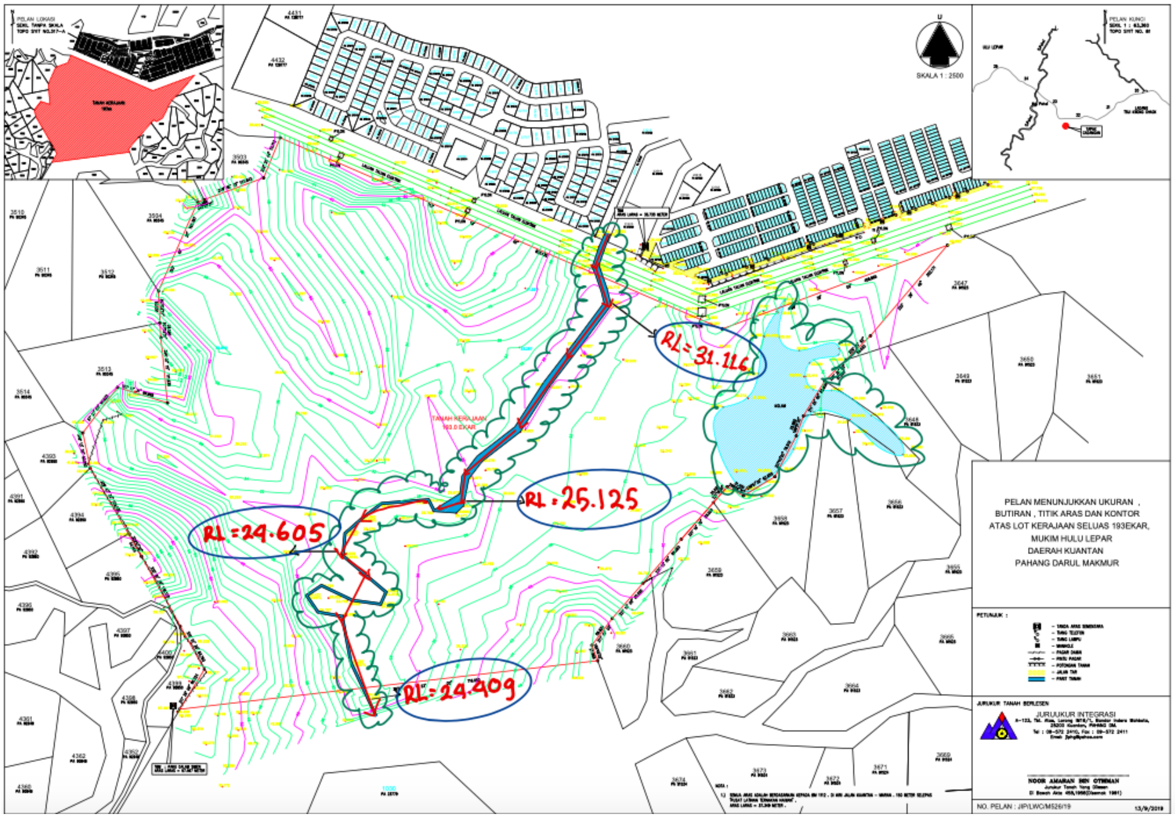
Site inventory is made of several components, including site boundaries and access, topography, vegetation, hydrology, wildlife, cultural resources, infrastructure, microclimate and community and social context.

Some factors of site investigation include existing terrain (whether it is flat, undulating or both), adjacent land use (unused or used), existing road networks (location, levels, single/dual lanes) and existing water and drainage bodies (location, invert levels, drainage reserves and existence natural ponds/streams).

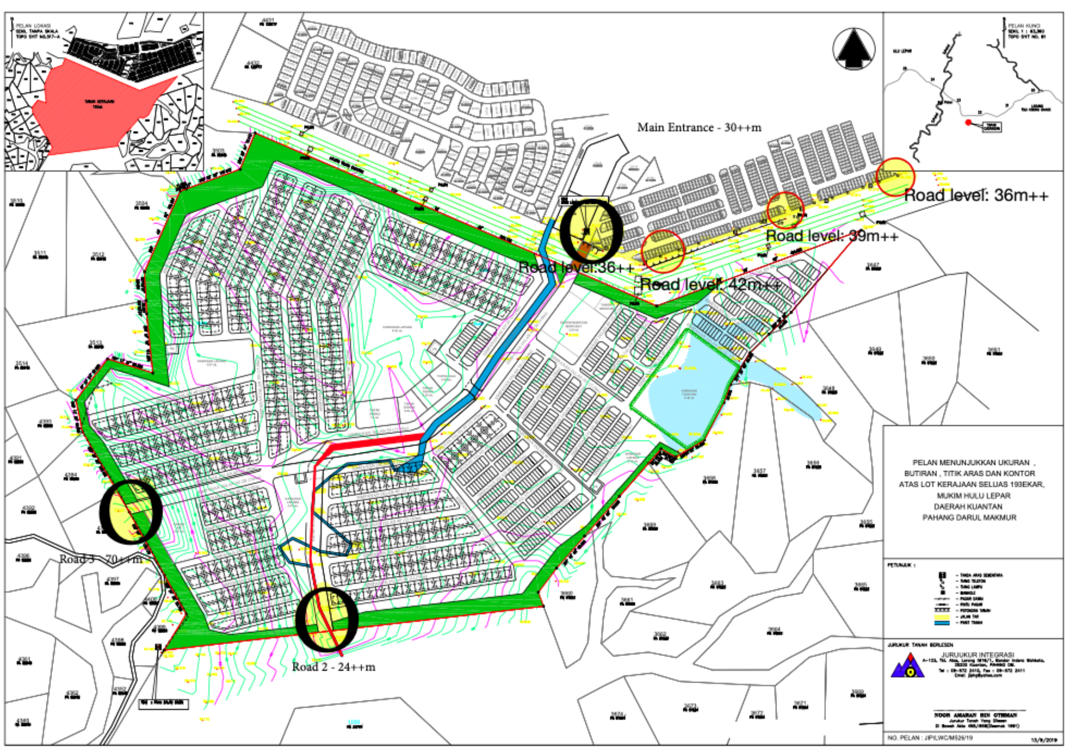
TERRAIN OBSERVATION



EXISTING NATURAL DRAINAGE



ROAD LEVELS



3.5 Site Analysis

Site analysis is the second step of earthwork. It is a systematic process of assessing the physical, environmental, and social characteristics of a site for the purpose of designing a built environment or landscape. Site analysis is typically conducted by architects, landscape architects, urban planners, and other design professionals as a part of the planning and design process. It uses information from the site inventory to plan out the grid and conceptual grading levels which is necessary for planning out utilities.

The site analysis process involves two steps: document site inventory, note down beneficial/harmful features.

Site analysis in earthwork plays a vital role in the comprehensive project planning and execution process, as it serves to ensure the feasibility, design excellence, and safe implementation of earthwork projects while adhering to environmental regulations, thereby enabling the attainment of successful and cost-effective outcomes by effectively identifying potential risks, optimizing designs to suit site-specific conditions, and considering logistical factors to streamline resource allocation and enhance project efficiency.

We retrieve documentation from Google Earth based on the available locations.
Site analysis documentation plays a critical role in identifying potential risks and hazards associated with the site. By documenting factors such as soil stability, slope steepness, or proximity to water bodies, engineers can assess the potential for landslides, erosion, or other geotechnical issues. This information allows them to develop appropriate risk mitigation strategies and design structures or measures to enhance safety and stability.


Lor GD 20

With the site data analyzed into useful information and the information sorted during site analysis phase, the knowledge obtained can be used to obtain grid, grading levels and proposed levels.

3.6 Proposed Levels

Proposed level refers to the intended elevation or height of a structure or landform that is planned to be built or modified. The proposed level is typically included in architectural or engineering plans and is used as a guide during the construction or modification process.

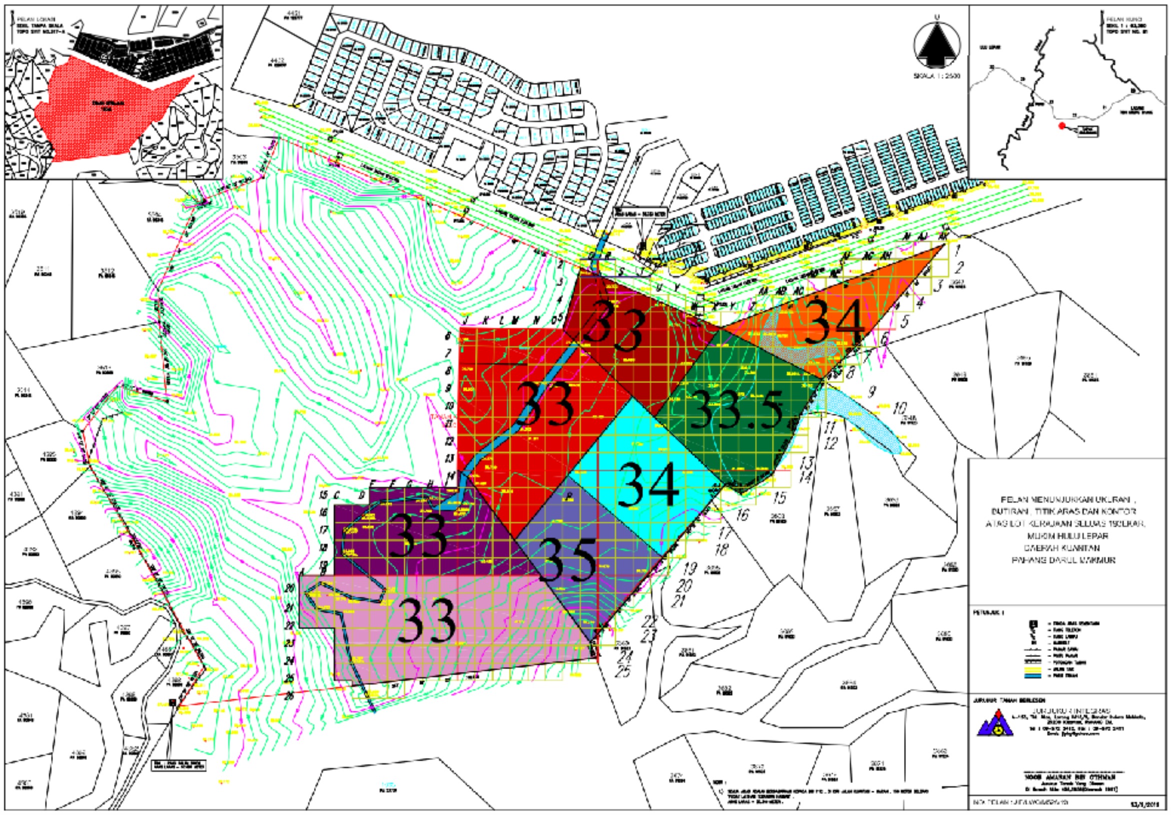
In construction projects, the proposed level is typically determined through a process called site grading, which involves reshaping the site's surface to achieve the desired slope, drainage, and foundation conditions. The proposed level can also be used to determine the amount of excavation or filling required to achieve the desired elevation.

The proposed level is typically based on the project's design specifications and the site's topography, soil conditions, and other physical factors. It is important to ensure that the proposed level is compatible with the surrounding landscape and does not cause any negative impacts on the environment or neighboring properties.

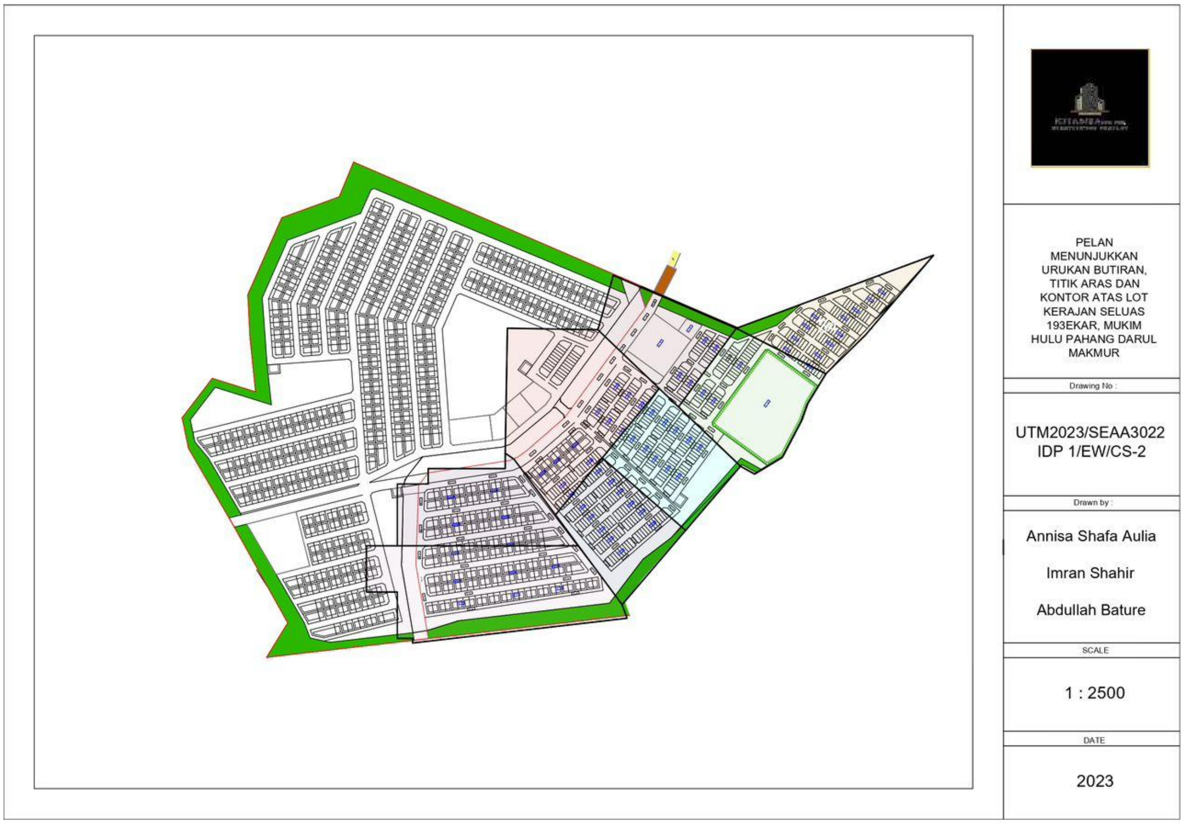
Before construction or modification, it is necessary to obtain the required permits and approvals from the local authorities, including zoning boards, building departments, and environmental agencies. The proposed level is typically included in the plans and specifications submitted for review and approval by these authorities.

We have divided the area into 8 zones of varying levels.

Zone 1 (Orange) - 34++m
Zone 2 (Green) - 33.5++m
Zone 3 (Brown) - 33++m
Zone 4 (Red) - 33++m
Zone 5 (Cyan) - 34++m
Zone 6 (Blue) - 35++m
Zone 7 (Purple) - 33++m
Zone 8 (Pink) - 33++m


33
34
33
33.5
34
33
35
33
PELAN MENUNJUKKAN UKURAN ,
BUTIRAN , TITIK ARAS DAN KONTOR
ATAS LOT KERAJAAN SELUAS 190EKAR,
MUKIM HULU LEPAR
DAERAH KUANTAN
PAHANG DARUL MAKMUR
PETUNJUK :

3.6.1 Proposed Level Drawing



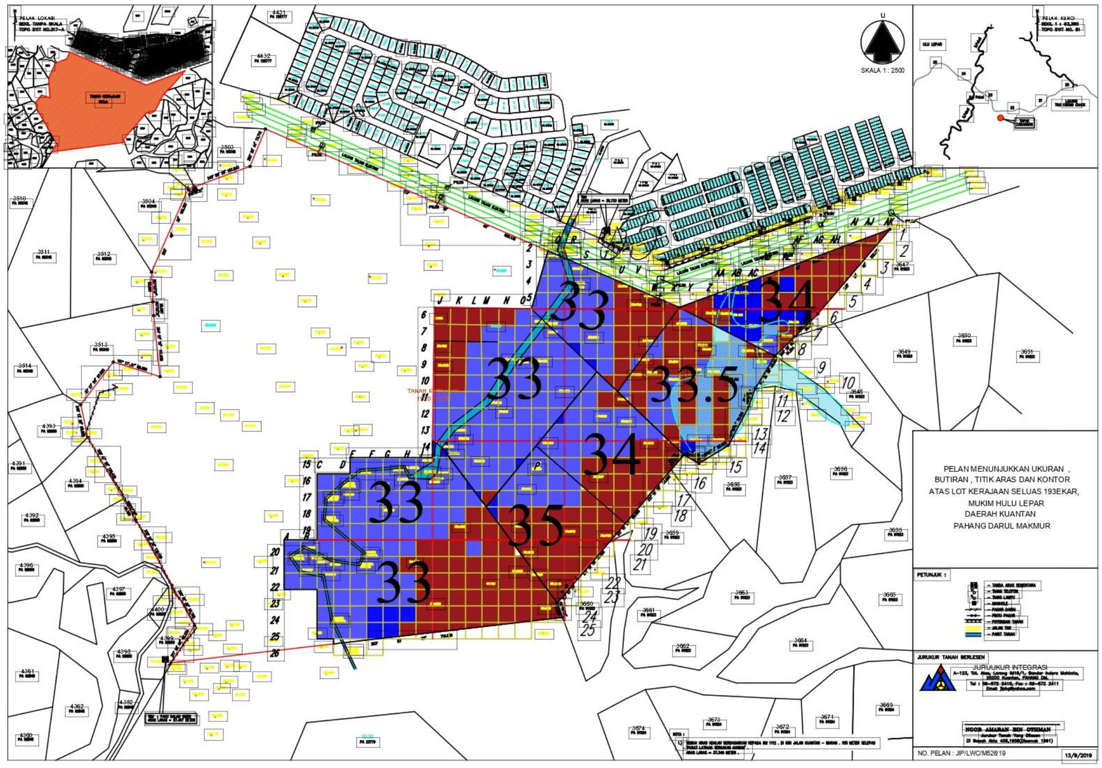
3.7 Cut & Fill

Cut & fill is one of the major components of pre-construction; most time-consuming and costly, and it refers to the process conducted for the purpose of readjusting the ground elevation of different spots on the site to the elevation required in design. It is done by excavating excess soil from a high level area and substituting it into a lower level area that needs to be uplifted in terms of height above sea level and vice versa.

Cut refers to the process where excess soil/rock is extracted from the cut area and transported onto an area where it can be used as fill, this way the process of searching for replacement soil is eliminated. This is typically done to create a level surface for building or construction purposes.

Fill is the process of using the excavated soil/rock to raise the elevation of a different area, in this process the soil/rock is typically spread and compacted in layers until the desired elevation is achieved. This is done to create a level surface for construction or to provide additional support to existing structures.

3.7.1 Cut And Fill Drawing



3.8 Cut And Fill calculation (Grid Method)

In order to determine the area & volume needed for cut & fill, there are several methods which can be applied, such as cross-sectional, grid, total station survey, 3d modeling software etc. For our project we have decided to go with the grid method as it is much straightforward and the most suitable method to use with the information we have in hand, we will apply the knowledge of grid in this project in order to determine the amount of soil needed for the cut & fill process

The grid method involves dividing the site into a grid of squares and calculating the volume of soil in each cell using the average of 4 spot heights and the area of the grid. The volume of cut and fill can then be determined by summing the volumes of all the cells. We have decided to choose a grid section of 30mx30m, according to our lecturer this is the minimum grid size that can be taken, and we go for the minimum size because according to the grid method theory, the smaller the grid size the more accurate the value for area & volume.

Let us take Grid A20 for example:

Insert pic of A20

We will estimate the height of each of the four spot heights by referring to the value of the contour lines and the spot heights inside or close to the grid.

In our case, the spot heights are

29.2	26.25	25.01	30.1

Then the average of the four spot heights that have been calculated are taken to find the average spot height:

Average Value = (29.2+26.25+25.01+30.1)/4 m
= 27.64m

Then the differences among the average spot height and proposed level are calculated:

Height Difference = Proposed Level - Average Spot Height
= 33 - 27.64 m
= +5.36m

The height difference is positive, which means that the proposed level is greater than the average spot height, so filling will be done to increase the average spot height to the proposed level.
The area of the grid is calculated. As the grid is square shaped, the area can easily be calculated using the 30mx30m dimension:

Area of grid = 30m x 30m = 900m2

The volume of the cut or fill, in this case fill, can be calculated by multiplying the area of the grid with the height difference:

Fill Volume = Height Difference * Area of Grid
= (Proposed Level - Average Spot Height) * Area of Grid
= 5.36m * 900m2
= 6624m3

Cut Volume (m3)	576588.5017
Fill Volume (m3)	639570.447
Difference	-10.92320522

Examples of the cut and fill for each zone are shown below:

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
ZONE 1	Y5	40	42	41		41	34	254	1778	
	Y6/1	40	38	39		39	34	164	820	
	Z5	36	34	35	36	35.25	34	595	743.75	
	Z6/1	35	36	35	35	35.25	34	422	527.5	
	AA4	34.4	34.4	34.4		34.4	34	57	22.8	
	AA5	34.4	33	33.1	35	33.875	34	714		89.25
	AA6	36	33	33.1	34	34.025	34	830	20.75	
	AA7/1	33.3	33	32		32.76666667	34	164		202.2666667
	AB4	33	32.6	32.6	31	32.3	34	265		450.5
	AB5	33	32.6	31	32	32.15	34	900		1665
	AB6	33	33	33	33	33	34	900		900
	AB7/1	33	32	34	32	32.75	34	427		533.75
	AC4	32.4	33	32	38	33.85	34	432		64.8
	AC5	32.5	35	33.2	34	33.675	34	900		292.5
	AC6	32.6	32.6	33.4	33.4	33	34	900		900
	AC7	33.4	34	33.2	32	33.15	34	900		765
	AC8/1	33.3	32	31		32.1	34	432		820.8
	AD3	40	40	40		40	34	132	792	
	AD4	38.5	40	36	35	37.375	34	900	3037.5	
	AD5	33	36	35	34	34.5	34	900	450	
	AD6	36	32	33.4	34	33.85	34	900		135
	AD7	32	33.4	33.2	33.2	32.95	34	900		945
	AD8/1	33	33	34	34	33.5	34	446		223
	AE3	40	39.5	39	40	39.625	34	315	1771.875	
	AE4	39	3.5	38	37	29.375	34	900		4162.5
	AE5	36	35.5	37	35	35.875	34	900	1687.5	
	AE6	33	32	33.25	33.25	32.875	34	900		1012.5
	AE7	35	36.4	35.5		35.63333333	34	554	904.8666667	
	AE8	34	36	36		35.33333333	34	185	246.6666667	
	AF2	43.5	43.5	43.5		43.5	34	6.2	58.9	
	AF3	43.5	41	40	40	41.125	34	476	3391.5	
	AF4	40	39.8	38	37	38.7	34	900	4230	
	AF5	37	35.5	38	36	36.625	34	900	2362.5	
	AF6	33.3	31	32	36	33.075	34	549		507.825
	AF7	36.4	34	33.3		34.56666667	34	195	110.5	
	AG2	42	41.5	41.5	42	41.75	34	900	6975	
	AG3	40	39.5	38	38	38.875	34	900	4387.5	

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
	AG4	41	40	40	39.9	40.225	34	900	5602.5	
	AG5	35	34	35	35	34.75	34	543	407.25	
	AG6	36	36	36		36	34	95	190	
	AH2	44.2	40	41	41.5	41.675	34	366	2809.05	
	AH3	42.1	40	41	41.5	41.15	34	900	6435	
	AH4	41	40	41	41	40.75	34	366	2470.5	
	AH5	38	37	37	36	37	34	119	357	
	AI1	40	39	40		39.66666667	34	41	232.3333333	
	AI2	40	41	40	41	40.5	34	492	3198	
	AI3	40	39	38.5	38	38.875	34	515	2510.625	
	AI4	37	38	37	37	37.25	34	58	188.5	
	AJ1	40.3	40	41	42	40.825	34	250	1706.25	
	AJ2	42	41	40	39	40.5	34	465	3022.5	
	AJ3	37	36	37.5		38	34	18	72	
	AK1	41	42	40		41	34	190	1330	
	AK2	40	40	40		40	34	0.7	4.2	
	V8/2	34.2	34.2	34.2		34.2	33.5	57	39.9	
	V9/2	34.3	34.3	33.2	34.1	33.975	33.5	586	278.35	
	V10	34.1	33.2	34.6	35	34.225	33.5	900	652.5	
	V11/2	34.6	35	35	35	34.9	33.5	780	1092	
	V12/2	34.6	34.6	35		34.73333333	33.5	230	283.6666667	
	W7/2	34	37	35		35.33333333	33.5	200	366.6666667	
	W8/2	35	35	34.2	35	34.8	33.5	700	910	
	W9	34.3	36	33.25	32	33.8875	33.5	900	348.75	
	W10	33	33	33	33	33	33.5	900		450
	W11	33.2	34	33	35	33.8	33.5	900		180
	W12/2	33	34	32	32	32.75	33.5	856		214
	W13/2	32	31.5	33		32.16666667	33.5	201		67
	X6/2	40	40	40		40	33.5	335	2177.5	
	X7/2	40	40	40	40	40	33.5	537	3490.5	
	X8	38	37	38.1	38	37.775	33.5	900	3847.5	
	X9	38.1	38	36	34	36.525	33.5	900	2722.5	
	X10	33.3	33.3	32	31	32.4	33.5	900		90
	X11	33	34	33	32	33	33.5	900		450
	X12	32	33	31	32	32	33.5	900		450
	X13/2	33.6	34	35	33	33.9	33.5	738	295.2	
	X14/2	33.6	33.6	33.6		33.6	33.5	175	17.5	

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
ZONE 2	Y6/2	40	40	40	40		33.5	703		22847.5
	Y7	40	39.5	38	40	39.375	33.5	900	5287.5	
	Y8	38	36	39	38	37.75	33.5	900	3825	
	Y9	36	36.5	37	37	36.625	33.5	900	2812.5	
	Y10	34	35	34	33.4	34.1	33.5	900	540	
	Y11	35	36	36	35	35.5	33.5	900	1800	
	Y12	35	34	34.5	35	34.625	33.5	900	1012.5	
	Y13	33	34	31.4	32	32.6	33.5	900		360
	Y14	31.4	30.3	33.2	33.2	32.025	33.5	831		394.725
	Y15	33.2	33.6	34		33.6	33.5	119	11.9	
	Z6/2	34.4	35	35		34.8	33.5	258	335.4	
	Z7	36	33	35.5	35	34.875	33.5	900	1237.5	
	Z8	35.5	33.3	33.3	32	33.525	33.5	900	22.5	
	Z9	34	33	31.3	32	32.575	33.5	900		382.5
	Z10	32	31.3	32	33	32.075	33.5	900		382.5
	Z11	32	33	32	32	32.25	33.5	900		225
	Z12	32	33	32	32	32.25	33.5	900		225
	Z13	33	32	30	31.4	31.6	33.5	900		810
	Z14	31.4	30.3	33.2	33.2	32.025	33.5	546		259.35
	Z15	33.2	33.6	34		33.6	33.5	119	11.9	
	AA7/2	33.3	33	33	33.2	33.125	33.5	700		262.5
	AA8	34	33	32	33.3	33.075	33.5	900		382.5
	AA9	33	32	31.3	31.3	31.9	33.5	900		540
	AA10	31.3	32	32	32	31.825	33.5	900		607.5
	AA11	31.3	32	32	32	31.825	33.5	900		607.5
	AA12	33	32	32	34	32.75	33.5	900		225
	AA13	31	30.3	30.3	31	30.65	33.5	900		1665
	AA14	30	33.6	33	33.2	32.45	33.5	457		22.85
	AB7/2	33	32.5	32.5	31	32.25	33.5	250		62.5
	AB8	34	33	31.5	31.75	32.5625	33.5	900		393.75
	AB9	33	32.95	31.3	31.3	32.1375	33.5	900		326.25
	AB10	35	33	34	36	34.5	33.5	900	900	
	AB11	35	36	37.3	35	35.825	33.5	900	2092.5	
	AB12	35	34.8	35	35	34.95	33.5	775	1123.75	
	AB13	35	35	36		35.33333333	33.5	278	509.6666667	
	AB14	33.6	33.17	30.3		32.35666667	33.5	6.8		0.9746666667
	AC8/2	33.2	33.2	33.4	33	33.2	33.5	265		79.5

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
	AC9	33	33.5	33	33.5	33.25	33.5	900		225
	AC10	33	33	36	36	34.5	33.5	650	650	
	AC11	36	36	36	36	36	33.5	60	150	
	AC12	33	33	33		33	33.5	16		8
	AD8/2	33.4	34	33.4	33.4	33.55	33.5	169	8.45	
	AD9	33.4	33.4	33.4		33.4	33.5	35		3.5
	AD10	35	35	35		35	33.5	4.5	6.75	
Zone 3	P2	31.2	31.75	32		31.65	33	35		47.25
	P3	32	31.75	32	30	31.4375	33	245		382.8125
	P4	32	30	29.5	31	30.625	33	500		1187.5
	P5	31	29.5	29	30.5	30	33	775		2325
	P6/3	30.5	28.5	30		29.66666667	33	450		1500
	Q2	31.24	28	28	31.8	29.76	33	280		907.2
	Q3	32	28	29	30	29.75	33	900		2925
	Q4	30	29	28	29.5	29.125	33	900		3487.5
	Q5	29.5	28	30	28	29.125	33	900		3487.5
	Q6	28	30	30.75	30	29.6875	33	900		2981.25
	Q7/3	30	30.75	31		30.58333333	33	430		1039.166667
	R2	28				28	33	10		50
	R3	28	30.7	30	29	29.425	33	750		2681.25
	R4	29	30	30.25	28.75	29.5	33	900		3150
	R5	28.75	30.25	31.5	30	30.125	33	900		2587.5
	R6	30	31.5	32	30.5	31	33	900		1800
	R7	30.5	32	32	31	31.375	33	900		1462.5
	R8/3	31	32	32.25		31.75	33	350		437.5
	S3	32		30	30	30.66666667	33	415		968.3333333
	S4	30	30	31.5	30.25	30.4375	33	900		2306.25
	S5	30.25	31.5	32	31	31.1875	33	900		1631.25
	S6	31	32	32.5	32	31.875	33	900		1012.5
	S7	32	32.5	32.5	32	32.25	33	900		675
	S8	32	32.5	33	32.25	32.4375	33	900		506.25
	S9/3	32.25	33	33		32.75	33	325		81.25
	T3	30	30	30		31.25	33	70		122.5
	T4	30	31.5	32	31.5	32.125	33	830		726.25
	T5	31.5	32	33	32	32.125	33	900		787.5
	T6	32	33	33	32.5	32.625	33	900		337.5
	T7	32.5	33	33	32.5	32.75	33	900		225

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
	T8	32.5	33	33	32.5	32.75	33	900		225
	T9	32.5	33	33	33	32.875	33	900		112.5
	T10/3	33	33	34.25		33.41666667	33	290	120.8333333	
	U4	31	35	35	32	33.25	33	530	132.5	
	U5	32	35	33.5	33	33.375	33	900	337.5	
	U6	33	33.5	33.5	33	33.25	33	900	225	
	U7	33	33.5	33.75	33.25	33.375	33	900	337.5	
	U8	33.25	33.75	34	33.5	33.625	33	900	562.5	
	U9	33.5	34	34	33.75	33.8125	33	900	731.25	
	U10/3	33.75	34	35		34.25	33	510	637.5	
	V4	35		40	35	36.66666667	33	150	550	
	V5	35	40	37	33.75	36.4375	33	900	3093.75	
	V6	33.75	37	36	33.5	35.0625	33	900	1856.25	
	V7	33.5	36	35	33.75	34.5625	33	900	1406.25	
	V8/3	33.75	35			34.375	33	850	1168.75	
	V9/3	33	33	32		32.66666667	33	840		280
	W5	40	42	42	37	40.25	33	650	4712.5	
	W6	37	42	39	36	38.5	33	900	4950	
	W7/3	36	39	35	35	36.25	33	700	2275	
	W8/3	34.24	36	35		35.08	33	115	239.2	
	X5	42	43	42	42	42.25	33	260	2405	
	X6/3	42	42	39	39	40.5	33	480	3600	
	X7/3	39	39	39			33	15		495
	J6	39	39	35.5	36	37.375	33	900	3937.5	
	J7	36	35.5	35.5	35	35.5	33	900	2250	
	J8	35	35.5	35	35	35.125	33	900	1912.5	
	J9	35	35	36	35	35.25	33	900	2025	
	J10	35	36	34.5	32.5	34.5	33	900	1350	
	J11	32.5	34.5	32	31	32.5	33	900		450
	J12	31	32	31	30	31	33	900		1800
	J13	30	31	30.5	29	30.125	33	900		2587.5
	J14/4	29	30.5	31.72		30.40666667	33	450		1167
	K6	39	38	35	35.5	36.875	33	900	3487.5	
	K7	35.5	35	34	35	34.875	33	900	1687.5	
	K8	35	34	33.5	35.5	34.5	33	900	1350	
	K9	35.5	33.5	34	36	34.75	33	900	1575	
	K10	36	34	33.5	34	34.375	33	900	1237.5	

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
Zone 4	K11	34	33.5	32	32	32.875	33	900		112.5
	K12	32	32	31	31	31.5	33	900		1350
	K13	31	31	30.5	30.5	30.75	33	900		2025
	K14	30.5	30.5	32	30	30.75	33	900		2025
	K15/4	30	32	32	30	31	33	570		1140
	K16/4	30	31			30.5	33	10		25
	L6	38	37.5	34	35.5	36.25	33	900	2925	
	L7	35.5	34	32.5	34	34	33	900	900	
	L8	34	32.5	31.5	33.5	32.875	33	900		112.5
	L9	33.5	31.5	32	34	32.75	33	900		225
	L10	34	32	32	33.5	32.875	33	900		112.5
	L11	33.5	32	29.5	32	31.75	33	900		1125
	L12	32	29.5	31	30.5	30.75	33	900		2025
	L13	30.5	31	31.5	31	31	33	900		1800
	L14	31	31.5	32.5	32	31.75	33	900		1125
	L15	32	32.5	31.5	30.5	31.625	33	900		1237.5
	L16/4	30	32.5	32.5	30	31.25	33	750		1312.5
	L17/4	32.5	32.5	32.5		32.5	33	150		75
	M6	37.5	36	33	34	35.125	33	900	1912.5	
	M7	34	33	31	33	32.75	33	900		225
	M8	33	31	29.5	31.5	31.25	33	900		1575
	M9	31.5	29.5	29	32	30.5	33	900		2250
	M10	32	29	29.5	31.5	30.5	33	900		2250
	M11	31.5	29.5	30.5	32	30.875	33	900		1912.5
	M12	32	30.5	31	31	31.125	33	900		1687.5
	M13	31	31	31.5	32	31.375	33	900		1462.5
	M14	32	31.5	32.5	32.5	32.125	33	900		787.5
	M15	32.5	32.5	33	32.5	32.625	33	900		337.5
	M16	32.5	33	33.5	33	33	33	900	0	0
	M17/4	33	33.5			33.25	33	500	125	
	N6	36	33.5	31	33	33.375	33	900	337.5	
	N7	33	31	29	31	31	33	900		1800
	N8	31	29	28	29.5	29.375	33	900		3262.5
	N9	29.5	28	30	30	29.375	33	900		3262.5
	N10	30	30	30.5	30	30.125	33	900		2587.5
	N11	30	30.5	31	30	30.375	33	900		2362.5
	N12	30	31	31.5	31	30.875	33	900		1912.5

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
	N13	31	31.5	31.75	31.5	31.4375	33	900		1406.25
	N14	31.5	31.75	32	32.25	31.875	33	900		1012.5
	N15	32.25	32	33	33	32.5625	33	900		393.75
	N16/4	33	33	33		33	33	430	0	0
	O6	33.5	30.5	28.5	31	30.875	33	900		1912.5
	O7	31	28.5	28	29.5	29.25	33	900		3375
	O8	29.5	28	29.5	28	28.75	33	900		3825
	O9	28	29.5	30.5	30	29.5	33	900		3150
	O10	30	30.5	31	30.5	30.5	33	900		2250
	O11	30.5	31	31.75	31	31.0625	33	900		1743.75
	O12	31	31.75	31.75	31	31.375	33	900		1462.5
	O13	31	31.75	31.75	31.25	31.4375	33	900		1406.25
	O14/4	31.5	32	32	32	31.875	33	880		990
	O15/4	32	32	32.5		32.16666667	33	320		266.6666667
	P6/4	30	30	28		29.33333333	33	450		1650
	P7	28.5	30	30	28	29.125	33	900		3487.5
	P8	28	30	30.5	30	29.625	33	900		3037.5
	P9	30	30.5	31	30	30.375	33	900		2362.5
	P10	30	31	32	30.5	30.875	33	900		1912.5
	P11	30.5	32	31	30.5	31	33	900		1800
	P12	30.5	31	32.25	31.75	31.375	33	900		1462.5
	P13/4	32	32.5	32.5	32	32.25	33	780		585
	P14/4	32	32	32		32	33	150		150
	Q7/4	30	31	30			33	470		15510
	Q8	30	31	31.5	30.5	30.75	33	900		2025
	Q9	30.5	31.5	32	31.75	31.4375	33	900		1406.25
	Q10	31.75	32	32.5	32	32.0625	33	900		843.75
	Q11	32	32.5	32.5	32.25	32.3125	33	900		618.75
	Q12/4	32.25	32.5	32.5	32.25	32.375	33	780		487.5
	Q13/4	32.5	32.5	32.5		32.5	35	150		375
	R8/4	32.25	31.5	32.5		32.08333333	33	550		504.1666667
	R9	31.5	32.25	32.5	32	32.0625	33	900		843.75
	R10	32	32.5	32.75	32.25	32.375	33	900		562.5
	R11/4	32.5	32.5	32.5		32.5	33	530		265
	S9/4	32.5	32.5	33		32.66666667	33	370		123.3333333
	S10/4	33	33	33		33	33	440	0	0
	S10		33.5	33.5	33.8	33.6	34	532.84		213.136

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
ZONE 5	T10	33.5		33.8	34.5	33.93333333	34	605		40.33333333
	R11		33		33.5	33.25	34	372.36		279.27
	S11	33	33.6	33.5	33.9	33.5	34	900		450
	T11	33.6	34.6	33.9	34.6	34.175	34	900	157.5	
	U11	34.2	34.6	33.4		34.06666667	34	638.12	42.54	
	R12		33.5	33	33.5	33.33333333	34	883.69		589.1266667
	S12	33.5	34	33.5	34	33.75	34	900		225
	T12	34	34	34	34	34	34	900		0
	U12	34	34	34	33.3	33.825	34	900		157.5
	V12	34		33.3	33.5	33.6	34	669.97		267.988
	Q13		33	32.2	33	32.73333333	34	832.25		1054.183333
	R13	33	33.5	33	33.7	33.3	34	900		630
	S13	33.5	34	33.7	34	33.8	34	900		180
	T13	34	34	34	34	34	34	900		0
	U13	34	33.3	34	33.5	33.7	34	900		270
	V13	33.3	33.8	33.5	33.8	33.6	34	900		360
	W13	33.8		33.8	34	33.86666667	34	698.07		93.076
	Q14	32.2	33		33.4	32.86666667	34	897.28		1016.917333
	R14	33	33.8	33.4	34	33.55	34	900		405
	S14	33.8	34	34	34	33.95	34	900		45
	T14	34	34	34	34	34	34	900		0
	U14	34	33.8	34	34	33.95	34	900		45
	V14	33.8	33.8	34	36	34.4	34	900	360	
	W14	33.8	33.6	36	36	34.85	34	900	765	
	X14	33.6		36	34	34.53333333	34	723.89	386.07	
	R15	33.5	34		34	33.83333333	34	884.3		147.3833333
	S15	34	34	34	34.7	34.175	34	900	157.5	
	T15	34	34	34.7	36	34.675	34	900	607.5	
	U15	34	35	36	37	35.5	34	900	450	
	V15	35	36	37	38	36.5	34	900	1350	
	W15	36	35.5	38	38	36.875	34	900	1687.5	
	X15	35.5	34	38		35.83333333	34	713.05	594.21	
	S16	34	34.7		35.5	34.73333333	34	841.82	617.5	
	T16	34.7	36	35.5	38	36.05	34	900	945	
	U16	36	37	38	40	37.75	34	900	2475	
	V16	37	39	40	42	39.5	34	900	4050	
	W16	39	38	42		39.66666667	34	710.51	3315.71	

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
	T17	36	38	36	38	37	34	900	1800	
	U17	38	40	38	41	39.25	34	900	3825	
	V17	40	42	41		41	34	790.62	4743.72	
	U18	38	41			39.5	34	663.75	2986.75	
Zone 6	M17/6	33.4	33.9	33.5		33.6	35	85		119
	M18/6	33.5	33.9	35.9		34.43333333	35	335		189.8333333
	N16/6	33	33	33.7	33.5	33.3	35	470		799
	N17	33.5	33.7	35.8	33.9	34.225	35	900		697.5
	N18	33.9	35.8	37.8	35.9	35.85	35	900	765	
	N19/6	35.9	37.8	39.9	40	38.4	35	571	1941.4	
	N20/6	39.9	40	41		40.3	35	750	3975	
	O14/6	31.8	31.8	31.7		31.76666667	35	46		148.7333333
	O15/6	31.7	31.9	33	33	32.4	35	624		1622.4
	O16	33	33	34	33.7	33.425	35	900		1417.5
	O17	33.7	34	35.8	35.8	34.825	35	900		157.5
	O18	35.8	35.8	37.7	37.8	36.775	35	900	1597.5	
	O19	37.8	37.7	39.6	40	38.775	35	900	3397.5	
	O20/6	40	39.6	44	43	41.65	35	770	5120.5	
	O20/7	40	39.6			39.8	35	756	3628.8	
	O21/6	43	44	48		45	35	166	1660	
	P14/6	32	32.5	31.9	31.8	32.05	35	385		1135.75
	P15	31.9	32.5	33	33	32.6	35	900		2160
	P16	33	33	33.8	34	33.45	35	900		1395
	P17	34	33.8	35.1	35.8	34.675	35	900		292.5
	P18	35.8	35.1	35.8	37.7	36.1	35	900	990	
	P19	37.7	35.8	39	39.6	38.025	35	900	2722.5	
	P20	39.6	39	44.2	44	41.7	35	900	6030	
	P21	44	44.2	51	50	47.3	35	900	11070	
	P22/6	51	51	55.4		52.46666667	35	368	6427.733333	
	Q15/6	32.5	33.6	33.7	33	33.2	35	572		1029.6
	Q16	33	33.7	34.2	33.8	33.675	35	900		1192.5
	Q17	33.5	34.2	35	35.1	34.45	35	900		495
	Q18	35.1	35	36.6	35.8	35.625	35	900	562.5	
	Q19	35.8	36.6	39	39	37.6	35	900	2340	
	Q20	39	39	44.1	44.2	41.575	35	900	5917.5	
	Q21	44.2	44.1	49.5	51	47.2	35	900	10980	
	Q22	51	49.5	53	55.4	52.225	35	900	15502.5	

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
	Q23/6	55.4	53	53	55.3	54.175	35	447	8571.225	
	R15/6	33.6	33.7	33.7		33.66666667	35	22		29.33333333
	R16/6	33.7	34.3	34.4	34.2	34.15	35	670		569.5
	R17	34.2	34.4	35.7	35	34.825	35	900		157.5
	R18	35	35.7	36.8	36.6	36.025	35	900	922.5	
	R19	36.6	36.8	37.8	39	37.55	35	900	2295	
	R20	39	37.8	41	44.1	40.475	35	900	4927.5	
	R21	44.1	41	46	49.5	45.15	35	900	9135	
	R22/6	49.5	46	52	53	50.125	35	630	9528.75	
	R23/6	53	52	53		52.66666667	35	38	671.3333333	
	S16/6	34.3	34.4	34.5		34.4	35	58		34.8
	S17/6	34.4	35.8	35.8	35.7	35.425	35	753	320.025	
	S18	35.7	35.8	36.9	36.8	36.3	35	900	1170	
	S19	36.8	36.9	37.7	37.8	37.3	35	900	2070	
	S20	37.8	37.7	39.9	41	39.1	35	900	3690	
	S21/6	41	39.9	46		42.3	35	515	3759.5	
	T17/6	35.8	36.2	35.8		35.93333333	35	113	105.4666667	
	T18/6	35.8	38.1	38.2	36.9	37.25	35	816	1836	
	T19	36.9	38.2	39.8	37.7	38.15	35	900	2835	
	T20/6	37.7	39.8	39.9		39.13333333	35	375	1550	
	U18/6	38.1	40	38.2		38.76666667	35	66	248.6	
	U19	38.2	40	39.8		39.33333333	35	77	333.6666667	
	C16	25.5	26	24	25.5	25.25	33	900		6975
	C17	25.5	24	24.8	26	25.075	33	900		7132.5
	C18	26	24.8	24	26	25.2	33	900		7020
	C19	26	24	26	26	25.5	33	900		6750
	D16	26	26	25	24	25.25	33	900		6975
	D17	24	25	25.5	24.5	24.75	33	900		7425
	D18	24.5	25.5	25	24	24.75	33	900		7425
	D19	24	25	25.5	24	24.625	33	900		7537.5
	E15	28.4	28.6	25	26	27	33	900		5400
	E16	26	25	25	26	25.5	33	900		6750
	E17	26	25	26.5	26.8	26.075	33	900		6232.5
	E18	26.8	26.5	26	25.7	26.25	33	900		6075
	E19	25.7	26	27.8	25.8	26.325	33	900		6007.5
	F15	28.5	28	26	26	27.125	33	900		5287.5
	F16	26	26	27.5	26	26.375	33	900		5962.5

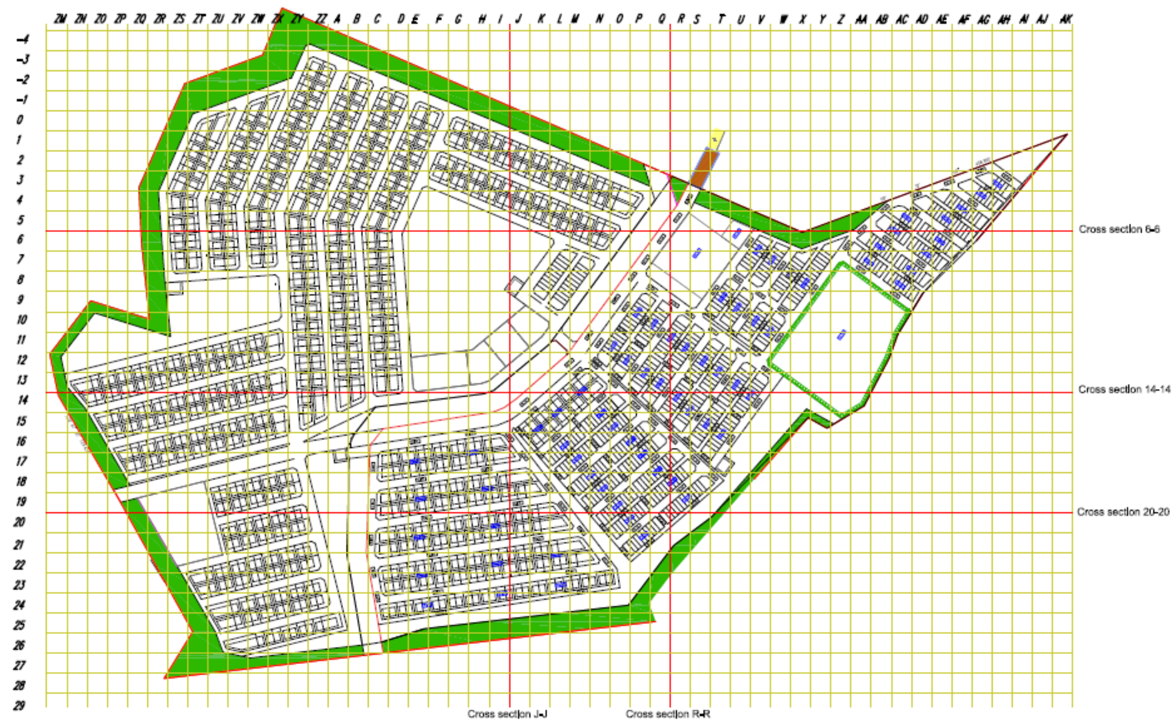
	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
ZONE 7	F17	26	27.5	27.5	26.5	26.875	33	900		5512.5
	F18	26.5	27.5	27.8	26.2	27	33	900		5400
	F19	26.2	27.8	27.9	26	26.975	33	900		5422.5
	G15	28	28	26	26	27	33	900		5400
	G16	26	26	26	26	26	33	900		6300
	G17	26	26	27.8	27.8	26.9	33	900		5490
	G18	27.8	27.8	27.9	29.9	28.35	33	900		4185
	G19	29.9	27.9	30.5	28.9	29.3	33	900		3330
	H15	26	30	26	26	27	33	900		5400
	H16	26	26	26.2	26.3	26.125	33	900		6187.5
	H17	26.3	26.2	28.2	27.8	27.125	33	900		5287.5
	H18	27.8	28.2	30.3	29.7	29	33	900		3600
	H19	29.7	30.3	31	27.5	29.625	33	900		3037.5
	I15	30	28	26	26	27.5	33	900		4950
	I16	26	26	26.2	26.2	26.1	33	900		6210
	I17	26.2	26.2	28.7	28.3	27.35	33	900		5085
	I18	28.3	28.7	31	30.5	29.625	33	900		3037.5
	I19	30.5	31	32.8	32	31.575	33	900		1282.5
	J14/7	30	29.97	30.2	31	30.2925	33	535		1448.5125
	J15	31	30.2	26.8	23.7	27.925	33	900		4567.5
	J16	23.7	26.8	28	26.3	26.2	33	900		6120
	J17	26.3	28	29.5	28.7	28.125	33	900		4387.5
	J18	28.7	29.5	31.5	30.8	30.125	33	900		2587.5
	J19	30.8	31.5	33.5	32.7	32.125	33	900		787.5
	K15/7	30.1	29.7	27		28.93333333	33	355		1443.666667
	K16/7	27	29.7	31.7	28	29.1	33	867		3381.3
	K17	28	31.7	32.2	29.5	30.35	33	900		2385
	K18	29.5	32.2	33	31.5	31.55	33	900		1305
	K19	31.5	33	34.6	33.6	33.175	33	900	157.5	
	L16/7	31	32.3	31.7		31.66666667	33	160		213.3333333
	L17/7	31.7	32.3	33.3	32.2	32.375	33	750		468.75
	L18	32.2	33.3	34.2	33	33.175	33	900	157.5	
	L19	33	34.2	37	34.3	34.625	33	900	1462.5	
	M17/7	33	33.3	33		33.1	33	40	4	
	M18/7	33	33.3	35.7	34.2	34.05	33	565	593.25	
	M19	34.2	35.7	38.3	37	36.3	33	900	2970	
	N19/7	35.7	39.6	38.3		37.86666667	33	332	1615.733333	

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
	A20	29.2	26.25	25.01	30.1	27.64	33	900		4824
	A21	30.1	25.01	26.4	32	28.3775	33	900		4160.25
	A22	32	26.4	30.7	36.4	31.375	33	900		1462.5
	B20	36.4	30.7	26	26	29.775	33	900		2902.5
	B21	26	26	26	26	26	33	900		6300
	B22	26	26	26	26	26	33	900		6300
	C20	26.4	24	26	26	25.6	33	900		6660
	C21	26	26	26	26	26	33	900		6300
	C22	26	26	26	26	26	33	900		6300
	C23	26	26	26	28.5	26.625	33	900		5737.5
	C24	28.5	26	26	30.2	27.675	33	900		4792.5
	C25	30.2	26	26.6	31.2	28.5	33	900		4050
	D20	26	26	26	26	26	33	900		6300
	D21	26	26	26	26	26	33	900		6300
	D22	26	26	26	26	26	33	900		6300
	D23	26	26	26	26	26	33	900		6300
	D24	26	26	26	26	26	33	900		6300
	D25	26	26	26	26.8	26.2	33	900		6120
	D26	26.8	26	26	27.5	26.575	33	220		1413.5
	E20	26	26	26	26	26	33	900		6300
	E21	26	26	26	26	26	33	900		6300
	E22	26	26	26.2	26	26.05	33	900		6255
	E23	26	26.2	27.3	26	26.375	33	900		5962.5
	E24	26	27.3	27.6	26	26.725	33	900		5647.5
	E25	26	27.6	26.6	26	26.55	33	900		5805
	E26	26	26.6	26.4	26	26.25	33	116		783
	F20	26	27.6	27.6	26	26.8	33	900		5580
	F21	26	27.6	28	26	26.9	33	900		5490
	F22	26	28	28.2	26.2	27.1	33	900		5310
	F23	26.2	28.2	29.3	27.3	27.75	33	900		4725
	F24	27.3	29.3	29	27.5	28.275	33	900		4252.5
	F25	27.5	29	28.2	26.4	27.775	33	900		4702.5
	F26	26.4	28.2	26.4		27	33	20		120
	G20	27	24	24.5	23.4	24.725	33	900		7447.5
	G21	23.4	23.4	24.5	25	24.075	33	900		8032.5
	G22	25	26.5	27	25.8	26.075	33	900		6232.5
	G23	26.5	27	26	28	26.875	33	900		5512.5

	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	2	3	4	Average			Cut Volume	Fill Volume
Zone 8	G24	27	26.8	28.5	28.5	27.7	33	900		4770
	G25	31	32.5	33.5	33.5	32.625	33	808		303
	H20	29.6	30	33	33	31.4	33	900		1440
	H21	33	34	34	33.5	33.625	33	900	562.5	
	H22	31	30	32	31.5	31.125	33	900		1687.5
	H23	30.6	31	31.5	32	31.275	33	900		1552.5
	H24	33	32	32	31.8	32.2	33	900		720
	H25	33	33	34	34	33.5	33	703	351.5	
	I20	32	32.6	34.5	33.5	33.15	33	900	135	
	I21	33.5	34.5	35.9	34.2	34.525	33	900	1372.5	
	I22	34.2	35.9	35.4	33	34.625	33	900	1462.5	
	I23	33	35.4	35.3	33.1	34.2	33	900	1080	
	I24	33.1	35.3	36.1	33.2	34.425	33	900	1282.5	
	I25	33.2	36.1	36.6	34	34.975	33	607	1198.825	
	J20	32.7	33.5	35.5	34.3	34	33	900	900	
	J21	34.3	35.5	37.2	35.9	35.725	33	900	2452.5	
	J22	35	35.5	35.2	35.2	35.225	33	900	2002.5	
	J23	35.2	35.2	38	35.3	35.925	33	900	2632.5	
	J24	35.2	35.2	35.8	36	35.55	33	900	2295	
	J25	36	35.8	39.7	36.8	37.075	33	500	2037.5	
	K20	33.5	34	35.2	35	34.425	33	900	1282.5	
	K21	35.2	35	35.2	35.5	35.225	33	900	2002.5	
	K22	36	35.8	35.8	35.8	35.85	33	900	2565	
	K23	35.2	35.7	35.5	35	35.35	33	900	2115	
	K24	35.5	36	36	36	35.875	33	900	2587.5	
	K25	36	36.5	35	36	35.875	33	389	1118.375	
	L20	31.8	32	34	34.1	32.975	33	900		22.5
	L21	34.5	34	34	34	34.125	33	900	1012.5	
	L22	34	34	34	35.2	34.3	33	900	1170	
	L23	35	35.2	35.2	35.5	35.225	33	900	2002.5	
	L24	35	35.2	36	35.7	35.475	33	900	2227.5	
	L25	35.7	36	35.5	35	35.55	33	285	726.75	
	M20	37.5	38	40	39	38.625	33	900	5062.5	
	M21	39	40	39.5	38.5	39.25	33	900	5625	
	M22	40	41.1	41.1	41.1	40.825	33	900	7042.5	
	M23	42	41	40	41.5	41.125	33	900	7312.5	
	M24	44	43	45	46	44.5	33	900	10350	

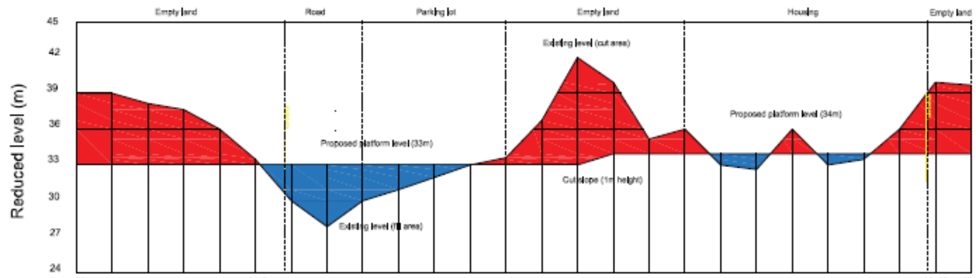
	Grid	Existing spot height (m)					roposed level (m	Area (m2)	Earthwork	
		1	**2**	**3**	**4**	**Average**			**Cut Volume**	**Fill Volume**
	M25	46	45.5	45.8	46	45.825	33	181	2321.325	
	N20/8	39.6	39	41.5	40	40.025	33	857	6020.425	
	N21	42.7	43	45.6	43	43.575	33	900	9517.5	
	N22	43	45.6	43	43.8	43.85	33	900	9765	
	N23	43.8	43	45	44	43.95	33	900	9855	
	N24	44	45	41.5	42	43.125	33	900	9112.5	
	N25	44.2	41	40	40	41.3	33	76.7	636.61	
	O20/8	42	43	42.7		42.56666667	33	140	1339.333333	
	O21/8	42.8	43.1	50	45	45.225	33	740	9046.5	
	O22	45	50	51.7	47.8	48.625	33	900	14062.5	
	O23	47.8	51.7	51.7	47.7	49.725	33	900	15052.5	
	O24	47.7	51.7	48.5	53	50.225	33	900	15502.5	
	P21/8	48.2	50.7	50		49.63333333	33	30	499	
	P22/8	50	50.8	55.1	51.7	51.9	33	533	10073.7	
	P23	51.7	55.1	56	53	53.95	33	900	18855	
	P24	53	56	55.3	53	54.325	33	768	16377.6	
	Q23/8	55	53.8	56		54.93333333	33	300	6580	
	Q24	55.8	53.8	52.6	55.7	54.475	33	515	11059.625	
								362783.42		
		Total Cut	**Total Fill**	**%Diff**	**Average Spot Height**					
		576588.5017	639570.447	-10.92320522	33.83816532					

3.9 Cross Section



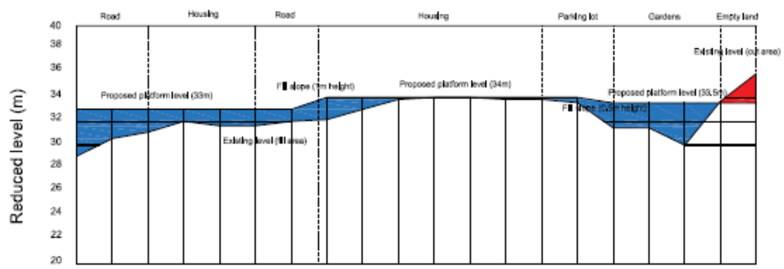
To visualize a cross section, visualize a construction component that has had its middle cut out. The observer would be able to see all the many parts that make up the overall element being rendered as a result. If the cross section was of the foundation wall, you would see the height of the foundation wall, the detail of the sill, the depth of the footing, and the top of the external wall, as it is supposed to be built. Cross sections provide more information about the structure and enclosure, which facilitates the construction of designs. More cross sections with different viewpoints are required as designs get more intricate and contain more elements. Plotting a cross-section of the proposed and existing levels at typical spans across the project site is part of the cross-section technique. In the general layout plan, we place three cross-sectional diagrams at the Northern, Central, and Southern zones. To have a clearer and more meaningful picture of our cut-and-fill outcome as well as the height difference between the proposed level and the original ground level in the chainage, these drawings will depict suggested levels and the average height of the chainages along the plotted axis.

Cross-section 6-6



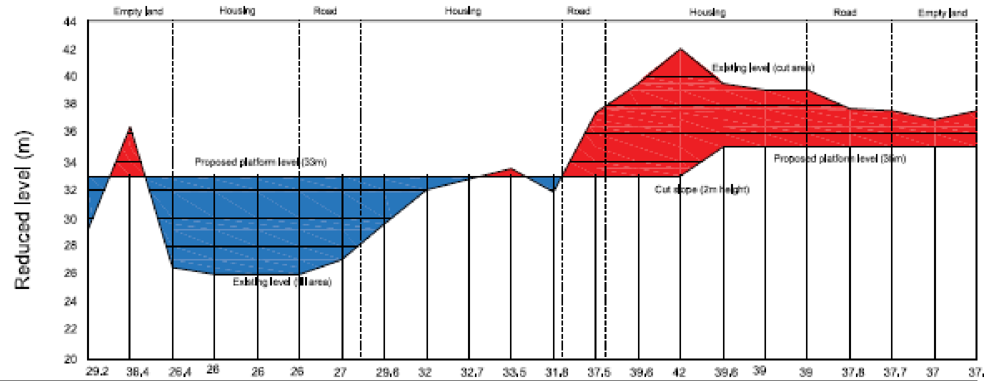
EXISTING LEVELS (m)	39	39	38	37,5	36	33,5	30	28	30	31	32	33	33,75	37	42	40	35	36	33	32,6	36	33	33,3	36	40.25	39.7
PROPOSED PALTFORM LEVEL (m)	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	34	34	34	34	34	34	34	34	34	34	34
DISTANCE ALONG CROSS SECTION (m)	0	30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570	600	630	660	690	720	750

Cross-section 14-14



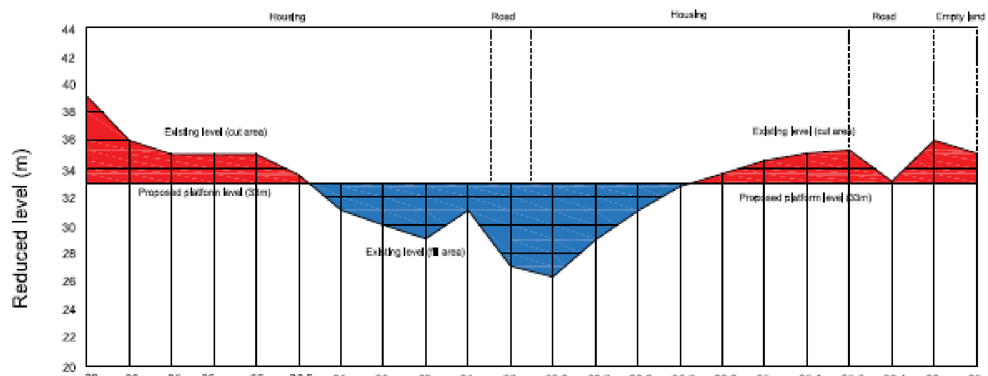
EXISTING LEVELS (m)	29	30,5	31	32	31,5	31,5	32	32,2	33	33,8	34	34	33,8	33,8	33,6	31,4	31,4	30	33,6	35,9
PROPOSED PALTFORM LEVEL (m)	33	33	33	33	33	33	33	34	34	34	34	34	34	34	34	33,5	33,5	33,5	33,5	33,5
DISTANCE ALONG CROSS SECTION (m)	0	30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570

Cross-section 20-20



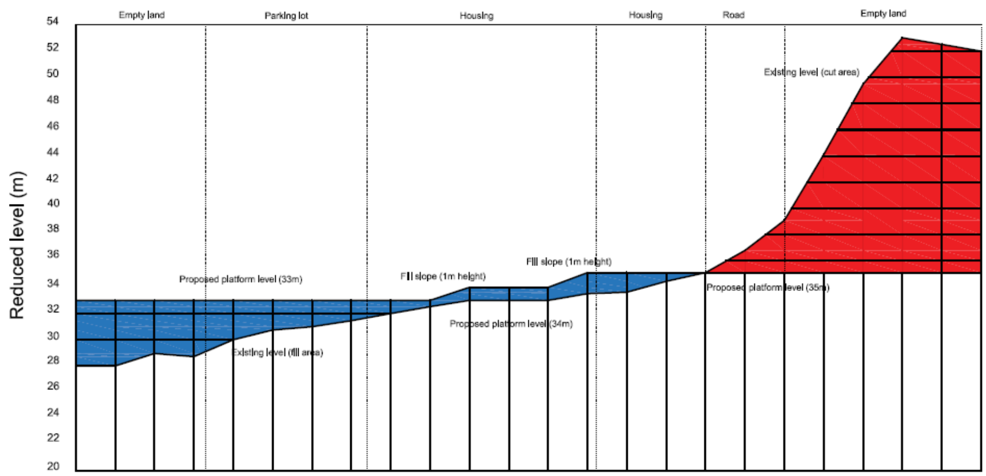
EXISTING LEVELS (m)	29.2	36.4	26.4	26	26	26	27	29.6	32	32.7	33.5	31.8	37.5	39.6	42	39.6	39	39	37.8	37.7	37	37.5
PROPOSED PALTFORM LEVEL (m)	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	35	35	35	35	35	35	35
DISTANCE ALONG CROSS SECTION (m)	0	30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570	600	630

Cross-section J-J



EXISTING LEVELS (m)	39	36	35	35	35	32.5	31	30	29	31	27	26.3	28.7	30.8	32.7	33.3	35	35.1	35.2	33.1	36	35
PROPOSED PALTFORM LEVEL (m)	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
DISTANCE ALONG CROSS SECTION (m)	0	30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570	600	630

Cross-section R-R



EXISTING LEVELS (m)	28	28	29	28.75	30	30.75	31	31.5	32	32.5	33	33	33	33.6	33.7	34.4	35	36.8	39	44.1	49.5	53	51.5	52
PROPOSED PALTFORM LEVEL (m)	33	33	33	33	33	33	33	33	33	33	34	34	34	35	35	35	35	35	35	35	35	35	35	35
DISTANCE ALONG CROSS SECTION (m)	0	30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570	600	630	660	690

3.10 Slope Stability Calculation

Slope stability is the measurement of the slope capacity to resist failure due to external forces such as gravity, applied load, seismic activity or water pressure and to be able to maintain its stability under these external forces. At times naturally soil or rocks tend to be situated at an angle, in cases like these we need to ensure that the forces we apply do not exceed the capacity of the slope so our buildings placed at an elevated angle can be stable. There are many factors which will affect the stability of the slope, factors such as the soil type & properties, the geological and environmental conditions and the presence of water table.

Slope stability analysis is a static, analytical, or empirical procedure for assessing the stability of excavated slopes or natural slopes in soil or rock. Preventing slope failure on a construction site is one of the most important aspects of any construction endeavor. The stability of a slope is founded on the interaction of two types of soil.

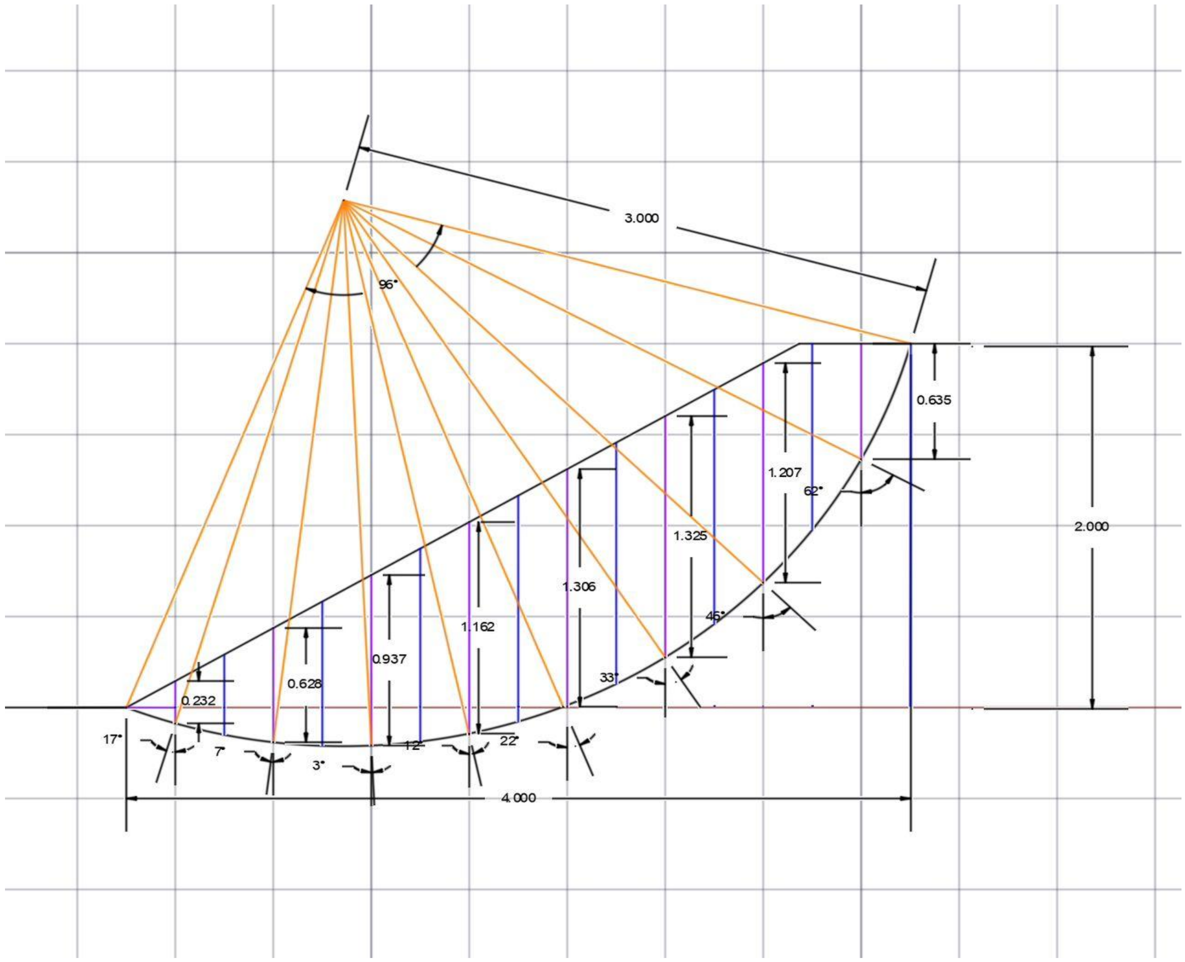
There are two types of forces: propelling forces and opposing forces. Driving forces facilitate the movement of material downslope, whereas resisting forces impede movement. When propelling forces surpass resisting forces, the slope becomes unstable and mass loss ensues. Typically, the primary propelling force in most land movements is gravity, while the primary resisting force is the shear strength of the material.

A slope failure is a phenomenon in which a slope collapses suddenly as a result of impaired self-retaining capacity of the earth caused by rainfall or an earthquake. When a slope collapses suddenly near a residential area, many people are unable to evacuate, resulting in an increased rate of facilities. Generally speaking, there are two categories of slopes: natural and man-made. Natural slopes are slopes that were formed by natural processes and occur naturally. Such gradients are present in hilly regions. In contrast, there are two types of man-made slopes: excavated or cut slopes and embankment or fill slopes.

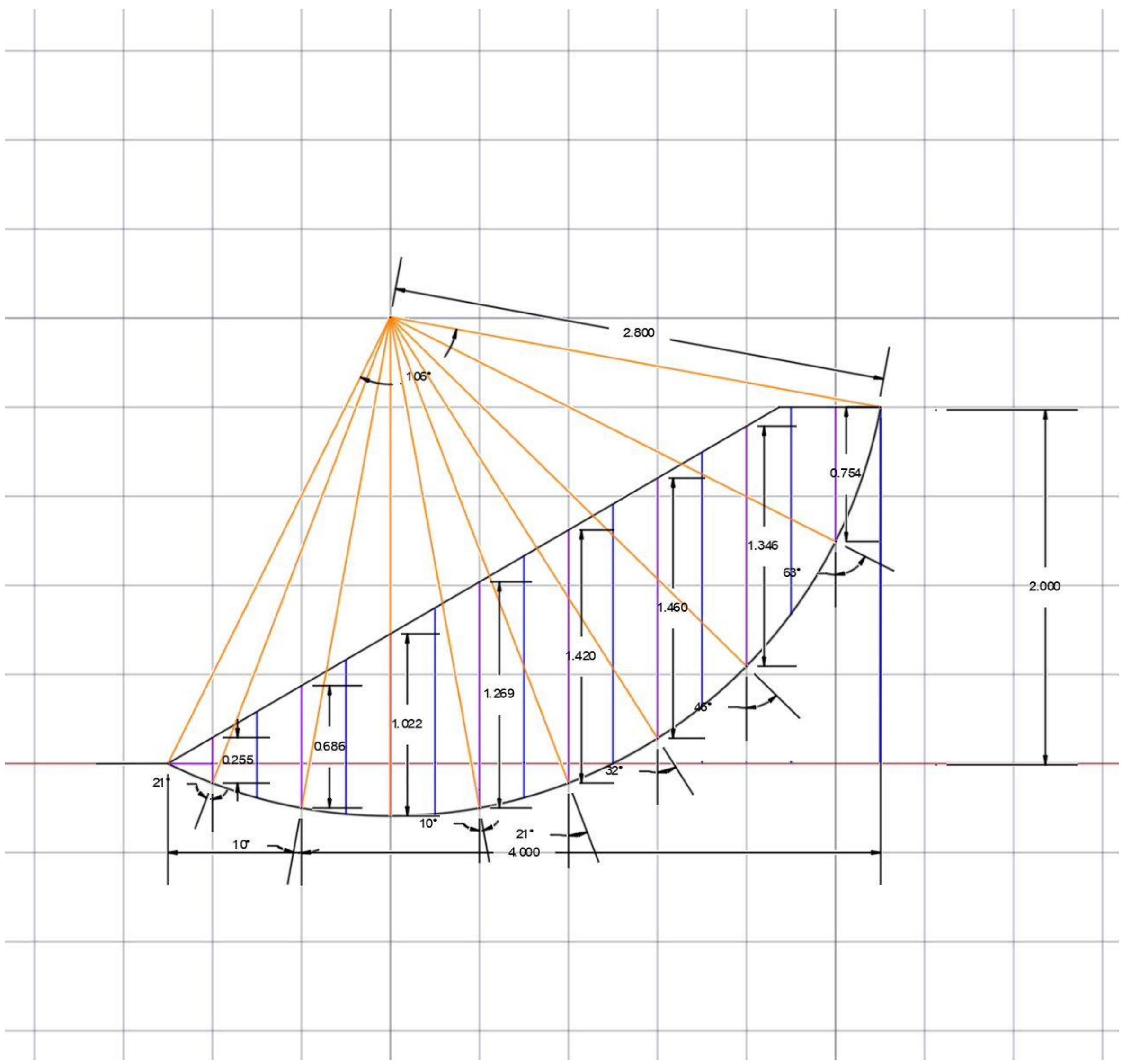
Since there will be a difference between our proposed level and the existing level of the surrounding area when we develop our project site, cut and fill will be used to meet our requirements. Due to the elevation difference between two proposed areas, a slope would be required to connect them. Moreover, our construction site's hilly terrain will place the environment at risk from natural disasters like landslides and pose a threat to life and property. Consequently, analysis of the slope must be performed.

To ensure the stability of slope we will need to calculate the Factor of Safety (FS), which is obtained by FS= Resisting forces/Driving forces. A factor of safety greater than 1 indicates that the slope is stable, while a factor of safety less than 1 indicates that the slope is unstable and may be at risk of failure. In practice, it is often recommended to design for a factor of safety greater than 1.5 to ensure a higher level of safety and to account for any uncertainties or potential changes in the site conditions.

The slope's stability is crucial due to its potential to cause erosion, landslides, and loss of life. For this project's design inclination, we should use the Bishop method to determine the minimum safety factor necessary to meet safety requirements.



3.000
96°
0.635
2.000
1.207
62°
1.325
1.306
1.162
46°
0.937
0.628
0.232
33°
17°
7°
3°
12°
22°
4.000



2.800
106°
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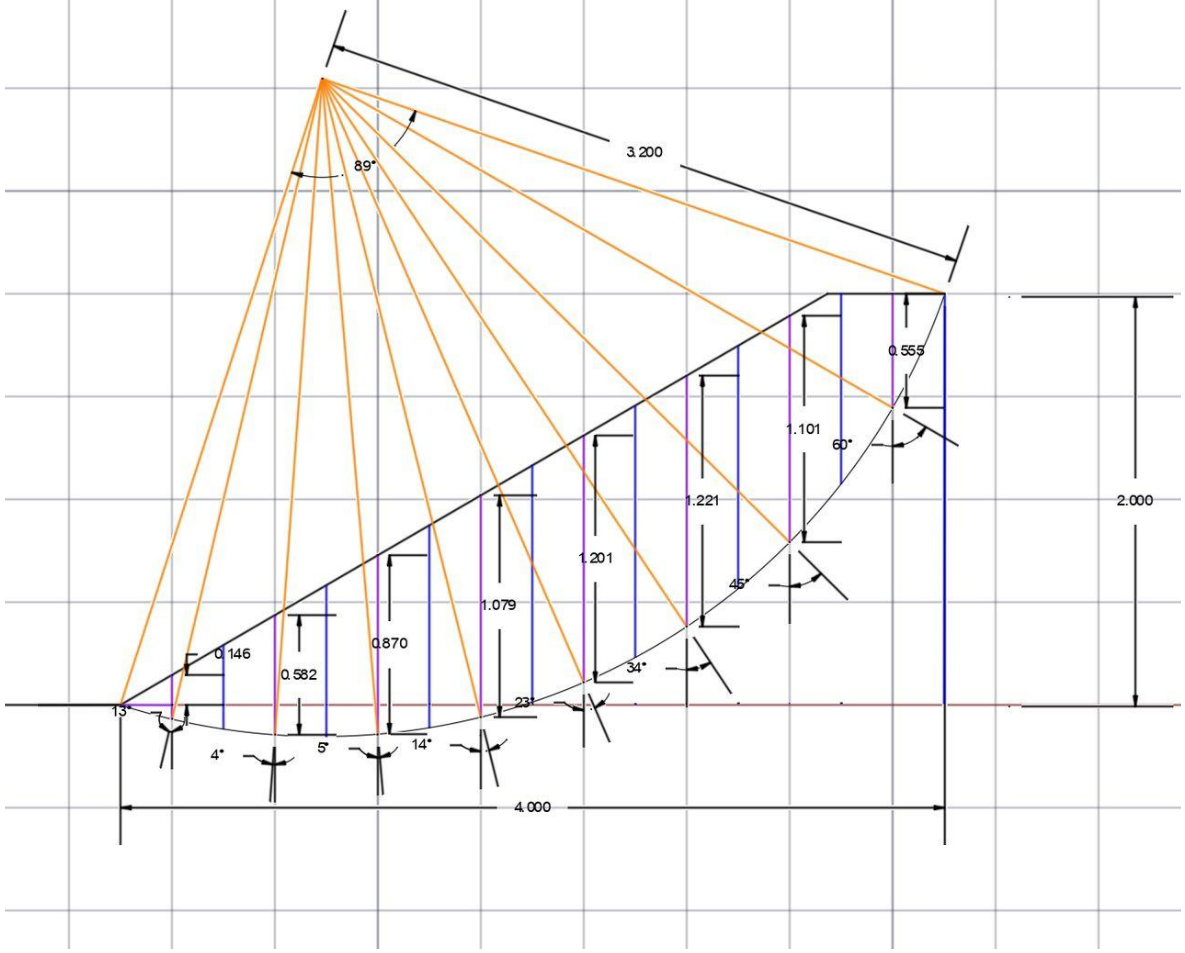
1.346
63°
2.000
1.460
1.420
1.269
1.022
0.686
0.255
45°
32°
21°
10°
21°
10°
4.000


3.200
89°
2.000
0.555
1.101
60°
1.221
1.201
45°
1.079
0.870
34°
0.146
0.582
23°
13°
4°
5°
14°
4.000

R = 3

r =3																					
Slice	c	phi	phirad	h	b	gamma	alpha	alpharad	w	sin alpha	cos alpha	w*sin(alpha)	w*cos(alpha)	c*b	tan phi	sec alpha	tan alpha	cb + Wtan phi	ma	Assumed	LHS
1	10	30	0.524	0.232	0.5	20	-17	-0.297	2.32	-0.2923717047	0.956304756	-0.678302355	2.218627034	5	0.5773502692	1.045691756	-0.3057306815	5.577350269	1.111064452	3	6.196795623
2	10	30	0.524	0.628	0.5	20	-7	-0.122	6.28	-0.1218693434	0.9925461516	-0.7653394766	6.233189832	5	0.5773502692	1.007509825	-0.1227845609	5.577350269	1.031893362	3	5.755230721
3	10	30	0.524	0.937	0.5	20	-3	-0.052	9.37	-0.05233595624	0.9986295348	-0.49038791	9.357158741	5	0.5773502692	1.001372346	-0.05240777928	5.577350269	1.011574972	3	5.64190794
4	10	30	0.524	1.162	0.5	20	12	0.209	11.62	0.2079116908	0.9781476007	2.415933847	11.36607512	5	0.5773502692	1.022340595	0.2125565617	5.577350269	0.9821636872	3	5.477870905
5	10	30	0.524	1.306	0.5	20	22	0.384	13.06	0.3746065934	0.9271838546	4.89236211	12.10902114	5	0.5773502692	1.078534743	0.4040262258	5.577350269	1.000723596	3	5.581386018
6	10	30	0.524	1.325	0.5	20	33	0.576	13.25	0.544639035	0.8386705679	7.216467214	11.11238503	5	0.5773502692	1.192363293	0.6494075932	5.577350269	1.059898692	3	5.911426253
7	10	30	0.524	1.207	0.5	20	46	0.803	12.07	0.7193398003	0.6946583705	8.68243139	8.384526531	5	0.5773502692	1.43955654	1.035530314	5.577350269	1.200342751	3	6.694731967
8	10	30	0.524	0.635	0.5	20	62	1.082	6.35	0.8829475929	0.4694715628	5.606717215	2.981144424	5	0.5773502692	2.130054468	1.880726465	5.577350269	1.563978678	3	8.722856899
												26.87988203									49.98220633
																FOS	1.859465241				

R = 2.8

r =2.8																FOS	#DIV/0!				
Slice	c	phi	phirad	h	b	gamma	alpha	alpharad	w	sin alpha	cos alpha	w*sin(alpha)	w*cos(alpha)	c*b	tan phi	sec alpha	tan alpha	cb + Wtan phi	ma	Assumed	LHS
1	10	30	0.524	0.255	0.5	20	-21	-0.367	2.55	-0.3583679495	0.9335804265	-0.9138382713	2.380630088	5	0.5773502692	1.071144994	-0.383864035	5.577350269	1.156587512	3	6.450693672
2	10	30	0.524	0.686	0.5	20	-10	-0.175	6.86	-0.1736481777	0.984807753	-1.191226499	6.755781186	5	0.5773502692	1.015426612	-0.1763269807	5.577350269	1.051094607	3	5.862322788
3	10	30	0.524	1.022	0.5	20	0	0.000	10.22	0	1	0	10.22	5	0.5773502692	1	0	5.577350269	1	3	5.577350269
4	10	30	0.524	1.269	0.5	20	10	0.175	12.69	0.1736481777	0.984807753	2.203595375	12.49721039	5	0.5773502692	1.015426612	0.1763269807	5.577350269	0.9820998934	3	5.477515105
5	10	30	0.524	1.42	0.5	20	21	0.367	14.2	0.3583679495	0.9335804265	5.088824884	13.25684206	5	0.5773502692	1.071144994	0.383864035	5.577350269	0.9974581071	3	5.563173242
6	10	30	0.524	1.46	0.5	20	32	0.559	14.6	0.5299192642	0.8480480962	7.736821258	12.3815022	5	0.5773502692	1.179178403	0.6248693519	5.577350269	1.052597113	3	5.870702794
7	10	30	0.524	1.346	0.5	20	45	0.785	13.46	0.7071067812	0.7071067812	9.517657275	9.517657275	5	0.5773502692	1.414213562	1	5.577350269	1.18597296	3	6.614586607
8	10	30	0.524	0.754	0.5	20	68	1.187	7.54	0.9271838546	0.3746065934	6.990966263	2.824533714	5	0.5773502692	2.669467163	2.475086853	5.577350269	1.80817698	3	10.08483636
												29.43280028									51.50118084
																FOS	1.749788683				

R = 3.2

r =3.2																					
Slice	c	phi	phirad	h	b	gamma	alpha	alpharad	w	sin alpha	cos alpha	w*sin(alpha)	w*cos(alpha)	c*b	tan phi	sec alpha	tan alpha	cb + Wtan phi	ma	Assumed	LHS
1	10	30	0.524	0.146	0.5	20	-13	-0.227	1.46	-0.2249510543	0.9743700648	-0.3284285393	1.422580295	5	0.5773502692	1.026304108	-0.2308681911	5.577350269	1.074023626	3	5.990205961
2	10	30	0.524	0.582	0.5	20	-4	-0.070	5.82	-0.06975647374	0.9975640503	-0.4059826772	5.805822773	5	0.5773502692	1.002441898	-0.06992681194	5.577350269	1.016116202	3	5.667235972
3	10	30	0.524	0.87	0.5	20	5	0.087	8.7	0.08715574275	0.9961946981	0.7582549619	8.666893873	5	0.5773502692	1.003819838	0.08748866353	5.577350269	0.9871981832	3	5.505950053
4	10	30	0.524	1.079	0.5	20	14	0.244	10.79	0.2419218956	0.9702957263	2.610337254	10.46949089	5	0.5773502692	1.030613629	0.2493280028	5.577350269	0.9834257198	3	5.484909703
5	10	30	0.524	1.201	0.5	20	23	0.401	12.01	0.3907311285	0.9205048535	4.692680853	11.05526329	5	0.5773502692	1.086360377	0.4244748162	5.577350269	1.004317466	3	5.60143029
6	10	30	0.524	1.221	0.5	20	34	0.593	12.21	0.5591929035	0.8290375726	6.827745351	10.12254876	5	0.5773502692	1.206217949	0.6745085168	5.577350269	1.067629758	3	5.954545116
7	10	30	0.524	1.101	0.5	20	45	0.785	11.01	0.7071067812	0.7071067812	7.785245661	7.785245661	5	0.5773502692	1.414213562	1	5.577350269	1.18597296	3	6.614586607
8	10	30	0.524	0.555	0.5	20	60	1.047	5.55	0.8660254038	0.5	4.806440991	2.775	5	0.5773502692	2	1.732050808	5.577350269	1.5	3	8.366025404
												26.74629386									49.18488911
																FOS	1.838942224				

3.10.1 Critical Slope

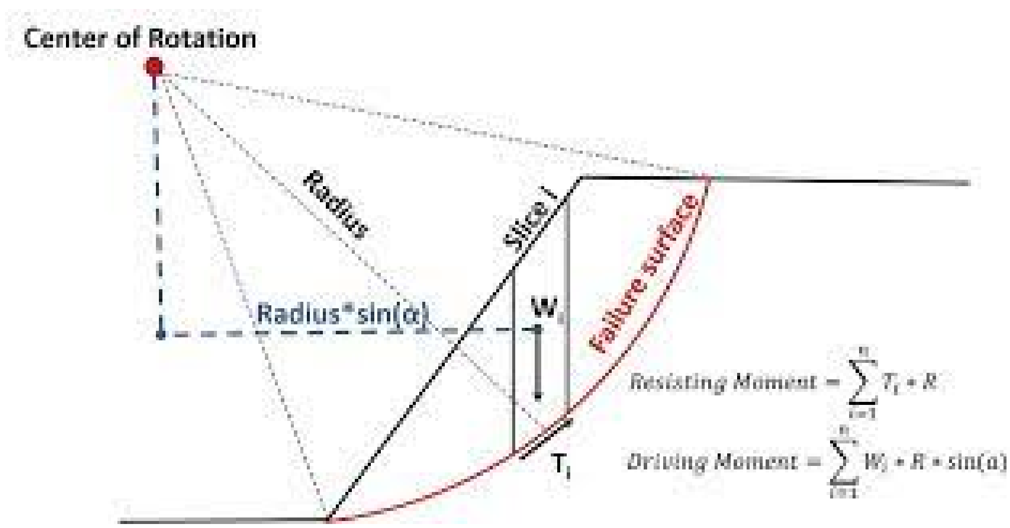
The chosen slope for analysis is depicted inside the yellow envelope marked on red and dark blue zones on the plan below (from 35m to 33m). This slope is referred to as the critical slope because the height difference between each extremity is typically the greatest of the entire slope. The critical slope is the utmost angle between the slope and the horizontal land with relatively large height differences at each end. As the critical slope has the maximum probability of failure along the failure surface, if this slope can be shown to be stable with a safety factor greater than 1.5, the surrounding slopes will also be stable. Several radii of slopes were assumed, then calculations were performed on each assumption, and the results were plotted so that the FOS could be determined by the projection (the lowest point on the curve).

We assumed that the soil layer is silty sand with unit weight γ=20.0 kN/m3 . The shear strength parameters c = 10.0 kPa and φ = 30°. We assumed the groundwater table is far below the ground (u=0).

3.10.2 Bishop Method

In 1955, Alan Wilfred Bishop introduced the Bishop's Method. This is one of the few methods to derive the factor of safety using the method of slices as its fundamentals. This approach of calculation differs from the ordinary method of slices created by Fellinius. In this method, instead of using forces to conduct the analysis, stress is used. Next, the significant difference between these two methods is that the resolution of forces that takes place is different.

The simplified Bishop method uses the method of slices to discretize the soil mass and determine the FS(Factor of Safety). This method satisfies vertical force equilibrium for each slice and overall moment equilibrium about the center of the circular trial surface. Since horizontal forces are not considered at each slice, the simplified Bishop method also assumes zero interslice shear forces:



Where,
W = Weight of soil above the failure surface
N’ = Effective Normal Force at the base of the slice
T = Shearing force along the base
V_{i+1} and V_{i-1} = Shear interslice forces
X_{i+1} and V_{i-1} = Reaction from the adjacent slices

Bishop method is done by the following steps:
Step 1: Define a 2D cross-section
Draw the embankment and the slope using the reduced level of the slope.

Step 2: Define the failure surface
Assume the radius of circular failure slope is drawn using AutoCAD.

Step 3: Divide the model into slices
Divide the surface into several slices (8-15 usually), the widths of the slices do not necessarily
have to be the same.

Step 4: Calculate the weight of each slice
$Ai = Hi \times Bi$ then, $Wi = Ai \times \gamma$ (kN/m)

Step 5: Calculate the resisting forces acting on each slice

Normal effective force is derived: $N_i = W_i \cos \alpha_n$

Corresponding frictional force: $T_f = N_i \tan\varphi' n_n$
Cohesive resisting forces: $T_c = c'_n\, b_n$
Total Resisting Force: $\boldsymbol{T} = \boldsymbol{T}_f + \boldsymbol{T}_c = \boldsymbol{N}_i \tan \boldsymbol{\varphi}'_n + \boldsymbol{c}'_n\, \boldsymbol{b}_n$

Step 6: Derive the driving forces acting on each slice:
The tangential driving force is parallel to the base of the slope, $W_{xi} = W_i \sin\alpha_n$

Step 7: Calculate the FOS
= Sum(Resisting Force) / Sum(Driving Force) = $\boldsymbol{N}_i \tan \boldsymbol{\varphi}'_n + \boldsymbol{c}'_n\, \boldsymbol{b}_n / \mathbf{W}_i \sin\boldsymbol{\alpha}_n$

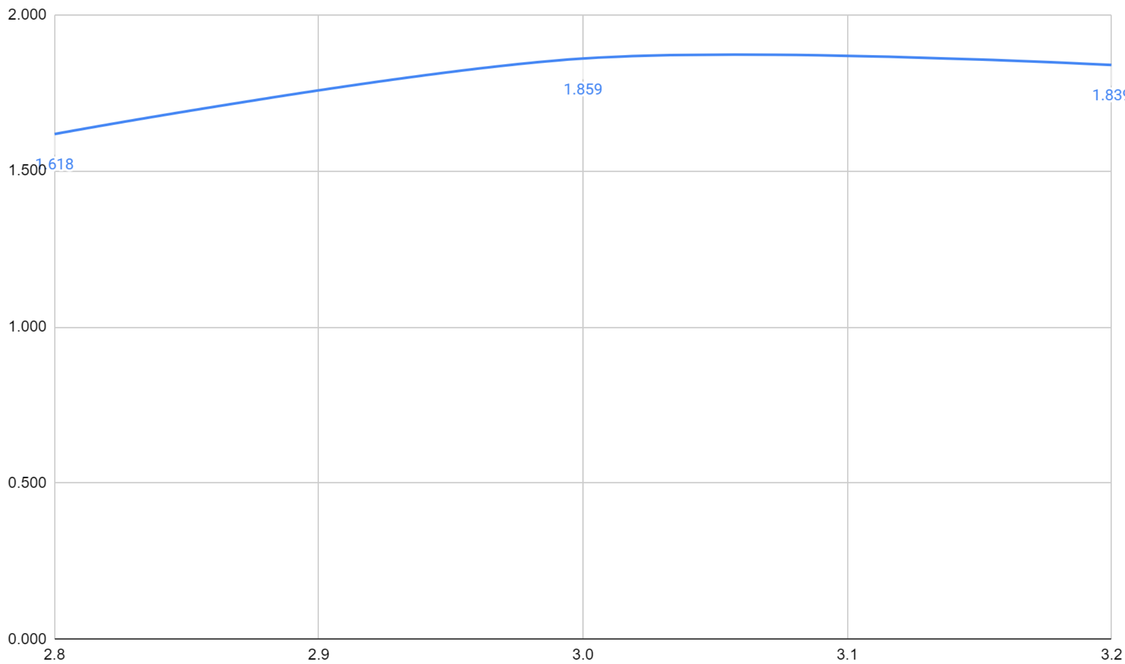
3.10.3 Factor of Safety

The factor of safety is a fundamental concept used in slope stability analysis to assess the stability of a slope or embankment. It is an important parameter that helps engineers determine whether a slope is at risk of failure or if it can safely withstand the forces acting upon it.

The factor of safety is defined as the ratio between the resisting forces (such as shear strength) and the driving forces (such as gravitational forces). It represents the margin of safety and is calculated by dividing the resisting forces by the driving forces. The resulting value indicates how much stronger the slope is compared to the forces that tend to make it fail.

After performing a slope stability analysis, engineers obtain a factor of safety value. This value serves as an indication of the stability of the slope. If the factor of safety is greater than 1, it implies that the slope is considered stable because the resisting forces are greater than the driving forces. On the other hand, if the factor of safety is less than 1, it suggests that the slope is potentially unstable and may experience failure under the applied forces.

The factor of safety is a crucial parameter for making design and engineering decisions. It helps engineers assess the need for slope reinforcement or modifications to ensure the stability of the slope. Additionally, it is used in the design of slopes and embankments to determine appropriate safety measures and to establish construction specifications that can prevent slope failures.



Our average FOS is 1.772, which is greater than 1.5 so it is safe to use.

3.11 Conclusion

The given information describes a contour map indicating the highest and lowest elevations of a specific area. To ensure efficient construction work, a proposed level needs to be established based on the current reduced level. This allows for the regulation of the cut and fill difference, aiming for a 15% margin to prevent shrinkage.

To assess the profile of the projected level and make necessary adjustments to the cut and fill of the development area, horizontal and vertical cross-section views are created. These views provide a detailed understanding of the land's features and aid in determining the required excavation and filling volumes.

Using the grid method in Excel, the cut and fill volumes are calculated. The team has conducted two experiments to optimize the estimation process and reduce costs associated with excavation .The fill volume is 576588.5017 m^3 and the Cut Volume is 639570.447m^3.

The overall percentage difference between the cut and fill volumes is determined to be -10. This percentage indicates the variation between the volumes and helps in evaluating the filling operations.

Furthermore, the slope stability of the steepest slope, characterized by a lowered level difference of 9.00 meters, is evaluated. The chosen slope angle is 1:1.5 (horizontal to vertical), which means for every 1.5 units horizontally, the slope increases by 1 unit vertically. The slope stability is satisfactory with a factor of safety (FS) of 1.772>1.5 which meets the required stability criteria.

In summary, the information provided discusses the elevation range, proposed level, cut and fill computations, volume differences, and the evaluation of slope stability for the sharpest slope.

4.0 Water Reticulation

4.1 Introduction

Water reticulation systems are networks that must be built and then treated before being provided to customers. Water systems are now often delivered through an infrastructure consisting of pipes constructed of materials such as plastic, metal, or even concrete. Before any pipes are installed, the system must be created and planned by municipal planners, city engineers, and consultants who are hired to work out every aspect of the system. The size of the pipes to be used, their location, future extension plans, leakage risk calculations, various pressure considerations, and how close these systems are to fire departments are all issues to consider while establishing the system.

A water reticulation system helps get water from its source to the user. The volume of water required is another factor to consider while planning and developing the system. Water moves with the help of energy and must overcome any impediment. When shifting heights, the same problem is encountered. The difficulties mentioned above should be taken into account since they have the potential to affect operational expenditures. Gravity may be used to assist with this movement, which is beneficial for a less expensive surgery. Gravity will allow water to flow from the higher reservoirs and then be dispersed and regulated via valves. Gravity flow systems are often chosen and regarded as trustworthy.

This project will be built based on water demand in order to offer customers sufficient water pressure and quantity, as well as to store sufficient water in a specific zone when water sources are suddenly cut off. Water needs will be used to design the water tank. Furthermore, the cost of the distribution system should be kept as low as possible. Water reticulation systems are usually built to meet the water requirements of a combination of home, business lot, hotel, and firefighting purposes.The pressure available in the system at a given flow rate can be used to evaluate the performance of a reticulation system. The distribution system consists of a network of pipes of various sizes, diameters, and lengths that transport water to the customer's tap. The water tank should also be built in such a way that its storage capacity exceeds the area's water usage.

4.2 Project Background

The water reticulation system is intended to bring clean water to our site in Pahang, which includes residential, industrial, and commercial districts. All designs adhere to the Design Guidelines for Water Supply Systems of the Malaysian Water Association (MWA) and Suruhanjaya Perkhidmatan Air Negara (SPAN). In this project, we employed both a dead-end network and a closed-looping pipe network. This design has 70 pipes, 49 nodes, and 33 loops. To get the best outcomes, our project's design considerations are focused on peak flow.

4.3 Objectives

The primary goal of a water reticulation system is to deliver treated water to users at a suitable pressure and quantity. To achieve the goal, we have:

1. To calculate the amount of water required in a given region.

2. To calculate flow rates in pipes
3. To verify that the minimal residual pressure heads are met.
4. Selecting the right pipe size and type
5. Determine the storage water tank's capacity.
6. Determine the size of the storage water tank (form and height).

4.4 Design Criteria

There are several concepts that were considered during designing pipe reticulations as follows:

4.4.1. Pipe Network system

We are determined to use both a dead-end network and a closed-loop pipe network since they are more effective and appropriate. The dead-end network was created for a single consumer type, but the closed-loop pipe network was designed to ensure that water can still reach other consumers even if a portion of the pipeline is blocked for repair. To get flow rates in each pipe, we used the Hazen-Williams balancing method. The residual pressure head was calculated using Bernoulli's equation. Following the flow balancing for peak flow rate, we ran the Hardy Cross computation. The computation was done by trial and error with the programme. All pipe diameters are assumed and changed until they meet the criteria. When the pipe network achieves the node pressure and pipe unit head loss requirements, the network is solved.

4.4.2 Design Manual and Standard References

The project's proposed design in Malaysia must adhere to the norms and rules set out by each state's water authority. Given that the project's site is in Kuantan, Pahang, Malaysia, Pengurusan Air Pahang Berhad (PAIP) is the water authority involved. The Design Guidelines for Water Supply Systems published by the Malaysian Water

Association (MWA), Suruhanjaya Perkhidmatan Air Negara (SPAN), and Pengurusan Air Pahang Berhad (PAIP) are followed in all designs.

4.4.3 Pipe Design

The main objective of the design is to find the precise pipe sizes that will provide a suitable residual pressure head at each node. In this water reticulation system, a looping system using HDPE pipe was implemented.

High-density polyethylene (HDPE) pipes are effective for the large scale transfer of liquids given that they can withstand high amounts of pressure and are unaffected by rust due to their thermoplastic quality. Unlike traditional metal pipe fittings, HDPE pipes do not rust, corrode or rot. PE pipes are also resistant to biological growth, eliminating the costly problems associated with corrosion and fouling. HDPE pipe is lightweight, making it more cost-effective to transport than metal pipes. Additionally, HDPE pipe manufacturing does not emit hazardous levels of toxins into the air during production or welding.

Table 1: Pipe material and its properties

Pipe Material	Coefficient, C	Diameter, d (mm)
HDPE	120	120 and 200

4.4.4 Flow Design

The following designs were taken into account when designing pipe reticulations

4.4.4.1 Water Demand for Each Node

Table 2: Tabulation of Estimated Water Demand Rate based on SPAN Water Demand Guideline

Type of Premises/Buildings	Average Daily Water Demand (Litres)

Low cost terrace house / low cost flat	1100 / unit
Single storey terrace house / low cost house (less than RM25,000) / low medium & medium cost flats	1300 / unit
Double storey terrace house / high cost flat / apartment/townhouse	1500 / unit
Semi detached house / cluster	2000 / unit
Bungalow / condominium	2000 / unit
Wet market	1500 / stall
Dry market	450 / stall
Shop house (single storey) / low cost shop	2000 / unit
Shop house (double storey)	3000 / unit
Shop house (three storey)	4100 / unit
Shop house (four storey)	4550 / unit
Light industrial workshop	1500 / unit
Semi detached / bungalow workshops	1500 / unit
Building for heavy industry*	65,000 / hectare
Building for medium industry*	50,000 / hectare
Building for light industry*	33,000 / hectare
Office / complex / commercial (domestic usage)	1000 / 100 square meter
Community centers or halls	1000 / 100 square meter
Hotel	1500 / room
Education institutions (other than school and kindergarten)	100 / student
Day school / kindergarten	50 / student
Fully residential school/ institution of higher learning with hostels facilities	250 / student
Hospital	1500 / bed

Mosque or other place of worship	50 / person
Prison	250 / person
Army camp	250 / person
Bus terminal	900 / service bay
Petrol kiosk (with car washing bay)	50,000 / unit
Petrol kiosk (without car washing bay)	10,000 / unit
Stadium	55 / person
Golf course	1000 / 100 square meter
Warehouse	1500 / unit
Restaurant	25 / square meter
Airport	25 / passenger
Others	As per the estimated water demand by the developer or owner

4.4.4.2 Peak Flow Rates

Peak flow rate is used to design pipes approaching domestic storage water tank without fire flow, where the flow to the fire hydrant and Bomba tank is zero. The formula of peak flow is given by Qpeak = f x Qavg.

Table 3: Peak Flow Factor

Area	Peak Factor, f
Urban and rural areas	2.5
Felda schemes	3.0

4.4.4.3 FireFlow Rates

The flow rate in the fire protection pipes is equal to the number of fire hydrants used. Flow in domestic pipes is equal to the average flow rate. Based on SAJ guidelines, fire flow should be 300 gallons per minute, and the internal spacing for fire hydrants should be less than 180m.

Table 4: Class of risk and its building types

Class of risk	Building types	Average total flow (liters/minutes)	Max. no of hydrants used simultaneously
Class A risk	Large buildings, shopping complexes, high rise buildings, large industrial buildings, warehouses, and ports.	4100	3 @ 1370 lpm
Class B risk	Congested areas with buildings up to 5 storeys	2700	2 @ 1370 lpm
Class C risk	Shop houses up to 3 storeys and light industries	1370	1
Class D risk	Residential Terrace houses, detached and semi detached	1140	1
Class E risk	Others	680	1

*lpm= litres/minutes

4.4.5 Minimum Residual Pressure Head

In order to design a water reticulation system, we need to know the value of residual pressure head. According to the SPAN Design Guidelines for Water Supply System, the minimum residual pressure head at tapping point in the main pipe as follows:

Table 5: SPAN Recommendation for Residual Pressure main

Residual Pressure	Rural	Urban	Felda
Minimum	10 meters	22 meters	10 meters
Maximum	30 meters	60 meters	40 meters

4.4.6 Head Losses

In this project, the value of head losses can be calculated using Hazen-Williams formula:

$$h_L = \frac{10.69\,L}{C^{1.85} d^{4.87}} Q^{1.85}$$

Where

L = effective length pipe (actual length + total equivalent length),m

Q = flow rate in pipe, m3/s

D = pipe diameter, m

C = Hazen- Williams' pipe roughness coefficients, 120 for HDPE pipe

4.4.7 Maximum Allowable Velocity

According to SPAN's guidelines, the highest permitted flow velocity in any pipeline should be set at 2.6 m/sec in order to minimize erosion due to turbulence at high speeds, while the minimum velocity should be no less than 0.3 m/sec. When criteria cannot be satisfied, reasons for lower flow velocities can be given to the commission or certifying agency for review.

4.4.8 The Height of Elevated Tank

Once the ultimate pressure head at the supply node (Node 2) is determined, the height of the raised supply water tank may be computed. The raised water tank's height may be calculated using Bernoulli's equation, which is:

$$H_0 + z_0 = H_1 + z_1 + \frac{10.69\, L}{C^{1.85} d^{4.87}} Q^{1.85}$$

Where

H_1 = Final satisfactory pressure head at node

z_1 = Elevation of node from the datum

The term L and d is the pipe length and diameter of the pipe from the elevated water tank to Node 1. The values of L and d should be designed accordingly. The pipe diameter must not be less than the diameter in the looped pipe system of the housing scheme. The flow rate Q, is equal to the flow rate supplying to node 1 (larger Q value is taken between the peak flow and fire flow).

4.4.9 Capacity of the Elevated water tank

The capacity or volume of the raised water tank is equivalent to the overall average water demand for our site project per day storage. To guarantee that the water flow continues even if there is a water disruption, we considered the previous 3 days' water consumption.

4.4.10 Node Static Level

- All water reticulation pipes must be buried underground.
- Depth of pipeline buried below ground:
    - 1200mm for side and under roadways
    - 900mm if away from roadways

- Maximum slope is 1:500, if it is more than 1:500, anchor block is needed to prevent sliding.
- Node numbers are marked for junction, pipe type and diameter changes.

4.5 Design Analysis

The design steps are as follow:

Table 7: Water Reticulation Design Steps

Step	Description
1	Prepare layout of pipe flow for the whole project area
2	Numbering of node and pipe
3	Calculation of water demand (average flow)
4	Calculation of water demand (peak flow)
5	Calculation of water demand (fire flow)
6	Perform balancing flow for initial peak flow rate
7	Perform hardy cross computations by using the EPANET software for both peak and fire flow
8	Perform water tank design for the system

4.5 Computation of Water Demand

Water demand is the total volume of water that consumers require to satisfy their needs. Establishing the water demand is crucial for constructing a project that can effectively handle water. Knowing how much water will be required and the varied demand patterns allows for an accurate estimation of water demand. The majority of demand comes from residential, institutional, industrial, and public use. in accordance with Table 8.

4.5.1 Calculate of Water Demand

Table 8: Water Demand Calculation Table

Out of Node	Water Demand Calculation	Water Demand	Unit	Qtt	Total Demand (L/day)	Average Flow (L/s)
1	Semi Detached House	2000	lpd	14	28000	0.324
2	Semi Detached House	2000	lpd	14	28000	0.324
3	Semi Detached House	2000	lpd	12	24000	0.278
4	Semi Detached House	2000	lpd	12	24000	0.278
5	Semi Detached House	2000	lpd	12	24000	0.278
	Semi Detached House	2000	lpd	10	20000	0.231
6	Semi Detached House	2000	lpd	8	16000	0.185
	Semi Detached House	2000	lpd	10	20000	0.231
7	Semi Detached House	2000	lpd	10	20000	0.231
	Semi Detached House	2000	lpd	10	20000	0.231
8	Semi Detached House	2000	lpd	10	20000	0.231
	Semi Detached House	2000	lpd	8	16000	0.185
9	Semi Detached House	2000	lpd	8	16000	0.185
	Semi Detached House	2000	lpd	8	16000	0.185
10	Semi Detached House	2000	lpd	8	16000	0.185
	Semi Detached House	2000	lpd	6	12000	0.139
11	Semi Detached House	2000	lpd	8	16000	0.185
12	Semi Detached House	2000	lpd	6	12000	0.139
13	Semi Detached House	2000	lpd	5	10000	0.116
14	Semi Detached House	2000	lpd	5	10000	0.116

15	Semi Detached House	2000	lpd	5	10000	0.116
	Double Storey House	1500	lpd	10	15000	0.174
16	Semi Detached House	2000	lpd	5	10000	0.116
	Double Storey House	1500	lpd	10	15000	0.174
17	Double Storey House	1500	lpd	10	15000	0.174
18	Double Storey House	1500	lpd	11	16500	0.191
19	Double Storey House	1500	lpd	10	15000	0.174
	Double Storey House	1500	lpd	10	15000	0.174
20	Double Storey House	1500	lpd	11	16500	0.191
	Double Storey House	1500	lpd	11	16500	0.191
21	Double Storey House	1500	lpd	10	15000	0.174
	Double Storey House	1500	lpd	10	15000	0.174
22	Double Storey House	1500	lpd	12	18000	0.208
	Double Storey House	1500	lpd	12	18000	0.208
23	Double Storey House	1500	lpd	10	15000	0.174
24	Double Storey House	1500	lpd	13	19500	0.226
25	Double Storey House	1500	lpd	7	10500	0.122
26	Double Storey House	1500	lpd	9	13500	0.156
27	Double Storey House	1500	lpd	7	10500	0.122
28	Double Storey House	1500	lpd	10	15000	0.174
29	Double Storey House	1500	lpd	8	12000	0.139
	Double Storey House	1500	lpd	8	12000	0.139

30	Double Storey House	1500	lpd	10	15000	0.174
	Double Storey House	1500	lpd	10	15000	0.174
31	Double Storey House	1500	lpd	9	13500	0.156
	Double Storey House	1500	lpd	9	13500	0.156
32	Double Storey House	1500	lpd	10	15000	0.174
	Double Storey House	1500	lpd	10	15000	0.174
33	Double Storey House	1500	lpd	10	15000	0.174
	Double Storey House	1500	lpd	10	15000	0.174
34	Double Storey House	1500	lpd	10	15000	0.174
	Double Storey House	1500	lpd	10	15000	0.174
35	Single Storey House	1300	lpd	8	10400	0.120
36	Single Storey House	1300	lpd	9	11700	0.135
37	Single Storey House	1300	lpd	8	10400	0.120
	Single Storey House	1300	lpd	8	10400	0.120
38	Single Storey House	1300	lpd	10	13000	0.150
	Single Storey House	1300	lpd	11	14300	0.166
39	Single Storey House	1300	lpd	8	10400	0.120
40	Single Storey House	1300	lpd	8	10400	0.120
41	Single Storey House	1300	lpd	16	20800	0.241
	Single Storey House	1300	lpd	8	10400	0.120
42	Single Storey House	1300	lpd	8	10400	0.120
	Single Storey House	1300	lpd	9	11700	0.135

43	Single Storey House	1300	lpd	8	10400	0.120
	Single Storey House	1300	lpd	6	7800	0.090
44	Single Storey House	1300	lpd	7	9100	0.105
	Single Storey House	1300	lpd	9	11700	0.135
45	Single Storey House	1300	lpd	6	7800	0.090
	Single Storey House	1300	lpd	5	6500	0.075
46	Single Storey House	1300	lpd	5	6500	0.075
	Single Storey House	1300	lpd	3	3900	0.045
47	Single Storey House	1300	lpd	4	5200	0.060
	Single Storey House	1300	lpd	6	7800	0.090
48	Single Storey House	1300	lpd	2	2600	0.030
49	Single Storey House	1300	lpd	3	3900	0.045
				Total	**1061000**	**12.280**

4.5.2 Calculate of Water Demand (Peak Flow)

Table 9: Peak Flow Rate Calculation Table

Out of Node	Average Flow (L/s)	Peak Flow Rate (L/s)
1	0.324	0.810
2	0.324	0.810
3	0.278	0.694
4	0.278	0.694
5	0.509	1.273
6	0.417	1.042
7	0.463	1.157
8	0.417	1.042
9	0.370	0.926
10	0.324	0.810

11	0.185	0.463
12	0.139	0.347
13	0.116	0.289
14	0.116	0.289
15	0.289	0.723
16	0.289	0.723
17	0.174	0.434
18	0.191	0.477
19	0.347	0.868
20	0.382	0.955
21	0.347	0.868
22	0.417	1.042
23	0.174	0.434
24	0.226	0.564
25	0.122	0.304
26	0.156	0.391
27	0.122	0.304
28	0.174	0.434
29	0.278	0.694
30	0.347	0.868
31	0.313	0.781
32	0.347	0.868
33	0.347	0.868
34	0.347	0.868
35	0.120	0.301
36	0.135	0.339
37	0.241	0.602
38	0.316	0.790
39	0.120	0.301
40	0.120	0.301
41	0.361	0.903
42	0.256	0.639
43	0.211	0.527
44	0.241	0.602
45	0.166	0.414
46	0.120	0.301
47	0.150	0.376
48	0.030	0.075
49	0.045	0.113
	Total	**30.700**

4.5.3 Calculate of Water Demand (Fire Flow)

Table 10: Fire Flow Rate Calculation Table

Out of Node	Average Flow (L/s)	Peak Flow Rate (L/s)
1	0.324	0.324
2	0.324	0.324
3	0.278	0.278
4	0.278	0.278
5	0.509	0.509
6	0.417	0.417
7	0.463	0.463
8	0.417	0.417
9	0.370	0.370
10	0.324	0.324
11	0.185	0.185
12	0.139	0.139
13	0.116	0.116
14	0.116	0.116
15	0.289	0.289
16	0.289	0.289
17	0.174	0.174
18	0.191	0.191
19	0.347	0.347
20	0.382	0.382
21	0.347	0.347
22	0.417	0.417
23	0.174	0.174
24	0.226	0.226
25	0.122	0.122
26	0.156	0.156
27	0.122	0.122
28	0.174	0.174
29	0.278	0.278
30	0.347	0.347
31	0.313	0.313
32	0.347	0.347
33	0.347	0.347
34	0.347	0.347
35	0.120	0.120
36	0.135	0.135
37	0.241	0.241
38	0.316	0.316
39	0.120	0.120

40	0.120	0.120
41	0.361	0.361
42	0.256	0.256
43	0.211	0.211
44	0.241	0.241
45	0.166	0.166
46	0.120	0.120
47	0.150	0.150
48	0.030	0.030
49	0.045	0.045
	Total	**12.280**

4.6 The Height of Elevated Water Tank

Final Satisfactory pressure head at Node 2, $H_1 = 13.38m$

Elevation of Node 2, $z_1 = 35\ m$

Pipe length, L = 20.12 m

Pipe Diameter, d = 200 mm

Flow rate from peak flow, Q = 30.7

Hazen William' s Coefficient, C = 120

$$z_0 = H + z_1 + \frac{10.69L}{C^{1.85} d^{4.87}}(Q)^{1.85}$$

$$= 13.38 + 35 + \frac{10.69(20.12)}{(120)^{1.85}(0.12)^{4.87}}(0.0307)^{1.85}$$

$$= 51 \text{ m}$$

Bottom water level, BWL = 51 m (1.0 m from the tank bottom to allow sediment settlement)

4.7 Capacity of Elevated Water Tank

The overall average daily storage needed for our site project is equivalent to the volume or capacity of the elevated water tank. In our project, we were able to determine a total average water consumption of 12.28 L/s. Our water tank's capacity was determined as follows:

Capacity of elevated water tank = Total water demand * 3 days

= 1061000 L/d * 3 days

= 3183000 L

Total Volume = 3183000 L

= 3183 m^3

Utilizing a reinforced concrete cylindrical shaped elevated water tank with a diameter of 30 m and a workable storage height of 6 m, the workable storage is 3183 m3, which is more than the necessary amount of water tank volume.

Diameter, d = 30 m

Height, h = 6 m

Volume $= \frac{\pi d^2}{4} h = \frac{\pi(30)^2}{4}(6) = 4241.2\, m^3 > 3183\, m^3$ - OK!

Top water level, TWL = BWL + Height of tank

= 51 + 6.0

= 57 m

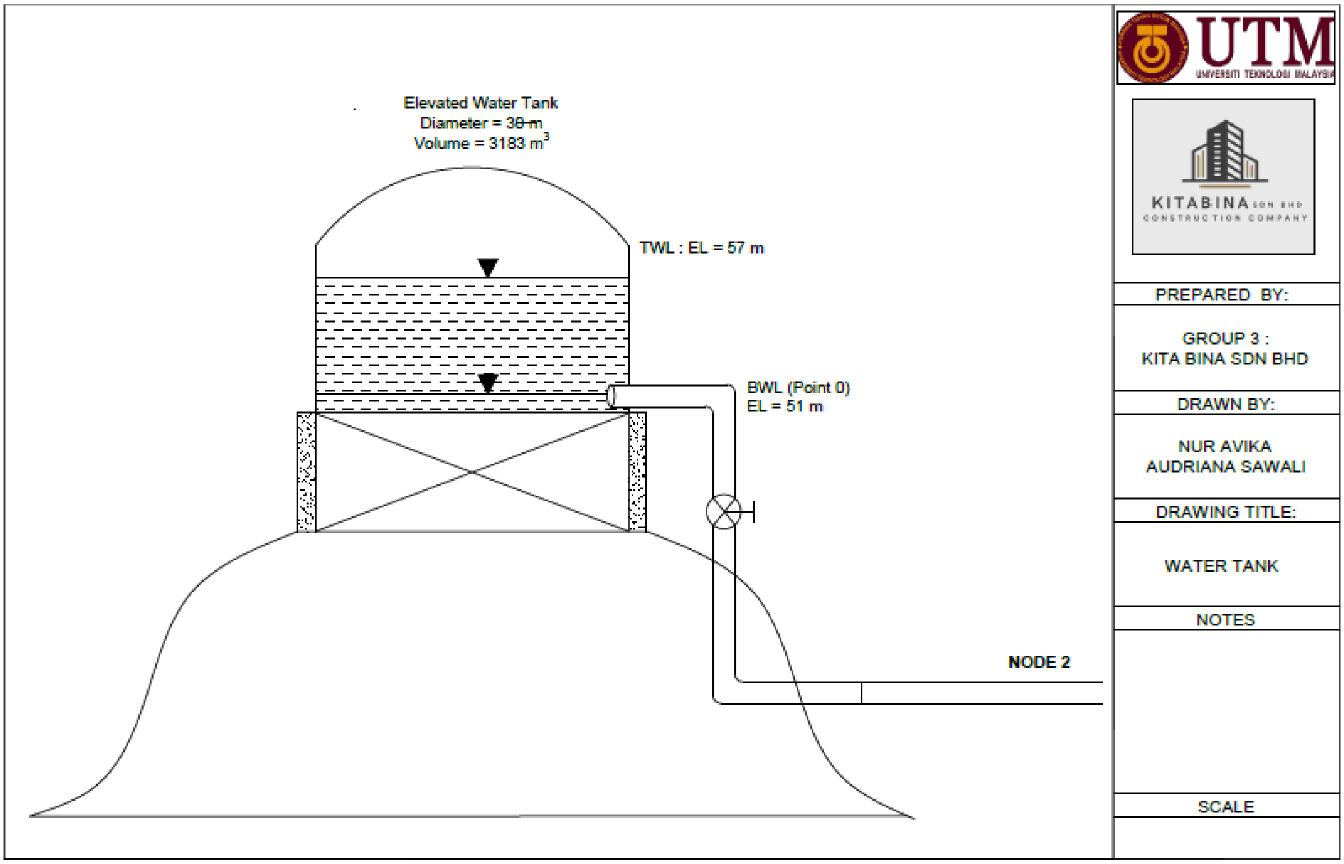


Figure 1: Elevated Water Tank

4.8 Tapping Point System

Location: Jalan Gambang Damai

Total length pipe from		
tapping point to Reservoir	=	1730
Using pipe	=	Mild Steel
Size	=	500mm Dia.
Reduced Level	=	35.123 m
Low-Level Tapping Point	=	60 m
Critical Flow Rate, Q	=	30.700 L/s
TWL	=	57 m

(Use HDPE for the pipe so C = 120, Diameter pipe = 200mm, Length pipe = 20.12m, d must be less or equal to the main pipe d which is 500mm)

Velocity in this pipe, $\frac{4(0.0307)}{\pi(0.2)^2}$ = 0.98 m/s < 2.6 m/s **OK!**

Z_B = TWL = 57 m

To check the residual pressure head at the TWL of the elevated water tank:tapping point to

Point A: at the main pipe

Point B: at Top Water Level

$$H_A + Z_A = H_B + Z_B + \frac{10.69L}{C^{1.85}d^{4.87}}Q^{1.85}$$

$$60 + 35.123 = H_B + 57 + \frac{10.69(20.12)}{(120)^{1.85}(0.2)^{4.87}}(0.0307)^{1.85}$$

H_B = 38 m > 7.62 m

Suction Tank Not Required!

4.9 The Results from EPANET software for Peak Flow

The EPANET programme is used to compute the results analysis and display the findings for nodes and pipelines. The programme computed demand, head, pressure, and quality values for the nodes' results, while the results for the pipes' length, diameter, flow, velocity, unit head loss, and status were shown. For this project, HDPE pipes with diameters of 120 mm and a roughness coefficient of 120 were used. The planned level drawing from our Earthwork department served as the source for the elevation for each node. We gathered all the information necessary for the water reticulation design by adhering to the SPAN Water Demand Guideline. The table that follows is an attachment that details our assumptions on the different types of buildings that were suggested.

Table 11: Assumptions of Proposed Building Types

Assumption	Water Demand
Semi-detached House	2000 /unit
Single Storey House	1300 /unit
Double Storey House	1500 /unit

Based on calculations and adjustments, it can be concluded that the unit head loss for each pipe and the residual pressure head for each node are both within the permitted range. Using the EPANET programme, the peak flow data are shown below. However, due to pipe network complexity, not all pipes can fulfill the minimum velocity of 0.3 m/sec.

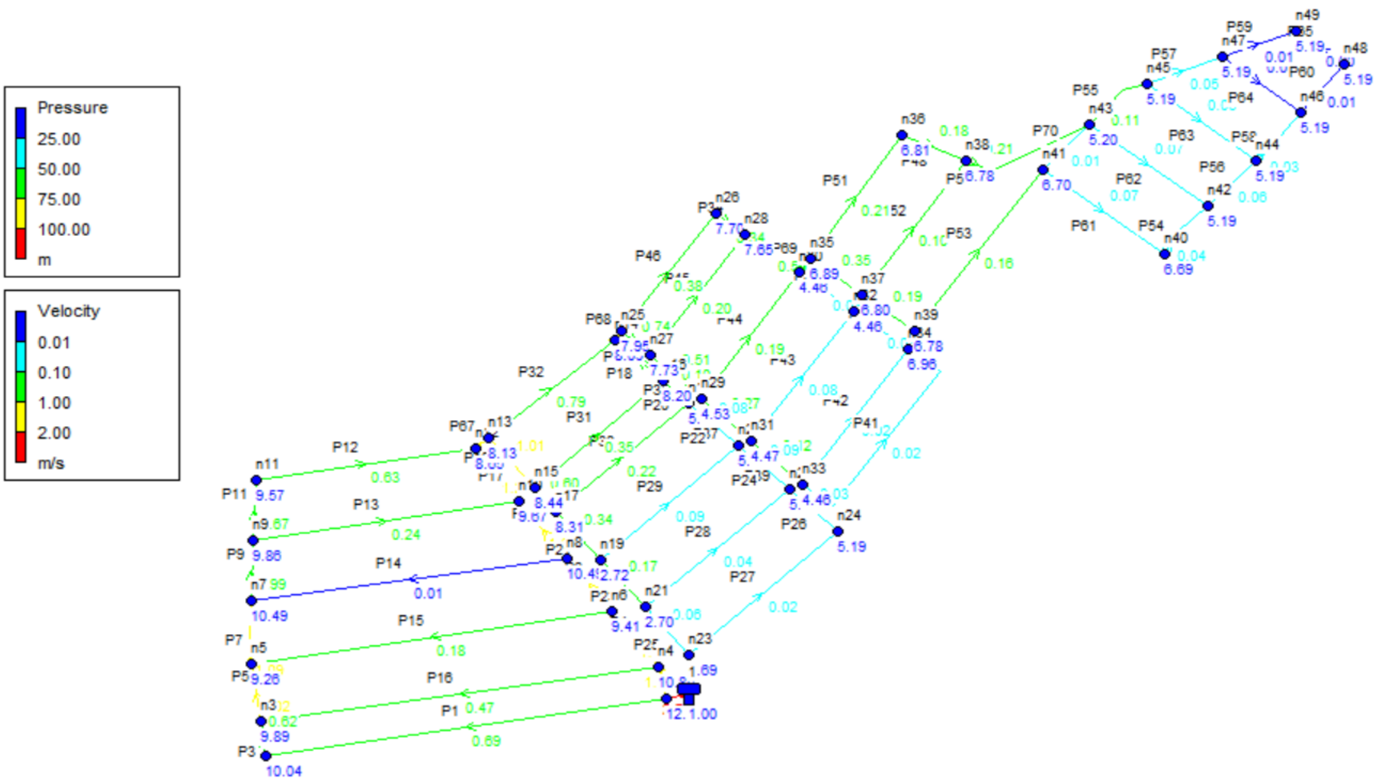


Figure 2: EPANET Results

(Residual Head Pressure and Unit Head Loss)

Peak Flow Results

These are the results that we obtain after entering the data into the Epanet App, as displayed in Tables 12 and 13.

Table 12.0 Network Table - Links

Link ID	Length m	Flow LPS	Velocity m/s	Unit Headloss m/km
Pipe P12	190	-7.10	0.63	4.82
Pipe P16	344.6	-5.26	0.47	2.77
Pipe P15	311.6	-2.03	0.18	0.48
Pipe P14	273.4	-0.06	0.01	0.00
Pipe P13	230.6	2.75	0.24	0.83
200Pipe P27	170.3	-0.23	0.02	0.01
Pipe P28	163.8	0.40	0.04	0.02
Pipe P29	157.2	1.04	0.09	0.14
Pipe P30	150.6	2.50	0.22	0.07
Pipe P31	147.3	3.92	0.35	1.60
Pipe P42	152.4	0.28	0.02	0.01
Pipe P43	147	0.87	0.08	0.10
Pipe P44	141.6	2.09	0.19	0.50
Pipe P45	136.1	2.28	0.20	0.59
Pipe P52	151.1	1.19	0.10	0.18
Pipe P61	129.2	0.75	0.07	0.08
Pipe P65	51	0.01	0.00	0.00
Pipe P62	125.8	0.81	0.07	0.09
Pipe P63	116.3	0.32	0.03	0.01

Pipe P64	84.04	0.05	0.00	0.00
Pipe P1	347.3	-7.81	0.96	5.75
Pipe P2	30.2	-22.08	1.95	39.42
Pipe P5	53.3	11.57	1.02	11.91
Pipe P7	57.2	12.33	1.09	13.40
Pipe P9	55.9	11.23	0.99	11.28
Pipe P11	54.8	7.56	0.67	5.41
Pipe P4	65.5	16.12	1.43	22.01
Pipe P6	61.5	13.04	1.15	14.87
Pipe P8	65.1	11.94	1.06	12.63
Pipe P10	61.1	13.88	1.23	16.69
Pipe P33	32.8	8.41	0.74	6.59
Pipe P35	59.5	5.82	0.51	3.34
Pipe P37	57.7	3.04	0.27	1.00
Pipe P39	58.5	1.39	0.12	0.23
Pipe P41	213.4	0.24	0.02	0.01
Pipe P40	58.2	-0.35	0.03	0.02
Pipe P38	57.8	-0.35	0.03	0.02
Pipe P36	59	-5.71	0.50	3.22
Pipe P34	30.7	-3.86	0.34	1.56
Pipe P48	59.1	2.03	0.18	0.47
Pipe P50	113.1	2.43	0.21	0.66
Pipe P70	113.1	0.17	0.01	0.00
Pipe P55	62.7	1.26	0.11	0.20
Pipe P57	69.1	0.53	0.05	0.04

Pipe P59	67.4	0.10	0.01	0.00
Pipe P54	58.8	0.45	0.04	0.03
Pipe P56	57.9	0.62	0.06	0.05
Pipe P58	59.2	0.34	0.03	0.02
Pipe P60	57.5	0.09	0.01	0.00
Pipe P3	31.4	-7.00	0.62	4.70
Pipe P17	59.5	11.42	1.01	11.63
Pipe P19	28.5	6.78	0.60	4.43
Pipe P21	58	3.84	0.34	1.55
Pipe P23	57.7	1.93	0.17	0.43
Pipe P25	58	0.66	0.06	0.06
Pipe P18	56.1	-4.33	0.38	1.93
Pipe P22	58.2	0.89	0.08	0.10
Pipe P24	58.5	0.98	0.09	0.12
Pipe P26	57.1	0.34	0.03	0.02
Pipe P20	29.4	-1.14	0.10	0.16
Pipe P47	55.1	3.91	0.35	1.60
Pipe P49	57	2.12	0.19	0.52
Pipe P67	14.93	20.63	1.82	34.77
Pipe P32	140.93	8.92	0.79	7.36
Pipe P68	9.98	12.96	1.15	14.71
Pipe P46	133.07	4.25	0.38	1.87
Pipe P69	16.43	6.58	0.58	4.19

Pipe P51	137.13	2.37	0.21	0.63
Pipe P53	183.5	1.82	0.16	0.39
Pipe P66	20.12	-30.70	2.71	72.58

EPANET 2.2

Table 13.0 Network Table - Nodes

Node ID	Elevation m	Demand LPS	Head m	Pressure m
Junc n2	35	0.81	47.04	12.04
Junc n12	33	0.35	41.65	8.65
Junc n11	33	0.46	42.57	9.57
Junc n1	35	0.81	45.04	10.04
Junc n3	35	0.69	44.89	9.89
Junc n4	35	.69	45.85	10.85
Junc n5	35	1.27	44.26	9.26
Junc n6	35	1.04	44.41	9.41
Junc n7	33	1.16	43.49	10.49
Junc n8	33	1.04	43.49	10.49
Junc n9	33	0.93	42.86	9.86
Junc n10	33	0.81	42.67	9.67
Junc n14	32	0.29	40.09	8.09

Junc n24	35	0.56	40.19	5.19
Junc n23	37.5	0.43	40.19	2.69
Junc n13	33	0.29	41.13	8.13
Junc n21	37.5	0.87	40.20	2.70
Junc n22	35	1.04	40.19	5.19
Junc n19	37.5	0.87	40.22	2.72
Junc n20	35	0.96	40.20	5.20
Junc n17	32	0.43	40.31	8.31
Junc n18	35	0.48	40.21	5.21
Junc n15	32	0.72	40.44	8.44
Junc n16	32	0.72	40.20	8.20
Junc n26	32	0.39	39.70	7.70
Junc n25	32	0.30	39.95	7.95
Junc n33	35	0.87	39.46	4.46
Junc n34	32.5	0.87	39.46	6.96
Junc n31	35	0.78	39.47	4.47
Junc n32	35	0.87	39.46	4.46
Junc n29	35	0.69	39.53	4.53
Junc n30	35	0.87	39.46	4.46
Junc n27	32	0.30	39.73	7.73
Junc n28	32	0.43	39.65	7.65
Junc n36	32.5	0.34	39,31	6.81

Junc n35	32.5	0.30	39.39	6.89
Junc n39	32.5	0.30	39.28	6.78
Junc n43	34	0.53	39.20	5.20
Junc n37	32.5	0.60	39.30	6.80
Junc n38	32.5	0.79	39.28	6.78
Junc n41	32.5	0.90	39.20	6.70
Junc n40	32.5	0.30	39.19	6.69
Junc n48	34	0.08	39.19	5.19
Junc n49	34	0.11	39.19	4.19
Junc n42	34	0.64	39.19	5.19
Junc n45	34	0.41	39.19	5.19
Junc n44	34	0.60	39.19	5.19
Junc n47	34	0.38	39.19	5.19
Junc n46	34	0.30	39.19	5.19
Tank 1	47.5	-30.70	48.50	1.00

EPANET 2.2

4.10 Layout of Pipe Flow

The pipelines are installed so that each and every residence or business in the housing development is supplied with water. In this project, pipes are installed beneath the street in front of each residential unit. It is necessary to know the categories of buildings and the number of stories in order to proceed with the designs. The pipe layout is shown in Figures 3 and 4.

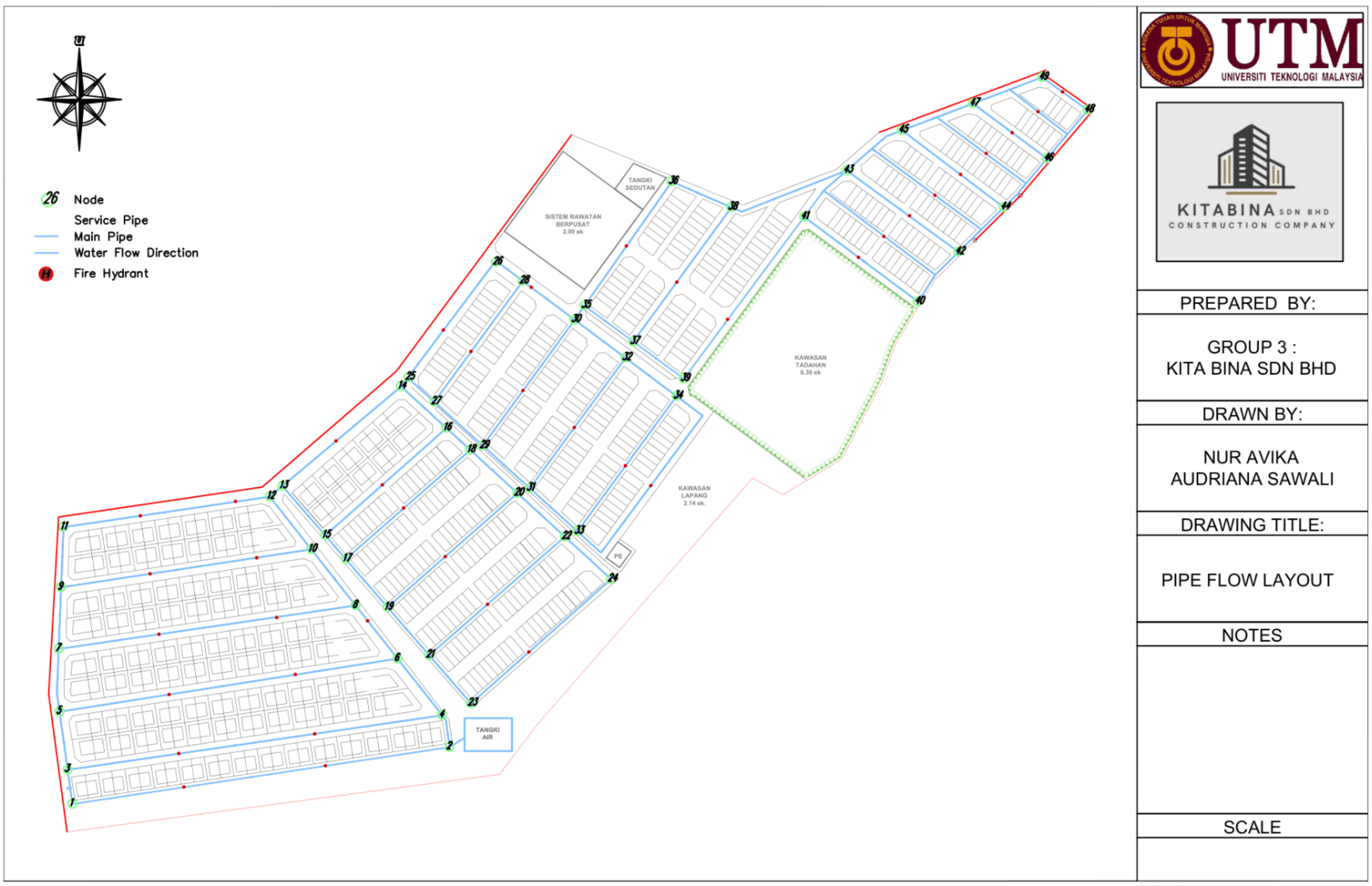


Figure 3: Pipe Flow Layout

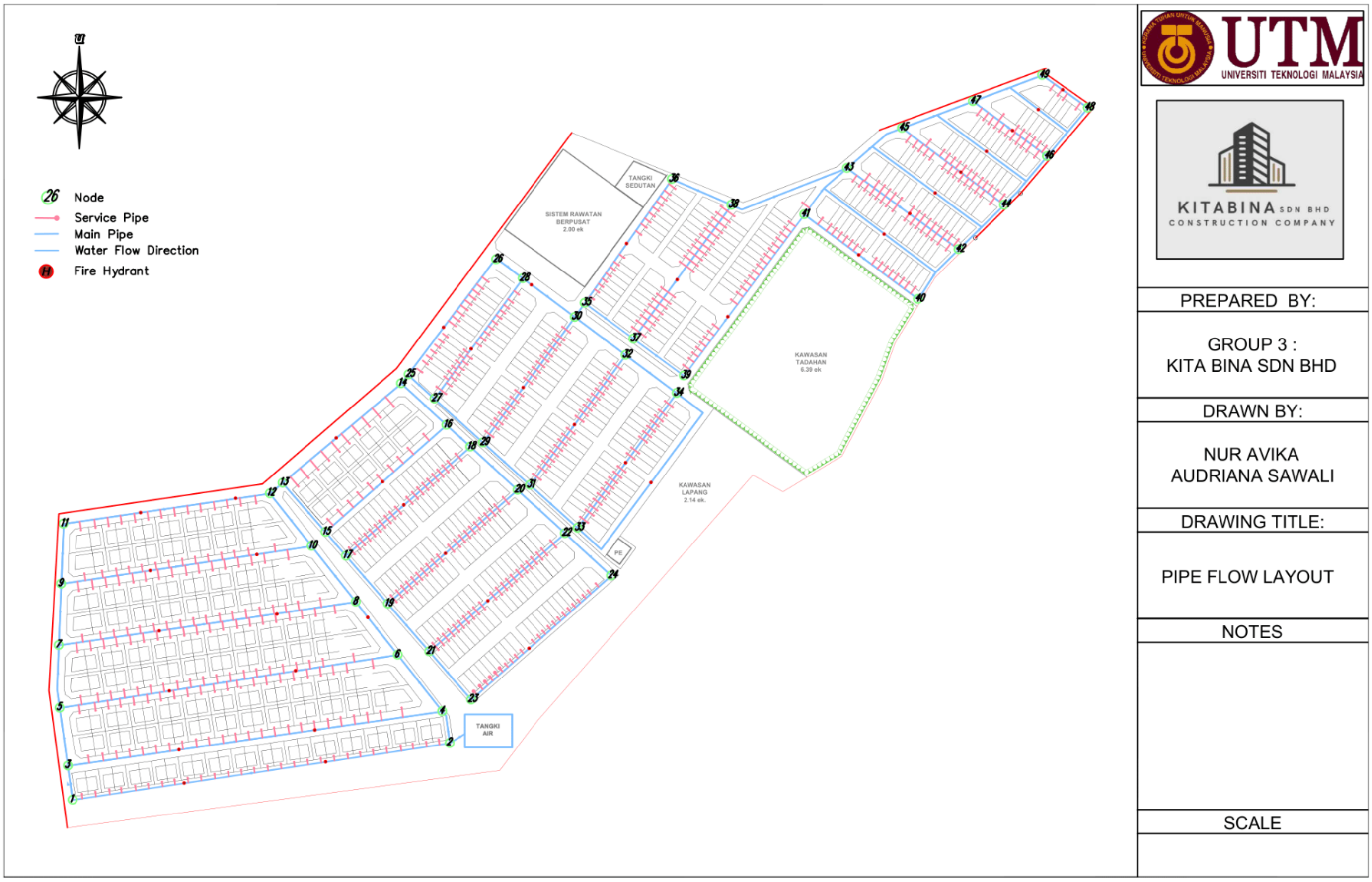


Figure 4: Pipe Network with Service Pipe

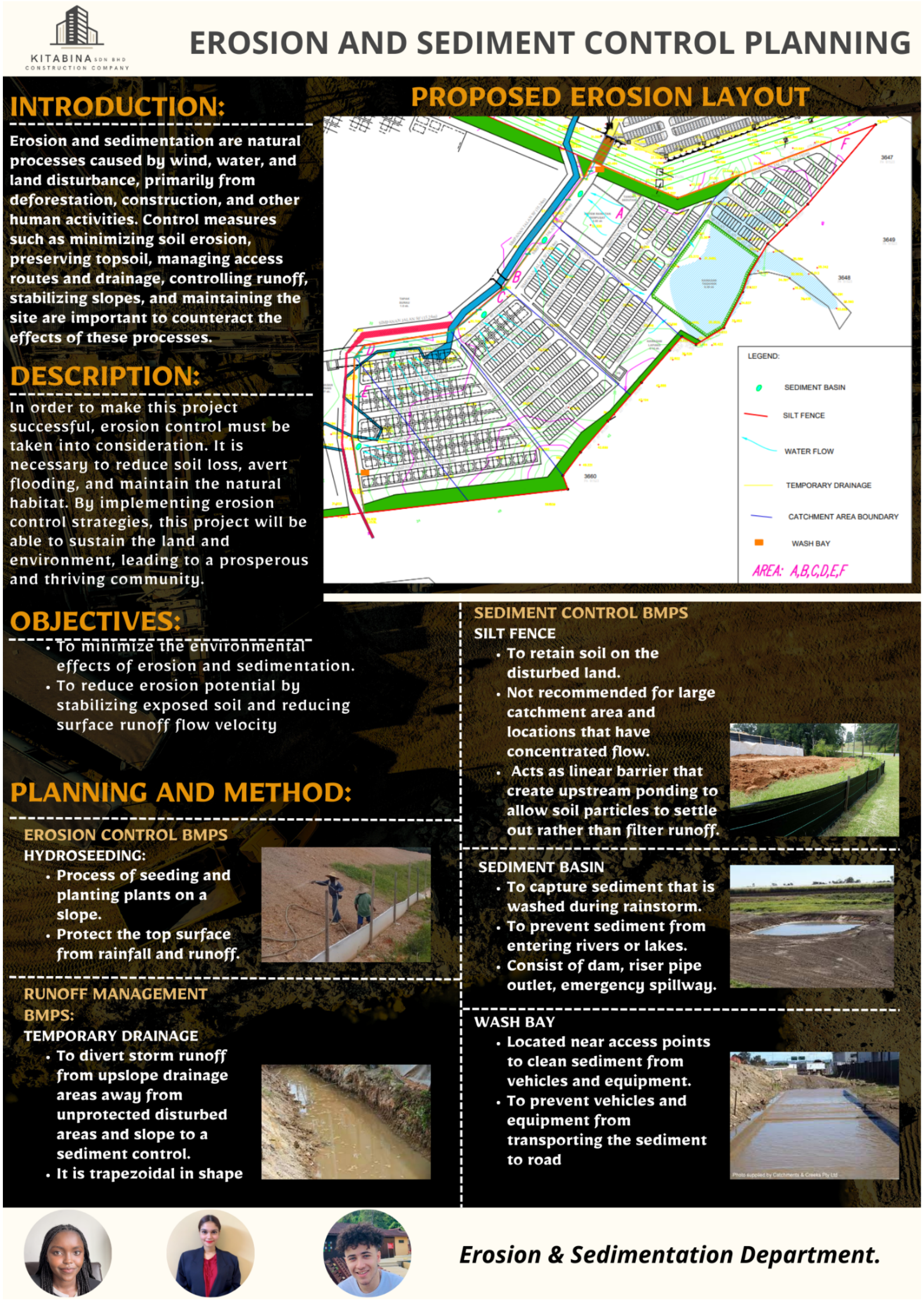
4. Conclusion

Based on our calculation, and with the help of the EPANET software, we were able to determine the most suitable pipe size and water tank height for our project. We have decided to use only 1 pipe size of 120 mm. The pipes were chosen to fulfill the residual and unit head loss requirements of SPAN. We have chosen HDPE pipes with a coefficient of 120 to supply water from node to node in our water reticulation network system.

For our elevated water tank design, calculation steps have been shown above, where we have obtained the Top Water Level (TWL) to be 88.03 m, and the Bottom Water Level (BWL) to be 82.03 m. The size of the water tank has been designed so that it stores water demand 3 days prior. Therefore, the suitable diameter of the cylindrical water tank is 30 m, with a height of 6 m.

Besides, the elevation of the location of water tanks is 47.5 m. It can provide the best operating pressure to every node. Since water can flow through the pipe through gravity force, a pump is not needed in this situation. Therefore, we have also succeeded in saving costs for maintenance of suction tank and installation of pumps.

5.0 Erosion & Sedimentation Control



5.1 Introduction

Sedimentation and erosion are natural occurrences on our planet. It mainly occurs in tropical regions like Malaysia. These processes happen every day on all types of land, mostly as a result of deforestation, wind-exposed building projects, rain and runoff, and unchecked land disturbance. The separation and movement of soil particles caused by natural factors, usually wind and water, are referred to as erosion in the context of soil and watershed conservation. Geologic materials, such as shattered rock, will be mechanically weathered into smaller, transportable bits that will be carried by erosion. This procedure took place within the waterway and the watershed that surrounds it. The shear pressures of water flowing over the soil surface caused the transfer of soil particles from active development and construction regions. Channel erosion occurs when the vegetation along the bank is disturbed or when a stream's flow rate rises significantly over the critical levels.

Sedimentation is the accumulation of sediment on the ground or in a watercourse's bed. It is the process by which particles are transported from their place of origin by either natural or human-enhanced processes and are deposited in water bodies or land surfaces. The natural result of stream erosion, sediment load can be increased by human practices and activities. Due to siltation, sedimentation has a negative impact on water quality. Increased sources of sediment in the watershed include locations with exposed soil, such as building sites, deforested areas, agriculture, and streambanks without vegetation.

To effectively combat the effects of erosion and sedimentation processes, control is crucial. For the purpose of controlling erosion and sedimentation, the following eight principles are advised:

1. Reduce soil erosion
2. Maintaining the soil and other resources
3. Site management and access routes
4. Runoff and drainage management
5. Earthmoving and preventing erosion
6. Control and prevention of sediment
7. Stabilization of Slopes Control of Erosion and Sediment 160
8. Site maintenance

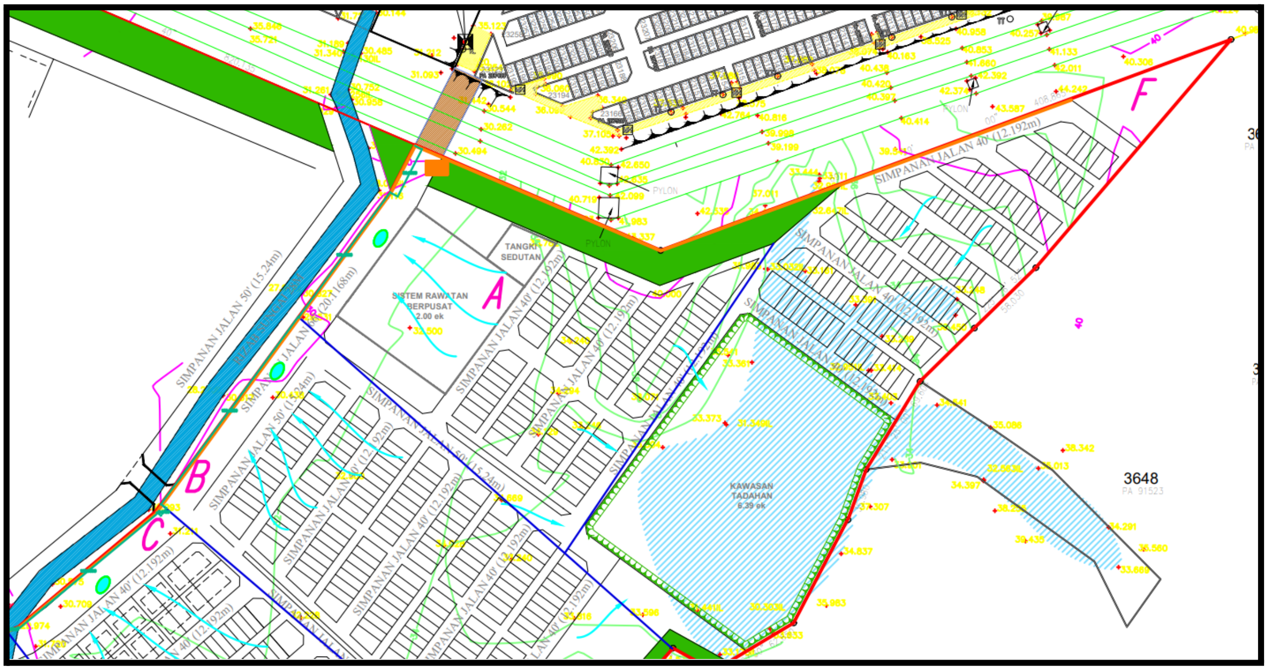
5.2 Site Description

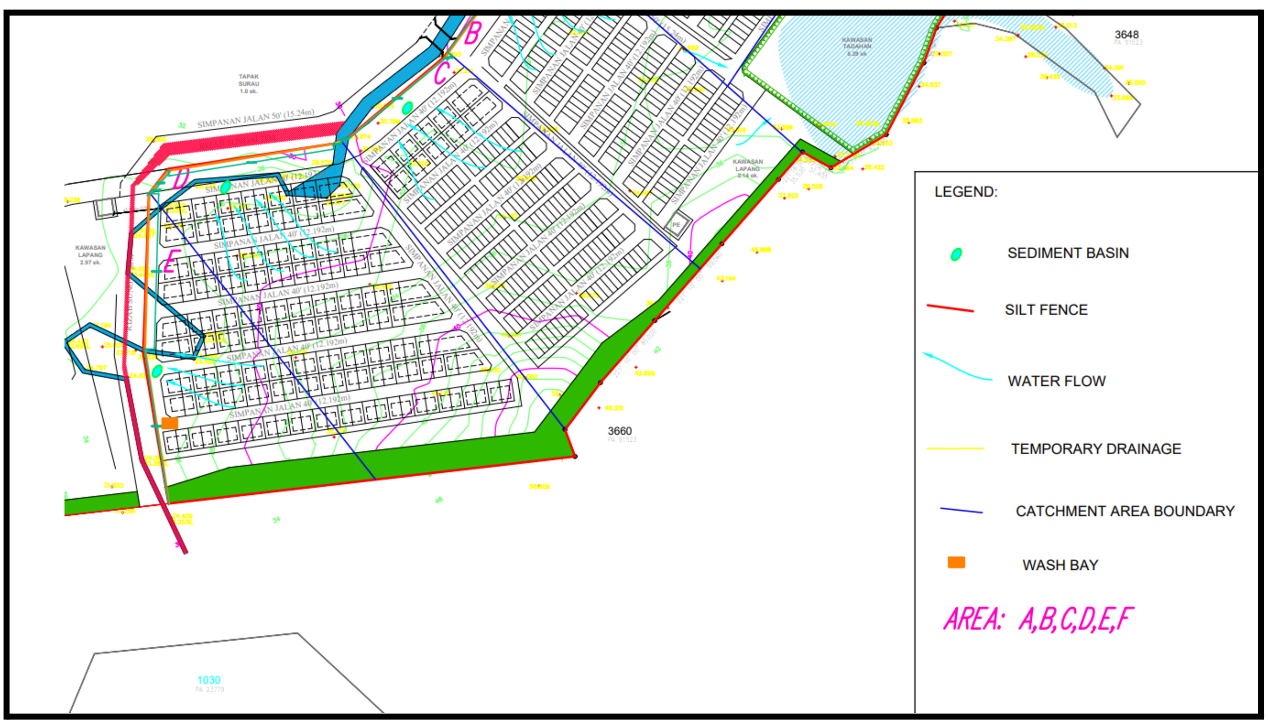
A site description ought to give a thorough rundown of a specific location. It should provide details about the physical characteristics of the location, like its size, topography, and vegetation.The history of the location should also be covered, along with any noteworthy occurrences or advancements that have taken place there.A site description should also include details on the property's current use, including any structures or buildings that are there. The site's location, accessibility, and any related environmental or cultural factors are examples of additional pertinent data.A site description should give a thorough summary of the location that is helpful for many different things, like planning, research, or tourism.

5.3 Design Guideline For Erosion and Sediment Control BMPs

In the process of completing this project, our group referred to the Urban StormWater Management Manual for Malaysia, MASMA, published by the Department of Irrigation and Drainage (DID) Malaysia as the ultimate guideline for our erosion and sediment control. This manual has apparent policy and instructions on the best management practices in each category. The category that has been classified is runoff management BMPs, sediment control BMPs and erosion control BMPs.

PROPOSED EROSION LAYOUT





5.4 Run off management Best Management Practice (all)

Water quality is maintained and improved using Best Management Practices for stormwater runoff. Managing runoff means controlling the direction, velocity, and volume of storm water on the property in a safe and efficient manner. A number of methods are involved in reducing pollutants entering our water resources, including engineered structural devices, natural vegetation, and conservation practices. By implementing these strategies, we can reduce the impact of runoff on our environment and ensure a healthier living environment for all.

5.4.1 Design Criteria

Estimating rainfall data and the site's ground condition are essential factors in calculating and planning the temporary drainage and earth basin. The sediment basin and temporary drainage must be capable of withstanding the site's maximum peak discharge. Data analysis for frequency, duration, and intensity are three factors that are involved in rainfall estimation. It may be divided into Time of Concentration, Average Rainfall Intensity, and Average Recurrence Interval (ARI).

1.Time Of Concentration (tc) - The travel time of runoff flows from the most hydraulically remote point upstream in the contributing catchment area to the point under consideration downstream. In designing a stormwater drainage system, tc is the sum of overland flow (to) and time of travel in drainage (td). From the early stages of construction, the site was considered a natural catchment area because there was no early development. Therefore, the time of concentration, including the travel time in natural channels for natural catchment areas expressed as:

$$tc = to + td$$

$$to = (107)(n^*)(L^{(1/3)}) / (S^{(1/5)})$$

$$\text{And } td = l/v$$

Where

tc = Time of concentration (minutes)

to = Overland sheet flow travel time (minutes)

td = Drain flow travel time (minutes)

L = Length of overland sheet flow (m)

n* = Horton’s roughness value

S = Slope of overload surface (%)

l = Length of drainage flow (m)

v = velocity of flow (m/minutes)

2. Average Recurrence Interval (ARI)- ARI is based on the selected frequency and return period. It is the rainfall and subsequent discharge estimate. ARI is the average length of time between rain events over the same magnitude, volume or duration. It is assumed that the design flow of a given ARI is produced by a design storm rainfall of the same ARI.

3. Average Rainfall Intensity, i- Intensity-duration-frequency (IDF) curve is the relationship between design rainfall and the data required for the use of peak flow estimation. Average rainfall intensity can be estimated by using an empirical equation:

$$i = \lambda (T^k) / (d+\theta)^n$$

Where
i = Average rainfall intensity (mm/hour)
T = Average Recurrence Interval – ARI
d = Storm duration (hours)
λ ,k,θ,n = Fitting constants dependent on the rain gauge location

5.4.2 Peak Discharge Estimation

The most frequently used method in peak discharge estimation is the rational method that always gives good results of peak discharge estimates for small catchment areas. That is why our site was divided into six catchment areas to calculate peak flow.

$$Q_p = (CIA) / (360)$$

Where
Q = Peak flow (m3 /s)
C = Runoff coefficient
I = Average rainfall intensity (mm/hr)
A = Drainage area (ha)

Sample Calculation for ARI, Tc and QP

<table>
<tr><th>Reference</th><th>Calculation</th><th>Output</th></tr>
<tr><td></td><td>The construction site was divided into 6 catchment Areas

A= 4.4013476 ha
B= 5.0490224 ha
C= 5.6474085 ha
D= 6.6787183 ha
E= 3.2737579 ha
F= 6.0798544 ha</td><td></td></tr>
<tr><td></td><td>Time of concentration (tc)
Catchment Area B = 4.4013476 ha

Horton’s roughness, n* = 0.06 (densely grassed)

Length of drainage = 156.39 m

Length overland sheet flow of drainage = 315.12 m

Height difference = 42 m- 30 m = 12 m

Average slope surface, S = (12/315.12)x100% = 3.84 %

Table 2.1: Equations to Estimate Time of Concentration (QUDM, 2007)
<table>
<tr><th>Travel Path</th><th>Travel Time</th><th>Remark</th></tr>
<tr><td>Overland Flow</td><td>$t_o = \frac{107.n^*.L^{1/3}}{S^{1/5}}$</td><td>$t_o$ = Overland sheet flow travel time (minutes)
L = Overland sheet flow path length (m)
for Steep Slope (>10%), L ≤ 50 m
for Moderate Slope (<5%), L ≤ 100 m
for Mild Slope (<1%), L ≤ 200 m
n^* = Horton’s roughness value for the surfac (Table 2.2)
S = Slope of overland surface (%)</td></tr>
</table>

Therefore, to=(107x0.06x315.12^⅓)/ 3.84^⅕ = 33.29min

td= 156.39/60 = 2.6min

tc=to + td = 33.29+2.6= 35.89min</td><td>td=2.6 min
tc=35.89min</td></tr>
</table>

<table>
<tr>
<td>Table 2.B2

Table 1.1</td>
<td>

Average Rainfall Intensity, I (mm/hr)

ARI Location:
Rainfall station at Pintu Kaw. Pulau Kertam

<table>
<tr><td>Pahang</td><td>1</td><td>2630001</td><td>Sungai Pukim Sungai</td><td>63.9783</td><td>0.3906</td><td>0.2556</td><td>0.8717</td></tr>
<tr><td></td><td>2</td><td>2634193</td><td>Anak Endau Kg</td><td>79.4310</td><td>0.3639</td><td>0.1431</td><td>0.7051</td></tr>
<tr><td></td><td>3</td><td>2828173</td><td>Gambir</td><td>61.1933</td><td>0.3857</td><td>0.1878</td><td>0.8237</td></tr>
<tr><td></td><td>4</td><td>3026156</td><td>Pos Iskandar</td><td>59.9903</td><td>0.3488</td><td>0.2262</td><td>0.8769</td></tr>
<tr><td></td><td>5</td><td>3121143</td><td>Simpang Pelangai</td><td>64.9653</td><td>0.3229</td><td>0.3003</td><td>0.8995</td></tr>
<tr><td></td><td>6</td><td>3134165</td><td>Dispensari Nenasi</td><td>88.6484</td><td>0.3830</td><td>0.4040</td><td>0.7614</td></tr>
<tr><td></td><td>7</td><td>3231163</td><td>Kg Unchang</td><td>71.6472</td><td>0.3521</td><td>0.1805</td><td>0.7886</td></tr>
<tr><td></td><td>8</td><td>3424081</td><td>JPS Temerloh</td><td>62.2075</td><td>0.3528</td><td>0.3505</td><td>0.8368</td></tr>
<tr><td></td><td>9</td><td>3533102</td><td>Rumah Pam Pahang Tua</td><td>80.8887</td><td>0.3611</td><td>0.4800</td><td>0.7578</td></tr>
<tr><td></td><td>10</td><td>3628001</td><td>Pintu Kaw. Pulau Kertam</td><td>63.5073</td><td>0.3830</td><td>0.2881</td><td>0.8202</td></tr>
<tr><td></td><td>11</td><td>3818054</td><td>Setor JPS Raub</td><td>61.3432</td><td>0.3692</td><td>0.3929</td><td>0.8445</td></tr>
<tr><td></td><td>12</td><td>3924072</td><td>Rmh Pam Paya Kangsar</td><td>58.3761</td><td>0.3334</td><td>0.2421</td><td>0.8430</td></tr>
<tr><td></td><td>13</td><td>3930012</td><td>Sungai Lembing PCC Mill</td><td>77.0004</td><td>0.4530</td><td>0.5701</td><td>0.8125</td></tr>
<tr><td></td><td>14</td><td>4023001</td><td>Kg Sungai Yap</td><td>77.1488</td><td>0.3725</td><td>0.3439</td><td>0.8810</td></tr>
<tr><td></td><td>15</td><td>4127001</td><td>Hulu Tekai Kwsn."B"</td><td>60.2235</td><td>0.4650</td><td>0.1241</td><td>0.8020</td></tr>
<tr><td></td><td>16</td><td>4219001</td><td>Bukit Bentong</td><td>67.6128</td><td>0.2706</td><td>0.2459</td><td>0.8656</td></tr>
<tr><td></td><td>17</td><td>4223115</td><td>Kg Merting</td><td>62.7511</td><td>0.2843</td><td>0.3630</td><td>0.9024</td></tr>
<tr><td></td><td>18</td><td>4513033</td><td>Gunung Brinchang</td><td>42.1757</td><td>0.2833</td><td>0.1468</td><td>0.7850</td></tr>
</table>

λ= 63.5073
$\mathcal{K}$= 0.383
θ= 0.2881
η= 0.8202

From above calculations, tc=d=35.89min

Take ARI, T = 2years since our area is a construction site

$I = (\boldsymbol{\lambda} * T^{\wedge}\boldsymbol{\mathcal{K}})/(d + \theta)^{\wedge}\eta$
= (63.5073 x 2^0.383)/ (35.89/60 +0.2881)^0.8202

</td>
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I= 91.42mm/hr

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<tr>
<td></td>
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Peak Discharge Estimation
Runoff Coefficient C = 0.4 (grass cover)

Peak flow, Qp=CIA/360

= (0.4 x 91.42 x5.0490224)/360

</td>
<td>

Qp=0.51m³/s

</td>
</tr>
</table>

Table 2.5: Recommended Runoff Coefficients for Various Landuses
(DID, 1980; Chow et al., 1988; QUDM, 2007 and Darwin Harbour, 2009)

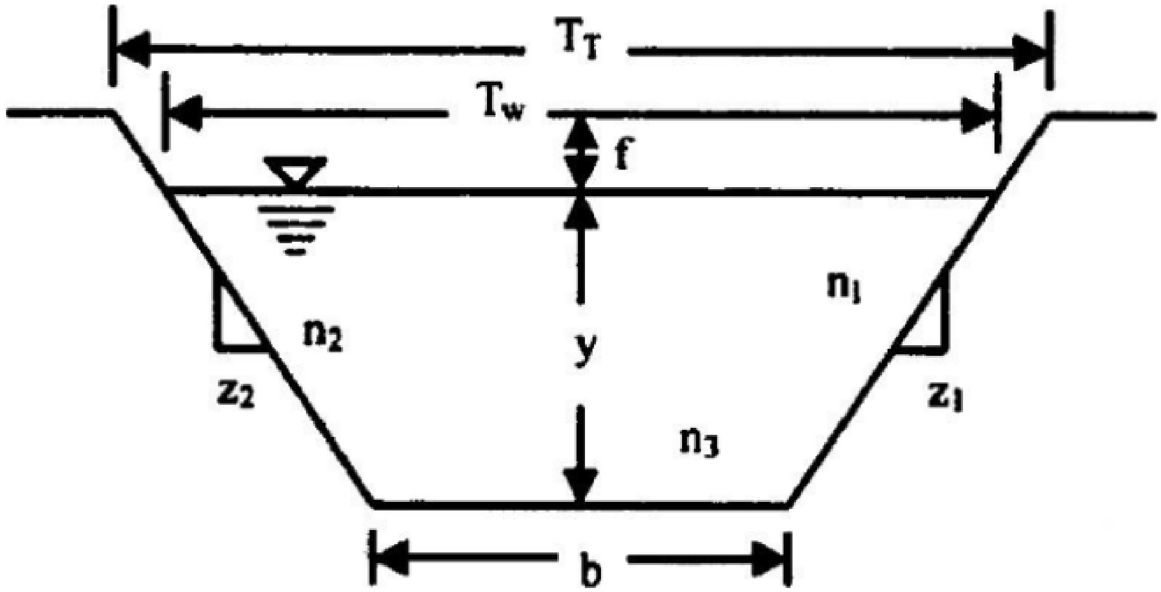
Landuse	Runoff Coefficient (C) For Minor System (≤10 year ARI)	Runoff Coefficient (C) For Major System (> 10 year ARI)
Residential		
Bungalow	0.65	0.70
Semi-detached Bungalow	0.70	0.75
Link and Terrace House	0.80	0.90
Flat and Apartment	0.80	0.85
Condominium	0.75	0.80
Commercial and Business Centres	0.90	0.95
Industrial	0.90	0.95
Sport Fields, Park and Agriculture	0.30	0.40
Open Spaces		
Bare Soil (No Cover)	0.50	0.60
Grass Cover	0.40	0.50
Bush Cover	0.35	0.45
Forest Cover	0.30	0.40
Roads and Highways	0.95	0.95
Water Body (Pond)		
Detention Pond (with outlet)	0.95	0.95
Retention Pond (no outlet)	0.00	0.00

Note: The runoff coefficients in this table are given as a guide for designers. The near-field runoff coefficient for any single or mixed landuse should be determined based on the imperviousness of the area.

5.4.3 Temporary Earth Drainage

The main principle for establishing an excellent temporary drainage system in development sites is to direct runoff water so that it does not run across disturbed and undisturbed areas. A temporary drainage system should be designed such that the system does not contribute to the sedimentation problems that is stable channel design. The runoff surface water channel to a sediment basin or silt trap before discharge to the nearest natural watercourses such as a sediment basin or silt trap. The design will vary based on the condition of the site terrain. It is essential to regularly inspect the earth drain where all runoff from undisturbed areas should not mix with the runoff from disturbed areas.

For the temporary drainage design, we decided to use the trapezoidal shape, where the depth shall not exceed 1.2m and not less than 0.6m. In order to ease the construction project, it is recommended to use swales with trapezoidal cross-sections. The bottom width should be controlled between 0.5m and 3.0m because the minimum bottom width function allows for construction considerations and provides a minimum filtering surface for water quality treatment. While the maximum bottom width is 3.0 m, it prevents shallow flows from concentrating and potentially erodes the flow channels.



5.4.4 TRAPEZOIDAL SHAPE BEST HYDRAULIC SECTION

Theta = 60°, $z = 1 / \sqrt{3}$, and $R = y/2$

And we know that for trapezoidal shape:

$T = 2w$ and $B = y\sqrt{1 + z^2}$

Simplify B:

$B = y\sqrt{1 + (1 \ \sqrt{3})^2}$

$B = (y*2\sqrt{3})/3$

SAMPLE CALCULATION OF TEMPORARY EARTH DRAINAGE DESIGN

Reference	Calculation	Output
	Design Drainage area for catchment area zone B Use the Best Hydraulic Section of Trapezoidal for uniform flow in open channels and implement the Manning Formula: $Q = \frac{A \times R^{\frac{2}{3}} \times \sqrt{S_o}}{n}$ Where: Q = Flow rate of discharge (m^3/s) A = Cross section area m^2 R = Hydraulic Radius (m) So = Channel bed slope n = Manning's Coefficient Drainages must pass Qp=1.98m^3/s Channel bed slope: $S = \frac{Max\ height - \min height}{Horizontal\ distance Length\ of\ drain}$ $= \frac{42-30}{156.39}$ Based on the BHS of Trapezoidal Section: Propose: T: 1.2 m Y: 0.6 m B: 0.7 m Taking the value of freeboard to be more than 50mm hence the freeboard assumed = 0.3m	So=0.077

	Height of Channel, H H = y + Freeboard = 0.6 m + 0.3m	 H=0.9
	Area of the channel,A: A = (T + B)/ 2 x (H) = (1.2 + 0.7) /2 x (0.9)	A=0.85m^2
	Hydraulics radius of the channel, R: R= Y/2 = 0.6/ 2	R=0.3m
	Velocity, V	

$$V = \frac{R^{\frac{2}{3}} \times \sqrt{S_o}}{n}$$

Table 2.3: Values of Manning's Roughness Coefficient (n) for Open Drains and Pipes (Chow, 1959; DID, 2000 and French, 1985)

Drain/Pipe	Manning Roughness n
Grassed Drain	
Short Grass Cover (< 150 mm)	0.035
Tall Grass Cover (≥ 150 mm)	0.050
Lined Drain	
Concrete	
Smooth Finish	0.015
Rough Finish	0.018
Stone Pitching	
Dressed Stone in Mortar	0.017
Random Stones in Mortar or Rubble Masonry	0.035
Rock Riprap	0.030
Brickwork	0.020
Pipe Material	
Vitrified Clay	0.012
Spun Precast Concrete	0.013
Fibre Reinforced Cement	0.013
UPVC	0.011

	For the earth drainage we will be taking Manning's roughness for short grass which is n = 0.035 $$V = \frac{0.3^{2/3} \times \sqrt{0.077}}{0.035}$$ **Discharge, Q** Q = AV = (0.85) (3.5)	V=3.5m/s Q=3.02m^3/s Qp=0.51m^3/s Q>Qp ok!

RESULTS:

CONCENTRATION TIME, tc

Horton's Roughness = 0.06(dencely grassed)

Catchment Area Area	Drainage	Area (ha)	Length of Drainage (Ld)	Length of overland sheet flow, (Lo)	Height Difference (h)	Surface slope % (s)	Overland flow, (to), min	Drain flow, min (td)	Concentrated flow (tc), min
A	A1	4.4013476	179.55	156.0766	10	6.407110355	23.84049046	2.9925	26.83299046
	A2		139.87	212.55	10	4.704775347	28.10914396	2.331166667	30.44031062
B	B1	5.0490224	156.39	312.59	12	3.838894398	33.29294054	2.6065	35.89944054
C	C1	5.6474085	135.23	311.7	24.6	7.892204042	28.79658369	2.253833333	31.05041702
D	D1	6.6787183	198.71	451.33	30.61	6.782177121	33.58092102	3.311833333	36.89275435
E	E1	3.2737579	150.84	249.34	14.97	6.003850164	28.23447461	2.514	30.74847461
	E2		151.87	192.22	14	7.283321194	24.90779751	2.531166667	27.43896418
F	F1	6.0798544	163.63	208	6	2.884615385	30.7755075	2.727166667	33.50267416

AVERAGE RAINFALL INTENSITY, I

ARI = 10 years

λ= 63.5073, $\mathcal{K}$= 0.383, θ= 0.2881, η= 0.8202

Catchment Area Area	Drainage	Area (ha)	Concentrated flow (tc), min	Average Rainfall Intensity, I (mm/hr)	Peak Flow Qp, (m^3/s)
A	A1	4.4013476	26.83299046		
	A2		30.44031062	75.847	0.2781908428
B	B1	5.0490224	35.89944054	91.42449511	0.512893693
C	C1	5.6474085	31.05041702	108.2237691	0.509319861
D	D1	6.6787183	36.89275435	98.5548506	0.5485167369
E	E1	3.2737579	30.74847461		
	E2		27.43896418	75.0927	0.2048627665
F	F1	6.0798544	33.50267416	103.9189072	0.5265098544

TEMPORARY DRAINAGE DESIGN

Freeboard = 0.3m, z = 1 /√3

Catchment Area	Drainage	Area (ha)	Peak Flow	Channel Bed Slope	Y	B	T	H	R	A	V	Q	Condition
Area			Qp, (m^3/s)	So	(m)	(m)	(m)	(m)	(m)	(m^2)	(m/s)	(m^3/s)	
A	A1	4.4013476		0.05569479254	0.6	0.69	1.2	0.9	0.3	0.8505	3.021714445	2.569968136	Q>Qp ok!
	A2		0.2781908428	0.07149495961	0.6	0.69	1.2	0.9	0.3	0.8505	3.423606467	2.9117773	Q>Qp ok!
B	B1	5.0490224	0.512893693	0.0767312488	0.6	0.69	1.2	0.9	0.3	0.8505	3.54676373	3.016522553	Q>Qp ok!
C	C1	5.6474085	0.509319861	0.1819122976	0.6	0.69	1.2	0.9	0.3	0.8505	5.461062602	4.644633743	Q>Qp ok!
D	D1	6.6787183	0.5485167369	0.1540435811	0.6	0.69	1.2	0.9	0.3	0.8505	5.025368678	4.274076061	Q>Qp ok!
E	E1	3.2737579		0.0992442323	0.6	0.69	1.2	0.9	0.3	0.8505	4.033655127	3.430623685	Q>Qp ok!
	E2		0.2048627665	0.09218410483	0.6	0.69	1.2	0.9	0.3	0.8505	3.887533521	3.30634726	Q>Qp ok!
F	F1	6.0798544	0.5265098544	0.03666809265	0.6	0.69	1.2	0.9	0.3	0.8505	2.451829609	2.085281083	Q>Qp ok!

5.5 Sediment Control BMP (all)

Sediment control is the process of retaining eroded soil from a building site so that it won't be swept away and contaminate surrounding waterways. It may be accomplished through a number of methods. To contain the surplus sediment created, structures like sediment basins and traps are typically placed downstream of building sites. To be able to meet the demand on-site, these buildings need to be correctly planned.

5.5.1 Soil Loss Estimation

The soil loss estimation aims to determine the site's erosion risk. This process happens by examining the erosion risk. It has three phases that are before development takes place, during earthwork without control and during earthwork with control. The site is divided into 6 catchment areas where all surface runoff accumulated at 6 sedimentation basins that were located across the site before being discharged to the clean water stream of a drain. The Universal Soil Loss Equation (USLE) is a semi-empirical equation used to assess soil losses under different cropping systems and land management practices.

The USLE is given as: $A = R \times K \times LS \times C \times P$

Where

A = Annual soil loss (tonnes/ha/year)

R = Rainfall erosivity factor, an erosion index for the given storm period in MJ (mm/ha/h)

K = Soil erodibility factor

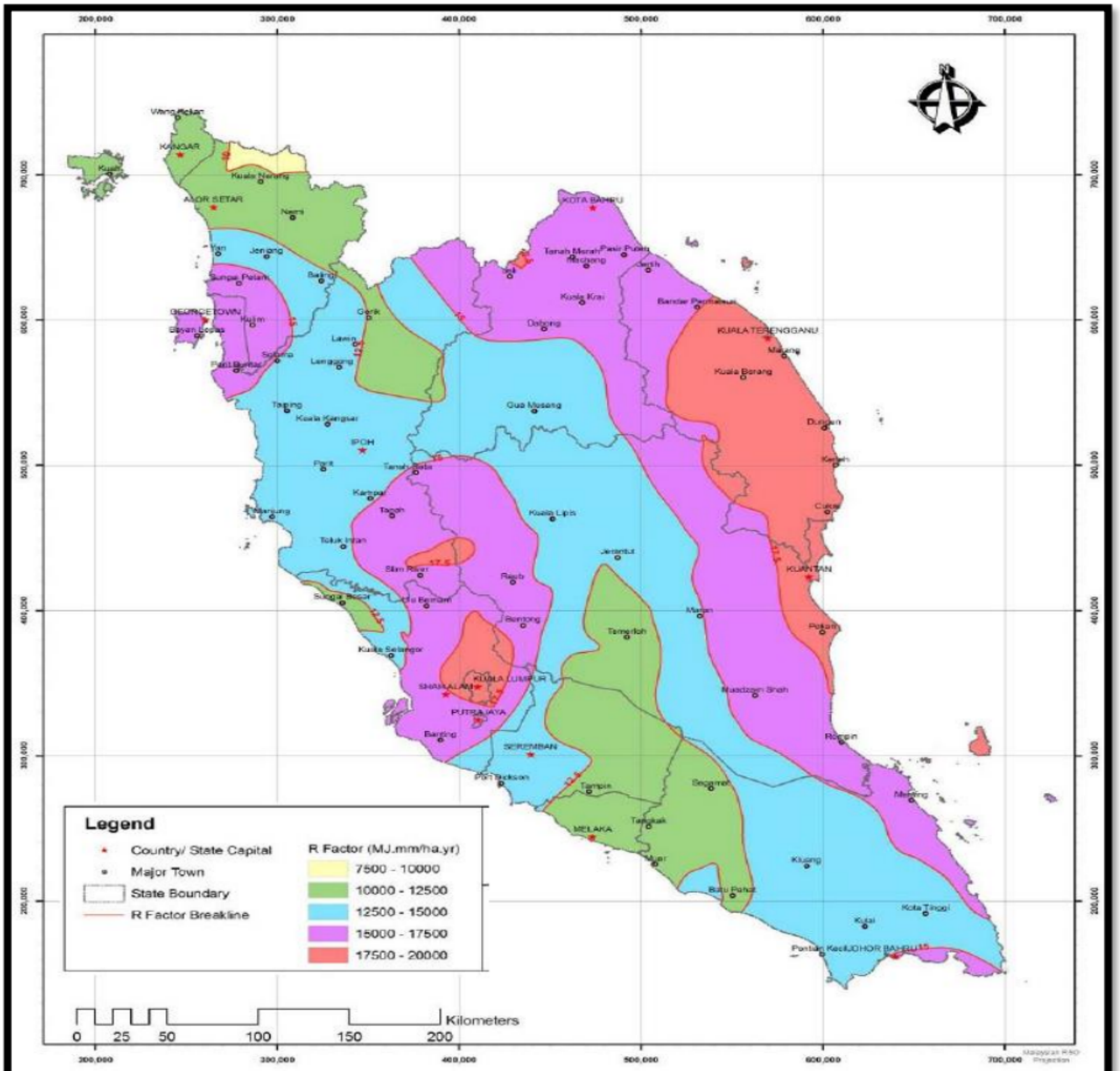
LS = Slope length and steepness factor

C = Cover management factor, represents the protective coverage of canopy and organic material in direct contact with the ground

P = Support practice factor

a) Rainfall Erosion Factor (R)

This rainfall erosivity factor is related directly between the soil loss to rainfall parameter. Soil losses are directly proportional to the rainstorm parameter when other functions are held constant. The total storm energy(E) times the maximum 30-minutes intensity(I30). The average annual total of the storm (EI30) in a particular locality is represented by the rainfall erosivity factor, R, for that locality.



* Note: The highest value found in Peninsular Malaysia (20,000) shall be applicable for the entire East Malaysia.

Figure 5.5: Rainfall Erosivity Factor in Peninsular Malaysia

b) Soil Erodibility Factor (K)

Soil erodibility defines the resistance of the soil to both detachment and transport. It is an important index to measure soil susceptibility to water, an essential parameter for soil prediction. The soil erodibility factor (K) represents the effect of soil properties and soil profile characteristics such as soil texture, aggregate stability, shear strength, infiltration capacity, and organic and chemical contents on soil loss.

K = [1x10^(-4) (12-OM)M^(1.14) + 4.5(S-3)+8.0(P-2)] /(100)

Where

M = (% silt + %very fine sand) x (100 - %clay)

OM = % of organic matter

S = Soil Structure code

P = permeability class

Table 12.2: Soil Structure Code and Permeability Class for Various Soil Textures

Soil Texture	Permeability Code[1]	Hydrologic Soil Group[2]	Soil Structure Code[3]
Heavy Clay	6	D	4
Clay	6	D	4
Silty Clay Loam	5	C	4
Sandy Clay	5	C	4
Sandy Clay Loam	4	C	4
Clay Loam	4	C	4
Loam	3	B	2
Silty Loam	3	B	3
Loamy Sand	2	A	1
Sandy Loam	2	A	2
Sand	1	A	1

Note: 1 – National Soil Survey Handbook (NRCS, 2005)
2 – National Engineering Handbook (NRCS, 2007)
3 – Field Manual for Describing Soils in Ontario (Ontario Centre for Soil Resource Evaluation, 1993)

c) Slope Length and Steepness Factor (LS)

The rate of soil erosion by water is very much affected by both slope length(L) and slope steepness(S) in terms of gradient/ percent slope.

Table 12.3: *LS* Factor for Various Slopes and Slope Lengths

Slope Steepness, *S* (%)	Slope Length, λ (m)											
	2	5	10	15	25	50	75	100	150	200	250	300
0.1	0.043	0.052	0.059	0.064	0.071	0.082	0.089	0.094	0.102	0.108	0.113	0.117
0.5	0.055	0.067	0.076	0.083	0.092	0.106	0.114	0.121	0.131	0.139	0.146	0.151
1.0	0.057	0.075	0.093	0.105	0.122	0.150	0.170	0.185	0.209	0.228	0.243	0.257
2.0	0.089	0.117	0.144	0.163	0.190	0.234	0.264	0.288	0.325	0.354	0.379	0.400
3.0	0.100	0.144	0.190	0.224	0.275	0.362	0.426	0.478	0.563	0.631	0.690	0.742
4.0	0.135	0.195	0.257	0.302	0.371	0.489	0.575	0.646	0.759	0.852	0.932	1.002
5.0	0.138	0.218	0.308	0.377	0.487	0.688	0.843	0.973	1.192	1.376	1.539	1.686
6.0	0.173	0.273	0.387	0.474	0.612	0.865	1.059	1.223	1.498	1.730	1.934	2.119
8.0	0.255	0.404	0.571	0.699	0.903	1.277	1.564	1.806	2.212	2.554	2.855	3.128
10.0	0.353	0.559	0.790	0.968	1.250	1.767	2.165	2.499	3.061	3.535	3.952	4.329
15.0	0.525	0.909	1.378	1.757	2.388	3.619	4.616	5.486	6.997	8.315	9.506	10.605
20.0	0.848	1.470	2.228	2.841	3.860	5.851	7.463	8.869	11.311	13.442	15.368	17.145
25.0	1.249	2.164	3.279	4.183	5.683	8.613	10.986	13.055	16.651	19.788	22.623	25.239
30.0	1.726	2.991	4.533	5.782	7.855	11.906	15.185	18.046	23.017	27.353	31.272	34.887
40.0	2.911	5.045	7.646	9.752	13.250	20.083	25.614	30.440	38.824	46.139	52.749	58.846
50.0	4.404	7.631	11.567	14.753	20.044	30.382	38.749	46.050	58.733	69.798	79.798	89.023
60.0	6.204	10.751	16.296	20.784	28.239	42.802	54.590	64.875	82.744	98.333	112.420	125.416
70.0	8.312	14.404	21.833	27.846	37.833	57.344	73.138	86.917	110.856	131.741	150.615	168.026
80.0	10.728	18.590	28.177	35.938	48.827	74.008	94.391	112.174	143.070	170.025	194.383	216.854
90.0	13.451	23.309	35.329	45.060	61.221	92.793	118.350	140.648	179.386	213.182	243.723	271.898
100.0	16.482	28.560	43.289	55.212	75.014	113.700	145.016	172.337	219.803	261.214	298637	333.159

d) Cover Management Factor (C)
Crop management, the C factor function, controls soil loss at a specific site. It represents the various types of covers introduced to protect the bare ground from rain splash and sheet erosion. Reducing soil erosion at construction sites or disturbed land is very important.

Table 12.4a: Cover Management, *C* Factor for Forested and Undisturbed Lands

Erosion Control Treatment	C Factor
Rangeland	0.23
Forest/Tree	
25% cover	0.42
50% cover	0.39
75% cover	0.36
100% cover	0.03
Bushes/ Scrub	
25% cover	0.40
50% cover	0.35
75% cover	0.30
100% cover	0.03
Grassland (100% coverage)	0.03
Swamps/ mangrove	0.01
Water body	0.01

Note: The values are compiled from Layfield (2009), Troeh et al. (1999), Mitchell and Bubenzer (1980), ECTC (2006) and Ayad (2003).

Table 12.4b: Cover Management, C Factor for Agricultural and Urbanized Areas

Erosion Control Treatment	C Factor
Mining areas	1.00
Agricultural areas	
Agricultural crop	0.38
Horticulture	0.25
Cocoa	0.20
Coconut	0.20
Oil palm	0.20
Rubber	0.20
Paddy (with water)	0.01
Urbanized areas	
Residential	
Low density (50% green area)	0.25
Medium density (25% green area)	0.15
High density (5% green area)	0.05
Commercial, Educational and Industrial	
Low density (50% green area)	0.25
Medium density (25% green area)	0.15
High density (5 green area)	0.05
Impervious (Parking lot, road, etc.)	0.01

Note: The values are modified from Layfield (2009) and Troeh et al. (1999).

For our project, it covers the oil palm area. So, our group will take values 0.20 for C factor.

e) Support Practice Factor (P)

If the soil erosion has already occurred, factor P needed to stop the silt and sediment in flowing water from running off the site.

Table 12.5: Support Practice, *P* Factor for BMPs at Construction and Development Sites

Support/ Sediment Control Practice		P Factor
Bare soil		1.00
Disked bare soil (rough or irregular surface)		0.90
Wired log / Sand bag barriers		0.85
Check Dam		0.80
Grass buffer strips (to filter sediment laden sheet flow)		
Basin slope (%)		
0 to 10		0.60
11 to 24		0.80
Contour furrowed surface (maximum length refers to downslope length)		
Slope (%)	Maximum Length (m)	
1 to 2	120	0.60
3 to 5	90	0.50
6 to 8	60	0.50
9 to 12	40	0.60
13 to 16	25	0.70
17 to 20	20	0.80
> 20	15	0.80
Silt fence		0.55
Sediment containment systems (Sediment basin/Trap)		0.50
Berm drain and Cascade		0.50
Terracing		
Slope (%)		
1 to 2		0.12
3 to 8		0.10
9 to 12		0.12
13 to 16		0.14
17 to 20		0.16
> 20		0.18

Note: The values are compiled from Layfield (2009), Troeh et al. (1999), Mitchell and Bubenzer (1980), ECTC (2006), Israelsen et al (1980), Weischmeier and Smith (1978) and Kuenstler (2009)

5.5.1.1 SAMPLE CALCULATION OF SOIL LOSS ESTIMATION

Determining the Rainfall Erosivity, R Factor

Soil loss for Catchment area B
Location: Mukim Hulu Lepar, Daerah Kuantan, Pahang Darul Makmur
R: 15000 to 17500 MJ mm/ha.yr

Hence, for a safety evaluation purposes, higher limit was used:
R factor: 17500 MJ mm/ha.yr taken

Determining the Soil Erodibility, K Factor

As per given in the Soil Test Profile, our proposed location falls in Zone I and Zone III. The K factor values were given in the soil profile too.

Catchment Area	Percentage Of Soil Particles(%) Sand	Silt	Clay	Structure Code (S)	Permeability Code (P)	M	K factor
A	42.5	35.8	21.7	2	3	6130.89	0.037
B	42.5	35.8	21.7	2	3	6130.89	0.037
C	42.5	35.8	21.7	2	3	6130.89	0.037
D	44.9	38	17.1	2	3	6872.41	0.035
E	44.9	38	17.1	2	3	6872.41	0.035
F	42.5	35.8	21.7	2	3	6130.89	0.037

Determining Slope length and steepness factor (LS)

$$LS = (\lambda / \Psi)^m \times (0.065 + 0.046s + 0.0065s^2) \quad (3.9)$$

Where, λ = sheet flow path length (m or feet)
Ψ = 22.13 for SI Units and 72.6 for English Units (BU)
s = average slope gradient (%)
m = 0.2 for $s < 1$,
= 0.3 for $1 \leq s < 3$,
= 0.4 for $3 \leq s < 5$,
= 0.5 for $5 \leq s < 12$ and
= 0.6 for $s \geq 12\%$

The contours from topographic maps were used to determine the horizontal slope length and slope steepness in existing conditions. While for disturbed conditions, the designed proposed reduced level was used. For evaluating the average soil loss, the average slope length and slope steepness of the entire zone was referred.

Horizontal slope length =312.59m
Height Difference = 42 m – 30 m = 12m
Slope surface, S = (12/312.59)× 100% = 3.83 %
From table 12.3, Using interpolation of data,
When S = 3.83% and
Horizontal Slope Length= 312.59m
Then, LS= 1.002

Determining of Cover Management factor C

The existing condition of the site was residential area hence taking the C factor to be 0.25
C Factor = 0.25

Determining of Support Practice factor (P)

The existing condition has no support practice, and the site is an irregular surface,
Hence P factor = 1

Determining of Soil Loss

A = R x K x LS x C x P
A = 17500 x 0.037 x 1.437 x 0.25 x 1 = 232.61 ton/ha/yr

5.5.1.2 RESULTS OF SOIL LOSS ESTIMATION

				Catchment Area			
Condition	Parameters	A	B	C	D	E	F
	R	17500	17500	17500	17500	17500	17500
	K	0.037	0.037	0.037	0.035	0.035	0.037
Existing	LS	1.437	1.002	3.128	2.119	2.244	0.631
	C	0.25	0.25	0.25	0.25	0.25	0.25
	P	1	1	1	1	1	1
	A(ton/ha/yr)	232.614375	162.19875	506.345	324.471875	343.6125	102.143125

	R	17500	17500	17500	17500	17500	17500
	K	0.037	0.037	0.037	0.035	0.035	0.037
Earthwork (Uncontrolled)	LS	1.613	0.802	3.125	3.05	2.205	0.492
	C	1	1	1	1	1	1
	P	1	1	1	1	1	1
	A(ton/ha/yr)	1044.4175	519.295	2023.4375	1868.125	1350.5625	318.57
	R	17500	17500	17500	17500	17500	17500
	K	0.037	0.037	0.037	0.035	0.035	0.037
Earthwork (Controlled)	LS	1.613	0.802	3.125	3.05	2.205	0.492
	C	0.15	0.15	0.15	0.15	0.15	0.15
	P	0.5	0.5	0.5	0.5	0.5	0.5
	A(ton/ha/yr)	78.3313125	38.947125	151.7578125	140.109375	101.2921875	23.89275

5.6 Sediment Yield Estimation

The volume of sediment anticipated at the drainage point from the chosen location is the definition of sediment yield. As a consequence, the quantity of sediment required for the installation and upkeep of sediment control BMPs may be predicted using this estimation tool. Modified universal soil loss equation (MUSLE) is the formula that is frequently used to calculate the sediment yield in a catchment region. The projected sediment storage volume was employed in the construction of a sediment basin or trap.
The following is how this empirical connection for a particular storm event was stated.

$$Y=89.6(VQp)^{(0.56)} (K.LS.C.P)$$

Where
Y = Sediment yield per storm event
V = Runoff volume (m^3)
Qp = Peak discharge (m^3 /s)
K, LS, C, P = USLE factors

5.5.2.1 SAMPLE CALCULATION OF SEDIMENT YIELD ESTIMATION

Catchment Area B

Runoff Parameters

Design storm = 2 years
Catchment Area, B = 5.04 ha
Time of Concentration, tc= 35.9mins
Duration of storm, D = 1 hour = 60 mins
Intensity of design storm, I = 100.06 mm/hr

Peak Discharge
By applying the rational method, Runoff Coefficient, c = 0.30 (50% cover)
Intensity of design storm, I = 100.06 mm/hr
Catchment Area, B = 5.04 ha
Q = (CIA)/360 = 0.3(100.06)(5.0490224) /360 = 0.42 m^3/s

Runoff Volume
Rational Method Hydrograph Method (Type 2)
Time of Concentration, tc= 35.9mins
Peak Discharge, Qp= 0.42 m^3/s
V = 0.5 x (2 x tc) x Qp (Area below hydrograph)
= 0.5 x (2 x 35.9 x 60) x 0.42 = 906.84m^3

Sediment Yield Estimation
The value of K, LS, C and P factors are assumed to be the same as those used for soil loss estimation for an existing condition.
Using (MUSLE), the sediment yield can be calculated as shown below
Sediment yield, Y
Y = 89.6x(906.84 x 0.42)^0.56x(0.037 x 1.002 x 0.3 x1.0) = 27.78 tonnes

5.5.2.2 RESULTS OF SOIL PROPERTIES

	Percentage Of Soil Particles(%)			Structure	Permeability	M	K factor
Catchment Area	Sand	Silt	Clay	Code (S)	Code (P)		

A	42.5	35.8	21.7	2	3	6130.89	0.037
B	42.5	35.8	21.7	2	3	6130.89	0.037
C	42.5	35.8	21.7	2	3	6130.89	0.037
D	44.9	38	17.1	2	3	6872.41	0.035
E	44.9	38	17.1	2	3	6872.41	0.035
F	42.5	35.8	21.7	2	3	6130.89	0.037

5.5.2.3 SEDIMENT YIELD ESTIMATION

				Catchment Area			
Condition	Parameters	A	B	C	D	E	F
	Area (ha)	4.4013476	5.0490224	5.647085	6.6787183	3.2737183	6.079854
	tc (min)	28.63665054	35.89944054	31.05041702	36.89275435	29.0937194	33.502674
	Qpeak	0.2781908428	0.4210128889	0.509319861	0.5485167369	0.2048627665	0.5265098
	V (m^3)	477.987237	906.8476303	948.875645	1214.177594	357.6131907	1058.3692
Existing	K	0.037	0.037	0.037	0.035	0.035	0.037
	LS	1.437	1.002	3.128	2.119	2.244	0.631
	C	0.3	0.3	0.3	0.3	0.3	0.3
	P	1	1	1	1	1	1
	Y (tonnes)	22.10003033	27.81783648	99.09453026	75.99283389	23.38035153	21.64934
	Area (ha)	4.4013476	5.0490224	5.647085	6.6787183	3.2737183	6.079854
	tc (min)	28.63665054	35.89944054	31.05041702	36.89275435	29.0937194	33.502674
	Qpeak	0.2781908428	0.4210128889	0.509319861	0.5485167369	0.2048627665	0.5265098
	V (m^3)	477.987237	906.8476303	948.875645	1214.177594	357.6131907	1058.3692
Earthwork (Uncontrolled)	K	0.037	0.037	0.037	0.035	0.035	0.037
	LS	1.613	0.802	3.125	3.05	2.205	0.492
	C	1	1	1	1	1	1
	P	1	1	1	1	1	1
	Y (tonnes)	82.67345752	74.21661241	326.076915	364.7529986	76.58624032	56.237222
	Area (ha)	4.4013476	5.0490224	5.647085	6.6787183	3.2737183	6.079854
	tc (min)	28.63665054	35.89944054	31.05041702	36.89275435	29.0937194	33.502674

	Qpeak	0.2781908428	0.4210128889	0.509319861	0.5485167369	0.2048627665	0.52650983
	V (m^3)	477.987237	906.8476303	948.875645	1214.177594	357.6131907	1058.3692
Earthwork (Controlled)	K	0.037	0.037	0.037	0.035	0.035	0.037
	LS	1.613	0.802	3.125	3.05	2.205	0.492
	C	0.15	0.15	0.15	0.15	0.15	0.15
	P	0.5	0.5	0.5	0.5	0.5	0.5
	Y (tonnes)	6.201696056	5.566343526	24.74987269	27.34522692	5.743502129	4.2200790

5.7 Sediment Basin

A sediment basin is a structure that is typically created by excavating or constructing an embankment across a waterway or other appropriate location to collect and store the sediment from sites cleared, either permanently or temporarily, before re-establishing permanent vegetation and creating permanent drainage structures. It typically comprises an emergency spillway, a riser pipe outlet, a dam, and an impoundment. Similar to sediment that catches sediment before it leaves the building site, the sediment basin operates in a greater catchment region. The basin will be routinely maintained as a temporary remedy until the site area is totally secured from erosion and a permanent detention basin or water quality control structure is developed.

Design Criteria

The tables below show the design criteria and sediment basin requirements from MSMA.

Table 12.15: Design Criteria of Sediment Traps for Sediment Control

Parameter	Requirement
Runoff Quantity Design	Up to 10-year ARI
Runoff Quality Design	First 50 mm rainfall over contributing (equivalent impervious) catchment
Overspill	All flow up to 10-year ARI shall safely bypass the trap
Runoff Retention	All flow up to runoff quality design flow shall be retained within basin. Extended drawdown can be permitted by authority when deem necessary.
Flood Protection	Ensure upstream/ downstream flooding condition not aggravated
Maximum Contributing Area	2 ha
Storage Volume	• Total Storage: 125 m^3/ ha of contributing area • Permanent Pool: half of total storage
Basin Dimension	• Minimum length to width ratio: 2:1 • Minimum depth of 1 m • Depths exceeding 2 m are not recommended. In unavoidable circumstances, provide perimeter fencing for safety
Embankment	• Inside embankment: 2(H):1(V) or flatter • Outside embankment: (3(H):1(V) or flatter • Maximum embankment height should not exceed 1.5 m
Lining Materials	Suitable size rocks or rip rap
Erosion Protection	Outlet protection shall be provided for the emergency spillway

Table 12.16: Sediment Basin Types and Design Considerations

Category	Soil Description	Hydrological Soil Group	Basin Type	Design Considerations
I	Coarse-grained sand, sandy loam: less than 33% <0.02 mm	A	Dry	Settling velocity, sediment storage
II	Fine-grained loam, clay: more than 33% < 0.02 mm	B	Wet	Storm impoundment, sediment storage
III	Dispersible fine-grained clays: more than 10% of dispersible material	C, D	Wet	Storm impoundment, sediment storage, assisted flocculation

Table 12.17: Design Criteria of Sediment Basin for Sediment Control

Parameter	Requirement
Basin Type	Refer Table 12.16
Runoff Quantity Design	Up to 10-year ARI
Runoff Quality Design	First 50 mm rainfall over contributing (equivalent impervious) catchment
Runoff Control	• All flow up to runoff quality design shall be retained within the trap • The basin should drain within 24 hours (dry)/ 36 hours (wet) after the water quality design storm. • The primary outlet/riser should be used to control stormwater runoff. • The Emergency spillway should safely conveying flows up to 10-year ARI
Flood Protection	Ensure that upstream/ downstream flooding conditions do not aggravate possible failure of the embankment.
Minimum Contributing Area	2 ha
Storage Volume	Total Storage: Refer Table 12.18 (dry) or Table 12.19 (wet) Settling zone volume: half of total storage Sediment zone volume: half of total storage
Basin Dimension	• Minimum length to width ratio: 2:1 • Maximum length to settling depth ratio: 200:1 • Minimum settling zone depth: 0.6 m • Minimum sediment storage zone depth: 0.3 m
Embankment	Side slope: (2(H):1(V) or flatter
Erosion Protection	Outlet protection shall be provided for the emergency spillway
Sediment Trapping	90% of Total Suspended Solids Removal
Maintenance Frequency	Determined by dividing sediment storage capacity by the amount of sediment collected in a water quality design storm

Table 12.18: Dry Sediment Basin Sizing Criteria

Parameter	Time of Concentration of Basin Catchment (minutes)				
	10	20	30	45	60
Surface Area (m^2/ha)	333	250	200	158	121
Total Volume (m^3/ha)	400	300	240	190	145

REFERENCE	CALCULATION	OUTPUT
***Table 12.16 (MSMA 2nd edition, 2012)**	**Sediment basin** **(In catchment area A)** Type of sediment basin: Dry sediment basin	Basin type: dry
***Table 12.18 (MSMA 2nd edition, 2012)** ***Table 12.17 (MSMA 2nd edition, 2012)**	**Basin dimension:** When tc=20 mins , A=250 , V= 300 When tc=30 mins , A=200, V=240 Since, tc= 28.6 mins -by using interpolation method A= 207 m^2 / ha V= 248 m^3 / ha **Catchment area**= 4.4013476 ha **Surface area of basin required,A** =4.4013476 x 207 =911.0789532 m^2 **Total basin volume required,v** =4.04013476 x 248 = 1093.294744 m^3 **1) Setting zone** V1= 546.647372 (half of the total volume) ,	 A= 911.0789532 V= 1093.294744 V1= 1062.81 y1= 0.6

	SelectingY1 =0.6 Trying a setting zone average width, W1 =21 L1= V1 / W1 x Y1 L1= 46 Checking settling zone ratio: L1 / Y1 = 77 OK L1 / W1 = 2.1 OK Average surface area design= 46 x 21= 966 m^2 **2)Sediment storage zone** The required sediment storage zone volume is half the total volume, V2= 546.647372 For a side slope Z= 2(H):1(V) W2= W1- 2 x Y1/2 x Z = 21-2 X 0.6/2 X 2 =19.8 L2= L1-2 x Y1/2 x Z = 46-2 X 0.6/2 X 2 =44.8 V2=Z^2xY2^3-2Y2^2(W2+L2)+y2(W2L2)	W1= 21 L1= 46 Ad= 966 m^2 (ok) LET W2 = 20 LET L2 = 45

	546.647372= 4Y^3 -128Y^2+855Y X1= 23 X2= 8.3 X3= 0.7139635619 By taking Y2= 0.7 m Therefore, V2= 567.672 m^3	SINCE, 0.7>0.3 567.672 > 546.647372 (OK) V2 prov > V req
	3)Overall basin dimensions Wb=W1-2 x Z x (y1/2+Y2) = 21- 2 x Z x (0.6/2 + 0.7) = 17 Lb=L1-2 x Z x(Y1/2+Y2) = 46 -2 x 2 x (0.6/2 + 0.7) = 42	Wb= 17 Lb= 42
***Table 12.7 (MSMA 2nd edition, 2017)**	Depth: Y1= 0.6 Y2= 0.7	

	Z = 2(H):1(V) **4)Sizing of basin outlet** -The ARI is 10 years	
***Equation 2.2 (MSMA 2nd edition, 2012)**	Q required= Q2 - Qriser **1) Determination of Q10** CONSTANTS: y= 63.5073 k= 0.383 n= 0.8202 t= 10 theta= 0.2881 b= 0.69 h= 0.9 I = y T^k / (d+theta)^n = 191.140714 C= 0.3 Q10= (C x I x A) / 360 = 0.7 m^3/s	

*Equation 2.10 and table 2.7 (MSMA 2nd edition, 2012)	**2) Determination of Qriser** Qriser = Co Ao = 0.6 (pi (0.6)^2) /4) (2 x 9.81 x 0.3) = 0.4 m^3/s 3) Sizing spillway Qrequired = 0.7-0.4= 0.3 m^3/s Q spillway=Csp x B x HP^1.5 = 1.53 x 0.69 x 1.1^1.5 = 1.22 m^3/s **5) Total basin depth including spillway** Therefore, Total basin depth = 0.6+0.7+1.1+0.9 = 3.3	Q10= 0.7 m^3/s Qriser= 0.4 m^3/s Qspillway = 1.22>0.3 (ok)

	6) Trapping efficiency From the earthwork uncontrolled Y= 82.67345752 tonnes Sediment trapped = Y= 82.67345752 x 90 / 100 =74.40611177 Total sediment trapped =74.40611177 / 1.6 =46.50347347365 Trapping efficiency = 90% -It would require 546.647372 / 46.50347347365 = 11	

5.5.3.3 RESULTS OF DRY SEDIMENT BASIN DESIGN

SETTING ZONE

Catchment Area	Area, A (ha)	Tc (mins)	A (m^2)	V (m^3)	Y1 (m)	W1 (m)	L1 (m)	Aavg (>A (m^2))	L1/Y1 (<200)	L1/W1 (>2)	V1 (m)	CONDITI
A	4.4013476	28.63665054	911.0789532	1093.294744	0.6	21	46	966	77	2.1	546.647372	ok
B	5.0490224	35.84944054	927.8083562	1114.150943	0.6	21	46.5	976.5	77.5	2.2	557.0754715	ok
C	5.6474085	31.05041702	1111.974734	1334.670876	0.6	21	56	1176	93	2.7	667.335438	ok
D	6.6787183	36.8927435	1206.710822	1449.281871	0.6	21	60.5	1270.5	101	2.9	724.6409355	ok
E	3.2739579	29.0937194	667.9139359	803.4292687	0.6	21	33.5	703.5	56	1.5	401.7146344	not ok
F	6.0798544	33.50267416	1156.388307	1388.233421	0.6	21	58	1218	97	2.6	694.1167107	ok

SEDIMENT STORAGE ZONE

Catchment Area	Area, A (ha)	A (m^2)	V (m^3)	V2req (m)	L2 (m)	W2 (m)	Y2 (m)	V2prov (>V2req(m^3))	condition
A	4.4013476	911.0789532	1093.294744	546.647372	45	20	0.7	567.672	ok
B	5.0490224	927.8083562	1114.150943	557.0754715	45.5	20	0.7	574.182	ok
C	5.6474085	1111.974734	1334.670876	667.335438	55	20	0.7	697.872	ok
D	6.6787183	1206.710822	1449.281871	724.6409355	59.5	20	0.7	756.462	ok
E	3.27395798	669.5243906	803.4292687	401.7146344	32.5	20	0.7	404.922	ok
F	6.0798544	1156.388307	1388.233421	694.1167107	57	20	0.7	723.912	ok

OVERALL BASIN DIMENSION

		Top of water level		Base	Base	Depth	Depth
Catchment Area	Area, A (ha)	Wtwl (m)	Ltwl (m)	Wb (m)	Lb (m)	Y1 (m)	Y2 (m)
A	4.4013476	19.8	44.8	17	42	0.6	0.7
B	5.0490224	19.8	45.3	17	42.5	0.6	0.7
C	5.6474085	19.8	54.8	17	52	0.6	0.7
D	6.6787183	19.8	59.3	17	56.5	0.6	0.7
E	3.27395798	19.8	32.3	17	29.5	0.6	0.7
F	6.0798544	19.8	56.8	17	54	0.6	0.7

SIZING BASIN OUTLET

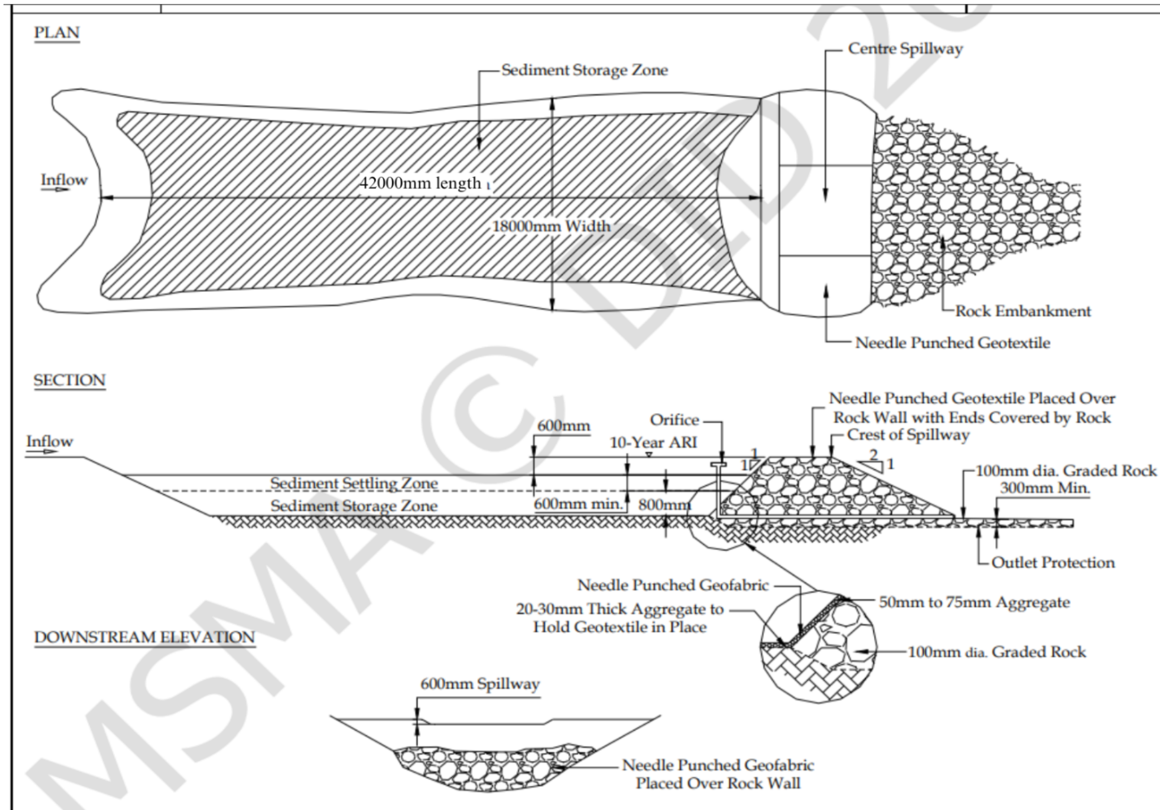
Catchment Area	Area, A (ha)	Q10 (m^3/s)	Q riser (m^3/s)	Qreq (m^3/s)	Hp (m)	Csp (m)	Q Spillway (m^3) (>Qreq)	Condition
A	4.4013476	0.7	0.4	0.3	1.1	1.53	1.22	ok
B	5.0490224	0.71	0.4	0.31	1.1	1.53	1.22	ok
C	5.6474085	0.86	0.4	0.46	1.1	1.53	1.22	ok
D	6.6787183	0.94	0.4	0.54	1.1	1.53	1.22	ok
E	3.27395798	0.52	0.4	0.12	1.1	1.53	1.22	ok
F	6.0798544	0.89	0.4	0.49	1.1	1.53	1.22	ok

TOTAL BASIN DEPTH INCLUDING SPILLWAY

Catchment Area	Y1 (m)	Y2 (m)	Hp (m)	Ho (m)	Total Depth (m)
A	0.6	0.7	1.1	0.9	3.3
B	0.6	0.7	1.1	0.9	3.3
c	0.6	0.7	1.1	0.9	3.3
D	0.6	0.7	1.1	0.9	3.3
E	0.6	0.7	1.1	0.9	3.3
F	0.6	0.7	1.1	0.9	3.3

TRAPPING EFFICIENCY

Catchment Area	Area, A (ha)	Y (tonnes)	Efficiency (%)	Sediment Trapped (Tonnes)	Sediment Trapped (m^3)	V2 req (m^3)	Number of storm events to fill the sediment trap
A	4.4013476	82.67345752	90%	74.40611177	46.50347347	546.647372	11
B	5.0490224	74.21661241	90%	66.79495117	41.74653369	557.0754715	12
c	5.6474085	326.076915	90%	293.4692235	183.4168992	667.335438	14
D	6.6787183	364.7529986	90%	328.2776987	205.1720342	724.6409355	16
E	3.27395798	76.58624032	90%	68.92761629	43.07943947	401.7146344	9
F	6.0798544	56.23722274	90%	50.61350047	31.63320229	694.1167107	15



Engineering Drawing for Dry Sediment Basin for Development Site

5.8 Erosion Control BMP

Erosion, the natural process of soil displacement by wind, water, or other environmental factors, poses significant challenges to land management, construction projects, and environmental stability. Uncontrolled erosion can lead to soil degradation, sediment runoff, and ecological imbalances. To mitigate these issues, erosion control Best Management Practices (BMPs) have been developed and implemented to manage soil erosion and sedimentation effectively.

Erosion control BMPs encompass a range of techniques, strategies, and measures designed to prevent or minimize soil erosion and sediment runoff in various settings, including construction sites, agricultural lands, and natural areas. These practices aim to stabilize soils, promote vegetation growth, control stormwater runoff, and maintain the integrity of ecosystems. One common erosion control BMP is the use of erosion control blankets or matting. These materials, typically made from biodegradable or synthetic fibers, are laid on the soil surface to provide immediate protection against erosive forces. Erosion control blankets help to retain moisture, prevent soil detachment, and promote vegetation establishment by shielding the soil from direct impact of raindrops and surface flow.

Another widely employed BMP is the implementation of sediment basins or detention ponds. These structures are designed to capture and retain sediment-laden runoff, allowing the sediments to settle out before the water is discharged into nearby water bodies. Sediment basins are often combined with sediment traps and sediment filters to enhance their efficiency and prevent sediment pollution downstream.

1. Wash Bay

A wash bay is a wash trough made to wash automobiles, trucks, containers, and other heavy machinery. The used water from each wash bay must be contained there for treatment before being discharged to a sewage network. In order to remove or discharge any silt that attaches to tyres, undercarriages, or even the body of machinery leaving the site, it is often situated near stabilized construction entrance or departure sites. It is crucial to make sure that every piece of construction equipment leaving the site gets washed at this wash bay. This makes sure that any debris from the building site is never present on the municipal roads. To guarantee that the equipment is clean before entering the site, every piece of machinery that enters must also pass through this wash trough. The accumulated sediment in the wash rack must be removed frequently to maintain the performance and efficiency of the wash-through system.

2. Silt Fence

In order to accommodate minor overland sheet flow, a silt fence is a temporary sediment management barrier that is used to hold sediments from sparsely vegetated regions. It is regarded as an on-site control and works best for securing the perimeter of the site, defending the topsoil stockpile, and stopping sheet flow along slope contours. It is a temporary sediment barrier made of wire fence backed by filter fabric, depending on the strength of the fabric chosen, stretched across and fastened to supporting poles. Regular examination is necessary for silt fence maintenance since it is susceptible to damage, particularly after rain. It is utilized during the earthwork phase up until the land disturbance operations are sufficiently finished to permit the start of permanent soil stabilization. A silt fence is usually made of porous fabric that and if the fabric fence is torn, where there will exist gaps between the fabric and ground, the fence should be replaced with a new one immediately.

3. Hydroseeding Methods

A planting technique called hydroseeding stabilizes and shields the soil's surface from precipitation and runoff from disturbed regions. It may efficiently finish in a short amount of time to cover a very vast region.

It may be particularly useful for preventing erosion on hill slopes and establishing grass quickly. Following the grading phase, which can be finished in one step or numerous ones, the hydroseeding should be carried out right away. When a combination of seeds is applied using the one-step hydroseeding method, the multiple-step approach enables the most possible direct contact of the seeds sown with the soil. Hydroseeding is to be used to stabilize the slope surfaces on both cut and fill slopes.

Conclusion

Vegetative measures, such as the establishment of erosion-resistant vegetation or the use of grassed waterways, are effective erosion control BMPs in both agricultural and construction contexts. By establishing a dense network of plant roots, vegetation stabilizes the soil, reduces surface runoff, and enhances infiltration, thus minimizing erosion and sediment transport. Grassed waterways, in particular, are strategically designed channels planted with erosion-resistant grasses that effectively convey runoff, preventing gully formation and promoting sediment deposition.

Additionally, erosion control BMPs often include the use of mulching materials, sediment barriers, silt fences, and erosion control logs. Mulching involves the application of organic or synthetic materials on the soil surface to provide temporary protection against erosion and encourage vegetation growth. Sediment barriers, silt fences, and erosion control logs are physical barriers placed strategically to slow down and filter sediment-laden runoff, preventing its migration and allowing sediment to settle.

The selection and implementation of erosion control BMPs depend on factors such as the type and severity of erosion, site conditions, climate, and project goals. Effective erosion control measures not only protect soil resources and prevent sediment pollution but also contribute to the overall ecological health, water quality, and long-term stability of landscapes.

In conclusion, erosion control BMPs play a crucial role in managing and mitigating the detrimental effects of erosion. By employing a combination of techniques and practices, including erosion control blankets, sediment basins, vegetation establishment, and physical barriers, these BMPs help to stabilize soils, control runoff, and protect the environment. Through the implementation of these measures, we can foster sustainable land management practices, preserve natural resources, and ensure the long-term integrity of our ecosystems.

6.0 COST AND ESTIMATING

6.1 Introduction

Estimating the cost of a construction project is an analytical calculation process based on construction methods, volume of work, and availability of various resources, all of which form an optimal implementation operation that requires financing. Cost estimation plays an important role in the implementation of construction projects. Estimating activity is one of the main processes in a construction project to find out the amount of funds that must be provided for a building. In general, a construction project requires a large amount of money. Inaccuracies that occur in its provision will have a negative impact on the parties involved in it. For project owners (owners), cost estimates are needed as a guide in determining the policies used to determine the amount of investment that must be carried out.

This estimation process is also to reduce costs outside the budget which will cause problems later. From the estimation process itself we can determine the cost of infrastructure to be used, this also helps us to measure the level of quality of work and the results later. In addition, its role as a complement to cost estimating is to provide support and evidence assisting the process of planning and efficient distribution of labor for the right flow of projects and reducing wastage or additional costs in handling materials or labor on site. The total gross costs are usually accumulated from all the departments that need sufficient funds to ensure the work is completed.

The Earthwork Department has the task of reviewing the project site which will then propose a cost estimate for working on the land. This includes site preparation (site clearing), excavation, grading, compaction, soil stabilization, drainage, erosion control, and site restoration. From the estimated cost provided by the earthwork department, a cost reduction of more than 20% was carried out from the initial plan set.

6.3 Earthwork Specifications

6.3.1 Site Clearing

Site clearing in earthwork is the process by which a construction site or portion of site is cleared of any elements that may get in the way of the construction process, such as shrubs, vegetation, rocks, and other debris. The goal of site clearing is to create a construction site conducive to the project, allowing the construction team to start working on building the actual structure. Site clearing is different from clearing and grubbing, which is a more specific term that refers to the removal of all vegetation (clearing) and roots that may remain in the soil (grubbing) after a site has been surveyed and demolition (if necessary)

The site clearing process typically includes the following steps:

1. Site inspection and assessment: The first step is to inspect and assess the site to determine the extent of the work required. This involves examining the site, identifying any obstacles or hazards, and determining the best way to proceed with the clearing process.

2. Marking the boundaries: Once the assessment is complete, the site boundaries are marked to ensure that the clearing process only takes place within the designated area.

3. Tree removal: Trees are removed using chainsaws, stump grinders, and other specialized equipment. The trees are cut down to the ground, and the stumps are either left in place or removed using stump grinders.

4. Clearing of underbrush and debris: The underbrush and debris are removed using specialized equipment such as bulldozers, excavators, and backhoes. The debris is then loaded onto trucks and hauled away from the site.

5. Rock removal: Any rocks or boulders that are found on the site are removed using specialized equipment such as rock hammers, rock drills, and explosives.

6. Soil excavation: The top layer of soil is excavated using bulldozers and backhoes to expose the subgrade. This process is necessary to ensure that the site is level and stable.

7. Disposal of waste: Once the clearing process is complete, the waste materials are transported to a landfill or recycling center for proper disposal.

It is important to note that the site clearing process must be carried out in compliance with all relevant environmental regulations and permits. The use of heavy equipment and machinery can have a significant impact on the surrounding environment, so it is important to take measures to minimize any adverse effects.

6.3.2 Excavation

Excavation is a process in construction that involves the removal of top soil 150mm deep, rock, or other materials from a site to create a space for the construction of a building, infrastructure, or other structures. Excavation is typically carried out using heavy equipment such as excavators, backhoes, bulldozers, and loaders, and may involve the use of explosives to remove rock or other hard materials.

The purpose of excavation is to create a foundation or a trench for laying underground pipes or cables, creating space for basements or underground parking, preparing a site for landscaping or water features, or creating space for retaining wallsor other structures. Excavation can also be used to remove contaminated soil, rocks, or other materials that may pose a risk to public health or the environment. Excavation is a critical process in construction, and it must be carried out with care and attention to safety to prevent accidents and damage to the surrounding environment. It is important to ensure that proper safety measures are in place, and that the excavation work is carried out by experienced professionals who have the necessary equipment, training, and expertise to complete the project safely and efficiently.

6.3.3 Cut and Fill

Cut and fill earthwork refers to a construction process that involves excavating and removing soil (cut) from one area and using it to fill and raise the ground level (fill) in another area to achieve the desired topography for a construction project. In more detail, here's the breakdown of the two components:

- Cut: The cut refers to the excavation and removal of soil or other materials from the ground. This process typically involves the use of heavy machinery, such as excavators or bulldozers, to dig into the ground and remove the excess material. The cut is necessary when the existing ground level is higher than the desired level for the construction project. The excavated soil is usually loaded onto trucks and transported away from the site.
- Fill: The fill refers to the process of using the excavated soil or other suitable materials to raise the ground level in a specific area. This is done when the existing ground level is lower than the desired level. The excavated soil is placed and compacted in layers to ensure stability and proper support for the construction. The fill process may also involve additional materials, such as gravel or rocks, to enhance stability and drainage.

Cut and fill earthwork is commonly employed in various construction projects, such as road construction, building foundations, land grading, and site development. It allows for the modification of the terrain to accommodate the desired structures or infrastructure while ensuring proper stability and drainage in the project area.

6.3.4 Grading

Grading in earthwork refers to the process of leveling or shaping the ground's surface to a desired slope or elevation. Grading is a crucial aspect of construction projects such as building foundations, roadways, and drainage systems. The grading process involves several steps, including site preparation, excavation, filling, compaction, and final grading. The first step is to clear the site of any vegetation or debris that might interfere with the grading process. The next step is excavation, where soil is removed from high areas and deposited inlow areas to create a level surface.

The quality of the grading work is critical to the success of a construction project. Poor grading can result in foundation settling, drainage problems, and other issues that can compromise the safety and stability of the structure. Therefore, it's essential to work with a qualified and experienced grading contractor who understands the requirements of the project and can execute the work with precision and care.

6.3.5 Compaction

Compaction in earthwork is the process of increasing the soil's density and stability by removing air voids between soil particles. This process is essential in the construction of foundations, roads, and other infrastructure projects where stability and load-bearing capacity are critical. The process of compaction involves the use of heavy machinery, such as a vibratory roller or plate compactor, to apply force to the soil. The equipment applies pressure to the soil surface, causing the soil particles to move closer together and reducing the volume of air voids. The compaction process increases the soil's density and reduces its permeability, making it more resistant to settling, erosion,and other forms of damage. The degree of compaction required depends on the type of soil and the intended use of the project. The compaction specification is usually determined by soil engineers and is based on the soil's properties, such as its moisture content, grain size distribution, and plasticity index. Inadequate compaction can result in soil settling, which can cause damage to the structure built on it.

Overcompaction can also be a problem, as it can cause the soil to become too dense and reduce its permeability, resulting in drainage issues. Therefore, it is essential to work with an experienced earthwork contractor who understands the compaction requirements of the project and has the proper equipment to achieve the necessary degree of compaction.

6.3.6 Soil Stabilization

Soil stabilization in earthwork refers to the process of improving the stability and load-bearing capacity of soil through various methods. This is often necessary in construction projects where the soil conditions are poor, and the soil needs to be strengthened to support the weight of the structures being built. There are various methods of soil stabilization, including:

1. Chemical Stabilization: This involves adding chemical agents to the soil to improve its strength and stability. These chemical agents can include lime, cement, or fly ash. The chemicals react with the soil to increase its density, reduce its permeability, and improve its load-bearing capacity.
2. Mechanical Stabilization: This method involves mixing the soil with other materials, such as gravel or crushed stone, to increase its strength and stability. This process is often used in road construction projects where the soil needs to be strengthened to withstand heavy traffic loads.
3. Geosynthetic Stabilization: This involves the use of geosynthetic materials, such as geotextiles or geogrids, to improve the soil's stability. These materials are placed between the soil layers and act as a reinforcing layer to distribute loads and reduce soil movement.

The method of soil stabilization used depends on various factors such as the soil type, the intended use of the project, and the budget. The stabilization process should be carried out by experienced earthwork contractors who understand the soil's properties and can select the appropriate stabilization method to achieve the desired results.

6.3.7 Erosion Controlling

Erosion control in earthwork refers to the measures and techniques used to prevent or reduce soil erosion during construction projects where the soil is exposed. Soil erosion is a natural process, but it can be accelerated during construction activities due to the removal of vegetation, grading, and excavation.

Erosion control measures in earthwork can include the use of erosion control blankets, vegetation cover, mulching, terracing, and drainage control. Erosion control blankets are temporary or permanent blankets made of natural or synthetic materials that are placed over the soil to reduce erosion. Vegetation cover involves planting vegetation such as grass, shrubs, or trees on the soil surface to reduce erosion. Mulching involves the application of a layer of organic material, such as straw or wood chips, to the soil surface to slow down water and wind. Terracing involves creating steps or terraces on slopes to reduce the speed of water and prevent it from carrying away soil. Drainage control measures such as installing swales, culverts, and erosion control pipes can help manage water flow and reduce soil erosion. Effective erosion control measures should be implemented early in the construction project and monitored continuously to ensure their effectiveness. Proper selection and application of erosion control techniques can help prevent soil erosion and ensure the stability and durability of the construction project.

6.3.8 Site Restoration

Site restoration is the process of returning a construction site to its original condition or an agreed-upon state after construction activities are completed. The goal of site restoration is to ensure that the land is usable and safe for future generations. The process of site restoration may include:

1. Removing all debris and waste materials: This involves cleaning up the site and removing all construction debris, including building materials, waste materials, and equipment.
2. Restoring vegetation: This involves replanting vegetation or restoring the natural landscape that was present before the construction began. The goal is to re-establish a healthy ecosystem and promote biodiversity.
3. Grading and leveling the site: This involves restoring the site to its original contours and removing any excess or uneven soil that may have been left behind during construction.
4. Restoring water features: If any water features, such as streams or ponds, were disturbed during construction, they should be restored to their original state or improved upon to promote better water management.
5. Installing erosion control measures: If any erosion control measures were installed during construction, they may need to be maintained or replaced to ensure that the site remains stable and erosion-free.

Site restoration is an important part of any construction project, as it helps to minimize the impact of the construction on the surrounding environment and promotes sustainability. Proper planning and implementation of site restoration measures can help to ensure that the site is restored to its original condition or an agreed-upon state, making it safe and usable for future generations.

6.4 Equipments and Machineries

Given that our company is in its early stages, we currently possess a limited number of owned machinery. To efficiently manage our resources, we prioritize the use of our in-house equipment for all earthwork operations before renting additional machinery to ensure the successful completion of projects. This approach allows us to maintain cost-effectiveness and optimize resource allocation while gradually expanding our inventory of machinery as the company grows.

On the other hand, in the process of machinery and equipment selection, each piece of machinery employed in the process underwent a meticulous selection procedure. After examining various options, the final choice was narrowed down to 3 or 4 models. This decision took into account several crucial factors, including budget constraints, the desired production rate, and the specific model's features and capabilities. By prioritizing these criteria, the most suitable machinery was selected to ensure optimal performance and efficiency in the given project or task. This careful approach to machinery selection also helped minimize potential issues and maximize overall productivity.

6.4.1 *Chainsaw*

Brand: STIHL
Model: MS382

A chainsaw is a portable mechanical saw that features a rotating chain with sharp cutting teeth along its edge. It is primarily used for cutting and trimming wood, particularly in the context of construction and forestry. The main purpose of a chainsaw in construction is to cut and remove trees, branches, and wood materials.

6.4.2 *Excavator*

Brand: Komatsu
Model: PC300SE-7
Capacity: 2.3m³

An excavator is a heavy construction machine that is primarily used for digging and moving large amounts of earth, soil, rocks, and other materials. It is a versatile piece of equipment commonly found on construction sites and is designed to handle a wide range of tasks. Excavators are equipped with a bucket or a scoop-like attachment at the end of a hydraulic arm, known as the boom, which provides the digging capability. These machines are involved in digging and removing materials from the ground to create foundations, trenches, ditches, and other excavations required for construction projects.

6.4.3 ***Wheel Loader***

Brand: Komatsu
Model: WA380-6
Bucket Capacity: 2.7 - 4.0 m^3

A wheel loader, also known as a front loader or bucket loader, is a heavy equipment machine commonly used in construction, mining, and agricultural industries. It is characterized by a large front-mounted bucket or scoop-like attachment that is operated by hydraulic arms. The bucket is used for lifting, loading, and transporting various materials within a construction site. Its main purpose is to handle bulk materials efficiently.

6.4.4 *Bulldozer*

Brand: Komatsu
Model: D475A-5 SD

A bulldozer is a powerful, heavy construction machine equipped with a large metal blade at the front and a crawler track system for mobility. It is primarily designed for pushing, grading, and leveling materials on construction sites. The blade can be adjusted for different angles and depths to perform various tasks. The main purpose of a bulldozer in construction is earthmoving and land clearing.

6.4.5 ***Dump Truck***

Brand: Hitachi
Model: EH600
Operating Weight: 56912 kg

A dump truck, also known as a tipper truck or dumper truck, is a heavy-duty truck specifically designed for transporting loose materials, such as soil, gravel, sand, rocks, and construction debris. It is equipped with a hydraulic lifting mechanism that allows the truck bed or cargo container to be tilted and emptied, facilitating the efficient unloading of materials at the destination. The main purpose of a dump truck in construction is the transportation and delivery of bulk materials.

6.4.6 *Roller*

Brand: Caterpillar
Model: CS76 XT
Compaction width: 2134 mm

A roller, also known as a road roller or compactor, is a heavy construction machine used for compacting and smoothing surfaces. It is primarily used in road construction, pavement maintenance, and other construction projects that require the compaction of soil, asphalt, or other materials. Rollers exert pressure on the surface to compress and level it, enhancing its strength, stability, and smoothness. The main purpose of a roller in construction is compaction and achieving proper density.

6.4.7 *Motor Grader*

Brand: Komatsu
Model: GD705-S
Grading width: 4320 mm

A motor grader, also known as a grader or road grader, is a heavy construction machine specifically designed for grading, leveling, and maintaining the surfaces of roads, highways, and other construction projects. It is equipped with a long, adjustable blade located beneath the center of the machine. The main purpose of a motor grader in construction is to create smooth and properly graded surfaces.

6.5 Cost of Consideration

For a comprehensive earthwork cost estimation, several necessary factors must be taken into consideration such as:

A. Volume
   i. Cut Quantity
   ii. Fill Quantity
A. Labor
   i. Skillset
   ii. Local or Foreigner
   iii. Rate per hour/day

iv. Project Size

A. Equipment

i. Usage hours

ii. Fuel Consumption

iii. Productivity Rate

iv. Operator

A. Material

A. Profit (20%)

6.6 Proposed Level

In order to meet the project specifications, the difference between the cut and fill volumes must be less than 15%. This is to ensure stability and safety in earthwork projects. When the difference between cut and fill slopes is significant, it can result in instability and potential slope failure due to the uneven distribution of weight and soil pressures. This can also cause problems with erosion and drainage. According to the Federal Highway Administration (FHWA), the maximum allowable difference between cut and fill should be no more than 15% to prevent slope instability and ensure safety in road construction projects. This guideline is also recommended by the American Society of Civil Engineers (ASCE) and the National Cooperative Highway Research Program (NCHRP). The percentage difference is determined through the use of Grid Technique, which is used to determine the cut and fill volumes.

6.7 Cost Estimation (Raffi)

6.7.1 Bill of Quantities

Table 6.7.1 - Bill of Quantities Before Cost Reduction

BILL NO	ACTIVTIES	UNIT	QUANTITY	RATE	COST (RM)
1	Removal of trees on site	nos	5378.0	74.6	405312.0
2	Excavation of top soil	m^3	54417.5	5.6	305136.0
3	Cut to formation level	m^3	576588.5	0.8	451200.0
4	Importing	m^3	62982.0	2.3	176688.0
5	Hauling	m^3	639570.5	2.8	1796328.0
6	Fill to formation level	m^3	639570.5	2.2	1425600.0
7	Compaction	m^3	639570.5	0.4	224647.2
8	Grading	^{2}	362783.4	0.0	3938.4
9	Imported Soil	m^3	62982.0	13.0	818765.3
		TOTAL COST			**5607614.9**

Table 6.7.2 - Bill of Quantities After Cost Reduction

BILL NO	ACTIVTIES	UNIT	QUANTITY	RATE	COST (RM)
1	Removal of trees on site	nos	5378.0	74.6	381996.0
2	Excavation of top soil	m^3	54417.5	5.6	263988.0
3	Cut to formation level	m^3	576588.5	0.8	430056.0
4	Importing	m^3	62982.0	2.3	158692.8
5	Hauling	m^3	639570.5	2.8	1700280.0
6	Fill to formation level	m^3	639570.5	2.2	1378080.0
7	Compaction	m^3	639570.5	0.4	197274.0
8	Grading	^{2}	362783.4	0.0	3328.4
9	Imported Soil	m^3	62982.0	13.0	818765.3
		TOTAL COST			**5332460.5**

- Cost Reduction

The project's cost reduction objective was successfully accomplished by employing value engineering techniques, resulting in a 4.9% decrease in expenses. Through this approach, the team was able to identify areas of inefficiency and waste, develop innovative solutions, and implement cost-effective measures without compromising quality or safety.

Moreover, the diagrams presented below outline the details and variances in the earthwork cost estimates for each site clearance activity before and after the successful implementation of cost reduction measures. The diagrams provide a comprehensive breakdown of the costs involved in each activity, highlighting areas where cost reductions were achieved and where further optimization could be possible.

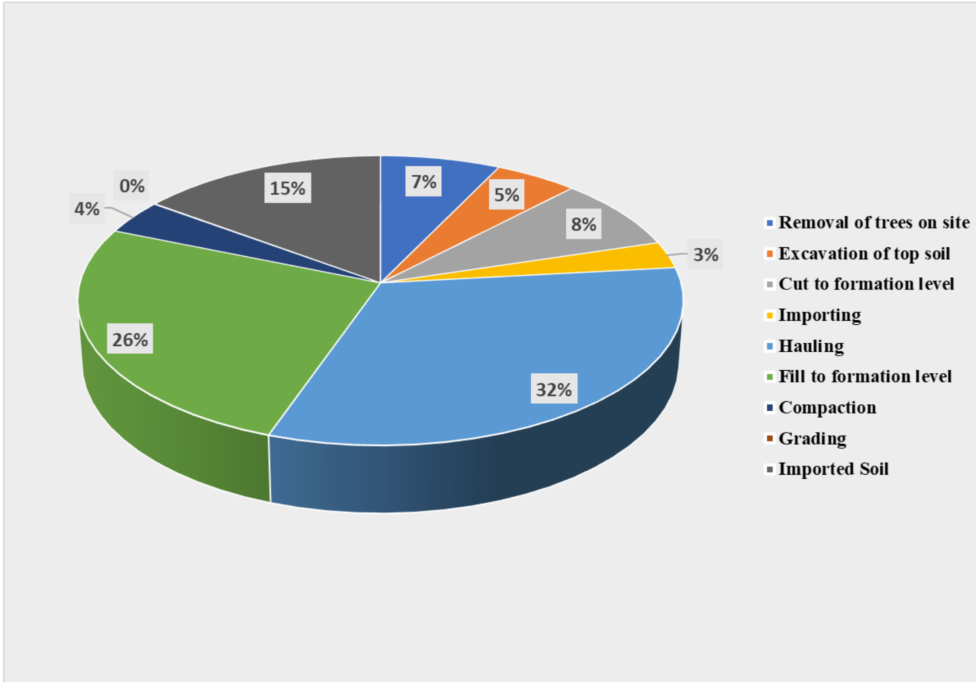


Diagram 6.7.1: Breakdown of Earthwork Cost Estimation Before Cost Reduction

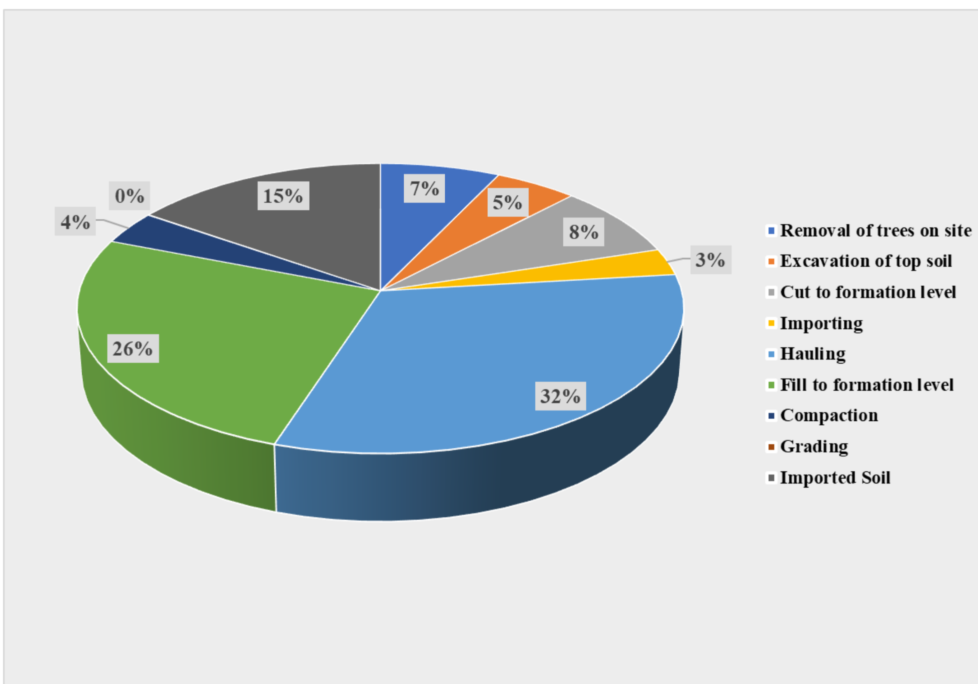


Diagram 6.7.2: Breakdown of Earthwork Cost Estimation Before Cost Reduction

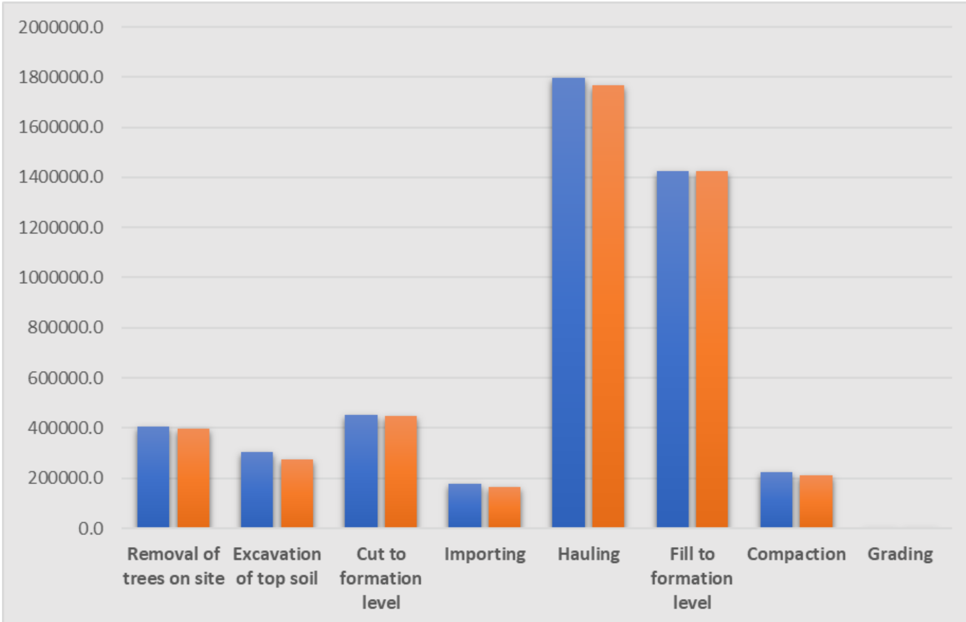


Diagram 6.7.3: Differences of Earthwork Cost Estimation in Each Activities

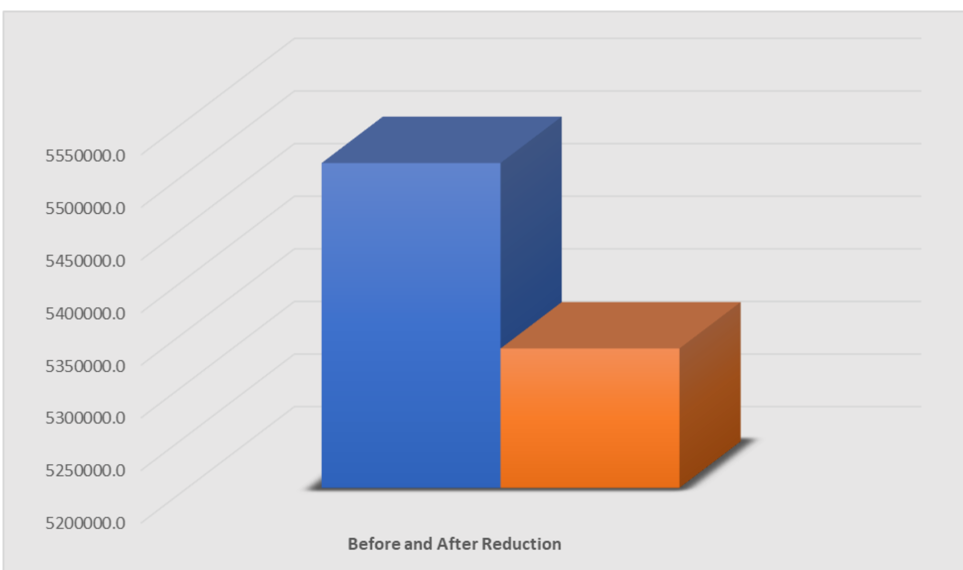


Diagram 6.7.4: Differences of Earthwork Cost Estimation in Each Activities

6.7.2 Project Timeline

In accordance with the clients' specifications, the earthwork project must adhere to a strict six-month timeline to guarantee the seamless progression of all subsequent activities within the project. This tight schedule emphasizes the importance of efficient resource allocation, effective management, and timely execution of tasks to prevent any delays or disruptions in the overall project plan. By meeting this deadline, we can maintain the clients' satisfaction and uphold our reputation for delivering high-quality results within the allotted time frame.

- Table 6.9.1 Timetable Before Cost Reduction

NO	ACTIVITIES	M1				M2				M3				M4				M5				M6		
		W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3
1	Removal of trees on site																							
2	Excavation of top soil																							
3	Cut to formation level																							
4	Importing																							
5	Hauling																							
6	Fill to formation level																							
7	Compaction																							
8	Grading																							

- Table 6.9.2 Timetable After Cost Reduction

NO	ACTIVITIES	M1				M2				M3				M4				M5				M6			
		W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
1	Removal of trees on site																								
2	Excavation of top soil																								
3	Cut to formation level																								
4	Importing																								
5	Hauling																								
6	Fill to formation level																								
7	Compaction																								
8	Grading																								

6.8 Summary of Work

6.8 Before Reduction

6.8.1 Site Clearing

The activity area's processes involve labor required for tree felling and cutting trees into sections using chainsaws. Bulldozers assist in removing tree roots and stumps by pushing them into piles. Excavators help transport the logs from the site to dump trucks, which then carry the logs to the site's boundary. It is assumed that these logs are subsequently sold to the appropriate authorities.

The summary of cost is as shown in the table below:

No.	Equipment/Labor	Unit	Time (days)	Total Cost (RM)
1	Bulldozer	9	16	198720
2	Bulldozer Operator	9	16	17280
3	Labour	25	10	20000
4	Chainsaw	25	10	17500
5	Excavator	2	11	38060
6	Excavator Operator	2	11	3300
7	Dump Truck	3	11	38940
8	Dump Truck Operator	3	11	3960
Total Cost for 5378 trees				337760
Total Cost per tree				62.20
20% profit per tree				12.4
Final Cost for 5378 trees				**405312.00**

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Bulldozer***
References	**Calculation & Description**
	Due to sheer number of trees. Tree counting is not possible thus assume quanity through Quick Method.
Field Manual (FM) No. 5-434	
	Step 1 - Total Area to be cleared (in acres)
	From the gathered data of Earthwork Department;
	Step 2 - Size and Number of dozers
	Dozer size, S = Large Tractor
	Number of bulldozer available, N = 9
	Step 3 - Maximum Tree Diameter
	*Based on geography and surrounding areas,
	Oil Palm Tree = 65 cm = 25.6 inches

	Step 4 - Time required (per acre)
(FM) Table 2-1	*Based on tree diameter
	Time required, D = 8hrs
	Step 5 - Work Efficiency Factor
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 6 - Operating Factor
(FM) Table 2-2	Since most work are done during daytime with an average optimum working capacity,
	Average Operator, O = 0.75
	Step 7 - Total Time (hrs)

	*Divide the total time in hrs by 8 working hrs
	Step 8 - Total Cost
	Bulldozer
	Brand: *Komatsu*
	Model: *D475A-5 SD*
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Rental cost per day = RM 950
	Cost of diesel = RM 2.15/liter
	Average diesel consumption for bulldozer = 25L/hr
	Total cost of diesel per bulldozer
	= RM 2.15 x 25 x 8 = 430 RM/day
	Total cost for 9 bulldozers
	= RM (950 +430) x 16 x 9 = RM 198720
	<u>Bulldozer Operator</u>
	Number of operator = 9
	Labor details
	Bulldozer Operator, Skilled, and Local
Quantity Surveyor Online Website - Labour Rates	

	Labor wage per day based on average listing for machine operator
	= RM 120/day
	Total cost
	= RM 120 x 9 x 16
	= RM 17280
	<u>Labour</u>
	Number of trees present in site
	Total Area of site = 89.64 acres
Site Visit (Google Earth)	Assumed average number of trees = 60 trees per acre
	Total number of trees
	= 89.64 acres x 60 trees
	= 5378 trees
Field Manual (FM) No. 5-434	Based on output efficiency, the total time it takes to fell a tree plus delays ≈ 5 minutes
	Assume number of available labour = 25
	Time required to fell corresponding trees
	Taking into consideration the maximum height of an oil palm tree which can reach upto 66 feet, roughly 20 meters tall.
	The length of a the cargo truck is 5.5m. Thus, the trees should be cut into averagely 20/5 = 4 sections

	Assume a labourer will take roughly 4 minutes to saw each section.
	Each tree will take 16 mins to be cut into 4 smaller sections.
	Required number of trees to be cut = 5378 trees
	Time required to cut all tree into logs
	Total time required to fell trees and cut into smaller sections
	= 18 hrs + 57 hrs = 75 hours = 9.4 days ≈ 10 days
Quantity Surveyor Online Website - Labour Rates	Labour details:
	General Labour, Local, Skilled
	Labor wage per day based on average listing for general construction
	= RM 80/day
	Total labour wage rate
	= RM 80 x 10 x 25
	= RM 20000
	<u>Chainsaw</u>
	Brand: *STIHL*
	Model: *MS382*

	No. of chainsaw = 25
	No. of labour = 25
	Assume rental price per 1 chainsaw (including transport)
	= RM 70/day
	Total number of days to cut trees = 10 days
	Total cost
	= RM 70 x 10 x 25
	= RM 17500
	Excavator
	Brand: Komatsu
	Model: PC300SE-7
	Capacity: $2.3m^3$
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Estimation area per logs based on diameter of the trunk
Field Manual (FM) No. 5-434	$= \pi \times (65/2)^2 = 3318$ cm
	Volume per log = $0.3318\ m^2 \times 5\ m = 1.66\ m^3$
	The bucket capacity of the hydraulic excavator = $2.3\ m^3$
	Thus, it is estimated that each trip can only load 1 log
	The cycle time including load, manoeuvre with four reversals of the direction (minimum travel) and dump is estimated to be 15 seconds

	(Expect 50 minutes of production time per hour for a well-managed job)
	Thus, output efficiency for excavator
	= initial time + delaying time due to efficiency factor
	= 15 + (1-0.83)(15) ≈ 18 s/log
https://www.constructionequipmentguide.com/charts/off-highway-trucks/hitachi/eh600/30754685	Dump capacity of cargo dump truck = 21 m^3
	Total number of logs carried per cycle
	= 21/2.3 ≈ 9 logs
	Loading time required for dump truck per trip
	= 9 logs x 18s/log = 162 sec = 2.7 ≈ 3 minutes
	Number of logs = 5378 x 3 = 16134 logs
	The dump truck is required to travel 1793 trips to complete transporting all logs.

	Based on the calculated data, the total time to complete the task
	= 3 mins x 1793
	= 5379 mins ≈ 90 hours ≈ 11 days
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Rental cost per day for excavator = RM 1300
	Cost of diesel = RM 2.15/L
	Average diesel consumption for excavator = RM 25L/hour
	Total cost of diesel per excavator = RM 2.15 x 25 x 8 = RM 430 day
	Total cost for 2 excavator
	= RM (1300 + 430) x 11 x 2
	= RM 38060
	<u>Excavator Operator</u>
	No. of operator = 2
	Details of Labour:
Pocket Costbook, 2020	Plant and machine operator, Skilled, Local
	Labor wage per day based on average listing for excavator operator
	= RM 150/day
	Total Cost
	= RM 150 x 11 x 2
	= RM 3300

	<u>Dump Truck</u>
	Brand: Hitachi
	Model: EH600
	Operating weight: 56,912 kg
	The dump truck is able to carry 9 logs per trip
	Number of trip required per dump truck = 16134/9 ≈ 1793 trips
	Max travelling speed of dump truck = 60km/hr
	Considering construction site speed limit,
	Average travelling speed of dump truck = 30km/hr
	Maximum distance travelled by dump truck = 210 m
	Average distance travelled by the dump truck = 110m
	Travel time per trip = 110/10000/30 = 0.004hr = 0.22 minutes
	Truck cycle time includes time spent traveling to the dump site, unloading, returning to the loading unit, and then being reloaded.
	Assume time to unload = time required for loading = 1 minute
	Loading time per truck = 9 x 1 = 9 minutes
	Dump Truck cycle time = (2 x 0.22) + (2 x 9) = 18.4 ≈ 19 minutes
	Number of trucks required
	= 1 + (truck cycle time/loader cycle time)

	= 1 + (19/9)
	= 3.11 ≈ 3 trucks
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost per dump truck per day = RM 750 /day
	Cost of diesel = RM 2.15/L
	Average diesel consumption for dump truck = RM 25L/hr
	Total cost of diesel per dump truck = RM 2.15 x 25 x 8 = 430 L/day
	Total cost for 3 dump trucks
	= RM (750 + 430) x 3 x 11
	= RM 38940
	Dump Truck Operator
	Number of operators = 3
	Details of Labour:
	Plant and Machine Operator, Skilled, Local
Pocket Costbook, 2020	Labor wage per day based on average listing for dump truck operator
	= RM 120/day
	Total cost for dump truck operators
	= RM 120 x 3 x 11
	= RM 3960

6.8.2 Excavate Topsoil

The activity's processes can be outlined as follows: bulldozers play a crucial role in stripping away the topsoil, while wheel loaders efficiently transfer the soil to dump trucks. These dump trucks are then responsible for transporting the soil to designated stockpile locations.

The summary of cost is shown in the table below:

No.	Equipment/Labor	Unit	Time (days)	Total Cost (RM)
1	Bulldozer	5	11	75900
2	Bulldozer Operator	5	11	6600
3	Wheel Loader	5	7	30030
4	Wheel Loader Operator	5	7	5250
5	Dump Truck	15	7	123900
6	Dump Truck Operator	15	7	12600
Total Cost for 54417.51 m³				254280
Total Cost per m³				4.67
20% profit per m³				0.93
Final Cost for 54417.51 m³				**305136.00**

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Bulldozer***
References	**Calculation & Description**
	Area to be stripped = 362783.42 m²
	Volume of soil to be stripped
	= 362783.42 x 0.15
	= 54417.51 m³
	= 71175.42 BCY
	Based on the soil type present, the soil classification for out given zone is Sandy Silt

https://www.soilquality.org.au/factsheets/bulk-density-measurement	Loam having bulk density of 1.3-1.7 g/cm³
https://hort.ifas.ufl.edu/woody/critical-value.shtml	Average bulk density = 1.45g/cm³ = 1450 kg/m³
	= 2443.25 pounds/BCY
Table 1-1 (FM) No. 5-434. 15 June 2000	= 1954.6 pounds/LCY
	Utilizing same model of bulldozer as below: -
	Brand: Komatsu
	Model: D475A-5 SD
	Blade capacity: 45.0 m³
	Blade length x height: 6465 mm x 2690 mm
Field Manual (FM) No. 5-434. 15 June 2000	**Step 1 - Determine maximum production of dozer**
	Based on type of dozer (D4 tractors)
	Assuming average dozing distance = 200 ft = 61 m,
	the estimated maximum production with universal blade is
	= 250 LCY/hour
	Step 2 - Determine the correction factors for different ideal conditions
	a) *Grade Correction Factor*
	Assume doom a 10 percent grade,
	Grade correction factor = 1.16
	b) *Material -weight Correction Factor*

	c) *Material-type Correction Factor*
	Since the soil type is a mixture of mostly sandy silt with clay loam, it is assumed that the soil is hard to drift thus having a factor of = 0.8
	d) *Operator Correction Factor*
	Since the work will mostly be done during daylight hours, the operator correction factor = 0.75
	e) *Operating Technique Correction Factor*
	Since the bulldozer utilizes slot dozing, the correction factor = 1.2
	f) *Efficiency Factor*
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 3 - Determine Total Correction Factor
	= 1.16 x 1.18 x 0.8 x 0.75 x 1.2 x 0.83

	= 0.82
	Step 4 - Determine dozer production
	Production (LCY per hour) = maximum production x the product of the correction factors
	= 250 x 0.82
	= 205 LCY/hour/dozer
	Step 5 - Convert production rate LCY per hour to BCY per hour
	Before the stripping process, the soil is in its natural state.
	Thus, LCY will be converted back to BCY
	Soil conversion factor for loam (loose to bank) = 0.8
	Dozer production in BCY = 205 x 0.8 = 164 BCY/hour/dozer
	Step 6 - Determine the total time required to complete the task
	Assume the number of available bulldozers = 5
	11 days
	Step 7 - Determine total cost
	Rental cost per bulldozer = RM 950
	Cost of diesel = RM 2.15/liter

	Average diesel consumption for bulldozer = 25 L/hr
	Total cost of diesel per bulldozer
	= Rm 2.15 x 25 x 8
	= RM 430/day
	Total cost for 5 bulldozers
	= RM (950 + 430) x 11 x 5
	= RM 75900
	Bulldozer Operator
	Number of operator = 5
Pocket Costbook, 2020	Labor details:
	Bulldozer Operator, Skilled, and Local
	Labor wage per day based on average listing for machine operator
	= RM 120/day
	Total cost for 5 bulldozers
	= RM 120 x 5 x 11
	= RM 6600
	Wheel Loader
	Volume of stripped soil = 54417.51 m^3
	However, due to the expansion of soil from bank to loose state

	Loam swelling factor = 1.25
	Volume of soil to be loaded
	= 54417.51 m³ x 1.25
	= 68022 m³
	= 88969.42 BCY
	= 111211.77 LCY
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	***Wheel Loader***
	Brand: Komatsu
	Model: WA380-6
https://www.komatsu.jp/en/worldwide/PDF/WA380-6.pdf	Bucket Capacity: 2.7 - 4.0 m³
Field Manual (FM) No. 5-434	**Step 1 - Determine the material type and the rated heaped-bucket capacity of the loader**
	The soil material type is Sandy Silt Load (Moist Loam)
Table 5-1	**Step 2 - Select the bucket fill factor based on material type**
	The wheel loader fill factor = 1.0
Table 5-2	**Step 3 - Determine the average cycle time based on the size of wheel loader**
	Average bucket capacity = 3.5 m³ = 4.6 BCY = 4.6 LCY

	Average Cycle Times for Wheel Loaders = 0.50 to 0.55 minutes
	Take average cycle time = 0.53 minutes
	(Includes load, maneuver with four reversals of direction (minimum travel), and dump.)
	Step 4 - Determine the Maximum Production Rate
	Step 5 - Determine the efficiency factor
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 6 - Determine the net production rate in LCY per hour
	Net production rate (LCY per hour) = maximum production rate (LCY per hour) x efficiency factor
	= 520 x 0.83
	= 432 LCY per hour

	Step 7 - Determine the time required to complete the task
	Assume the number of wheel loader available = 5
	Step 8 - Determine the total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost per day for wheel loader = RM 600
	Cost of diesel = RM 2.15/L
	Average diesel consumption for wheel loader = RM 15L/hour
	Total cost of diesel for wheel loader = RM 2.15 x 15 x 8 = RM 258 /day
	Total cost for 5 wheel loader
	= RM (600 + 258) x 7 x 5
	= RM 30030
	<u>Wheel Loader Operator</u>
	Number of operators = 5

	Assuming the cost for operator of wheel loader = cost for operator of excavator as both are categorized unde Plant and Machine Operators
	Details of Labour:
	Plant and machine operator, Skilled, Local
	Labor wage per day based on average listing for wheel loader operator
	= RM 150/day
	Total cost for 5 wheel loader operators
	= RM 150 x 7 x 5
	= RM 5250
	Dump Truck
	Brand: Hitachi
	Model: EH600
	Operating weight: 56,912 kg
Field Manual (FM) No. 5-434	**Step 1 - Determine the number of bucket loads required to fill a truck**
	Average wheel loader bucket capacity = 3.5 m^3 = 4.6 BCY = 4.6 LCY
	Dump truck capacity = 56912 kg ≈ 125469.48 pounds
	For loam, unit weight of loam to be transported = 2600 pounds per LCY

	Step 2 - Determine the loading time per haul unit
	Loading time per haul unit = bucket cycle time x number of bucket loads
	= 0.53 x 9
	= 4.77 minutes ≈ 5 minutes
	Step 3 - Determine the number of hauling units needed to support the loading unit
	Max travelling speed of dump truck = 60km/hr
	Considering construction site speed limit,
	Average travelling speed of dump truck = 30km/hr
	Maximum distance travelled by dump truck = 210 m
	Average distance travelled by the dump truck = 110m
	Travel time per trip = 110/10000/30 = 0.004hr = 0.22 minutes
	Truck cycle time includes time spent traveling to the dump site, unloading, returning to the loading unit, and then being reloaded.
	Assuming time required to unload = 3.8 mintues
	Truck cycle time = 0.22 + 0.22 + 3.8 + 3.8 ≈ 8 minutes

	3
	Since the number of wheel loader available is 5, to maintain the output efficiency, the number of dump trucks;
	= 3 x 5
	= 15
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Rental cost per dump truck per day = RM 750 /day
	Cost of diesel = RM 2.15/L
	Average diesel consumption for dump truck = RM 25L/hr
	Total cost of diesel per dump truck = RM 2.15 x 25 x 8 = 430 L/day
	Total cost for 15 dump trucks
	= RM (750 + 430) x 7 x 15
	= RM 123900
	<u>Dump Truck Operator</u>
	Number of operators = 15
	Details of Labour:
	Plant and Machine Operator, Skilled, Local

	Labor wage per day based on average listing for dump truck operator
	= RM 120/day
	Total cost for dump truck operators
	= RM 120 x 15 x 7
	= RM 12600

6.8.3 Cut to Formation Level

In this activity, a hydraulic excavator plays a crucial role in cutting the soil down to the specified reduced levels. This powerful and versatile piece of equipment allows for precise excavation and ensures that the desired depth is reached according to the project's requirements.

The summary of cost is shown in the table below:

No.	Equipment/Labor	Unit	Time (days)	Total Cost (RM)
1	Excavator	5	40	346000
2	Excavator Operator	5	40	30000
Total Cost for 576588.50 m³				376000
Total Cost per m³				0.65
20% cost profit per m³				0.13
Final Cost for 54417.51 m³				451200

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor :	***Excavator***
References	**Calculation & Description**
	Cut Volume
	= 576588.502 m³
	= 754149.29 BCY
Field Manual (FM) No. 5-434. 15 June 2000	
	Hydraulic Excavator
	Brand: Komatsu
	Model: PC300SE-7
	Bucket Capacity: 2.3m³ ≈ 3 yd³

Table 8-1 (FM) No. 5-434. 15 June 2000	**Step 1 - Determine the bucket fill factor based on the material type**
	Since the soil type is a mixture of mostly sandy silt with clay loam, it is assumed that the average fill factor is 100%
	Step 2 - Use a hoe cycle time based on past performance data if available or use the average cycle time
	Assuming the depth of cut between 40 and 60 percent of the machines rated maximum digging depth and a swing angle of between 30° to 60°
	The average cycle time for bucket sizes from 1 cubic yard to less than 2.5 cubic yards
	= 15 seconds
	Step 3 - Determine the ideal production rate (LCY per hour)
	Average bucket capacity of selected hydraulic excavator
	= 3 yd^3
	Step 4 - Determine the production rate (LCY per hour) by adjusting for efficiency
	(Expect 50 minutes of production time per hour for a well-managed job)

	Production rate = ideal production rate (LCY per hour) x efficiency factor
	Step 5 - Convert the production rate from LCY per hour to BCY per hour
	Before the stripping process, the soil is in its natural state.
	Thus, LCY will be converted back to BCY
	Soil conversion factor for loam (loose to bank) = 0.8
	Dozer production in BCY = 597.6 x 0.8 = 478.08 BCY/hour/excavator
	Step 6 - Determine the total time required to complete the task
	Assume the number of excavators = 5
	40 days
	Step 7 - Determine total cost
	Rental cost per excavator = RM 1300
	Cost of diesel = RM 2.15/liter
	Average diesel consumption for bulldozer = 25 L/hr

	Total cost of diesel per excavator
	= Rm 2.15 x 25 x 8
	= RM 430/day
	Total cost for 5 bulldozers
	= RM (1300 + 430) x 40 x 5
	= RM 346000
	<u>Excavator Operator</u>
	No. of operator = 5
	Details of Labour:
	Plant and machine operator, Skilled, Local
	Labor wage per day based on average listing for excavator operator
	= RM 150/day
	Total Cost
	= RM 150 x 40 x 5
	= RM 30000

6.8.4 Importing of Soil

The earthwork project presents a scenario where the cut-to-fill ratio is negative, indicating a higher demand for fill material. As a result, it becomes necessary to source additional soil from external locations to ensure the project's successful completion.

The summary of cost is shown in the table below:

No.	Equipment/Labor	Unit	Time (days)	Total Cost (RM)
1	Wheel Loader	3	10	25740
2	Wheel Loader Operator	3	10	4500
3	Dump Truck	9	10	106200
4	Dump Truck Operator	9	10	10800
Total Cost for 62981.945 m³				147240
Total Cost per m³				2.34
20% profit per m³				0.47
Final Cost for 62981.945 m³				**176688.00**

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Wheel Loader***
References	**Calculation & Description**
Field Manual (FM) No. 5-434. 15 June 2000	Volume of cut = 576588.502 m³
	Volume of fill = 639670.447 m³
	Volume of soil to be imported
	= 576588.502 - 639570.447
	= 62981.945 m³
	= 82377.274 BCY
	= 102971.59 LCY
https://buildingmaterials.com.my/products/details/top-soil-4351	Cost of soil per m³ = 13RM /m³
	Total Cost of Imported Soil
	= 62981.945 x 13
	= 818765.285 RM

CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	***Wheel Loader***
	Brand: Komatsu
	Model: WA380-6
https://www.komatsu.jp/en/worldwide/PDF/WA380-6.pdf	Bucket Capacity: 2.7 - 4.0 m^3
Field Manual (FM) No. 5-434. 15 June 2000	**Step 1 - Determine the material type and the rated heaped-bucket capacity of the loader**
	The soil material type is Sandy Silt Load (Moist Loam)
	Step 2 - Select the bucket fill factor based on material type
	The wheel loader fill factor = 1.0
	Step 3 - Determine the average cycle time based on the size of wheel loader
	Average bucket capacity = 3.5 m^3 = 4.6 BCY = 4.6 LCY
	Average Cycle Times for Wheel Loaders = 0.50 to 0.55 minutes
	Take average cycle time = 0.53 minutes
	(Includes load, maneuver with four reversals of direction (minimum travel), and dump.)
	Step 4 - Determine the Maximum Production Rate

	Step 5 - Determine the efficiency factor
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 6 - Determine the net production rate in LCY per hour
	Net production rate (LCY per hour) = maximum production rate (LCY per hour) x efficiency factor
	= 520 x 0.83
	= 432 LCY per hour
	Step 7 - Determine the time required to complete the task
	Assume the number of wheel loader available = 3

	Step 8 - Determine the total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost per day for wheel loader = RM 600
	Cost of diesel = RM 2.15/L
	Average diesel consumption for wheel loader = RM 15L/hour
	Total cost of diesel for wheel loader = RM 2.15 x 15 x 8 = RM 258 /day
	Total cost for 3 wheel loader
	= RM (600 + 258) x 10 x 3
	= RM 25740
	Wheel Loader Operator
	Number of operators = 3
	Assuming the cost for operator of wheel loader = cost for operator of excavator as both are categorized unde Plant and Machine Operators
	Details of Labour:
	Plant and machine operator, Skilled, Local

Pocket Costbook, 2020	Labor wage per day based on average listing for wheel loader operator
	= RM 150/day
	Total cost for 3 wheel loader operators
	= RM 150 x 10 x 3
	= RM 4500
	<u>Dump Truck</u>
	Brand: Hitachi
	Model: EH600
	Operating weight: 56,912 kg
Field Manual (FM) No. 5-434. 15 June 2000	
	Step 1 - Determine the number of bucket loads required to fill a truck
	Average wheel loader bucket capacity = 3.5 m^3 = 4.6 BCY = 4.6 LCY
	Dump truck capacity = 56912 kg ≈ 125469.48 pounds
	For loam, unit weight of loam to be transported = 2600 pounds per LCY

	Step 2 - Determine the loading time per haul unit
	Loading time per haul unit = bucket cycle time x number of bucket loads
	= 0.53 x 9
	= 4.77 minutes ≈ 5 minutes
	Step 3 - Determine the number of hauling units needed to support the loading unit
	Max travelling speed of dump truck = 60km/hr
	Considering construction site speed limit,
	Average travelling speed of dump truck = 30km/hr
	Maximum distance travelled by dump truck = 210 m
	Average distance travelled by the dump truck = 110m
	Travel time per trip = 110/10000/30 = 0.004hr = 0.22 minutes
	Truck cycle time includes time spent traveling to the dump site, unloading, returning to the loading unit, and then being reloaded.
	Assuming time required to unload = 3.8 mintues
	Truck cycle time = 0.22 + 0.22 + 3.8 + 3.8 ≈ 8 minutes

	3
	Since the number of wheel loader available is 3, to maintain the output efficiency, the number of dump trucks;
	= 3 x 3
	= 9
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Rental cost per dump truck per day = RM 750 /day
	Cost of diesel = RM 2.15/L
	Average diesel consumption for dump truck = RM 25L/hr
	Total cost of diesel per dump truck = RM 2.15 x 25 x 8 = 430 L/day
	Total cost for 9 dump trucks
	= RM (750 + 430) x 10 x 9
	= RM 106200
	<u>Dump Truck Operator</u>
	Number of operators = 9
	Details of Labour:
	Plant and Machine Operator, Skilled, Local

Pocket Costbook, 2020	
	Labor wage per day based on average listing for dump truck operator
	= RM 120/day
	Total cost for dump truck operators
	= RM 120 x 10 x 9
	= RM 10800

6.8.5 Transport from Cut to Fill

In this activity, wheel loaders play a crucial role in efficiently loading the excavated soil onto dump trucks. Once loaded, dump these trucks are responsible for safely transporting the soil to designated fill areas. This well-coordinated process ensures the timely relocation of the excavated material, contributing to the overall effectiveness and progress of the project.

The summary of cost is shown in the table below:

No.	Equipment/Labor	Unit	Time (days)	Total Cost (RM)
1	Wheel Loader	5	61	261690
2	Wheel Loader Operator	5	61	45750
3	Dump Truck	15	61	1079700
4	Dump Truck Operator	15	61	109800
Total Cost for 639570.447 m³				1496940
Total Cost per m³				2.34
20% profit per m³				0.47
Final Cost for 639570.447 m³ m³				**1796328.00**

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Wheel Loader***
References	**Calculation & Description**
Field Manual (FM) No. 5-434. 15 June 2000	Volume of soil to be filled
	= 639570.447 m³
	= 836526.56 BCY
Table 1-1 (FM) No. 5-434. 15 June 2000	Volume of soil to be transported to fill areas
	= 836526.56 x 1.25
	= 1045658.2 LCY

CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	***Wheel Loader***
	Brand: Komatsu
	Model: WA380-6
https://www.komatsu.jp/en/worldwide/PDF/WA380-6.pdf	Bucket Capacity: 2.7 - 4.0 m^3
Field Manual (FM) No. 5-434. 15 June 2000	**Step 1 - Determine the material type and the rated heaped-bucket capacity of the loader**
	The soil material type is Sandy Silt Load (Moist Loam)
	Step 2 - Select the bucket fill factor based on material type
	The wheel loader fill factor = 1.0
	Step 3 - Determine the average cycle time based on the size of wheel loader
	Average bucket capacity = 3.5 m^3 = 4.6 BCY = 4.6 LCY
	Average Cycle Times for Wheel Loaders = 0.50 to 0.55 minutes
	Take average cycle time = 0.53 minutes
	(Includes load, maneuver with four reversals of direction (minimum travel), and dump.)
	Step 4 - Determine the Maximum Production Rate

	Step 5 - Determine the efficiency factor
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 6 - Determine the net production rate in LCY per hour
	Net production rate (LCY per hour) = maximum production rate (LCY per hour) x efficiency factor
	= 520 x 0.83
	= 432 LCY per hour
	Step 7 - Determine the time required to complete the task
	Assume the number of wheel loader available = 5

	Step 8 - Determine the total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost per day for wheel loader = RM 600
	Cost of diesel = RM 2.15/L
	Average diesel consumption for wheel loader = RM 15L/hour
	Total cost of diesel for wheel loader = RM 2.15 x 15 x 8 = RM 258 /day
	Total cost for 5 wheel loader
	= RM (600 + 258) x 61 x 5
	= RM 261690
	<u>Wheel Loader Operator</u>
	Number of operators = 5
	Assuming the cost for operator of wheel loader = cost for operator of excavator as both are categorized unde Plant and Machine Operators
	Details of Labour:
	Plant and machine operator, Skilled, Local
	Labor wage per day based on average listing for wheel loader operator
	= RM 150/day
	Total cost for 5 wheel loader operators

	= RM 150 x 61 x 5
	= RM 45750
	Dump Truck
	Brand: Hitachi
	Model: EH600
	Operating weight: 56,912 kg
Field Manual (FM) No. 5-434. 15 June 2000	
	Step 1 - Determine the number of bucket loads required to fill a truck
	Average wheel loader bucket capacity = 3.5 m^3 = 4.6 BCY = 4.6 LCY
	Dump truck capacity = 56912 kg ≈ 125469.48 pounds
	For loam, unit weight of loam to be transported = 2600 pounds per LCY
	Step 2 - Determine the loading time per haul unit
	Loading time per haul unit = bucket cycle time x number of bucket loads
	= 0.53 x 9

	= 4.77 minutes ≈ 5 minutes
	Step 3 - Determine the number of hauling units needed to support the loading unit
	Max travelling speed of dump truck = 60km/hr
	Considering construction site speed limit,
	Average travelling speed of dump truck = 30km/hr
	Maximum distance travelled by dump truck = 210 m
	Average distance travelled by the dump truck = 110m
	Travel time per trip = 110/10000/30 = 0.004hr = 0.22 minutes
	Truck cycle time includes time spent traveling to the dump site, unloading, returning to the loading unit, and then being reloaded.
	Assuming time required to unload = 3.8 mintues
	Truck cycle time = 0.22 + 0.22 + 3.8 + 3.8 ≈ 8 minutes
	3
	Since the number of wheel loader available is 5, to maintain the output efficiency, the number of dump trucks;
	= 3 x 5
	= 15

CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Rental cost per dump truck per day = RM 750 /day
	Cost of diesel = RM 2.15/L
	Average diesel consumption for dump truck = RM 25L/hr
	Total cost of diesel per dump truck = RM 2.15 x 25 x 8 = 430 L/day
	Total cost for 15 dump trucks
	= RM (750 + 430) x 61 x 15
	= RM 1079700
	<u>Dump Truck Operator</u>
	Number of operators = 15
	Details of Labour:
	Plant and Machine Operator, Skilled, Local
Pocket Costbook, 2020	
	Labor wage per day based on average listing for dump truck operator
	= RM 120/day
	Total cost for dump truck operators
	= RM 120 x 61 x 15
	= RM 109800

6.8.6 Fill to Formation Level

In this activity, a bulldozer is employed to efficiently distribute soil, filling it to the designated reduced levels. This powerful and versatile piece of machinery ensures that the fill material is evenly spread and compacted according to the project's specifications.

The summary of cost is shown in the table below:

No.	Equipment/Labor	Unit	Time (days)	Total Cost (RM)
1	Bulldozer	12	66	1092960
2	Bulldozer Operator	12	66	95040
Total Cost for 639570.447 m³				1188000
Total Cost per m³				1.86
20% profit per m³				0.37
Final Cost for 639570.447 m³ m³				**1425600.00**

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Bulldozer***
References	**Calculation & Description**
Field Manual (FM) No. 5-434. 15 June 2000	Volume of soil to be filled
	= 639570.447 m³
	= 836526.56 BCY
Table 1-1 (FM) No. 5-434. 15 June 2000	Volume of soil to be transported to fill areas
	= 836526.56 x 1.25
	= 1045658.2 LCY
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Brand: Komatsu
	Model: D475A-5 SD
	Blade capacity: 45.0 m³
	Blade length x height: 6465 mm x 2690 mm

Field Manual (FM) No. 5-434. 15 June 2000	**Step 1 - Determine maximum production of dozer**
	Based on type of dozer (D4 tractors)
	Assuming average dozing distance = 200 ft = 61 m,
	the estimated maximum production with universal blade is
	= 250 LCY/hour
	Step 2 - Determine the correction factors for different ideal conditions
	a) *Grade Correction Factor*
	Assume doom a 10 percent grade,
	Grade correction factor = 1.16
	b) *Material -weight Correction Factor*
	c) *Material-type Correction Factor*
	Since the soil type is a mixture of mostly sandy silt with clay loam, it is assumed that the soil is hard to drift thus having a factor of = 0.8
	d) *Operator Correction Factor*
	Since the work will mostly be done during daylight hours, the operator correction factor = 0.75

	e) *Operating Technique Correction Factor*
	Since the bulldozer utilizes slot dozing, the correction factor = 1.2
	f) *Efficiency Factor*
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 3 - Determine Total Correction Factor
	= 1.16 x 1.18 x 0.8 x 0.75 x 1.2 x 0.83
	= 0.82
	Step 4 - Determine dozer production
	Production (LCY per hour) = maximum production x the product of the correction factors
	= 250 x 0.82
	= 205 LCY/hour/dozer
	Step 5 - Convert production rate LCY per hour to BCY per hour
	Before the stripping process, the soil is in its natural state.
	Thus, LCY will be converted back to BCY
	Soil conversion factor for loam (loose to bank) = 0.8

	Dozer production in BCY = 205 x 0.8 = 164 BCY/hour/dozer
	Step 6 - Determine the total time required to complete the task
	Assume the number of available bulldozers = 12
	66 days
	Step 7 - Determine total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost per bulldozer = RM 950
	Cost of diesel = RM 2.15/liter
	Average diesel consumption for bulldozer = 25 L/hr
	Total cost of diesel per bulldozer
	= Rm 2.15 x 25 x 8
	= RM 430/day
	Total cost for 12 bulldozers
	= RM (950 + 430) x 66 x 12

	= RM 1092960
	Bulldozer Operator
	Number of operator = 12
	Labor details:
	Bulldozer Operator, Skilled, and Local
Pocket Costbook 2020	
	Labor wage per day based on average listing for machine operator
	= RM 120/day
	Total cost for 5 bulldozers
	= RM 120 x 12 x 66
	= RM 95040

6.8.7 Compaction

In this activity, vibratory soil compactors play a crucial role in compacting the soil on-site. These specialized machines ensure that the soil is effectively compressed, resulting in a stable and well-prepared foundation for various construction projects. By employing these compactors, the team can achieve the desired level of soil compaction, ensuring optimal performance and longevity of the constructed structures.

The summary of cost is shown in the table below:

No.	Equipment/Labor	Unit	Time (days)	Total Cost (RM)
1	Compactor	6	41	157,686
2	Compactor Operator	6	41	29520
Total Cost for 639570.447 m³				187206
Total Cost per m³				0.29
20% profit per m³				0.06
Final Cost for 639570.447 m³ m³				**224647.20**

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***<u>Compactor</u>***
References	**Calculation & Description**
	Brand: Caterpillar
	Model: CS76 XT
	Compaction width: 2134 mm
Field Manual (FM) No. 5-434. 15 June 2000	
	Step 1 - Determine compactor production rate in CCY per hour
	where,
	16.3 = constant for converting the factors in feet, mph, and inches to CCY
	W = compacted width per pass, in feet
	S = compactor speed, in mph
	L = compacted lift thickness, in inches
	E = efficiency
	N = number of passes required
	Based on the compactor chosen,
	W = 2134 mm ≈ 70 feet
	The soil type is Sandy Silt Loam (SM).

	Thus,
	(Smooth Drum Vibratory Category)
	L = 9 inches
	S = 4 mph
	N = 8 (required)
	(Expect 50 minutes of production time per hour for a well-managed job)
	Efficiency Factor E = 0.83
	Therefore,
	Output of 1 compactor = 426 CCY per hour
	Step 2 - Determine the required time to complete the task
	Volume of soil to be filled
	= 639570.447 m^3
	= 836526.56 BCY
	Volume of soil to be transported to fill areas

	= 836526.56 x 1.25
	= 1045658.2 LCY
	Assuming 6 vibratory soil compactors are available (*2 owned; 4 rented*),
	Time required to complete the task with the given number of compactors:
	= 1045658.2 LCY/3195 $LCY\ per\ hour$
	= 327.28 hours ≈ 40.91 days ≈ 41 days
	Step 3 - Determine the total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost for compactor per day = RM 600

	Cost of diesel = RM 2.15/L
https://static1.squarespace.com/static/58877529414fb5283ed14a6b/t/5888f8df46c3c4d4d976a102/1485371615708/Fuel+Table+-+Compactors.pdf	Average diesel consumption for compactor = RM 14 L/hour
	Total cost of diesel per compactor
	= Rm 2.15 x 14 x 8
	= RM 241 /day
	Total cost for 2 compactors (owned)
	= RM 241 x 41 x 2
	= RM 19762
	Total cost for 4 compactors (rented)
	= RM (600 + 241) x 41 x 4
	= RM 137,924
	Total cost for 6 compactors
	= RM 19762 + RM 137924
	= 157,686
	Compactor Operator
	Number of operator = 6
	Labor details:

	Compactor Operator, Skilled, and Local
Pocket Costbook 2020	
	Labor wage per day based on average listing for machine operator
	= RM 120/day
	Total cost for 6 compactors
	= RM 120 x 6 x 41
	= RM 29520

6.8.8 Grading

In this activity, graders play a crucial role in the final stages of grading, which entails the smoothing of slopes, shaping of ditches, and adjusting the earthwork to achieve the desired elevation as outlined in the project plans and specifications. These specialized machines ensure that the site preparation is completed to the highest standards, creating a stable and well-graded foundation for subsequent construction activities.

The summary of cost is shown in the table below:

No.	Equipment/Labor	Unit	Time (days)	Total Cost (RM)
1	Grader	4	1	2682
2	Grader Operator	4	1	600
Total Cost for 362783.42 ²				3282
Total Cost per ²				0.009
20% profit per ²				0.0018
Final Cost for 362783.42 ²				**3938.40**

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Grader***

References	**Calculation & Description**
	Brand: Komatsu
	Model: GD705-5
	Grading width: 4320 mm
	Determine the grader production rate
	where,
	P = number of passes required
	D = distance traveled in each pass, in miles or feet
	S = speed of grader, in mph or fpm (multiply mph by 88 to convert to fpm)
	E = efficiency factor
	Assume number of passes, P = 5
	Assume distance of site, D = 760 m = 0.76 km
Table 4-1	For finishing, the gear range for the grader to operate is between third to fourth. For the selected model, (in km/h)
	Speed for second gear: 5.6 km/h
	Speed for third gear: 7.7 km/h
	Speed for fourth gear: 10.9 km/h

	Average speed, S = 8 km/h
	(Expect 50 minutes of production time per hour for a well-managed job)
	Efficiency Factor E = 0.83
	Grading area per round
	= 760 m x 0.4320
	= 328.32 = 328 m^2
	Therefore,
	Output efficiency where Total Time per Grading Width
	Area of the construction project = 362783.42 m^2
	Total Travel Time = 362783.42/328 x 35 min
	= 31.60 hours
	Assume number of graders = 4 (1 owned; 3 rented)
	= 31.60 hours / 4 graders
	= 7.9 hours ≈ 1 day

	Determine the total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost for grader per day = RM 550
	Cost of diesel = RM 2.15/L
https://www.scribd.com/document/458748773/fuel-consumption#	Average diesel consumption for compactor = RM 15 L/hour
	Total cost of diesel per grader
	= Rm 2.15 x 15 x 8
	= RM 258 /day
	Total cost for 1 compactor (owned)
	= RM 258 x 1 x 1
	= RM 258
	Total cost for 4 compactors
	= RM (550 + 258) x 1 x 3
	= RM 2424
	Total cost for 4 compactors
	= RM 258 + RM 2424
	= RM 2682
	<u>Grader Operator</u>
	Number of operator = 4
	Labor details:

	Motor Grader Operator, Skilled, and Local
	Labor wage per day based on average listing for machine operator
	= RM 150/day
	Total cost for 4 graders
	= RM 150 x 4 x 1
	= RM 600

6.9 After Cost Reduction

6.9.1 Site Clearing

The activity area's processes involve labor required for tree felling and cutting trees into sections using chainsaws. Bulldozers assist in removing tree roots and stumps by pushing them into piles. Excavators help transport the logs from the site to dump trucks, which then carry the logs to the site's boundary. It is assumed that these logs are subsequently sold to the appropriate authorities.

The summary of cost is as shown in the table below:

No.	Equipment / Labour	Unit	Time (days)	Total Cost (RM)
1	Bulldozer	10	14	193200
2	Bulldozer operator	10	14	9800
3	Labour	30	8	16800
4	Chainsaw	30	8	16800
5	Excavator	2	11	38060
6	Excavator operator	2	11	1760
7	Dump truck	3	11	38940
8	Dump truck operator	3	11	2970
Total cost for 5378 trees				**318330**
Total cost per tree				**59.19**
20% profit per tree				**11.84**
Final cost for 5378 trees				**381996**

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Bulldozer***
References	**Calculation & Description**
	Due to sheer number of trees. Tree counting is not possible thus assume quanity through Quick Method.
Field Manual (FM) No. 5-434	
	Step 1 - Total Area to be cleared (in acres)
	From the gathered data of Earthwork Department;

	Step 2 - Size and Number of dozers
	Dozer size, S = Large Tractor
	Number of bulldozer available, N = 10
	Step 3 - Maximum Tree Diameter
	*Based on geography and surrounding areas,
	Oil Palm Tree = 65 cm = 25.6 inches
	Step 4 - Time required (per acre)
(FM) Table 2-1	*Based on tree diameter
	Time required, D = 8hrs
	Step 5 - Work Efficiency Factor
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 6 - Operating Factor

(FM) Table 2-2	Since most work are done during daytime with an average optimum working capacity,
	Average Operator, O = 0.75
	Step 7 Total Time (hrs)
	*Divide the total time in hrs by 8 working hrs
	Step 8 - Total Cost
	Bulldozer
	Brand: *Komatsu*
	Model: *D475A-5 SD*
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Rental cost per day = RM 950
	Cost of diesel = RM 2.15/liter
	Average diesel consumption for bulldozer = 25L/hr
	Total cost of diesel per bulldozer

	= RM 2.15 x 25 x 8 = 430 RM/day
	Total cost for 10 bulldozers
	= RM (950 +430) x 14 x 10 = RM 193200
	<u>Bulldozer Operator</u>
	Number of operator = 10
	Labor details
	Bulldozer Operator, Semi-Skilled, and Local
Quantity Surveyor Online Website - Labour Rates	
	Labor wage per day based on average listing for machine operator
	= RM 70/day
	Total cost
	= RM 70 x 10 x 14
	= RM 9800
	<u>Labour</u>
	Number of trees present in site
	Total Area of site = 89.64 acres
Site Visit (Google Earth)	Assumed average number of trees = 60 trees per acre
	Total number of trees
	= 89.64 acres x 60 trees

	= 5378 trees
Field Manual (FM) No. 5-434	Based on output efficiency, the total time it takes to fell a tree plus delays ≈ 5 minutes
	Assume number of available labour = 30
	Time required to fell corresponding trees
	Taking into consideration the maximum height of an oil palm tree which can reach upto 66 feet, roughly 20 meters tall.
	The length of a the cargo truck is 5.5m. Thus, the trees should be cut into averagely 20/5 = 4 sections
	Assume a labourer will take roughly 4 minutes to saw each section.
	Each tree will take 16 mins to be cut into 4 smaller sections.
	Required number of trees to be cut = 5378 trees
	Time required to cut all tree into logs

	Total time required to fell trees and cut into smaller sections
	= 15 hrs + 48 hrs = 63 hours = 7.875 days ≈ 8 days
Quantity Surveyor Online Website - Labour Rates	Labour details:
	General Labour, Local, Semi-Skilled
	Labor wage per day based on average listing for general construction
	= RM 70/day
	Total labour wage rate
	= RM 70 x 8 x 30
	= RM 16800
	<u>Chainsaw</u>
	Brand: *STIHL*
	Model: *MS382*
	No. of chainsaw = 30
	No. of labour = 30
	Assume rental price per 1 chainsaw (including transport)
	= RM 70/day

	Total number of days to cut trees = 8 days
	Total cost
	= RM 70 x 8 x 30
	= RM 16800
	<u>Excavator</u>
	Brand: Komatsu
	Model: PC300SE-7
	Capacity: $2.3m^3$
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Estimation area per logs based on diameter of the trunk
Field Manual (FM) No. 5-434	$= \pi \times (65/2)^2 = 3318$ cm
	Volume per log = $0.3318\ m^2 \times 5\ m = 1.66\ m^3$
	The bucket capacity of the hydraulic excavator = $2.3\ m^3$
	Thus, it is estimated that each trip can only load 1 log
	The cycle time including load, manoeuvre with four reversals of the direction (minimum travel) and dump is estimated to be 15 seconds

	(Expect 50 minutes of production time per hour for a well-managed job)
	Thus, output efficiency for excavator
	= initial time + delaying time due to efficiency factor
	= 15 + (1-0.83)(15) ≈ 18 s/log
https://www.constructionequipmentguide.com/charts/off-highway-trucks/hitachi/eh600/30754685	Dump capacity of cargo dump truck = 21 m^3
	Total number of logs carried per cycle
	= 21/2.3 ≈ 9 logs
	Loading time required for dump truck per trip
	= 9 logs x 18s/log = 162 sec = 2.7 ≈ 3 minutes
	Number of logs = 5378 x 3 = 16134 logs

	The dump truck is required to travel 1793 trips to complete transporting all logs.
	Based on the calculated data, the total time to complete the task
	= 3 mins x 1793
	= 5379 mins ≈ 90 hours ≈ 11 days
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Rental cost per day for excavator = RM 1300
	Cost of diesel = RM 2.15/L
	Average diesel consumption for excavator = RM 25L/hour
	Total cost of diesel per excavator = RM 2.15 x 25 x 8 = RM 430 day
	Total cost for 2 excavator
	= RM (1300 + 430) x 11 x 2
	= RM 38060
	<u>Excavator Operator</u>
	No. of operator = 2
	Details of Labour:
Pocket Costbook, 2020	Plant and machine operator, Semi-Skilled, Local
	Labor wage per day based on average listing for excavator operator

	= RM 80/day
	Total Cost
	= RM 80 x 11 x 2
	= RM 1760
	Dump Truck
	Brand: Hitachi
	Model: EH600
	Operating weight: 56,912 kg
	The dump truck is able to carry 9 logs per trip
	Number of trip required per dump truck = 16134/9 ≈ 1793 trips
	Max travelling speed of dump truck = 60km/hr
	Considering construction site speed limit,
	Average travelling speed of dump truck = 30km/hr
	Maximum distance travelled by dump truck = 210 m
	Average distance travelled by the dump truck = 110m
	Travel time per trip = 110/10000/30 = 0.004hr = 0.22 minutes
	Truck cycle time includes time spent traveling to the dump site, unloading, returning to the loading unit, and then being reloaded.

	Assume time to unload = time required for loading = 1 minute
	Loading time per truck = 9 x 1 = 9 minutes
	Dump Truck cycle time = (2 x 0.22) + (2 x 9) = 18.4 ≈ 19 minutes
	Number of trucks required
	= 1 + (truck cycle time/loader cycle time)
	= 1 + (19/9)
	= 3.11 ≈ 3 trucks
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost per dump truck per day = RM 750 /day
	Cost of diesel = RM 2.15/L
	Average diesel consumption for dump truck = RM 25L/hr
	Total cost of diesel per dump truck = RM 2.15 x 25 x 8 = 430 L/day
	Total cost for 3 dump trucks
	= RM (750 + 430) x 3 x 11
	= RM 38940
	Dump Truck Operator
	Number of operators = 3
	Details of Labour:

	Plant and Machine Operator, Semi-Skilled, Local
Pocket Costbook, 2020	Labor wage per day based on average listing for dump truck operator
	= RM 80/day
	Total cost for dump truck operators
	= RM 80 x 3 x 11
	= RM 2970

6.9.2 Excavate Topsoil

The activity's processes can be outlined as follows: bulldozers play a crucial role in stripping away the topsoil, while wheel loaders efficiently transfer the soil to dump trucks. These dump trucks are then responsible for transporting the soil to designated stockpile locations.

The summary of cost is shown in the table below:

No.	Equipment/Labour	Unit	Times (days)	Total Cost (RM)
1	Bulldozer	6	9	74520
2	Bulldozer Operator	6	9	3780
3	Wheel Loader	6	5	25740
4	Wheel Loader Operator	6	5	2550
5	Dump Truck	18	5	106200
6	Dump Truck Operator	18	5	7200
Total cost for 54417.51 m^3				219990
Total cost per m^3				4.04
20% profit per m^3				0.81
Final cost for 54417.51 m^3				263988

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Bulldozer***
References	**Calculation & Description**
	Area to be stripped = 362783.42 m^2
	Volume of soil to be stripped
	= 362783.42 x 0.15
	= 54417.51 m^3
	= 71175.42 BCY
	Based on the soil type present, the soil classification for out given zone is Sandy Silt
https://www.soilquality.org.au/factsheets/bulk-density-measurement	Loam having bulk density of 1.3-1.7 g/cm^3
https://hort.ifas.ufl.edu/woody/critical-value.shtml	Average bulk density = 1.45g/cm^3 = 1450 kg/m^3
	= 2443.25 pounds/BCY
Table 1-1 (FM) No. 5-434. 15 June 2000	= 1954.6 pounds/LCY
	Utilizing same model of bulldozer as below: -
	Brand: Komatsu
	Model: D475A-5 SD
	Blade capacity: 45.0 m^3
	Blade length x height: 6465 mm x 2690 mm

Field Manual (FM) No. 5-434. 15 June 2000	**Step 1 - Determine maximum production of dozer**
	Based on type of dozer (D4 tractors)
	Assuming average dozing distance = 200 ft = 61 m,
	the estimated maximum production with universal blade is
	= 250 LCY/hour
	Step 2 - Determine the correction factors for different ideal conditions
	a) *Grade Correction Factor*
	Assume doom a 10 percent grade,
	Grade correction factor = 1.16
	b) *Material -weight Correction Factor*
	c) *Material-type Correction Factor*
	Since the soil type is a mixture of mostly sandy silt with clay loam, it is assumed that the soil is hard to drift thus having a factor of = 0.8
	d) *Operator Correction Factor*

	Since the work will mostly be done during daylight hours, the operator correction factor = 0.75
	e) *Operating Technique Correction Factor*
	Since the bulldozer utilizes slot dozing, the correction factor = 1.2
	f) *Efficiency Factor*
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 3 - Determine Total Correction Factor
	= 1.16 x 1.18 x 0.8 x 0.75 x 1.2 x 0.83
	= 0.82
	Step 4 - Determine dozer production
	Production (LCY per hour) = maximum production x the product of the correction factors
	= 250 x 0.82
	= 205 LCY/hour/dozer
	Step 5 - Convert production rate LCY per hour to BCY per hour
	Before the stripping process, the soil is in its natural state.

	Thus, LCY will be converted back to BCY
	Soil conversion factor for loam (loose to bank) = 0.8
	Dozer production in BCY = 205 x 0.8 = 164 BCY/hour/dozer
	Step 6 - Determine the total time required to complete the task
	Assume the number of available bulldozers = 6
	9 days
	Step 7 - Determine total cost
	Rental cost per bulldozer = RM 950
	Cost of diesel = RM 2.15/liter
	Average diesel consumption for bulldozer = 25 L/hr
	Total cost of diesel per bulldozer
	= RM 2.15 x 25 x 8
	= RM 430/day
	Total cost for 6 bulldozers
	= RM (950 + 430) x 9 x 6
	= RM 74520
	<u>Bulldozer Operator</u>

	Number of operator = 6
Pocket Costbook, 2020	Labor details:
	Bulldozer Operator, Semi-Skilled, and Local
	Labor wage per day based on average listing for machine operator
	= RM 70/day
	Total cost for 6 bulldozers
	= RM 70 x 6 x 9
	= RM 3780
	Wheel Loader
	Volume of stripped soil = 54417.51 m^3
	However, due to the expansion of soil from bank to loose state
	Loam swelling factor = 1.25
	Volume of soil to be loaded
	= 54417.51 m^3 x 1.25
	= 68022 m^3
	= 88969.42 BCY
	= 111211.77 LCY
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	***Wheel Loader***

	Brand: Komatsu
	Model: WA380-6
https://www.komatsu.jp/en/worldwide/PDF/WA380-6.pdf	Bucket Capacity: 2.7 - 4.0 m^3
Field Manual (FM) No. 5-434	**Step 1 - Determine the material type and the rated heaped-bucket capacity of the loader**
	The soil material type is Sandy Silt Load (Moist Loam)
Table 5-1	**Step 2 - Select the bucket fill factor based on material type**
	The wheel loader fill factor = 1.0
Table 5-2	**Step 3 - Determine the average cycle time based on the size of wheel loader**
	Average bucket capacity = 3.5 m^3 = 4.6 BCY = 4.6 LCY
	Average Cycle Times for Wheel Loaders = 0.50 to 0.55 minutes
	Take average cycle time = 0.53 minutes
	(Includes load, maneuver with four reversals of direction (minimum travel), and dump.)
	Step 4 - Determine the Maximum Production Rate

	Step 5 - Determine the efficiency factor
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 6 - Determine the net production rate in LCY per hour
	Net production rate (LCY per hour) = maximum production rate (LCY per hour) x efficiency factor
	= 520 x 0.83
	= 432 LCY per hour
	Step 7 - Determine the time required to complete the task
	Assume the number of wheel loader available = 6
	Step 8 - Determine the total cost

CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost per day for wheel loader = RM 600
	Cost of diesel = RM 2.15/L
	Average diesel consumption for wheel loader = RM 15L/hour
	Total cost of diesel for wheel loader = RM 2.15 x 15 x 8 = RM 258 /day
	Total cost for 6 wheel loader
	= RM (600 + 258) x 5 x 6
	= RM 25740
	Wheel Loader Operator
	Number of operators = 6
	Assuming the cost for operator of wheel loader = cost for operator of excavator as both are categorized unde Plant and Machine Operators
	Details of Labour:
	Plant and machine operator, Semi-Skilled, Local
	Labor wage per day based on average listing for wheel loader operator
	= RM 85/day
	Total cost for 6 wheel loader operators
	= RM 85 x 5 x 6

	= RM 2550
	Dump Truck
	Brand: Hitachi
	Model: EH600
	Operating weight: 56,912 kg
Field Manual (FM) No. 5-434	**Step 1 - Determine the number of bucket loads required to fill a truck**
	Average wheel loader bucket capacity = 3.5 m^3 = 4.6 BCY = 4.6 LCY
	Dump truck capacity = 56912 kg ≈ 125469.48 pounds
	For loam, unit weight of loam to be transported = 2600 pounds per LCY
	Step 2 - Determine the loading time per haul unit
	Loading time per haul unit = bucket cycle time x number of bucket loads
	= 0.53 x 9
	= 4.77 minutes ≈ 5 minutes

	Step 3 - Determine the number of hauling units needed to support the loading unit
	Max travelling speed of dump truck = 60km/hr
	Considering construction site speed limit,
	Average travelling speed of dump truck = 30km/hr
	Maximum distance travelled by dump truck = 210 m
	Average distance travelled by the dump truck = 110m
	Travel time per trip = 110/10000/30 = 0.004hr = 0.22 minutes
	Truck cycle time includes time spent traveling to the dump site, unloading, returning to the loading unit, and then being reloaded.
	Assuming time required to unload = 3.8 mintues
	Truck cycle time = 0.22 + 0.22 + 3.8 + 3.8 ≈ 8 minutes
	3
	Since the number of wheel loader available is 5, to maintain the output efficiency, the number of dump trucks;
	= 3 x 6
	= 18

CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Rental cost per dump truck per day = RM 750 /day
	Cost of diesel = RM 2.15/L
	Average diesel consumption for dump truck = RM 25L/hr
	Total cost of diesel per dump truck = RM 2.15 x 25 x 8 = 430 L/day
	Total cost for 18 dump trucks
	= RM (750 + 430) x 5 x 18
	= RM 106200
	Dump Truck Operator
	Number of operators = 18
	Details of Labour:
	Plant and Machine Operator, Semi-Skilled, Local
	Labor wage per day based on average listing for dump truck operator
	= RM 80/day
	Total cost for dump truck operators
	= RM 80 x 18 x 5
	= RM 7200

6.9.3 Cut to Formation Level

In this activity, a hydraulic excavator plays a crucial role in cutting the soil down to the specified reduced levels. This powerful and versatile piece of equipment allows for precise excavation and ensures that the desired depth is reached according to the project's requirements.

The summary of cost is shown in the table below:

No.	Equipment/Labour	Unit	Time (days)	Total cost (RM)
1	Excavator	6	33	342540
2	Excavator operator	6	33	15840
Total cost for 576588.50 m^3				358380
Total cost per m^3				0.62
20% cost profit per m^3				0.12
Final cost for 576588.50 m^3				430056

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Excavator***
References	**Calculation & Description**
	Cut Volume
	= 576588.502 m^3
	= 754149.29 BCY
Field Manual (FM) No. 5-434. 15 June 2000	
	Hydraulic Excavator

	Brand: Komatsu
	Model: PC300SE-7
	Bucket Capacity: $2.3m^3 \approx 3\ yd^3$
Table 8-1 (FM) No. 5-434. 15 June 2000	**Step 1 - Determine the bucket fill factor based on the material type**
	Since the soil type is a mixture of mostly sandy silt with clay loam, it is assumed that the average fill factor is 100%
	Step 2 - Use a hoe cycle time based on past performance data if available or use the average cycle time
	Assuming the depth of cut between 40 and 60 percent of the machines rated maximum digging depth and a swing angle of between 30° to 60°
	The average cycle time for bucket sizes from 1 cubic yard to less than 2.5 cubic yards
	= 15 seconds
	Step 3 - Determine the ideal production rate (LCY per hour)
	Average bucket capacity of selected hydraulic excavator
	$= 3\ yd^3$

	Step 4 - Determine the production rate (LCY per hour) by adjusting for efficiency
	(Expect 50 minutes of production time per hour for a well-managed job)
	Production rate = ideal production rate (LCY per hour) x efficiency factor
	Step 5 - Convert the production rate from LCY per hour to BCY per hour
	Before the stripping process, the soil is in its natural state.
	Thus, LCY will be converted back to BCY
	Soil conversion factor for loam (loose to bank) = 0.8
	Dozer production in BCY = 597.6 x 0.8 = 478.08 BCY/hour/excavator
	Step 6 - Determine the total time required to complete the task
	Assume the number of excavators = 6

	33 days
	Step 7 - Determine total cost
	Rental cost per excavator = RM 1300
	Cost of diesel = RM 2.15/liter
	Average diesel consumption for bulldozer = 25 L/hr
	Total cost of diesel per excavator
	= Rm 2.15 x 25 x 8
	= RM 430/day
	Total cost for 5 bulldozers
	= RM (1300 + 430) x 3 x 6
	= RM 342540
	<u>Excavator Operator</u>
	No. of operator = 6
	Details of Labour:
	Plant and machine operator, Skilled, Local
	Labor wage per day based on average listing for excavator operator
	= RM 80/day

	Total Cost
	= RM 80 x 33 x 6
	= RM 15840

6.9.4 Importing of Soil

The earthwork project presents a scenario where the cut-to-fill ratio is negative, indicating a higher demand for fill material. As a result, it becomes necessary to source additional soil from external locations to ensure the project's successful completion.

The summary of cost is shown in the table below:

No.	Equipment/Labour	Unit	Times (days)	Total Cost (RM)
3	Wheel Loader	4	7	24024
4	Wheel Loader Operator	4	7	2380
5	Dump Truck	12	7	99120
6	Dump Truck Operator	12	7	6720
Total cost for 54417.51 m^3				132244
Total cost per m^3				2.43
20% profit per m^3				0.49
Final cost for 54417.51 m^3				158692.8

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Wheel Loader***
References	**Calculation & Description**
Field Manual (FM) No. 5-434. 15 June 2000	Volume of cut = 576588.502 m^3
	Volume of fill = 639670.447 m^3

	Volume of soil to be imported
	= 576588.502 - 639570.447
	= 62981.945 m^3
	= 82377.274 BCY
	= 102971.59 LCY
https://buildingmaterials.com.my/products/details/top-soil-4351	Cost of soil per m^3 = 13RM /m^3
	Total Cost of Imported Soil
	= 62981.945 x 13
	= 818765.285 RM
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	***Wheel Loader***
	Brand: Komatsu
	Model: WA380-6
https://www.komatsu.jp/en/worldwide/PDF/WA380-6.pdf	Bucket Capacity: 2.7 - 4.0 m^3
Field Manual (FM) No. 5-434. 15 June 2000	**Step 1 - Determine the material type and the rated heaped-bucket capacity of the loader**
	The soil material type is Sandy Silt Load (Moist Loam)
	Step 2 - Select the bucket fill factor based on material type
	The wheel loader fill factor = 1.0

	Step 3 - Determine the average cycle time based on the size of wheel loader
	Average bucket capacity = 3.5 m³ = 4.6 BCY = 4.6 LCY
	Average Cycle Times for Wheel Loaders = 0.50 to 0.55 minutes
	Take average cycle time = 0.53 minutes
	(Includes load, maneuver with four reversals of direction (minimum travel), and dump.)
	Step 4 - Determine the Maximum Production Rate
	Step 5 - Determine the efficiency factor
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 6 - Determine the net production rate in LCY per hour

	Net production rate (LCY per hour) = maximum production rate (LCY per hour) x efficiency factor
	= 520 x 0.83
	= 432 LCY per hour
	Step 7 - Determine the time required to complete the task
	Assume the number of wheel loader available = 4
	Step 8 - Determine the total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost per day for wheel loader = RM 600
	Cost of diesel = RM 2.15/L
	Average diesel consumption for wheel loader = RM 15L/hour
	Total cost of diesel for wheel loader = RM 2.15 x 15 x 8 = RM 258 /day
	Total cost for 6 wheel loader
	= RM (600 + 258) x 7 x 4
	= RM 24024

	Wheel Loader Operator
	Number of operators = 6
	Assuming the cost for operator of wheel loader = cost for operator of excavator as both are categorized unde Plant and Machine Operators
	Details of Labour:
	Plant and machine operator, Semi-Skilled, Local
Pocket Costbook, 2020	Labor wage per day based on average listing for wheel loader operator
	= RM 85/day
	Total cost for 6 wheel loader operators
	= RM 85 x 7 x 4
	= RM 2380
	Dump Truck
	Brand: Hitachi
	Model: EH600
	Operating weight: 56,912 kg
Field Manual (FM) No. 5-434. 15 June 2000	
	Step 1 - Determine the number of bucket loads required to fill a truck
	Average wheel loader bucket capacity = 3.5 m^3 = 4.6 BCY = 4.6 LCY
	Dump truck capacity = 56912 kg ≈ 125469.48 pounds

	For loam, unit weight of loam to be transported = 2600 pounds per LCY
	Step 2 - Determine the loading time per haul unit
	Loading time per haul unit = bucket cycle time x number of bucket loads
	= 0.53 x 9
	= 4.77 minutes ≈ 5 minutes
	Step 3 - Determine the number of hauling units needed to support the loading unit
	Max travelling speed of dump truck = 60km/hr
	Considering construction site speed limit,
	Average travelling speed of dump truck = 30km/hr
	Maximum distance travelled by dump truck = 210 m
	Average distance travelled by the dump truck = 110m
	Travel time per trip = 110/10000/30 = 0.004hr = 0.22 minutes

	Truck cycle time includes time spent traveling to the dump site, unloading, returning to the loading unit, and then being reloaded.
	Assuming time required to unload = 3.8 mintues
	Truck cycle time = 0.22 + 0.22 + 3.8 + 3.8 ≈ 8 minutes
	3
	Since the number of wheel loader available is 6, to maintain the output efficiency, the number of dump trucks;
	= 3 x 4
	= 12
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Rental cost per dump truck per day = RM 750 /day
	Cost of diesel = RM 2.15/L
	Average diesel consumption for dump truck = RM 25L/hr
	Total cost of diesel per dump truck = RM 2.15 x 25 x 8 = 430 L/day
	Total cost for 12 dump trucks
	= RM (750 + 430) x 7 x 12

	= RM 99120
	Dump Truck Operator
	Number of operators = 12
	Details of Labour:
	Plant and Machine Operator, Semi-Skilled, Local
Pocket Costbook, 2020	
	Labor wage per day based on average listing for dump truck operator
	= RM 80/day
	Total cost for dump truck operators
	= RM 80 x 7 x 12
	= RM 6720

6.9.5 Transport from Cut to Fill

In this activity, wheel loaders play a crucial role in efficiently loading the excavated soil onto dump trucks. Once loaded, dump these trucks are responsible for safely transporting the soil to designated fill areas. This well-coordinated process ensures the timely relocation of the excavated material, contributing to the overall effectiveness and progress of the project.

The summary of cost is shown in the table below:

No.	Equipment/Labour	Unit	Time (days)	Total cost (RM)
1	Wheel loader	6	50	257400
2	Wheel loader operator	6	50	25500
3	Dump truck	18	50	1062000
4	Dump truck operator	18	50	72000
Total cost for 639570.447 m^3				1416900
Total cost per m^3				2.22

20% profit per m³	0.44
Final cost for 639570.447 m³	**1700280**

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Wheel Loader***
References	**Calculation & Description**
Field Manual (FM) No. 5-434. 15 June 2000	Volume of soil to be filled
	= 639570.447 m³
	= 836526.56 BCY
Table 1-1 (FM) No. 5-434. 15 June 2000	Volume of soil to be transported to fill areas
	= 836526.56 x 1.25
	= 1045658.2 LCY
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	***Wheel Loader***
	Brand: Komatsu
	Model: WA380-6
https://www.komatsu.jp/en/worldwide/PDF/WA380-6.pdf	Bucket Capacity: 2.7 - 4.0 m³

Field Manual (FM) No. 5-434. 15 June 2000	**Step 1 - Determine the material type and the rated heaped-bucket capacity of the loader**
	The soil material type is Sandy Silt Load (Moist Loam)
	Step 2 - Select the bucket fill factor based on material type
	The wheel loader fill factor = 1.0
	Step 3 - Determine the average cycle time based on the size of wheel loader
	Average bucket capacity = 3.5 m^3 = 4.6 BCY = 4.6 LCY
	Average Cycle Times for Wheel Loaders = 0.50 to 0.55 minutes
	Take average cycle time = 0.53 minutes
	(Includes load, maneuver with four reversals of direction (minimum travel), and dump.)
	Step 4 - Determine the Maximum Production Rate
	Step 5 - Determine the efficiency factor
	(Expect 50 minutes of production time per hour for a well-managed job)

	Step 6 - Determine the net production rate in LCY per hour
	Net production rate (LCY per hour) = maximum production rate (LCY per hour) x efficiency factor
	= 520 x 0.83
	= 432 LCY per hour
	Step 7 - Determine the time required to complete the task
	Assume the number of wheel loader available = 6
	Step 8 - Determine the total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost per day for wheel loader = RM 600
	Cost of diesel = RM 2.15/L
	Average diesel consumption for wheel loader = RM 15L/hour

	Total cost of diesel for wheel loader = RM 2.15 x 15 x 8 = RM 258 /day
	Total cost for 6 wheel loader
	= RM (600 + 258) x 50 x 6
	= RM 257400
	Wheel Loader Operator
	Number of operators = 6
	Assuming the cost for operator of wheel loader = cost for operator of excavator as both are categorized unde Plant and Machine Operators
	Details of Labour:
	Plant and machine operator, Semi-Skilled, Local
	Labor wage per day based on average listing for wheel loader operator
	= RM 85/day
	Total cost for 6 wheel loader operators
	= RM 85 x 50 x 6
	= RM 25500
	Dump Truck
	Brand: Hitachi
	Model: EH600
	Operating weight: 56,912 kg

Field Manual (FM) No. 5-434. 15 June 2000	
	Step 1 - Determine the number of bucket loads required to fill a truck
	Average wheel loader bucket capacity = 3.5 m³ = 4.6 BCY = 4.6 LCY
	Dump truck capacity = 56912 kg ≈ 125469.48 pounds
	For loam, unit weight of loam to be transported = 2600 pounds per LCY
	Step 2 - Determine the loading time per haul unit
	Loading time per haul unit = bucket cycle time x number of bucket loads
	= 0.53 x 9
	= 4.77 minutes ≈ 5 minutes
	Step 3 - Determine the number of hauling units needed to support the loading unit
	Max travelling speed of dump truck = 60km/hr
	Considering construction site speed limit,
	Average travelling speed of dump truck = 30km/hr

	Maximum distance travelled by dump truck = 210 m
	Average distance travelled by the dump truck = 110m
	Travel time per trip = 110/10000/30 = 0.004hr = 0.22 minutes
	Truck cycle time includes time spent traveling to the dump site, unloading, returning to the loading unit, and then being reloaded.
	Assuming time required to unload = 3.8 mintues
	Truck cycle time = 0.22 + 0.22 + 3.8 + 3.8 $\approx$ 8 minutes
	3
	Since the number of wheel loader available is 5, to maintain the output efficiency, the number of dump trucks;
	= 3 x 6
	= 18
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	
	Rental cost per dump truck per day = RM 750 /day
	Cost of diesel = RM 2.15/L
	Average diesel consumption for dump truck = RM 25L/hr

	Total cost of diesel per dump truck = RM 2.15 x 25 x 8 = 430 L/day
	Total cost for 15 dump trucks
	= RM (750 + 430) x 50 x 18
	= RM 1062000
	<u>Dump Truck Operator</u>
	Number of operators = 18
	Details of Labour:
	Plant and Machine Operator, Semi-Skilled, Local
Pocket Costbook, 2020	
	Labor wage per day based on average listing for dump truck operator
	= RM 80/day
	Total cost for dump truck operators
	= RM 80 x 50 x 18
	= RM 72000

6.9.6 Fill to Formation Level

In this activity, a bulldozer is employed to efficiently distribute soil, filling it to the designated reduced levels. This powerful and versatile piece of machinery ensures that the fill material is evenly spread and compacted according to the project's specifications.

The summary of cost is shown in the table below:

No.	Equipment / Labour	Unit	Time (days)	Total cost (RM)
1	Bulldozer	12	66	1092960
2	Bulldozer Operator	12	66	55440

Total cost for 639570.447 m^3	1148400
Total cost per m^3	1.8
20% profit per m^3	0.36
Final cost for 639570.447 m^3	1378080

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***<u>Bulldozer</u>***
References	**Calculation & Description**
Field Manual (FM) No. 5-434. 15 June 2000	Volume of soil to be filled
	= 639570.447 m^3
	= 836526.56 BCY
Table 1-1 (FM) No. 5-434. 15 June 2000	Volume of soil to be transported to fill areas
	= 836526.56 x 1.25
	= 1045658.2 LCY
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Brand: Komatsu
	Model: D475A-5 SD

	Blade capacity: 45.0 m³
	Blade length x height: 6465 mm x 2690 mm
Field Manual (FM) No. 5-434. 15 June 2000	**Step 1 - Determine maximum production of dozer**
	Based on type of dozer (D4 tractors)
	Assuming average dozing distance = 200 ft = 61 m,
	the estimated maximum production with universal blade is
	= 250 LCY/hour
	Step 2 - Determine the correction factors for different ideal conditions
	a) *Grade Correction Factor*
	Assume doom a 10 percent grade,
	Grade correction factor = 1.16
	b) *Material -weight Correction Factor*
	c) *Material-type Correction Factor*
	Since the soil type is a mixture of mostly sandy silt with clay loam, it is assumed that the soil is hard to drift thus having a factor of = 0.8

	d) *Operator Correction Factor*
	Since the work will mostly be done during daylight hours, the operator correction factor = 0.75
	e) *Operating Technique Correction Factor*
	Since the bulldozer utilizes slot dozing, the correction factor = 1.2
	f) *Efficiency Factor*
	(Expect 50 minutes of production time per hour for a well-managed job)
	Step 3 - Determine Total Correction Factor
	= 1.16 x 1.18 x 0.8 x 0.75 x 1.2 x 0.83
	= 0.82
	Step 4 - Determine dozer production
	Production (LCY per hour) = maximum production x the product of the correction factors
	= 250 x 0.82
	= 205 LCY/hour/dozer
	Step 5 - Convert production rate LCY per hour to BCY per hour
	Before the stripping process, the soil is in its natural state.
	Thus, LCY will be converted back to BCY

	Soil conversion factor for loam (loose to bank) = 0.8
	Dozer production in BCY = 205 x 0.8 = 164 BCY/hour/dozer
	Step 6 - Determine the total time required to complete the task
	Assume the number of available bulldozers = 12
	66 days
	Step 7 - Determine total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost per bulldozer = RM 950
	Cost of diesel = RM 2.15/liter
	Average diesel consumption for bulldozer = 25 L/hr
	Total cost of diesel per bulldozer
	= Rm 2.15 x 25 x 8
	= RM 430/day
	Total cost for 12 bulldozers

	= RM (950 + 430) x 66 x 12
	= RM 1092960
	<u>Bulldozer Operator</u>
	Number of operators = 12
	Labor details:
	Bulldozer Operator, Semi-Skilled, and Local
Pocket Costbook 2020	
	Labor wage per day based on average listing for machine operator
	= RM 70/day
	Total cost for 12 bulldozers
	= RM 70 x 12 x 66
	= RM 55440

6.9.7 Compaction

In this activity, vibratory soil compactors play a crucial role in compacting the soil on-site. These specialized machines ensure that the soil is effectively compressed, resulting in a stable and well-prepared foundation for various construction projects. By employing these compactors, the team can achieve the desired level of soil compaction, ensuring optimal performance and longevity of the constructed structures.

The summary of cost is shown in the table below:

No.	Equipment / Labour	Unit	Time (days)	Total cost (RM)
1	Compactor	5	49	147245
2	Compactor Operator	5	49	17150
Total cost for 639570.447 m²				164395
Total cost per m²				0.26

20% profit	0.052
Final cost for 639570.447 m²	197274

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***Compactor***
References	**Calculation & Description**
	Brand: Caterpillar
	Model: CS76 XT
	Compaction width: 2134 mm
Field Manual (FM) No. 5-434. 15 June 2000	
	Step 1 - Determine compactor production rate in CCY per hour
	$Production\ (CCY\ per\ hour) = \frac{16.3\ x\ W\ x\ S\ x\ L\ x\ E}{N}$
	where,
	16.3 = constant for converting the factors in feet, mph, and inches to CCY
	W = compacted width per pass, in feet
	S = compactor speed, in mph
	L = compacted lift thickness, in inches
	E = efficiency
	N = number of passes required

	Based on the compactor chosen,
	W = 2134 mm ≈ 70 feet
	The soil type is Sandy Silt Loam (SM).
	Thus,
	(Smooth Drum Vibratory Category)
	L = 9 inches
	S = 4 mph
	N = 8 (required)
	(Expect 50 minutes of production time per hour for a well-managed job)
	Efficiency Factor E = 0.83
	Therefore, $Compactor\ Production\ (CCY\ per\ hour) = \frac{16.3\ x\ 7\ x\ 4\ x\ 9\ x\ 0.83}{8}$ $= 426.16 = 426\ CCY\ per\ hour$
	Output of 1 compactor = 426 CCY per hour
	Step 2 - Determine the required time to complete the task
	Volume of soil to be filled
	= 639570.447 m^3
	= 836526.56 BCY
	Volume of soil to be transported to fill areas
	= 836526.56 x 1.25

	= 1045658.2 LCY
	$Compactors\ required = \frac{amount\ of\ fill\ delievered\ (LCY\ per\ hour)\ x\ soil\ conversion\ fact}{compactor\ production\ (CCY\ per\ hour)}$ $Amount\ of\ fill\ delievered\ (LCY\ per\ hour) = \frac{compactor\ production\ (CCY\ per\ hour)\ x\ co}{soil\ conversion\ factor(LCY:}$ Assuming 6 vibratory soil compactors are available (*2 owned; 4 rented*),
	$= \frac{426}{0.8}$ = 2662.5 LCY/hour
	Time required to complete the task with the given number of compactors:
	= 1045658.2 LCY/2662.5 $LCY\ per\ hour$
	= 392.74 hours ≈ 49 days
	Step 3 - Determine the total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost for compactor per day = RM 600
	Cost of diesel = RM 2.15/L

https://static1.squarespace.com/static/ 58877529414fb5283ed14a6b/ t/5888f8df46c3c4d4d976a102/ 1485371615708/Fuel+Table+-+Compactors.pdf	Average diesel consumption for compactor = RM 14 L/hour
	Total cost of diesel per compactor
	= Rm 2.15 x 14 x 8
	= RM 241 /day
	Total cost for 2 compactors (owned)
	= RM 241 x 49 x 2
	= RM 23618
	Total cost for 3 compactors (rented)
	= RM (600 + 241) x 49 x 3
	= RM 123627
	Total cost for 5 compactors
	= RM 23618 + RM 123627
	= RM 147245
	Compactor Operator
	Number of operator = 5

	Labor details:
	Compactor Operator, Skilled, and Foreign
Pocket Costbook 2020	
	Labor wage per day based on average listing for machine operator
	= RM 70/day
	Total cost for 5 compactors
	= RM 70 x 5 x 49
	= RM 17150

6.9.8 Grading

In this activity, graders play a crucial role in the final stages of grading, which entails the smoothing of slopes, shaping of ditches, and adjusting the earthwork to achieve the desired elevation as outlined in the project plans and specifications. These specialized machines ensure that the site preparation is completed to the highest standards, creating a stable and well-graded foundation for subsequent construction activities.

The summary of cost is shown in the table below:

No.	Equipment / Labour	Unit	Time (days)	Total cost (RM)
1	Grader	3	1.32	2473.68
2	Grader Operator	3	1.32	300
Total cost for 362783.42 m²				2773.68
Total cost per m²				0.0076
20% profit per m^2				0.0015
Final cost for 362783.42 m²				3328.42

Calculation and assumptions of the costing and estimating are as shown in the table below:

Equipment/Labor:	***<u>Grader</u>***
References	**Calculation & Description**
	Brand: Komatsu
	Model: GD705-5
	Grading width: 4320 mm
	Determine the grader production rate
	$Total\ Time = \dfrac{P\ x\ D}{S\ x\ E}$
	where,
	P = number of passes required
	D = distance traveled in each pass, in miles or feet
	S = speed of grader, in mph or fpm (multiply mph by 88 to convert to fpm)
	E = efficiency factor
	Assume number of passes, P = 5
	Assume distance of site, D = 760 m = 0.76 km
Table 4-1	For finishing, the gear range for the grader to operate is between third to fourth. For the selected model, (in km/h)
	Speed for second gear: 5.6 km/h

	Speed for third gear: 7.7 km/h
	Speed for fourth gear: 10.9 km/h
	Average speed, S = 8 km/h
	(Expect 50 minutes of production time per hour for a well-managed job)
	Efficiency Factor E = 0.83
	Grading area per round
	= 760 m x 0.4320
	= 328.32 = 328 m^2
	Therefore,
	Output efficiency where Total Time per Grading Width
	$Total\ Time = \frac{P\ x\ D}{S\ x\ E}$
	$= \frac{5\ x\ 0.76}{8\ x\ 0.83}$
	$\approx 34\ mins\ per\ 328\ m^2$
	Area of the construction project = 362783.42 m^2
	Total Travel Time = 362783.42/328 x 35 min
	= 31.60 hours
	Assume number of graders = (1 owned; 2 rented)
	= 31.60 hours / 3 graders

	= 10.53 hours ≈ 1.32 day
	Determine the total cost
CIDB Machinery 2015 Hire Rates and Equipment Purchase Price (List A) WP Kuala Lumpur	Rental cost for grader per day = RM 550
	Cost of diesel = RM 2.15/L
https://www.scribd.com/ document/458748773/fuel-consumption #	Average diesel consumption for compactor = RM 15 L/hour
	Total cost of diesel per grader
	= Rm 2.15 x 15 x 8
	= RM 258 /day
	Total cost for 1 compactor (owned)
	= RM 258 x 1 x 1.32
	= RM 340.56
	Total cost for 2 compactors (Rented)
	= RM (550 + 258) x 1.32 x 2
	= RM 2133.12
	Total cost for 3 compactors
	= RM 340.56 + RM 2133.12
	= RM 2473.68
	Grader Operator

	Number of operator = 3
	Labor details:
	Motor Grader Operator, Skilled, and Foreign
	Labor wage per day based on average listing for machine operator
	= RM 75/day
	Total cost for 3 graders
	= RM 75 x 4 x 1
	= RM 300

6.10 Conclusion

In the cost estimation process above, we have taken two steps in preparing costs. First, by submitting several numbers of machines and also several numbers of workers with salaries according to the references listed previously. After getting the total cost. We took the second step, namely adding several machines and laborers, while there were several parts that experienced a reduction in the number of machines. In addition, we also reduce costs by using the lowest salary benchmark for each step, which changes the standard of workers from skilled to semi-skilled. Therefore, the project's cost reduction objective was successfully accomplished by employing value engineering techniques, resulting in a 4.9% decrease in expenses.