

# CHAPTER 5

## CHAPTER 5: SECTORAL IMPACT ASSESSMENTS

This chapter discusses the sectoral assessments undertaken for the identification and evaluation of the potential environmental impacts associated or arising from the implementation of the Project.

### 5.1 IMPACT ON AIR QUALITY

Air quality impact assessment of the proposed Sungai Lembing to Jerantut Road is divided into two parts; (i) impacts during the construction phase; and (ii) impacts during the operational phase.

As the construction phase involves excavation, fill and grading operations, construction of roads, bridges and structures, significant amounts of air pollutants, mainly suspended particulate matter will be emitted by these activities.

On the other hand, during the operational phase of the Project, emissions are from motor vehicles travelling on the new road. Air pollution is mainly due to emissions from dust churned up by moving vehicles and vehicle engines. An assessment of the impact of these emissions is conducted.

#### 5.1.1 POTENTIAL IMPACT DURING CONSTRUCTION PHASE

The main pollutant of concern during the construction stage of the Project is suspended particulate matter due to fugitive dust generation and this may have substantial temporary impact on the local air quality. Emissions during the construction phase is associated with land clearing, ground excavation, fill and grading operations (i.e. earth moving), and construction of structures such as bridges and retaining walls and the road itself. Dust emissions often vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. A large portion of the emissions are from equipment traffic over temporary roads and unpaved surfaces at the Project site.

##### A. Emissions

The temporary nature of construction differentiates it from other fugitive dust sources as to estimation and control of emissions. Construction consists of a series of different operations, each with its own duration and potential for dust generation. In other words, emissions from any single construction site can be expected: (a) to have a definable beginning and an end; and (b) to vary substantially over different phases of the construction process. This is in contrast to most other fugitive dust sources, where emissions are either relatively steady or follow in a discernible annual cycle. Furthermore, there is often a need to estimate area wide construction emissions, without regard to the

actual plans of any individual construction project. For these reasons, it is very difficult to estimate the potential dust emissions from the sources. However, it can be said that the quantity of dust emissions from construction operations are: (a) proportional to the area of land being worked on and to the level of construction activity; (b) positively correlated with the silt content of the soil; (c) dependant on the speed and weight of the average vehicle; and (d) negatively correlated with the soil moisture content.

Based on a set of field studies which attempts to relate the emissions from construction directly to an emission factor, the approximate emission factor for such construction activity operations is (US EPA, 1995):

$$E = 2.69 \text{ megagrams (Mg)/hectare/month of activity}$$

This value is most useful for developing estimates of overall emissions from construction scattered throughout a geographical area. The value is most applicable to construction operations with: (a) medium activity level; (b) moderate silt contents, and (c) semi-arid climate.

## **B. Emission Rate**

The total construction area for the Project is estimated to be approximately 200 hectares. Based on a construction period of approximately 30 months and a construction area of 200 hectares, the amount of dust emitted without control measures is:

$$\text{Dust emission} = 2.69 \times 200 \times 30 = 16,140 \text{ Mg}$$

Assuming that construction activity is during the day and lasts approximately 12 hours a day from 7.00 a.m. to 7.00 p.m. The 16,140 Mg reduces to an emission rate of 415.1 g/s (worst case) spread over 200 hectares and is the emission rate at the height of construction activity. Over one hectare, the emission is  $415.1 / 200 = 2.07 \text{ g/s}$ . This emission rate was used in the modelling to predict the total suspended particulate (TSP) concentration in ambient air during the construction phase of the Project, assuming that there are no control measures. As at any one time, the area under construction activity is approximately 20 hectares, then the total emission rate is  $2.07 \times 20 = 41.5 \text{ g/s}$ . However, in the case when there are control measures such as keeping exposed surfaces moist and covered, the emission rate can be reduced by almost 98%; but for modelling purposes, the emission is estimated to be reduced by only 95%, the total emission rate used in the modelling was 2.07 g/s.

## **C. Modelling**

As fugitive dust in the form of TSP is a major concern during the construction phase of the Project, refined modelling of its impact is conducted. The model used in the study is the Industrial Source Complex Short Term Version Three (ISCST3) model. This model is an advanced Gaussian Plume Model.

#### **D. Model Description**

The Industrial Source Complex Short Term Version 3 (ISCST3) model is the US EPA's current regulatory model for many New Source Review (NSR) and other air permitting applications. The ISCST3 model is based on a steady-state Gaussian plume algorithm, and is applicable for estimating ambient impacts from a wide variety of sources such as point, area, and volume sources out to a distance of about 50 km. The ISCST3 model includes algorithms for addressing building downwash influences, dry and wet deposition algorithms, and also incorporates the complex terrain screening algorithms from the COMPLEX1 model (US EPA, 1995). The ISCST3 model utilises hourly meteorological data that have been pre-processed using the PCRAMMET program for meteorological data, and the Meteorological Processor for Regulatory Models (MPRM) for on-site data.

#### **E. Source Input Data**

Input for the ISCST3 model includes emission and source parameter data for the sources in the study area. The sources at the construction site are modelled as area sources as these are fugitive dust sources. The length of the source was set at 1,000 m in length and 20 m in width.

#### **F. Receptor Grid and Discrete Receptors**

In order to simulate the impact of emissions from ground and elevated sources, receptors must be chosen, and ground level ambient concentrations determined for each of the receptor locations.

In this assessment study, a 6 km x 6 km receptor grid is chosen to assess the impact of fugitive dust emissions from the construction site of the Project. The proposed roadway is set as the origin of the receptor grid.

#### **G. Meteorology**

The surface weather and upper air data used in the ISCST3 modelling input were collected from the Kuantan Airport Meteorological Station (Latitude N 03° 47'; Longitude E 103° 13'; elevation 15.3 m above MSL). This station is the nearest meteorological station with long term meteorological data for modelling. This station is operated by the Malaysian Meteorological Department. One year of the latest available data is used in the numerical simulation.

The ISCST3 "reads" the meteorological information on an hour-by-hour basis. The hourly weather data contains wind speed, wind direction, temperature, atmospheric stability, and mixing height. Hourly mixing height is computed according to the US EPA recommended formula:-

$$\text{Mixing height (M)} = \text{surface wind speed (m/s)} \times 320$$

If data on wind profile exponents and vertical potential temperature gradient are available, the user can assign these data to the model for computation, otherwise default values are automatically used by the ISCST3 programme.

## **H. Dispersion Options**

The ISCST3 model is especially designed to support the regulatory modelling assessments. The regulatory modelling options are selected for the mode of operation for the model. These include the use of stack-tip downwash, buoyancy-induced dispersion, final plume rise, routine for processing averages when calm winds occur, values for wind profile exponents and for the vertical potential temperature gradients.

The model has a rural and three urban options. Depending on the options selected, the mixing heights and diffusion coefficient values for the indicated stability category are used in the calculation such as urban mixing heights are used in urban modes. The rural mode is usually selected for industrial source complexes located in rural areas. However the urban option may also be considered in modelling an industrial source complex located in a rural area if the complex is large and contains tall buildings and/or large heat sources. This is to account for the enhanced turbulence generated during stable meteorological conditions by surface roughness and/or heat sources.

In this study the rural option is chosen as the proposed Project is located in an area surrounded mainly by vegetation and is undeveloped.

## **I. Model Output**

The types of output available with the model are:

- i. Summaries of high values (highest, second highest, etc.) by receptor for each averaging period and source group combination;
- ii. Summaries of overall maximum values for each averaging period and source group combination; and
- iii. Tables of concurrent values summarised by receptor for each averaging period and source group combination for each day of data processed.

In this assessment, the maximum incremental concentration for the period is computed. This means that for the 24-hour average concentration, the maximum 24-hour average concentration is the highest computed 24-hour average concentration over the entire meteorological data period.

In the case of the long-term average or the seasonal average concentration, the computed average concentration is the average of all the hourly concentration over the entire meteorological data period.

## **J. Output Parameters**

The following parameters are predicted for each package of the Project:

- i. Maximum 24-hour average TSP concentration; and
- ii. Annual average TSP concentration;

The prediction will be done for two scenarios i.e. (i) when there are control measures to reduce dust emissions; and (ii) worst case scenario when there are no control measures.

## K. Results

**Figure 5.1.1** shows the predicted maximum 24-hour average TSP incremental concentration in the receptor grid due to emissions from construction activities during the construction phase of the Project when there are dust control measures. The predicted maximum 24-hour average TSP incremental concentration is between  $10 \text{ ug/m}^3$  and  $60 \text{ ug/m}^3$ . Added to the existing baseline concentration of  $73 \text{ ug/m}^3$  at A1 and  $68 \text{ ug/m}^3$  at A2, the resulting TSP concentration is below the guideline limit of  $260 \text{ ug/m}^3$ .

The predicted annual average TSP concentration is below the guideline limit of  $90 \text{ ug/m}^3$  as the predicted highest incremental concentration is  $6 \text{ ug/m}^3$  and is below  $90 \text{ ug/m}^3$  when the existing baseline concentration is added to the incremental concentration. **Figure 5.1.2** shows the predicted annual average TSP incremental concentration.

However, when there are no dust control measures, the predicted TSP concentration is above the  $260 \text{ ug/m}^3$  guideline limit in areas up to 1 km from the construction areas. Obviously, the most affected areas are located at sites where there are active construction activities. The increase in TSP concentration varies between  $100 \text{ ug/m}^3$  at distances of about 2 km away and  $500 \text{ ug/m}^3$  near the construction site with the highest level of  $670 \text{ ug/m}^3$  occurring within the site. The contours of the predicted TSP incremental concentration are shown in **Figure 5.1.3**.

On annual average case basis, the incremental TSP concentration is between  $10 \text{ ug/m}^3$  and  $76 \text{ ug/m}^3$  as shown in **Figure 5.1.4**. These concentrations are just below the annual average concentration guideline limit of  $90 \text{ ug/m}^3$ .

## L. Conclusion

Dust as total suspended particulate (TSP) is the main pollutant emitted during the construction phase of the Project. Numerical modelling using the US EPA ISCST3 Model showed that the predicted ambient air TSP concentrations are below the Malaysian guideline limits when there are control measures to reduce dust emissions. However when there are no dust control measures, the predicted TSP is much higher and is above the guideline limits mainly in areas close to the Project site. Thus, dust control measures must be implemented during the construction phase of the Project.

**Figure 5.1.1: Maximum 24-hour average TSP incremental concentration ( $\mu\text{g}/\text{m}^3$ )  
(Construction Phase – with control measures)**

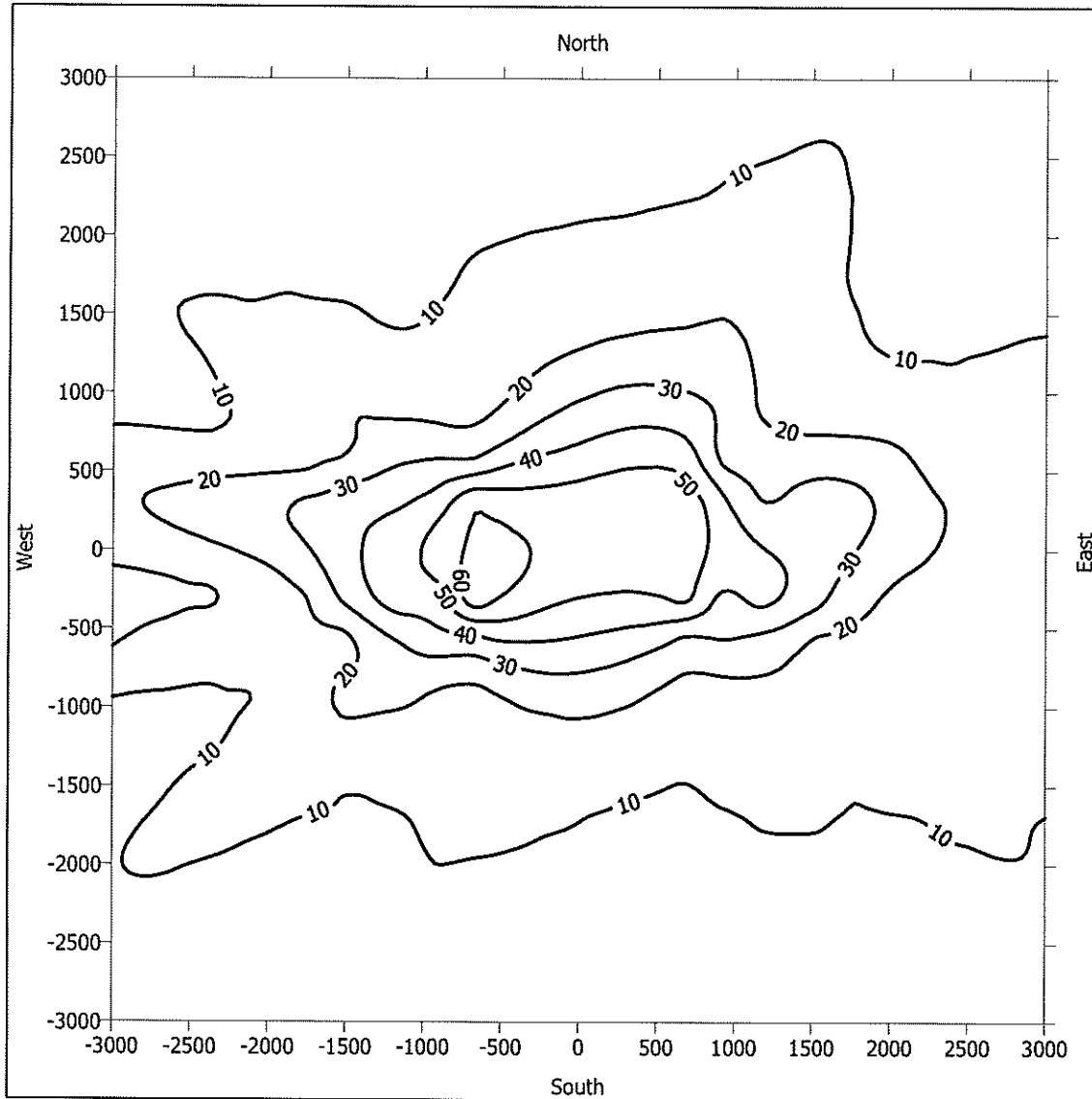
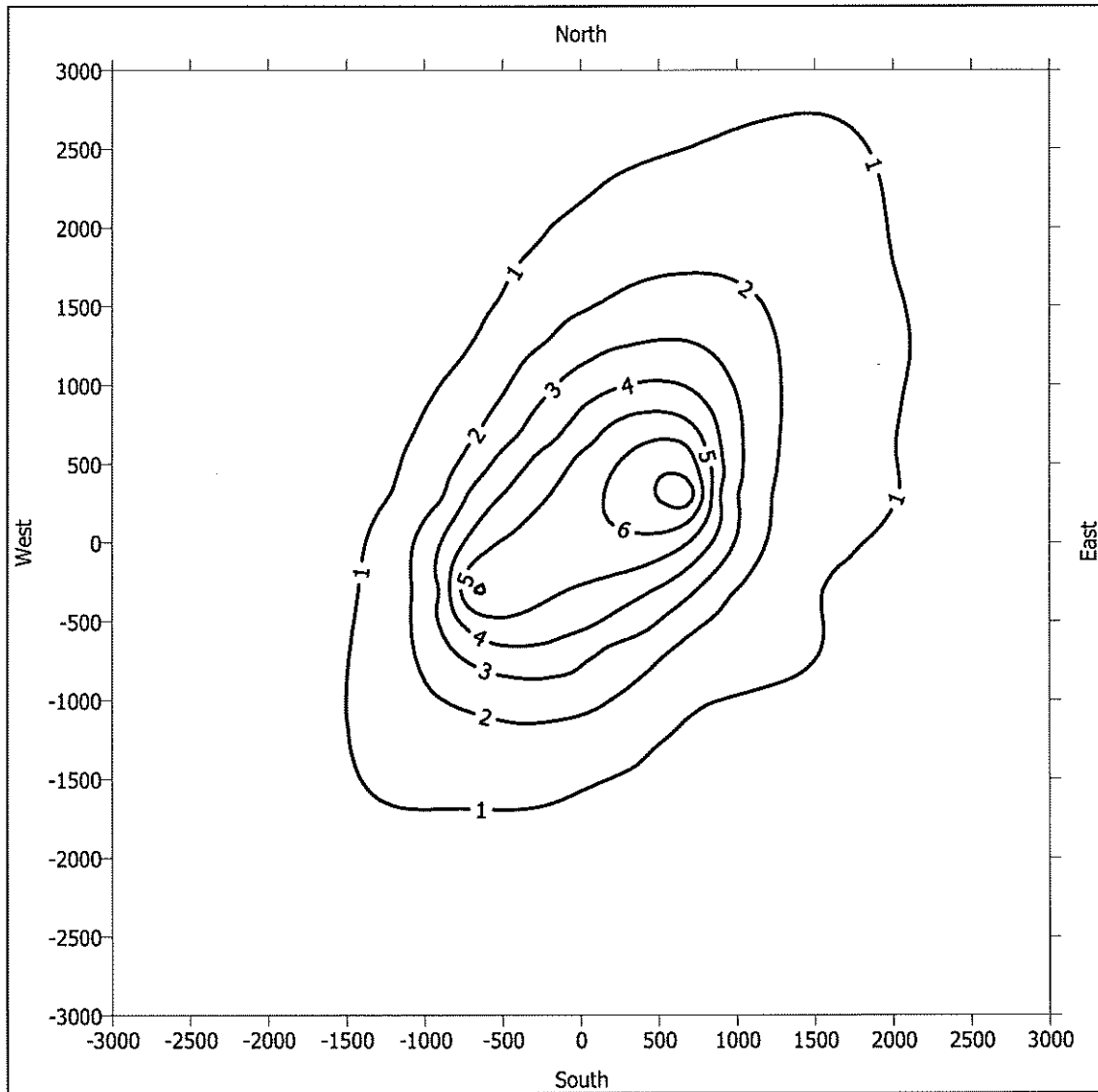


Figure 5.1.2: Annual average TSP incremental concentration ( $\mu\text{g}/\text{m}^3$ ) (Construction Phase – with control measures)



**Figure 5.1.3: Maximum 24-hour average TSP incremental concentration ( $\mu\text{g}/\text{m}^3$ )  
(Construction Phase – without control measures)**

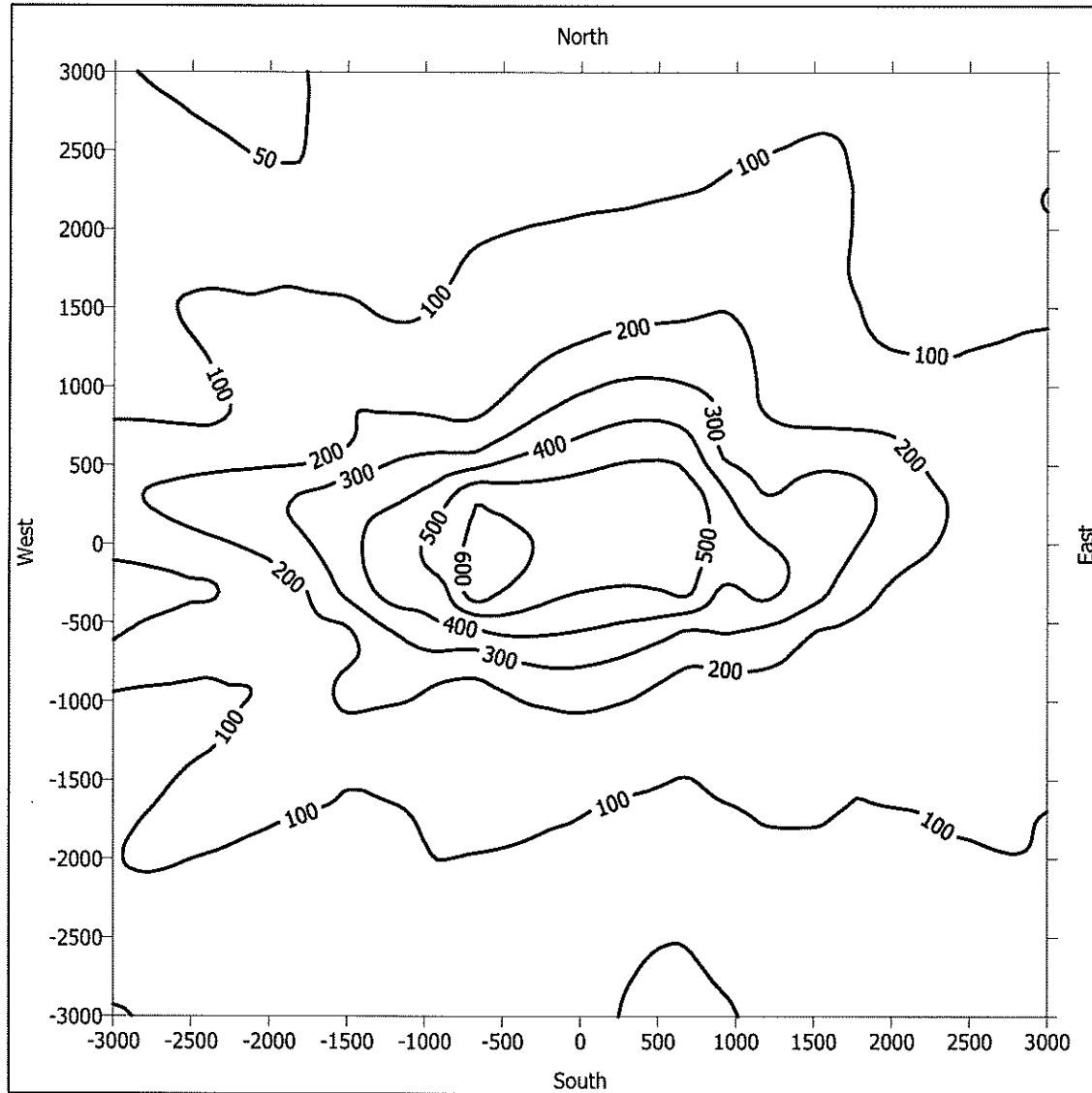
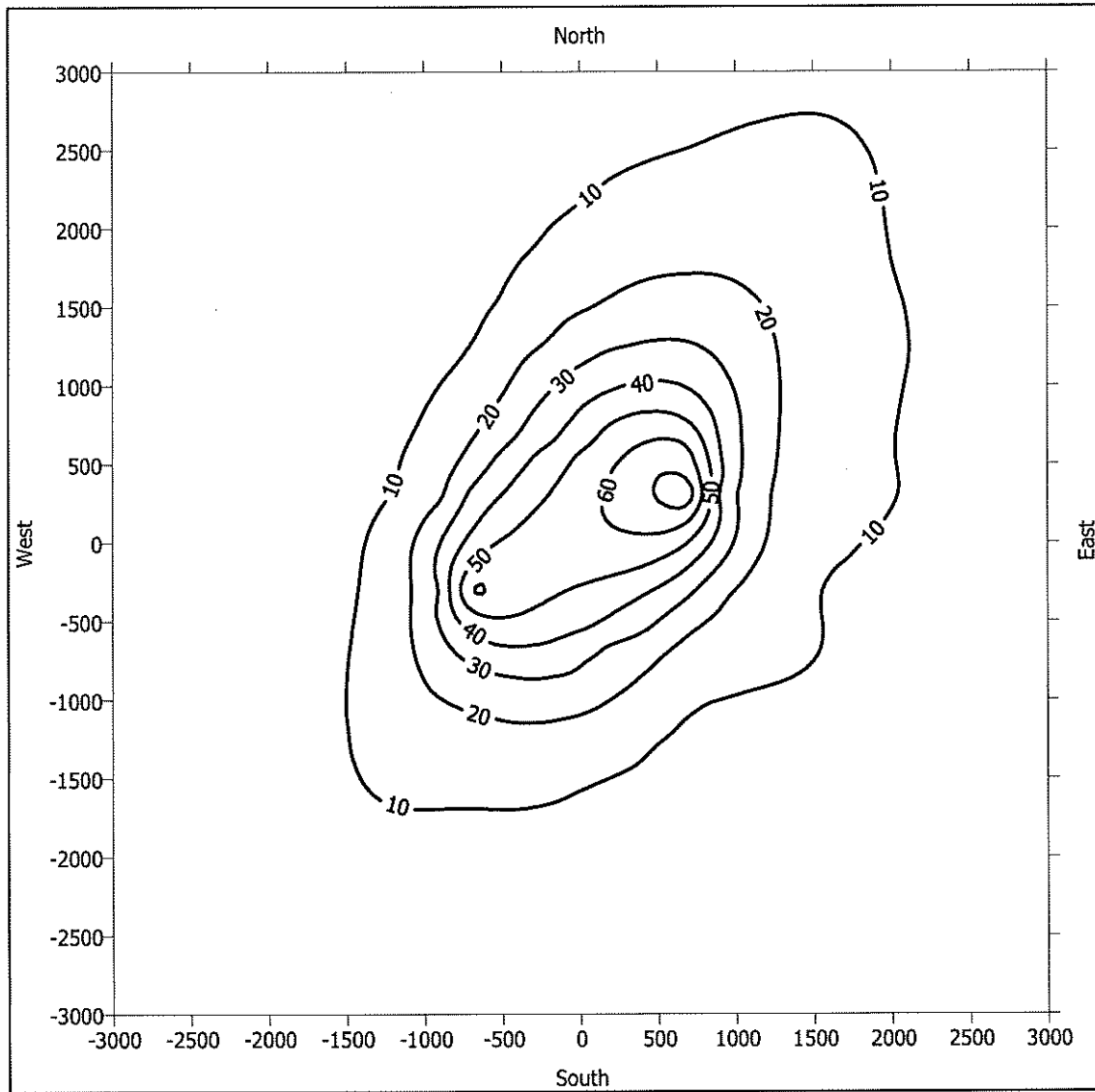


Figure 5.1.4: Annual average TSP incremental concentration ( $\mu\text{g}/\text{m}^3$ ) (Construction Phase – without control measures)



### 5.1.2 POTENTIAL IMPACTS DURING POST-CONSTRUCTION PHASE

As it is well known, motorised vehicles on roads emit air pollutants from fuel combustion. Depending on vehicle volume, the amount emitted may be significant. In this new road project, the impact on air quality resulting from vehicle emissions is assessed based on projected vehicle volume on this new road.

The traffic volume used for the modelling is the maximum surveyed traffic volume of the Kuantan - Sungai Lembing road. The morning peak traffic volume in the direction of Sungai Lembing to Kuantan is 173 vehicles per hour with a reverse peak of about 88 - 93 vehicles per hour in the afternoon and evening. The average vehicle composition used is 65.7 % for car/ van/ taxi, 8.6% medium lorry, 11.7% heavy lorry, 1.8% bus and 12.2% motorcycle.

Only carbon monoxide (CO) is assessed as it is the most significant air pollutant emitted by motor vehicles.

#### A. Emission Rate

The emission rate of CO from motor vehicles for the modelling study is computed from surveyed traffic flow volume and emission factors taken from the joint air quality management study for the Kelang Valley Region by the Japan International Cooperation Agency and Department of Environment, Malaysia (JICA, 1993). The rates are tabulated below.

**Table 5.1.1: Motor vehicle emission factors for Carbon monoxide (g/km)**

Vehicle Type	Average Speed (km/hr)				
	45	50	55	60	65
<b>Class 1:</b> Motorcars/ taxis	11.62	10.27	9.09	8.25	7.58
<b>Class 2:</b> Small vans and utility vehicles	19.10	16.89	14.97	13.59	12.48
<b>Class 3:</b> Medium weight lorries and large vans	2.93	2.63	2.42	2.25	2.12
<b>Class 4:</b> Heavy lorries	6.80	6.12	5.63	5.24	4.95
<b>Class 5:</b> Buses	9.73	8.76	8.06	7.50	7.09

Source: JICA, (1993).

Total emissions are computed based on surveyed vehicle flow volume and the emission factor for the class of vehicle. The estimated and projected total traffic flow volume (high) per hour of the proposed new road is shown in **Table 5.1.2** below.

**Table 5.1.2: Estimated and projected total traffic flow volume (high) per hour**

Vehicle Class	Vehicle flow volume per hour
Class 1	115
Class 2	20
Class 3	15
Class 4	20
Class 5	3
<b>Total</b>	<b>173</b>

Based on the values of the above two tables, the total amount of carbon monoxide in g/s emitted from the surveyed traffic flow volumes is as follow:

Pollutant	Motor vehicles emission rate (g/s)
Carbon monoxide	23.0

The basis of computation of the above emission rate is as follows:

In one hour, one unit of Class 1 car travelling at 65 km/h will emit  $65 \times 7.58 = 492.7$  g of CO. Since the cars flow volume is 115 cars per hour, therefore, in one hour, 115 cars travelling at 65 km/h will emit  $492.7 \times 115 = 56,660.5$  g of CO. In units of g/s, the emission rate is  $56,660.5/3,600 = 15.7$  g/s for cars (Class 1). By the same method of calculation, the CO emission rate for Classes 2, 3, 4 and 5 vehicles is 4.5 g/s, 0.6 g/s, 1.8 g/s and 0.4 g/s, respectively. The total CO emission rate is 23.0 g/s.

## B. Modelling

The model used in this part of the assessment is also the Industrial Source Complex Short Term Version Three (ISCST3) model. This model is described in **Section 5.1.1 D** above.

## C. Source Input Data

Input for the ISCST3 model includes emission and source parameter data for the sources in the study area. The sources in this case are vehicle emissions which are modelled as area sources as these are fugitive sources. The length of the source is set at 1,000 m in length and 20 m in width.

## D. Receptor Grid and Discrete Receptors

In order to simulate the impact of emissions from ground and elevated sources, receptors must be chosen, and ground level ambient concentrations determined for each of the receptor locations.

In this assessment study, a 6 km x 6 km receptor grid is chosen to assess the impact of vehicle emissions from the road. The proposed new road is set as the origin of the receptor grid.

## **E. Meteorology**

The surface weather and upper air data used in the ISCST3 modelling input were collected from the Kuantan Airport Meteorological Station as described above.

## **F. Modelling Results**

Maximum 1-hour and 8-hour average CO concentration were predicted in a 6 km x 6 km receptor grid based on peak traffic flow volume surveyed. The results of the modelling study are shown in **Figure 5.1.5** and **Figure 5.1.6** for the maximum 1-hour and 8-hour average concentrations, respectively.

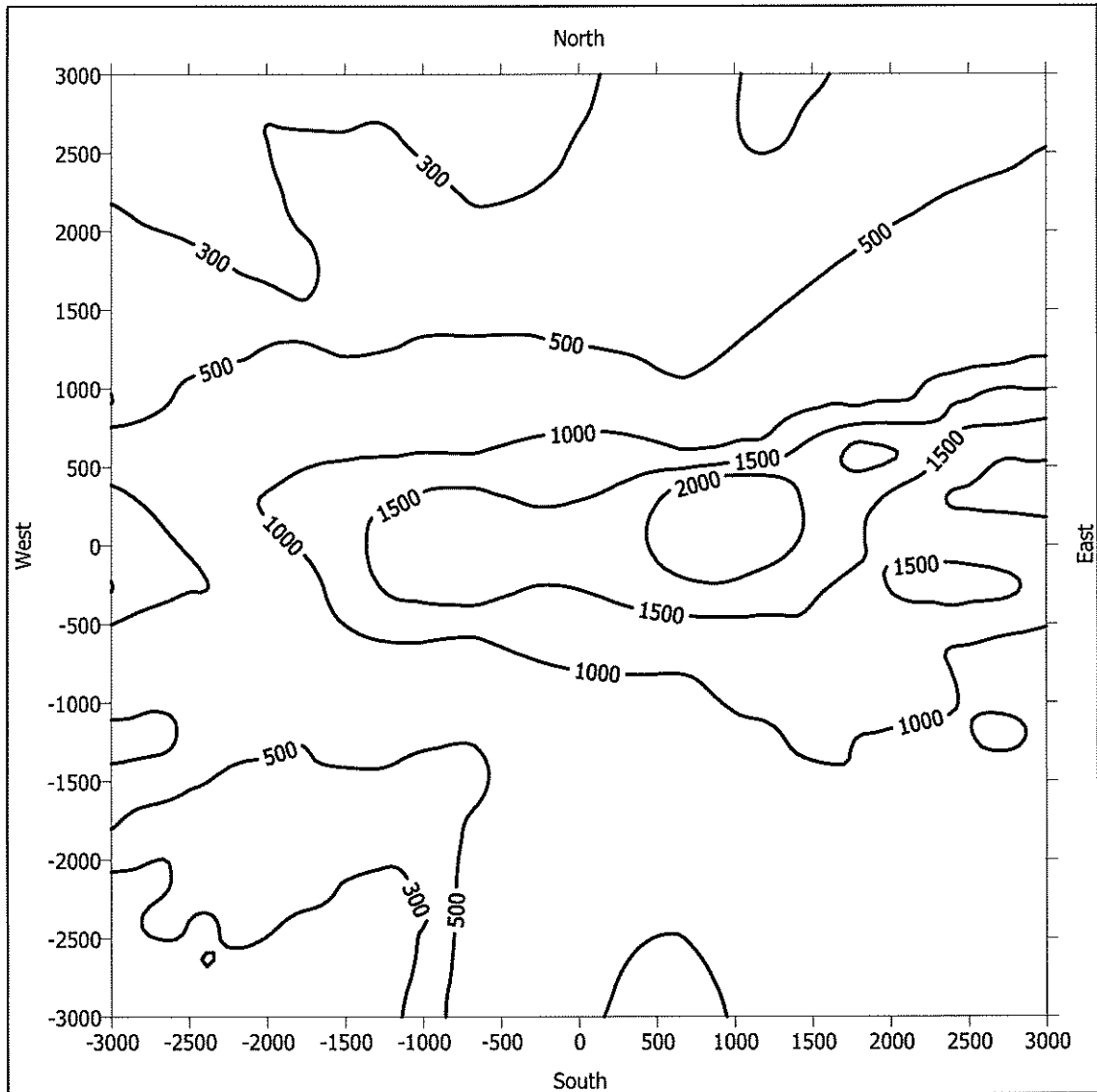
Highest concentrations are found near to the road, decreasing exponentially with distance from the source. The highest maximum 1-hour average CO concentration is expected to be about 2,801  $\mu\text{g}/\text{m}^3$ . In comparison with the ambient air quality limit of the Malaysian Ambient Air Quality Guidelines (MAAQG), the predicted CO concentration resulting from traffic using the proposed new road is well below the CO guideline limit of 35,000  $\mu\text{g}/\text{m}^3$ .

In the case of the maximum 8-hour average concentration, the predicted CO concentration is between 100  $\mu\text{g}/\text{m}^3$  and 518  $\mu\text{g}/\text{m}^3$ . This is also well below the guideline limit of 10,000  $\mu\text{g}/\text{m}^3$ .

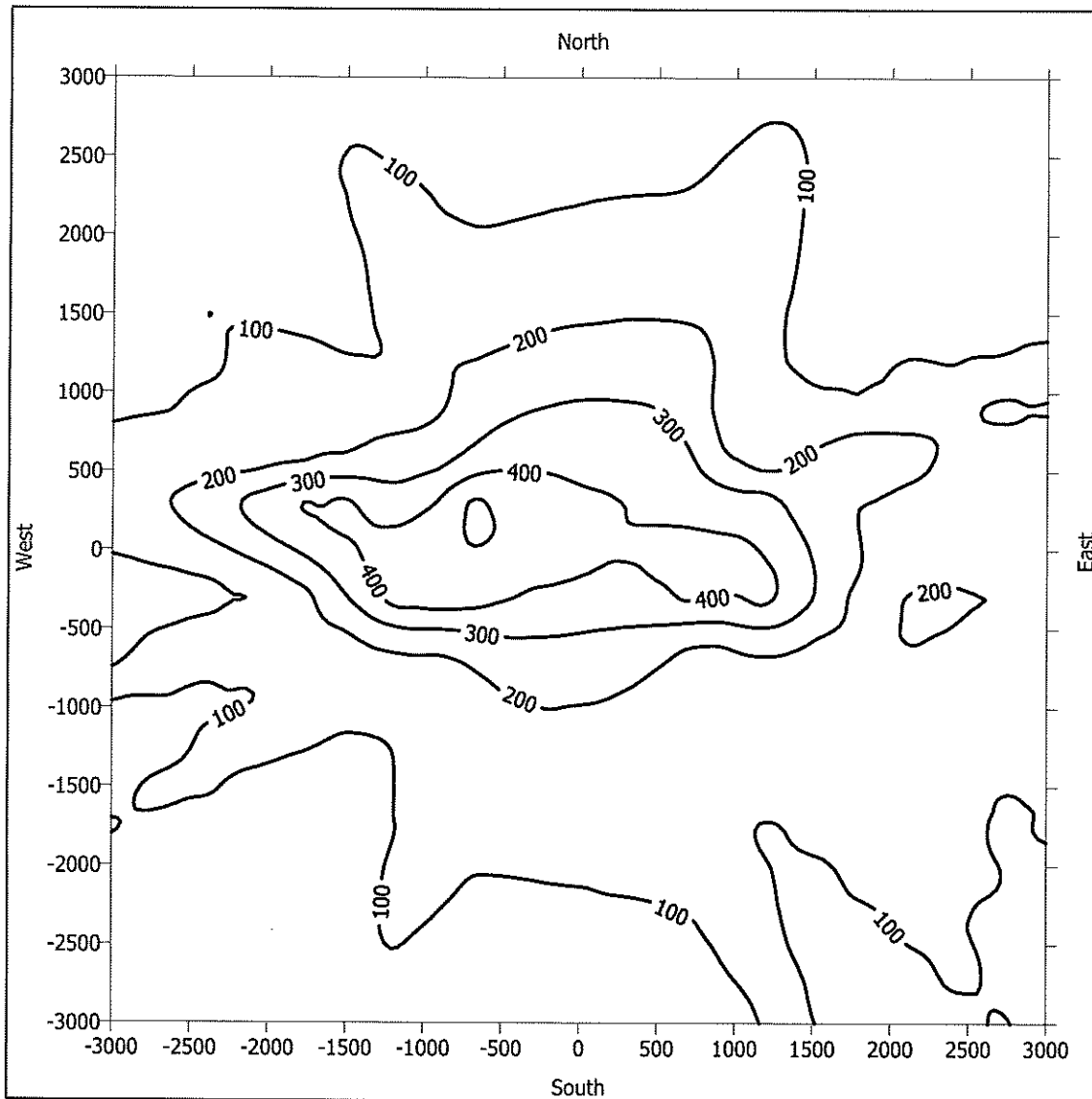
## **G. Conclusion**

During the operational phase of the Project, the proposed new road is expected to generate low to moderate amounts of motorised traffic. The air quality of the areas in the vicinity of the proposed new road is not expected to be impacted significantly as traffic volume is expected to increase gradually.

**Figure 5.1.5: Maximum 1-hour average CO incremental concentration ( $\mu\text{g}/\text{m}^3$ )  
(Operational Phase – peak traffic volume)**



**Figure 5.1.6: Maximum 8-hour average CO incremental concentration ( $\mu\text{g}/\text{m}^3$ )  
(Operational Phase – peak traffic volume)**



## 5.2 IMPACT ON NOISE LEVEL

During the pre-construction stage and upon completion of the proposed road, the impact on ambient noise level is anticipated to be insignificant. Noise pollution is only anticipated during the construction stage from the operation of construction equipment and machinery.

At the time of the PEIA study, details on the construction equipment and machinery that are to be used on site are not available. A typical list of construction machinery and their respective operating noise levels are summarised in **Table 5.2.1**.

**Table 5.2.1: Typical noise level emitted by construction machinery**

No.	Equipment	Typical Noise Level, $L_{Aeq}$ , at distance of 15 m in dB(A)
1.	Truck	88
2.	Portable air compressors	81
3.	Concrete mixer (truck)	85
4.	Jackhammer	88
5.	Dozer	87
6.	Paver	89
7.	Generator	76
8.	Bore piling	85
9.	Pneumatic tools	85
10.	Backhoe	85
11.	Mobile crane	77
12.	Tractors	73
13.	Pump	76
<b>Estimated on-site noise level (<math>L_{Aeq}</math>)</b>		<b>88.4</b>

*Note: The noise levels presented are without noise reduction mechanisms.*

*Source: May, D.N., 1978; Noise and Vibration (2006).*

Throughout the construction period, the estimated highest noise level is expected during the earthworks, where noise sources from trucks, dozers, backhoes, tractors and generators. Assuming the worst case scenario where earthwork activities are carried out simultaneously and the machinery are without noise reduction mechanisms, the combined noise level from these sources is estimated at 88.4 dB(A).

As a large section of the Project site is located within a forested area that is not inhabited, and coupled with staged development and installation of noise reduction mechanisms on the construction machinery, the predicted worst case scenario will not arise.

Apart from the noise generated at the construction site, another source is expected from the transportation of earth material along the access road. The maximum noise level over 1 hour during which 8 trucks utilise the access road can be predicted using the empirical equation developed by the Ontario Ministry of Transportation and Communications, i.e.:

$$L_{eq} = 42.3 + 10.2 \log_{10} (V_c + 6V_t) - 13.9 \log_{10} D + 0.13S$$

where,  $L_{eq}$  = energy equivalent sound level during one hour (dB(A))  
 $V_c$  = volume of automobiles (four tyres only) (veh/hr)  
 $V_t$  = volume of trucks (six or more tyres) (veh/hr)  
 $D$  = distance from edge of pavement to receiver (m)  
 $S$  = average speed of traffic flow during one hour (km/hr)

Several assumptions were made:

- i. Each vehicular noise source is a point source (one finite element) with constant traffic parameters and roadway characteristics.
- ii. Composition of traffic is 0 cars and 100% heavy trucks.
- iii. Average vehicular speed is 40 km/hr.

Therefore, by taking the distance  $D$  as 1.0 m, the traffic noise from source,  $L_{eq}$ , is estimated at 64.6 dB(A).

Comparing with the existing baseline noise level of 64.7 dB(A) to 67.8 dB(A), the traffic noise generated from the Project's earth/material transportation trucks will not aggravate the existing noise level to a detrimental situation. As the nearest sensitive receptors (i.e. Felda Lepar Utara settlements) are located more than 1 km away from the construction sites, noise level generated due to the Project during the construction stage would be highly insignificant.

### 5.3 IMPACT ON WATER QUALITY

#### 5.3.1 CONSTRUCTION STAGE

The potential impacts on water quality during the construction stage are:

##### A. Soil Erosion and Sedimentation

Soil erosion is a process of detachment and transportation of soil particles from their original mass by the actions of agents of erosion, e.g. rain or flowing water. Erosion and sediment runoff is expected to be the most prominent impact arising from the Project. Site clearing i.e. removal of trees and vegetation as well as earthworks (movement of heavy machineries, excavation and earth filling activities) are anticipated to be the major cause of soil erosion during the construction period. Eroded land usually has lower infiltration capacity and thus leads to increased surface runoff and loss of valuable topsoil. Of greater concern and importance is the negative impact on the water quality of the receiving waterways.

Uncontrolled soil erosion can cause an increase in sedimentation of downstream water bodies, landslides and flooding. Sedimentation would occur during the construction stage which may increase the turbidity and TSS level in nearby rivers and streams. This is expected to cause stress on the environment as well as aquatic life.

##### B. Contamination of river water

The construction works will be using numerous heavy machineries which require fuel supply as well as mechanical servicing and maintenance on site. As such, if not properly handled, spillages from fuel storage areas and workshops may occur and this may lead to contamination of the receiving waterways, especially during and after rain.

Another potential pollutant that may contaminate the receiving waterways is from sewage and sullage discharges from temporary workers camps and work areas. Direct discharge of sewage may contribute to an increase of *E. coli* and Coliform bacteria.

#### 5.3.2 POST-CONSTRUCTION STAGE

##### A. Stormwater Runoff

Stormwater runoff from roads is generally contaminated by heavy metals and organic compounds derived from motor vehicles emissions, i.e. exhaust emission as well as wear and tear of tyres and brake pads. Volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) are commonly found in stormwater at low concentrations. Polycyclic Aromatic Hydrocarbons (PAH) – a group of SVOCs – have been previously measured in stormwater; the source being evaporation from fuel.

## 5.4 IMPACT ON SOIL

### 5.4.1 PREDICTION OF SOIL LOSS AND SEDIMENT YIELD

#### A RUSLE (Revised Universal Soil Los Equation)

RUSLE is a science-based tool that has been improved over the last several years. Effects of soil roughness and the effects of local weather on the prediction of soil loss and sediment delivery were enhanced. Basically, it helps to evaluate site condition and to aid in the decision process of selecting erosion control measures. The equation is represented by:

$$\text{RUSLE, } A = RKLSCP$$

where,

- A = Computed soil loss per unit area (tonne/ha/year)
- R = Rainfall erosivity factor
- K = Soil erodibility factor, the erosion rate for a specific soil in continuous fallow condition on a 9% slope having a length of 22.1 m in tones/ha ( $\text{MJmmha}^{-1}\text{h}^{-1}$ ).
- LS = Topographic factor which represent the slope length and slope steepness. Standard conditions assumed at 9% slope and length of 22.13 meters.
 
$$= \frac{\sqrt{L}}{22.13} \times (0.065 + 0.045S + 0.0065S^2)$$
- C = Cover factor, which represents the protective coverage of canopy and organic material in direct contact with the ground. It is measured as the ratio of soil loss from land cropped under specific conditions to the corresponding loss from tilled land under clean-tilled continuous fallow (bare soil) conditions.
  - \*crop plantation 0.2 to 0.3
  - \*bare land 1.0
  - \*paved and turfed areas 0.10
- P = Erosion control practice factor, P = 1.0 when no conservation measures are instituted.

#### B. Soil Loss Estimation

Three scenarios are modelled and analysed:

- i. Natural stage (Pre-operation stage): The analysis is to understand the initial soil loss or sediment yield occurred every year and act as a benchmark for comparison between the pre- and post- operation stages.
- ii. Land clearing stage without control measures (Worst case scenario): The analysis assumed to be worst case scenario without any control measures. Significant soil loss is foreseen.
- iii. Construction stage with control measures: The applied control measures are conservatively assumed to have an effectiveness of 50%. Amount of soil loss shall reduce to half.

The parameter and its result of soil loss and sediment yield are tabulated in **Tables 5.4.1 to 5.4.3** below.

**Table 5.4.1: Estimation on Soil Loss during the Land Clearing Stage**

Parameter	Magnitude (tonne/ha/year)		
	Pre-Development Stage	Land Clearing Stage Without Mitigation	Land Clearing Stage With Mitigation
Computed Soil Loss	266.833	106,733	1,387

**Table 5.4.2: Estimation on Soil Loss during the Construction Stage**

Parameter	Magnitude (tonne/ha/year)		
	Pre-Development Stage	Construction Stage Without Mitigation	Construction Stage With Mitigation
Computed Soil Loss	266.833	90,723	1,067

**Table 5.4.3: Estimation on Soil Loss during the Post Development Stage**

Parameter	Magnitude (tonne/ha/year)	
	Pre-Development Stage	Post Development Stage With Mitigation
Computed Soil Loss	266.833	106.733

The total sediment yield is estimated and tabulated in **Table 5.4.4**.

**Table 5.4.4: Estimation of Total Sediment Yield from the Project**

Total Disturbed Area at the Project Site (ha)	During Land Clearing Stage
	Sediment Yield (tonne)
350.895	39.6

**Figures 5.4.1a to 5.4.1e** show the Soil Erosion Risk Analysis Map (SERA) for the pre-development stage while **Figures 5.4.2a to 5.4.2e** show the SERA map during the land clearing stage without implementation of Best Management Practices (BMPs). The SERA map during the land clearing stage with mitigations are illustrated in **Figures 5.4.3a to 5.4.3e**.

During the construction stage, the SERA map without mitigation and with mitigations are illustrated in **Figures 5.4.4a to 5.4.4e** and **Figures 5.4.5a to 5.4.5e**, respectively. For the post development stage, where all the permanent BMPs are installed and maintained regularly, the SERA maps are shown in **Figures 5.4.6a to 5.4.6e**.

## 5.4.2 SOURCE OF RUNOFF

Activities that have the potential to cause or increase surface runoff, erosion and water quality degradation in Sg. Pahang and Sg. Kuantan are primarily due to exposure of soils during construction (i.e. during vegetation clearance, soil stripping and earthworks activities). Initially, the Project will involve the development of the following components:

- Site clearing;
- Grading works including cut and fill;
- Construction of temporary site office and facility areas;
- Temporary access road and internal access roads;
- Earthworks including slope stabilisation;
- Construction of three major bridges;
- Construction of river / stream / channel crossings and aqueducts;
- Project ancillaries work (drainage system, road junctions, etc.)

The impacts from uncontrolled and untreated stormwater runoff from developed areas will cause significant changes to watershed hydrology, water quality and stream health:

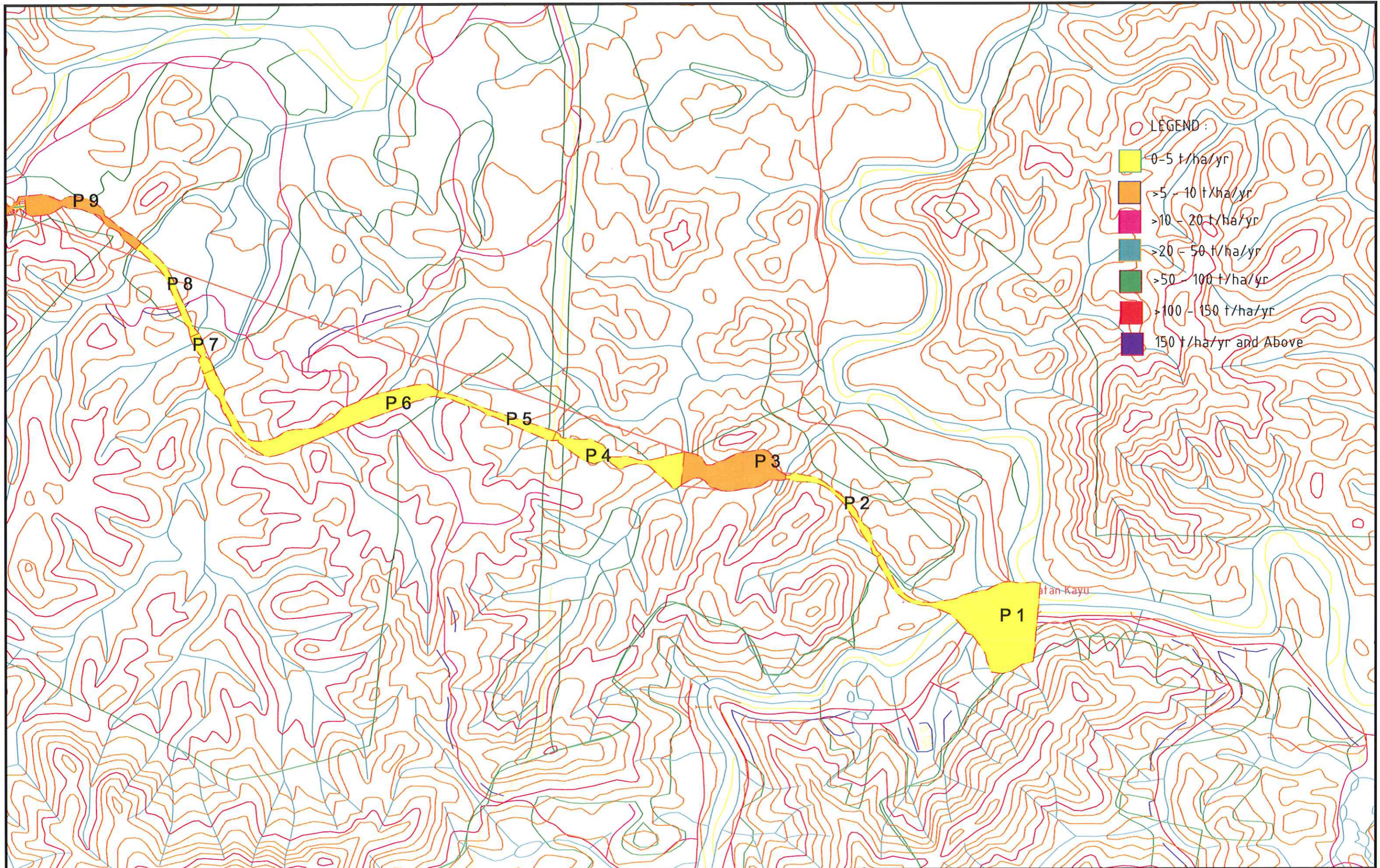
- i. Larger and more frequent flooding. Increased runoff from impervious surfaces increases streamflow and can increase the magnitude and frequency of downstream flooding.
- ii. Highly eroded soil. Higher stormflow and stormflow velocities cause accelerated surface soil erosion - generated sediments are delivered downstream where they can clog channels, culverts and pipes and can contribute significantly to the filling of sediment especially at the downstream area.
- iii. Highly polluted streams. Untreated stormwater runoff delivers a variety of pollutants to streams and rivers including sediment, nutrients, bacteria, oxygen demanding substances, oil and grease, trace metals, herbicides and pesticides, and other toxic and synthetic chemicals.
- iv. Degraded aquatic habitat. In-stream habitat for aquatic species is severely impacted by increased flows and higher loads of pollutants, particularly sediment.

#### 5.4.3 DISTURBED AREA



The expected area disturbance will be about 350.895 ha for the development of the proposed road. It is expected that there will be a change in ultimate impervious surface. An impact area includes the construction of all the infrastructure works. **Table 5.4.5** show the summary of the estimated disturbed area for the proposed development.

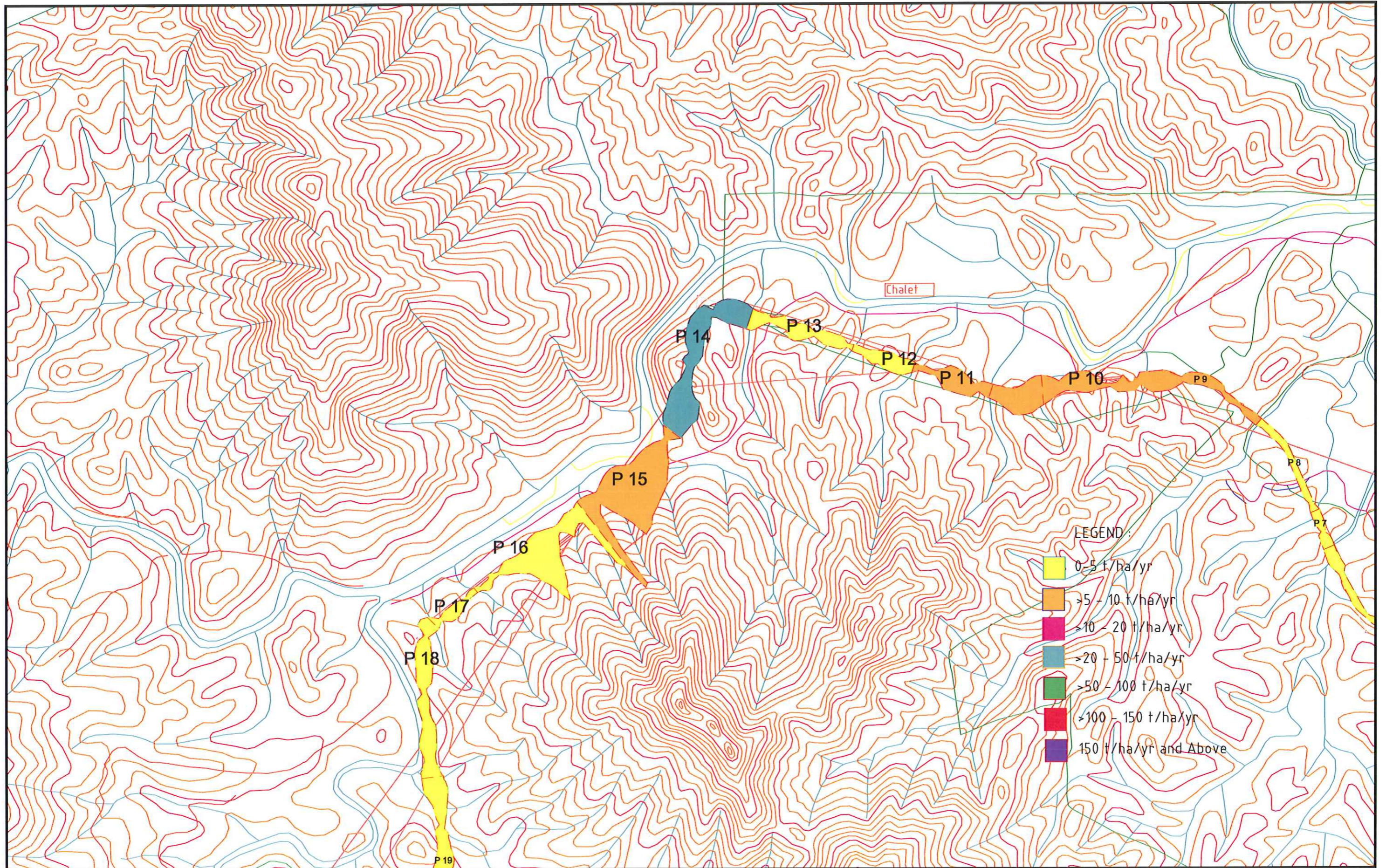
**Table 5.4.5: Summary of Estimated Disturbed Area from the Project**



No.	Sub-Catchment	Parcel	Disturbed Area (ha)
1.	SC 1	1	1.926
2.	SC 2	2	5.466
3.	SC 3	3	7.45
4.	SC 4	4	2.029
5.	SC 5	5	16.52
6.	SC 6	6	8.035
7.	SC 7	7	3.749

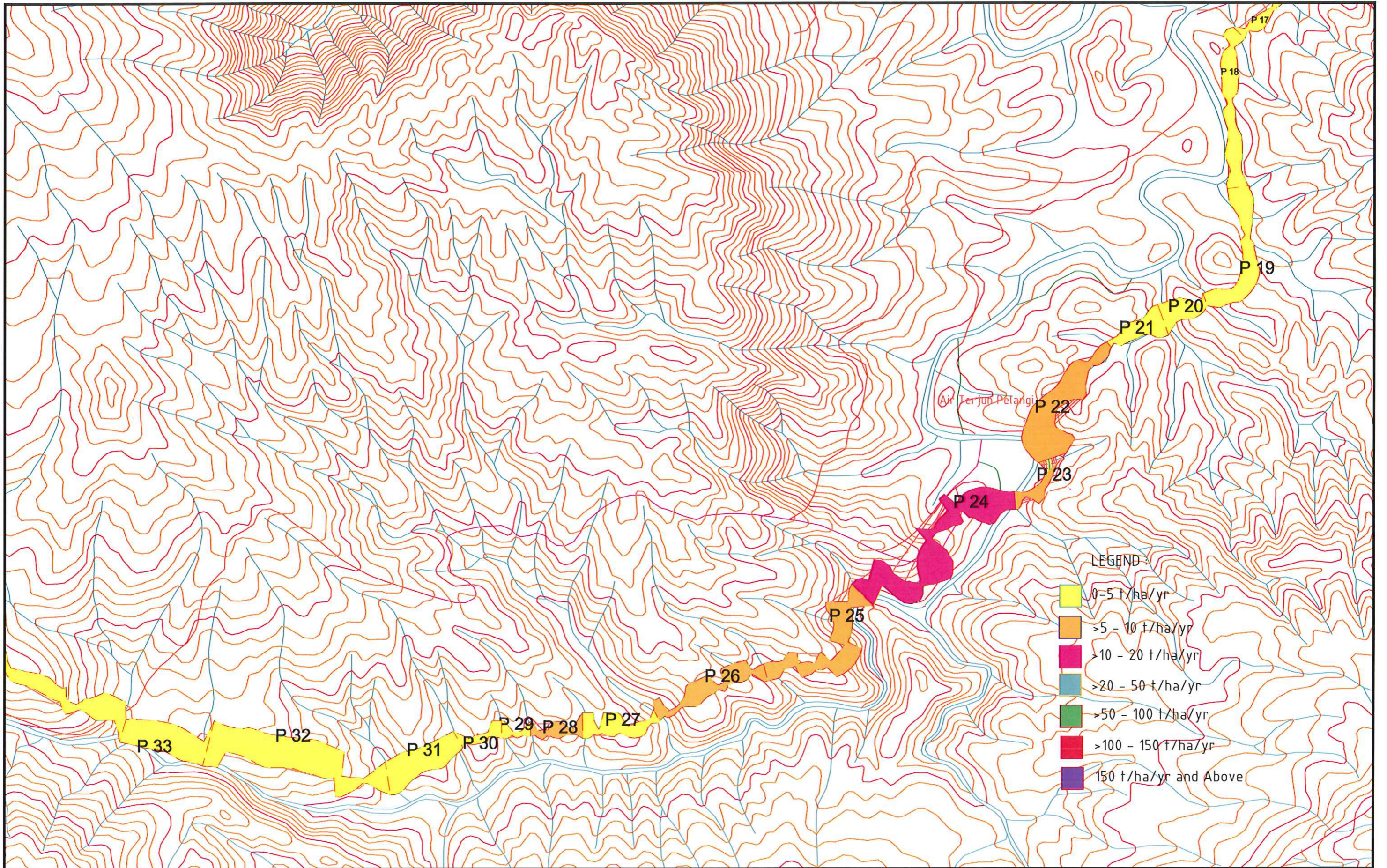




- LEGEND :
- 0-5 t/ha/yr
  - >5 - 10 t/ha/yr
  - >10 - 20 t/ha/yr
  - >20 - 50 t/ha/yr
  - >50 - 100 t/ha/yr
  - >100 - 150 t/ha/yr
  - 150 t/ha/yr and Above

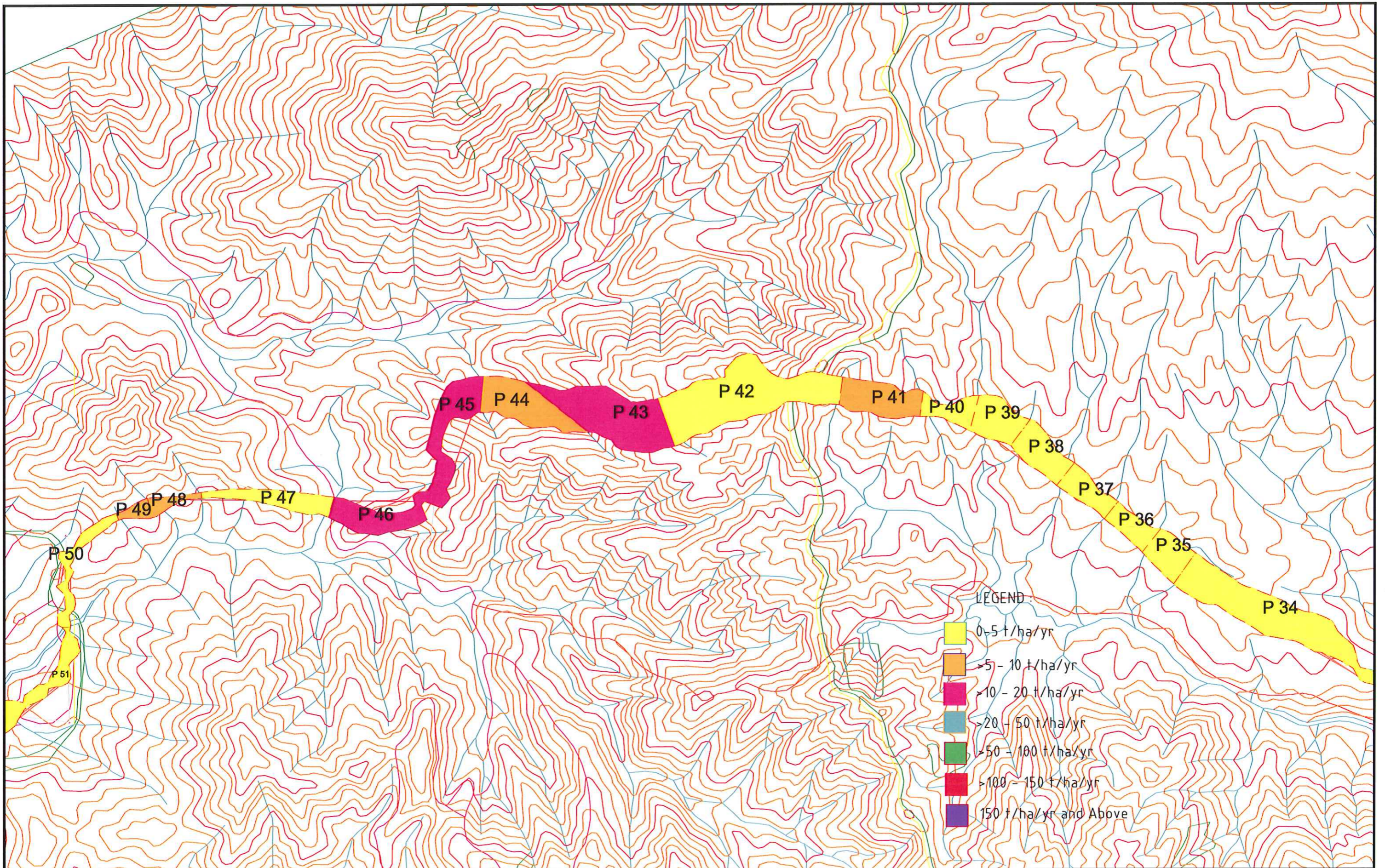
Tarikh	Butiran	Rujukan	DIREKA OLEH : DA DILUKIS OLEH : DA DILULUSKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MEM. CPSWO.	PERUNDING ALAM SEKITAR :  GUNUNG-GAHANG CORPORATION BDN. BHD. (0791134-9) NO. 52-5, JALAN SP 5/1, BLOK D12, TINGKAT 5, KAWASAN PERINDUSTRIAN, 43000 SEREMBAN, NEJERANG DARUL BAHAWA TEL: 03-8911338 FAX: 03-8912348	PEMILIK PROJEK :  JABATAN KERJA RAYA MALAYSIA	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK) TAJUK LUKSAN : Figure 5.4.1a : SERA Map During Pre-development Stage (P1 to P9)		
	PINDAAN		Scale 1:3000 UKURAN			TARIKH: 0005 2013	BIL. LUKSAN: PEM/SGLJ/00/13/SERA/PRE/01	REV. MUKASURAT: 5-20a-1



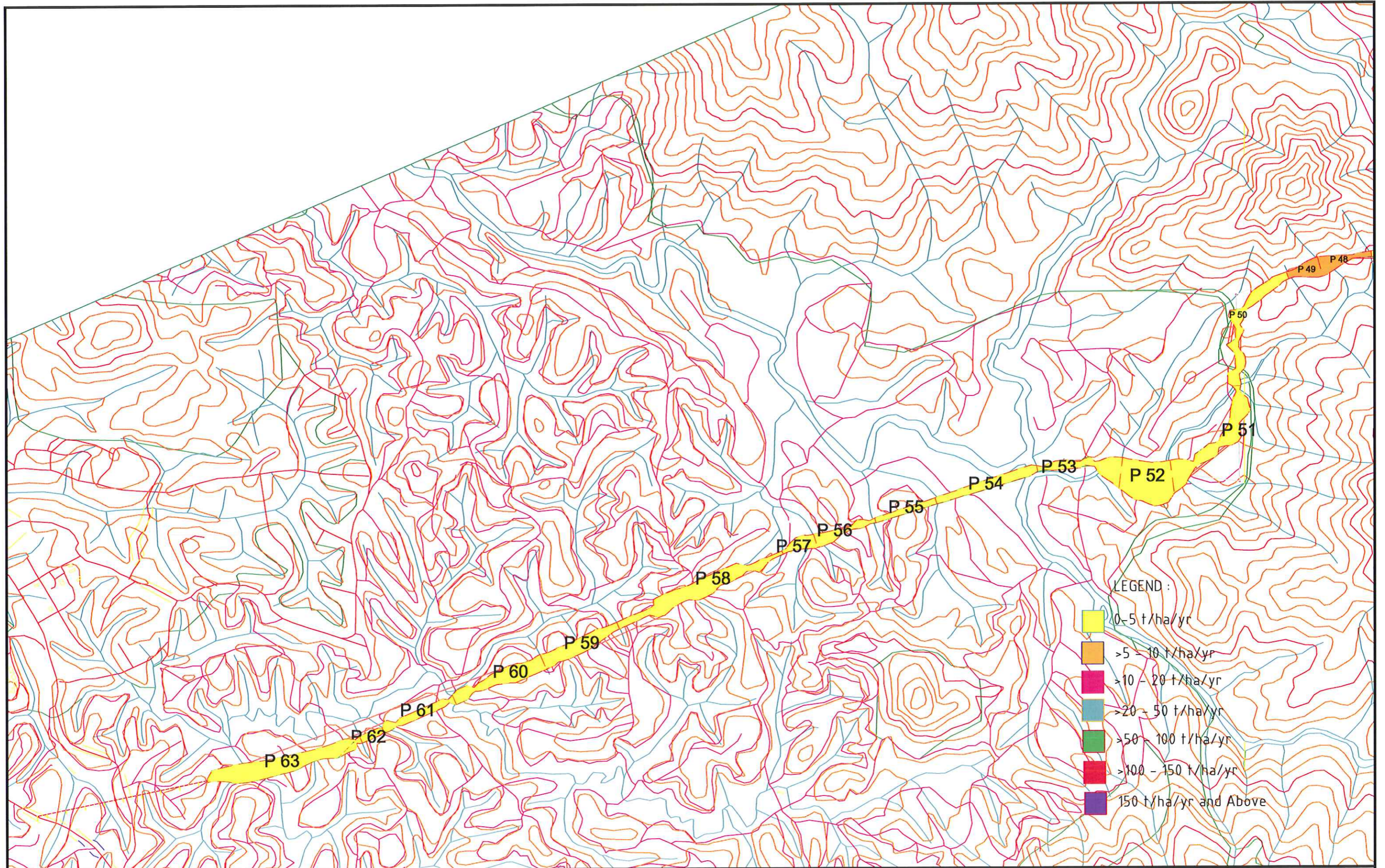
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			DILUKIS OLEH : DA	 GUNUNG-GAJAH CORPORATION SDN. BHD. (011174-P)	 JABATAN KERJA RAYA MALAYSIA	TAJUK LUKISAN : Figure 5.4.1b : SERA Map During Pre-development Stage (P10 to P18)		
			DILULUSKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MDM, CPSWQ.	NO. 53-A, JALAN SP 3/A, 82000 S. KUNING BERGANG PERANG, 43000 SUNGAI PEKAJANG, SELANGOR DARUL EDAH TEL: 03-89413308 FAX: 03-89422488		TARIKH: 15/08/2013	BIL. LUKISAN: PEM/SGUJ/GG/13/SERA/PRE/02	REV. MUKASURAT: 5-200-3
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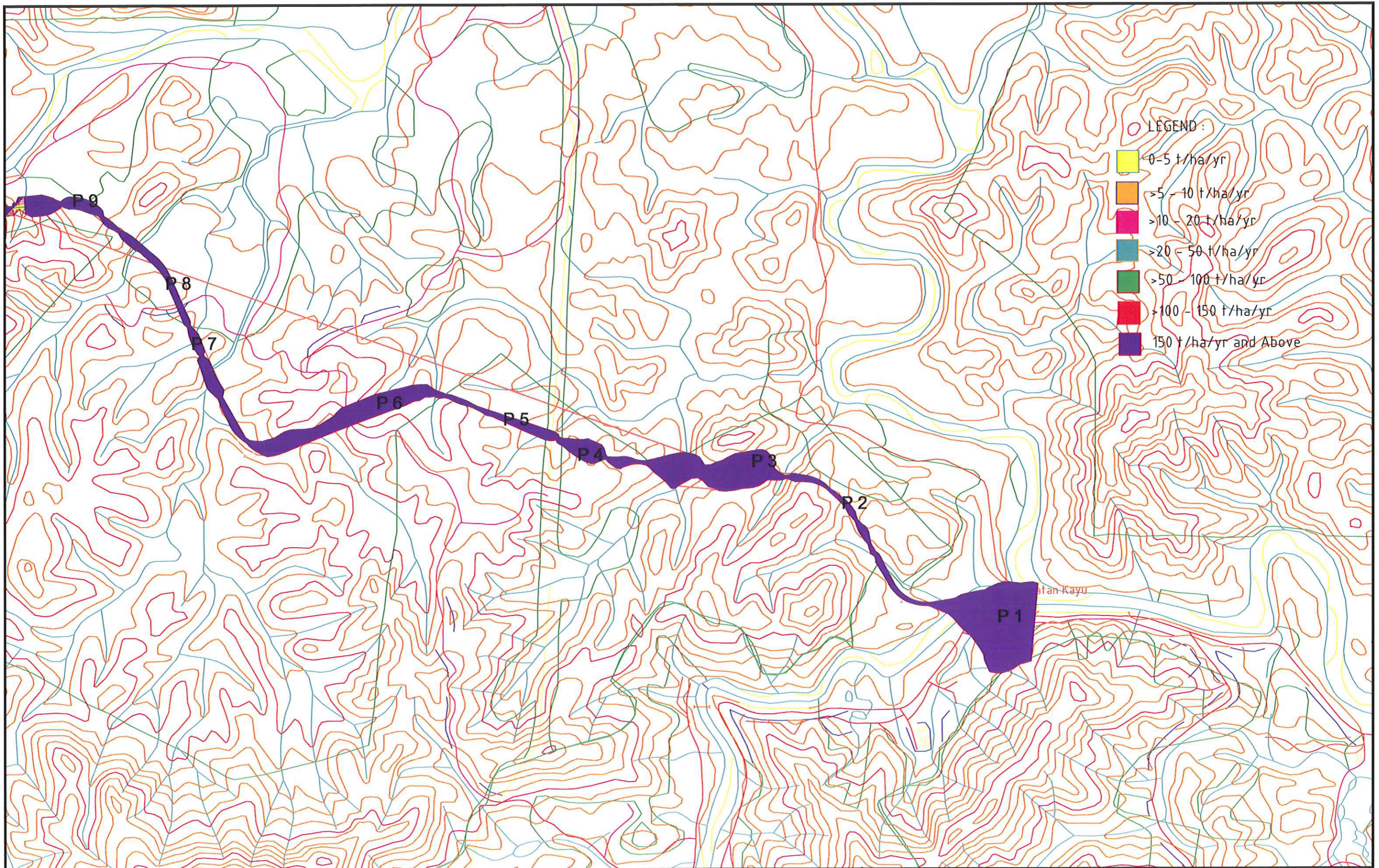
Tarikh	Butiran	Rujukan	DIREKA OLEH : DA DILUKIS OLEH : DA DISEMAK OLEH : I. AZMAN ABU BAKAR DILULUSKAN OLEH : I. AZMAN ABU BAKAR P.Eng., MIEA, CPSWG.	PERUNDING ALAM SEKITAR :  GUNUNG-GAUNG PERUNG-GAUNG CORPORATION SDN. BHD. (091124-0) NO. 83-3, JALAN SP 1/1, KECAMPAHAN 2, TAMAN SERDANG PERDANA, 4300 SERDANG, SELANGOR DARUL EHSAN TEL: 03-89415308 FAX: 03-89425488	PEMILIK PROJEK :  JABATAN KERJA RAYA MALAYSIA	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT (REKABETUK) TAJUK LUKISAN : Figure 5.4.1c : SERA Map During Pre-development Stage (P19 to P33) TARIKH: OGOS 2013 BL. LUKISAN: PEIA/SGU/06/13/SERA/PRE/03 REV. : MUKASURAT: 5-20c_ii
	PINDAAN		Scale 1:3000 UKURAN			





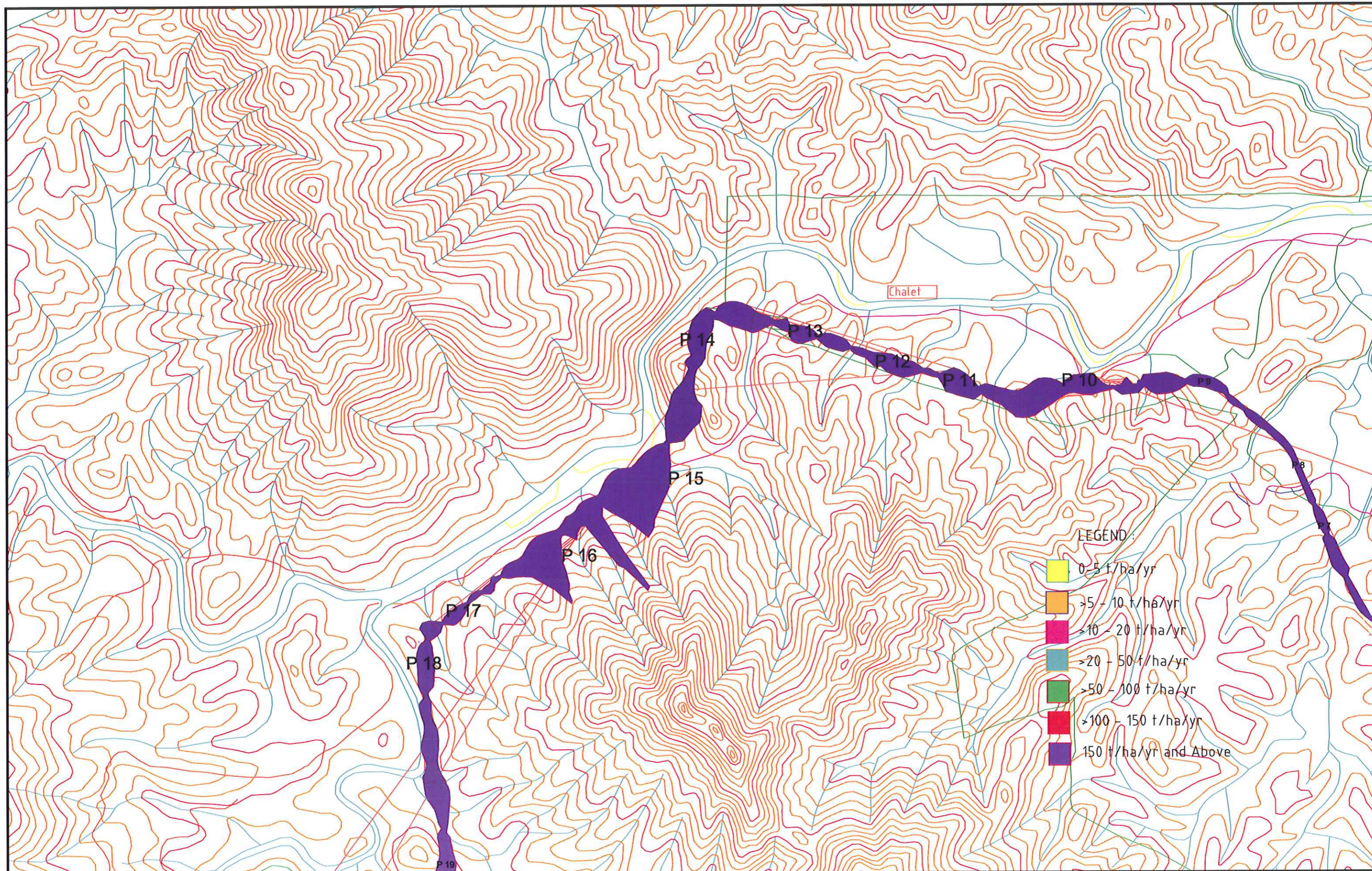
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			DILUKIS OLEH : DA	DISEMAK OLEH : Ir. AZMAN ABU BAKAR		TAJUK LUKISAN : Figure 5.4.1d : SERA Map During Pre-development Stage (P34 to P50)
			DILULUSKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MDM, CPSM.	NO. 52-A, JALAN SP 5/2, BLOK D1 2, 43200 SEREMBAN PERAKU, 43200 SEREMBAN, SELANGOR DARUL HAJAH TEL: 03-89418308 FAX: 03-89423488		TARIKH: OGOS 2013
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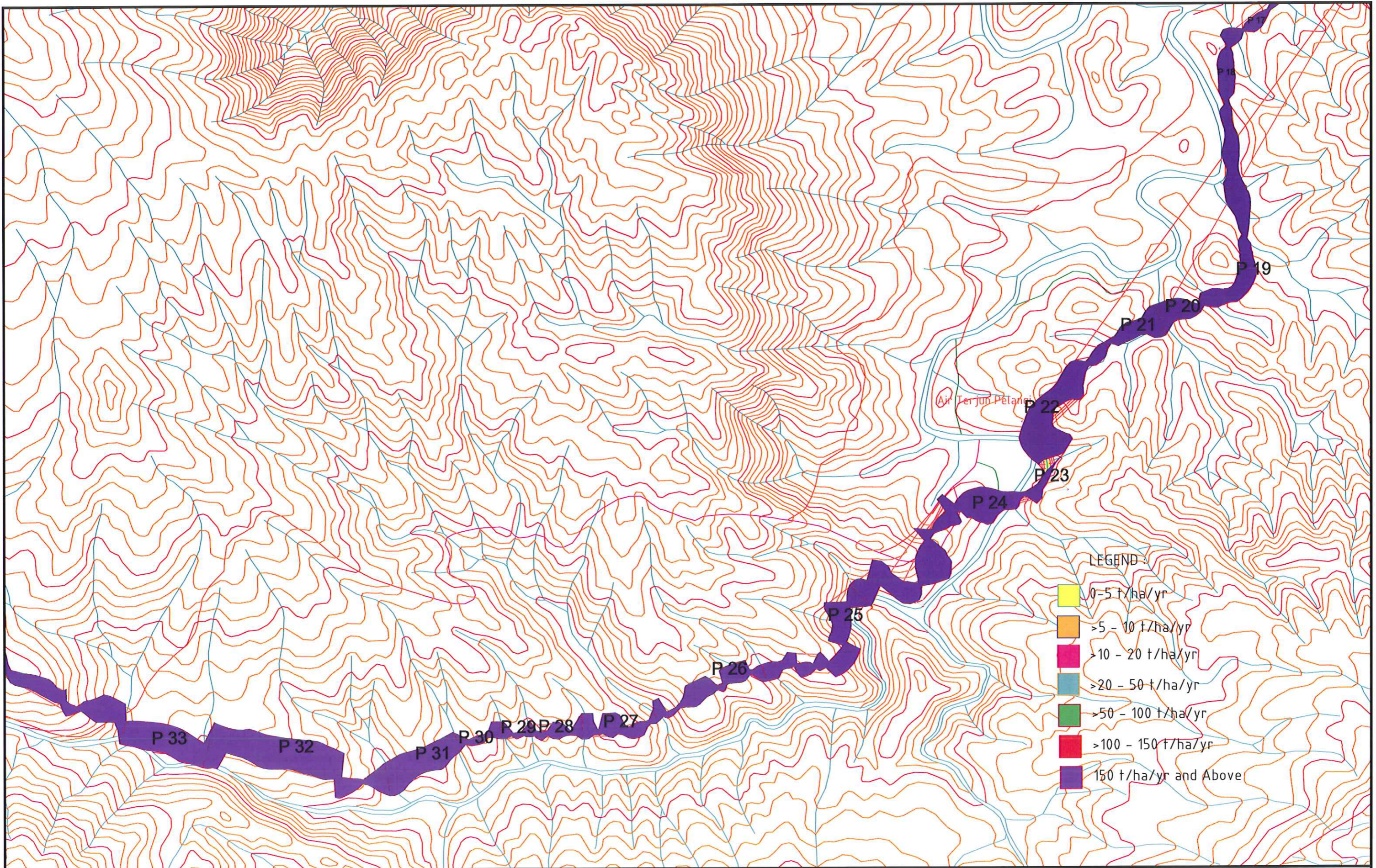
Tarikh	Bu/tran	Rujukan	DIREKA OLEH : DA	PERUNDING ALAM SEKITAR :  GUNUNG-GAANG CORPORATION BDN. BHD. (011174-9)	PEMLIK PROJEK :  JABATAN KERJA RAYA MALAYSIA	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK)	
			DILUKIS OLEH : DA	DISEMAK OLEH : Ir. AZMAN ABU BAKAR		TAJUK LUKISAN : Figure 5.4.1e : SERA Map During Pre-development Stage (P51 to P63)	
			DILULISKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MEM. CPSW.	NO. 67-A, JALAN BP 5/2, BLOK D K TANJONG BERING PONDOK, 12200 BUKIT KEMUNING, SELANGOR DARUL KEHAYAT TEL: 03-89413232 FAX: 03-89-025188		TARIKH: OGOS 2013	
	PINDAAN		Scale 1:3000 UKURAN			BIL. LUKISAN: PEIA/SGLU/00/13/SERA/PRE/05	REV. MUKASURAT: 5-20a-v



Tarikh	Butiran	Rujukan	DIREKA OLEH : DA	PERUNDING ALAM SEKITAR :  GUNUNG-QANANG CORPORATION SDN. BHD. (071174-P)	PEMILIK PROJEK :  JABATAN KERJA RAYA MALAYSIA	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK)
			DILUKIS OLEH : DA	DISEMAK OLEH : Ir. ADAM ABU BAKAR		TARIKH LUKISAN : Figure 5.4.2a : SERA Map During Land Clearing Stage Without Control Measures (P1 to P9)
			DILULUSKAN OLEH : Ir. ADAM ABU BAKAR P.Eng., MEd., CPD(SG)			TARIKH: 0005 2013
	PINDAAN		Scale 1:3000 UKURAN			BIL. LUKISAN: PEW/SGLJ/GG/13/SERA/LC/WOC/01
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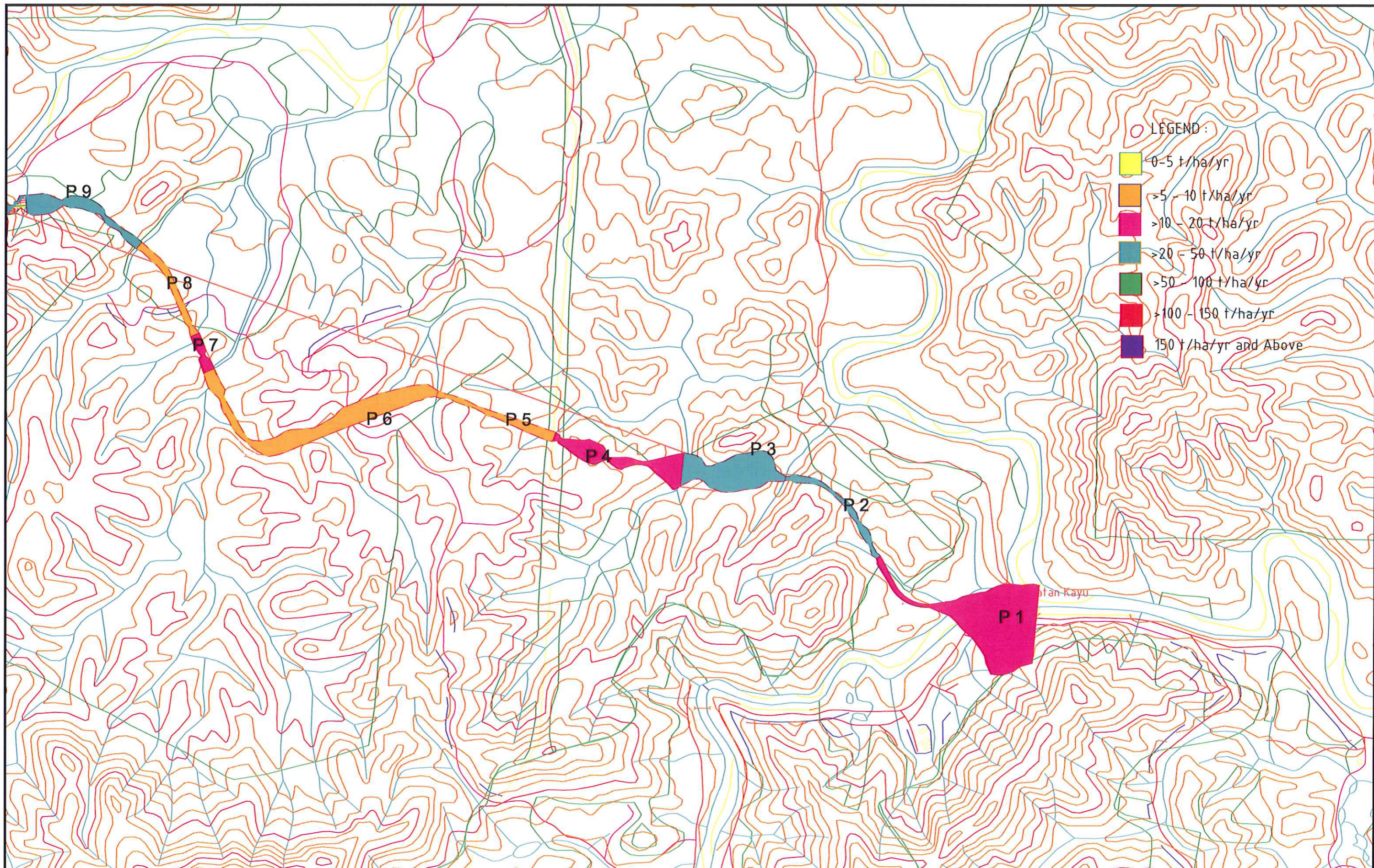
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			DILUKIS OLEH : DA	DISEMAK OLEH : Ir. AZMAN ABU BAKAR		TARUK LUKISAN :
			DILULUSKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MEM. CPSVO.			Figure 5.4.2b : SERA Map During Land Clearing Stage Without Control Measures (P10 to P18)
			Scale 1:3000 UKURAN			TARIKH: 0005 2013
						BIL. LUKISAN: PEM/SGLJ/00/13/SERA/LC/WOC/02
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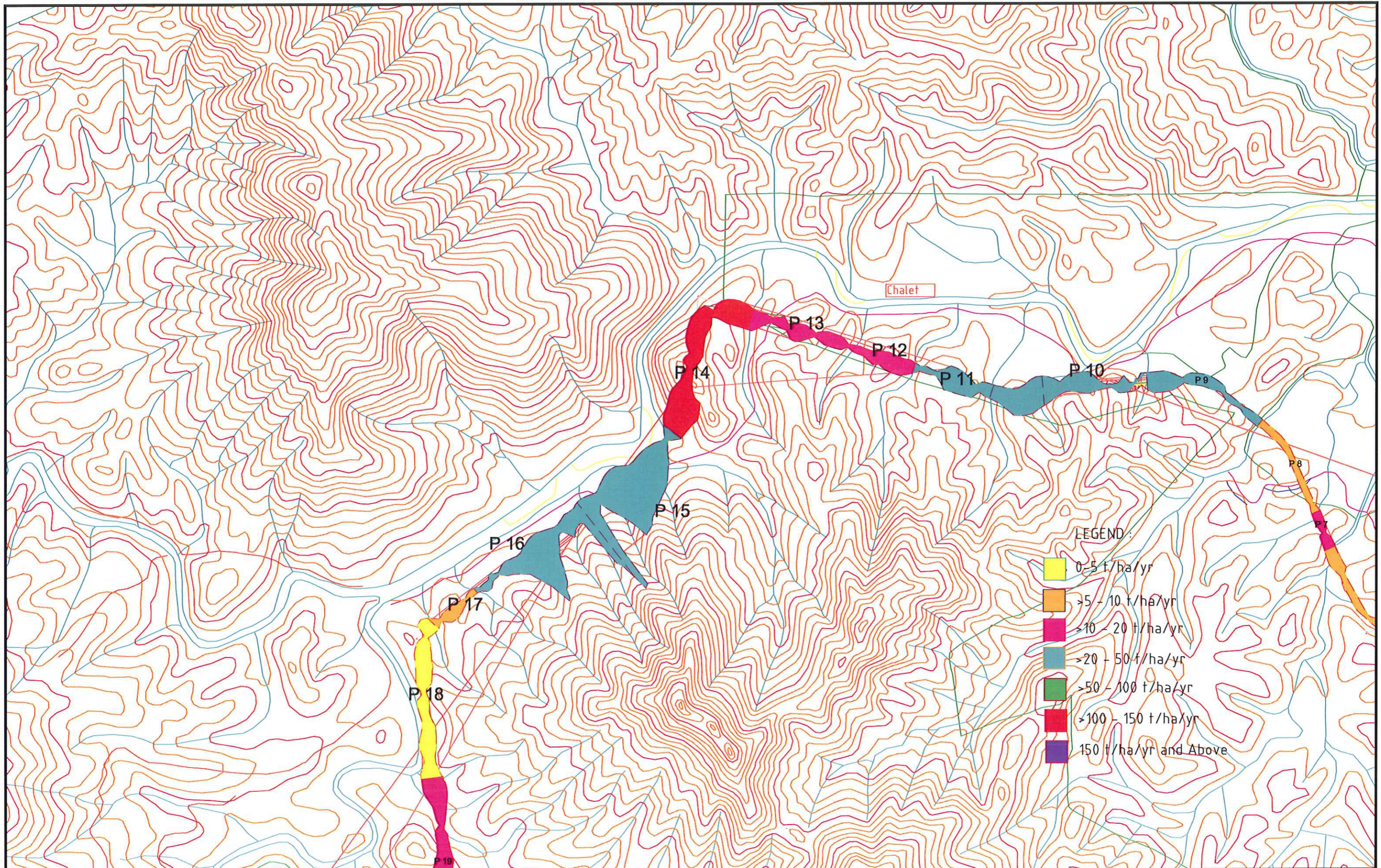
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			DILUKIS OLEH : DA	DISEMAK OLEH : I. AZMAN ABU BAWAR		TAJUK LUKISAN : Figure 5.4.2c : SERA Map During Land Clearing Stage Without Control Measures (P19 to P33)	
			DILULUSKAN OLEH : I. AZMAN ABU BAWAR P.Eng., MEM. CPSWG.			TARIKH: 15/06/2013	
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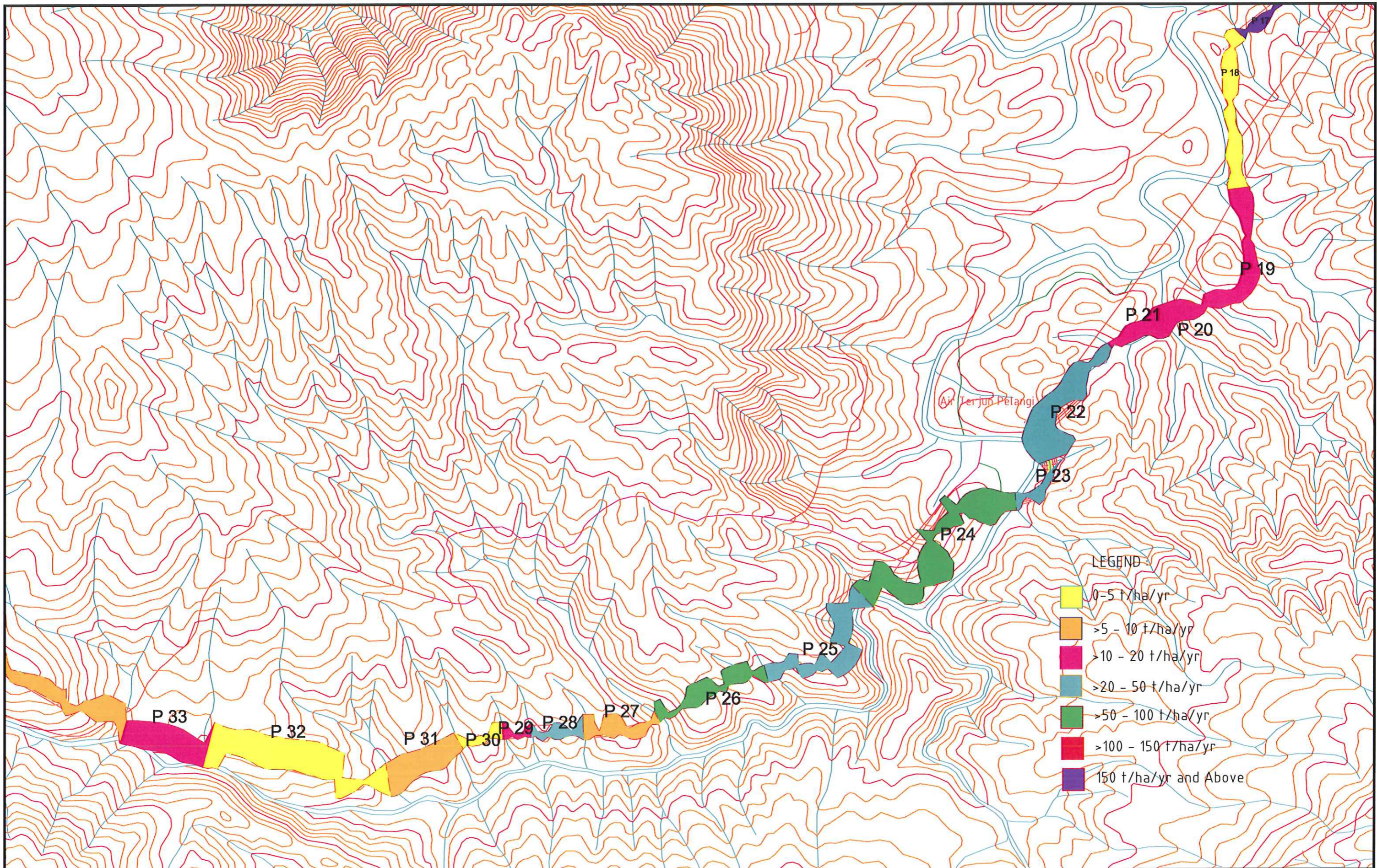




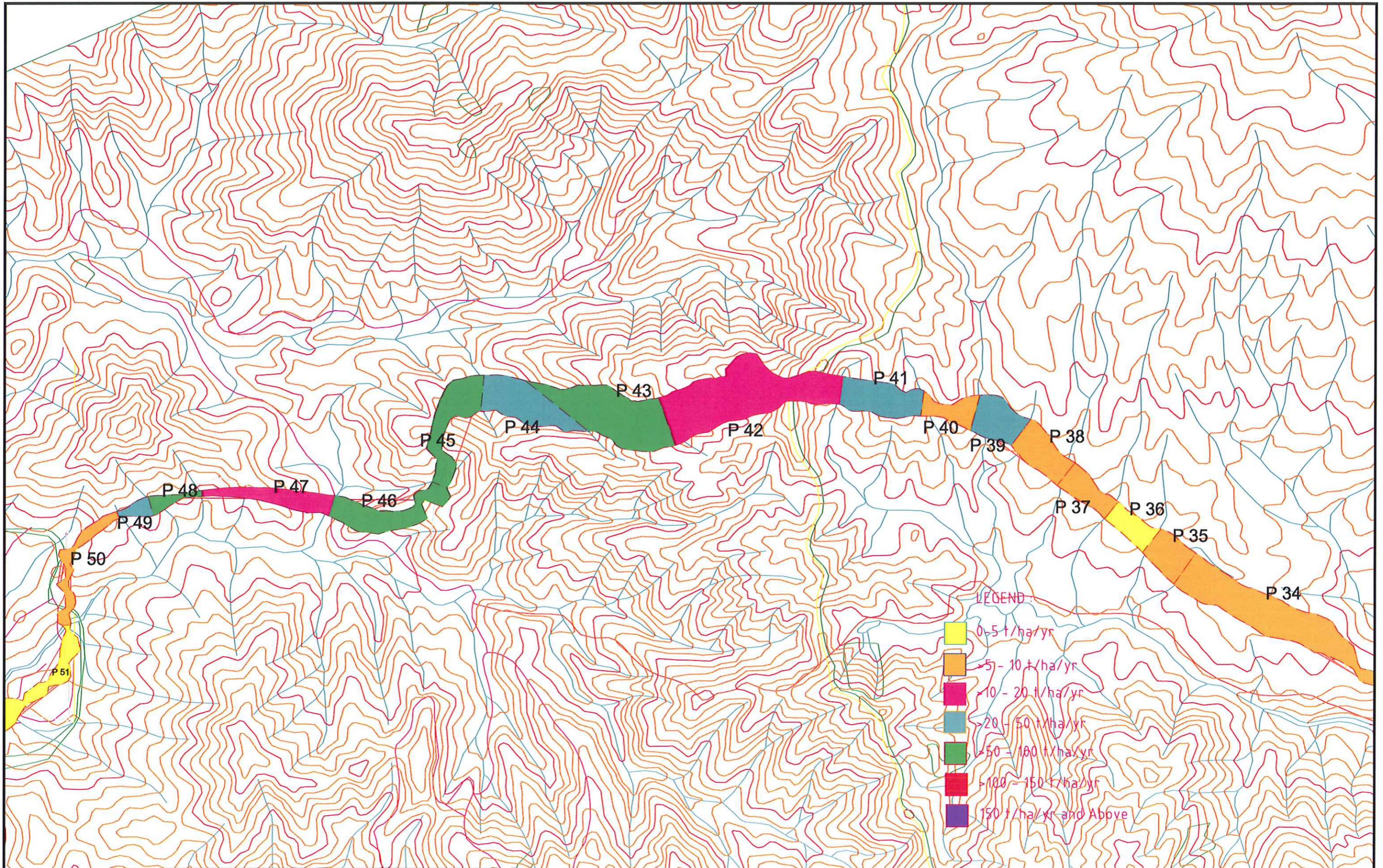
Tarikh	Bulan	Rujukan	DIREKA OLEH : DA	PERUNDING ALAM SEKITAR :  <b>GUNUNG-GAHANG CORPORATION SDN. BHD.</b> (1791174-9) NO. 81-5, JALAN BP 5/1, BLOK D11 5, TOWNSHIP PERINDIA, 43300 BUKIT SERISEMBAH, BELANGOR DARUL IDHAB TEL: 05-88413308 FAX: 05-88423488	PEMILIK PROJEK :  <b>JABATAN KERJA RAYA MALAYSIA</b>	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK) TAJUK LUKISAN : Figure 5.4.3a : SERA Map During Land Clearing Stage With Control Measures (P1 to P9) TARIKH: 0605 2013	BIL. LUKISAN: PEIA/SGU/GG/13/SERA/LC/WC/01 REV. : MUKASURAT: 5-20c-1
	PINDAAN		DILUKIS OLEH : DA DISEMAK OLEH : v. AZMAN ABU BAKAR DILULUSKAN OLEH : v. AZMAN ABU BAKAR P.Eng., MEd., CPSWQ.				
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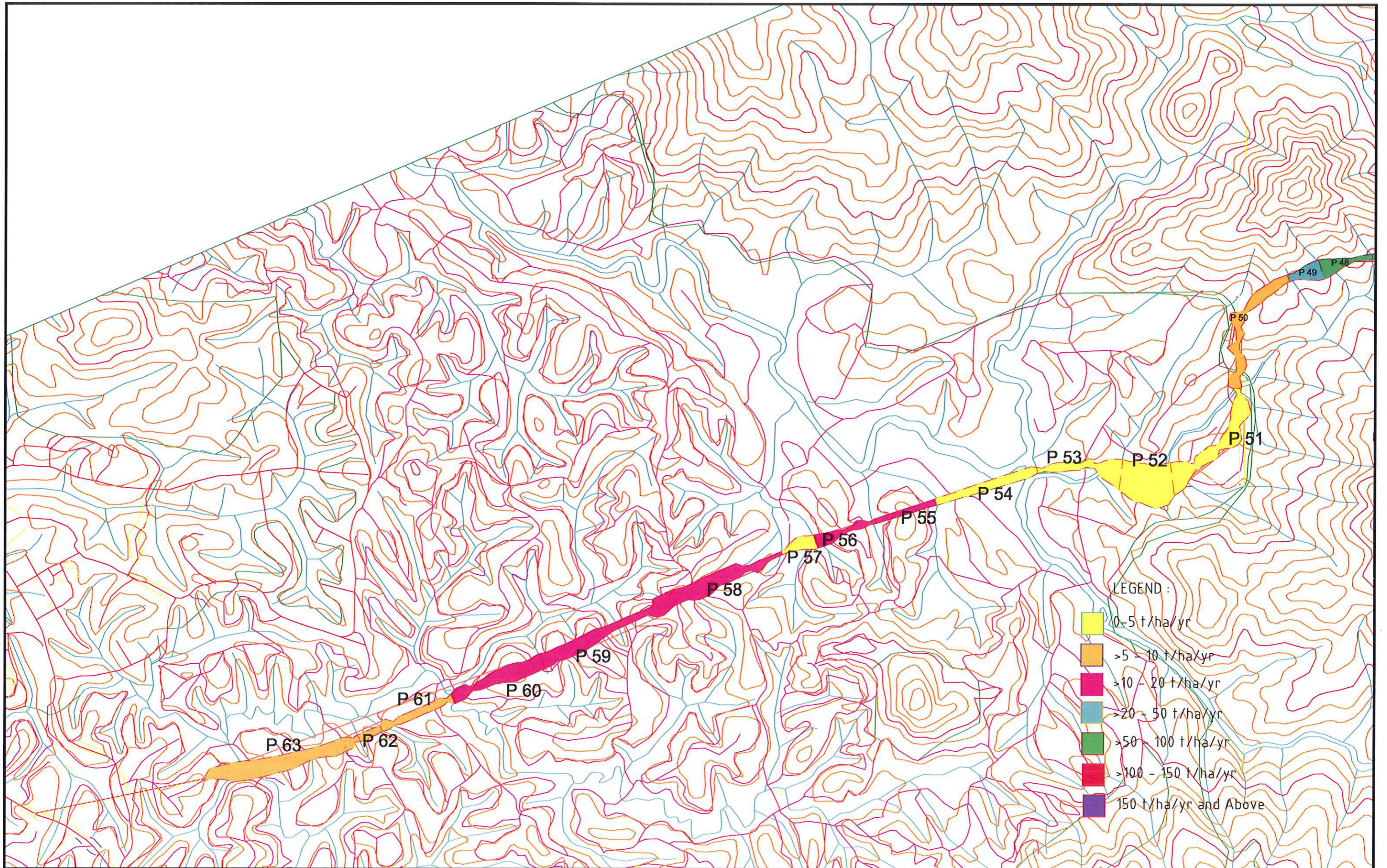
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			DILUKIS OLEH : DA DISEMAK OLEH : I. AZMAN ABU BAKAR DILULUSKAN OLEH : I. AZMAN ABU BAKAR P.Eng., MEd., CP210.			TAJUK LUKISAN : Figure 5.4.3b : SERA Map During Land Clearing Stage With Control Measures (P10 to P18)
	PINDAN		Scale 1:3000 UKURAN			TARIKH: 0605 2013
						BIL. LUKISAN: PEM/SGLJ/00/13/SERA/LC/WC/02
						REV. MUKASURAT: 5-20c-II





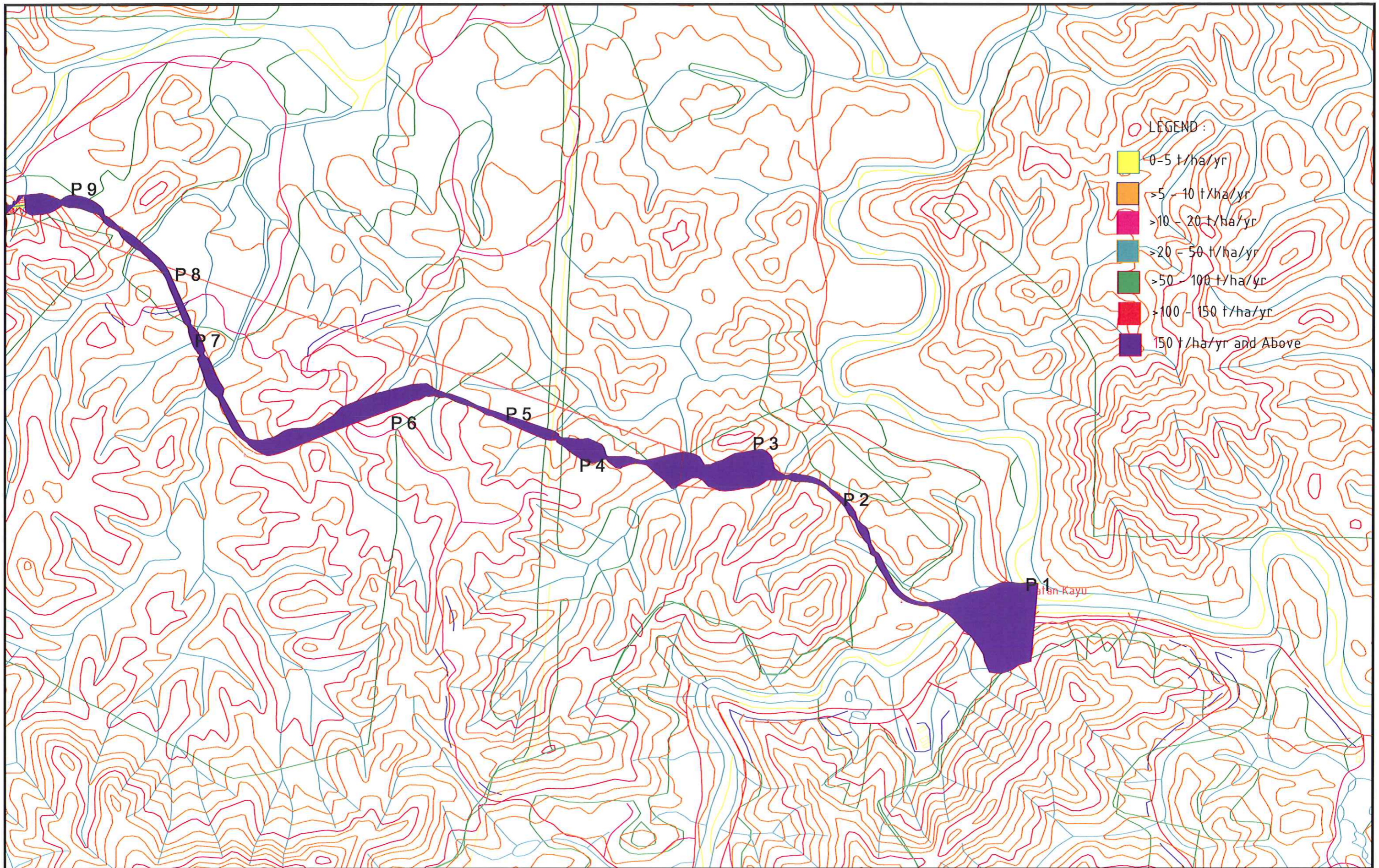
Tarikh	Butiran	Rujukan	DIBINA OLEH : DA DILUKIS OLEH : DA DILULUSKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MEd, CPSM.	PERUNDING ALAM SEKTAR :  <b>GUNUNG-GAHANG CORPORATION SDN. BHD.</b> (091174-P) NO. 83-3, JALAN BP 2/1, KOTA DAMAI 2, 4300 SEREMBAN, NEJAHOR DERA, DKGH TEL: 03-86113208 FAX: 03-86422168	PEMILIK PROJEK :  <b>JABATAN KERJA RAYA MALAYSIA</b>	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK) TAJUK LUKISAN : Figure 5.4.3c : SERA Map During Land Clearing Stage With Control Measures (P19 to P33) TARICAH: 0605 2013 BIL. LUKISAN: PEA/SGUJ/GO/13/SERA/LC/WC/03 REV. MUKASURAT: 5-20c-III
	PINDAAN		Scale 1:3000 UKURAN			





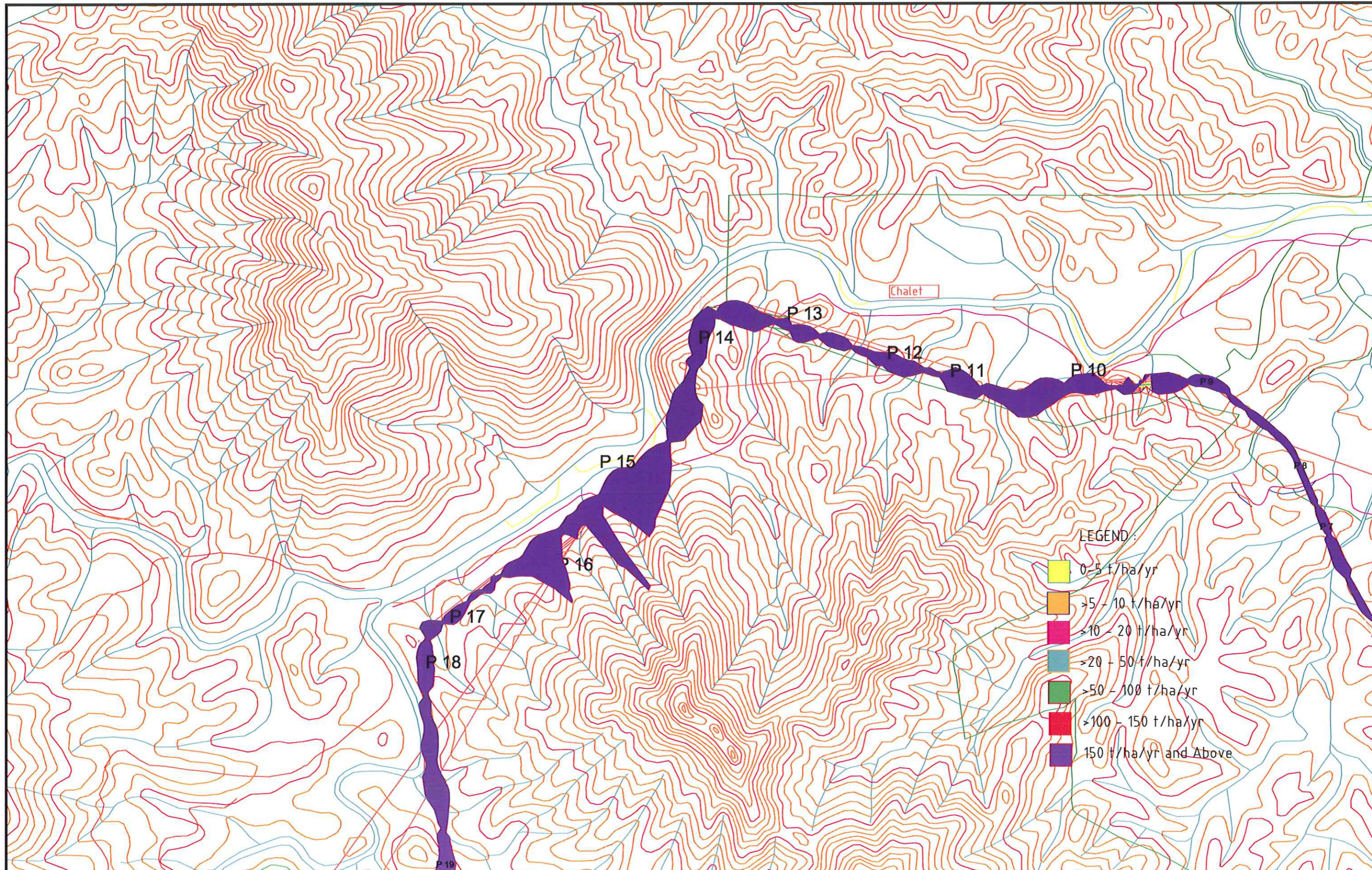
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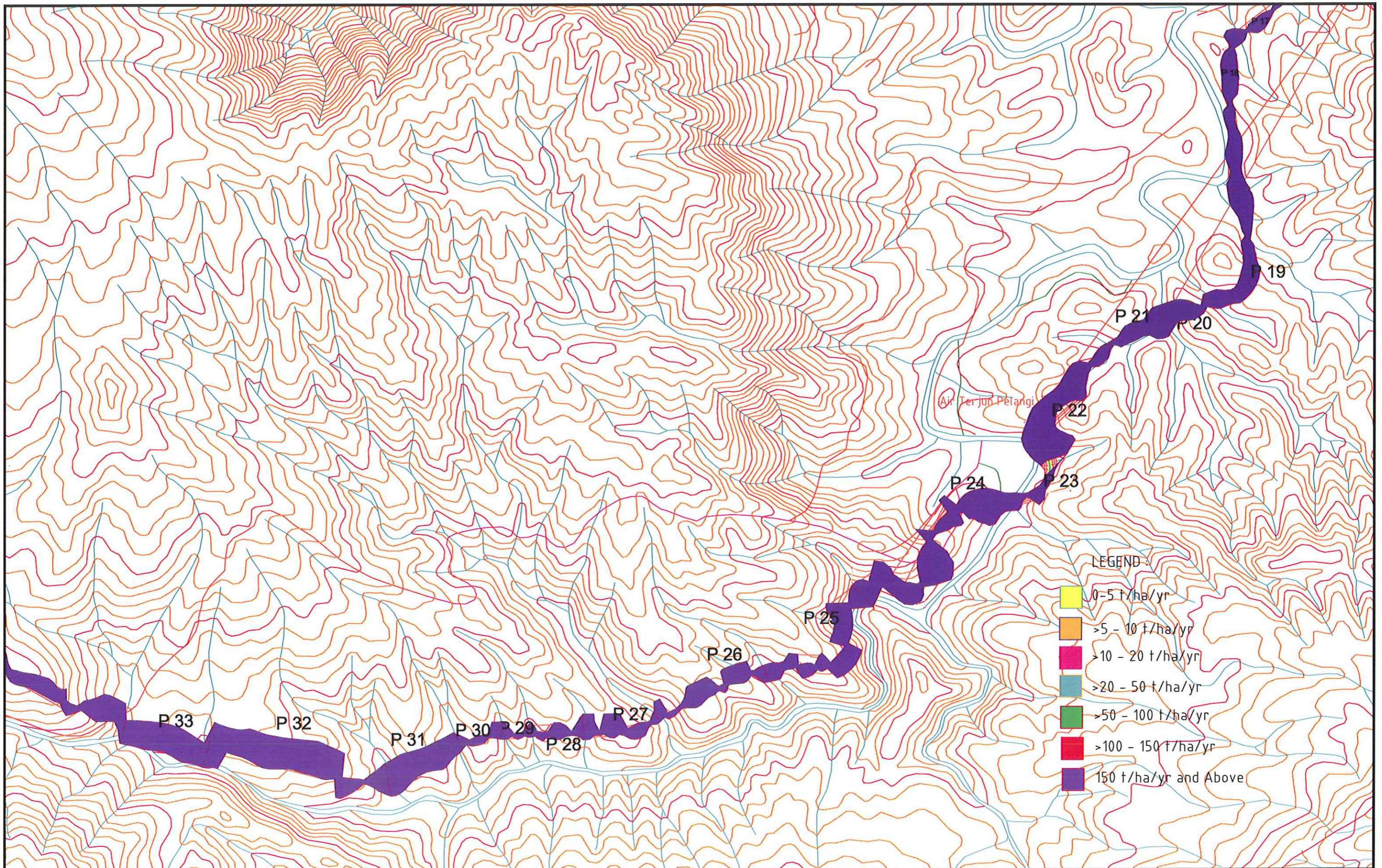
Tarikh	Butiran	Rujukan	DIREKA OLEH : DA DILUKIS OLEH : DA DILULUSKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MERA, CFSWQ.	PERLUNGAN ALAM SEKITAR :  <b>GUNUNG-GUANANG CORPORATION BHD.</b> (0191174-0) NO. 63-3, JALAN BP 2/1, BLOK D1 TAMAN BERSEKUTU MALAYA, 43200 SERI KEMBANGAN, SELANGOR DARUL KEHAYAT TEL: 03-89418308 FAX: 03-89421488	PEMILIK PROJEK :  <b>JABATAN KERJA RAYA MALAYSIA</b>	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT (REKABETUK) TAJUK LUKISAN : Figure 5.4.3e : SERA Map During Land Clearing Stage With Control Measures (P51 to P63) TARIKH: 0605 2013 BIL. LUKISAN: PEIA/SGLJ/00/13/SERA/LC/WC/05 REV. MUKASURAT: 5-20c-v
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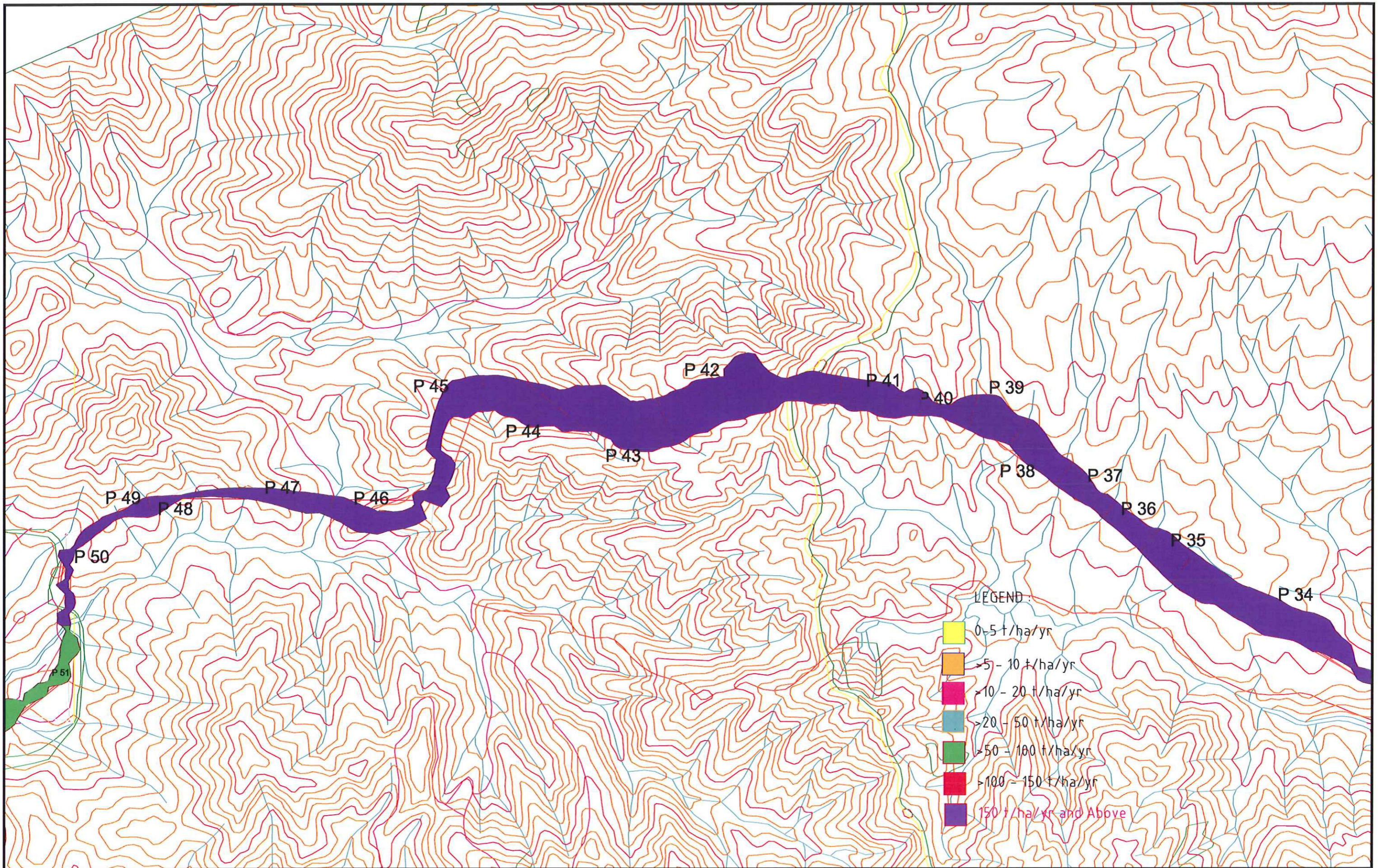
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	PINDAAN		Scale 1:3000 UKURAN			



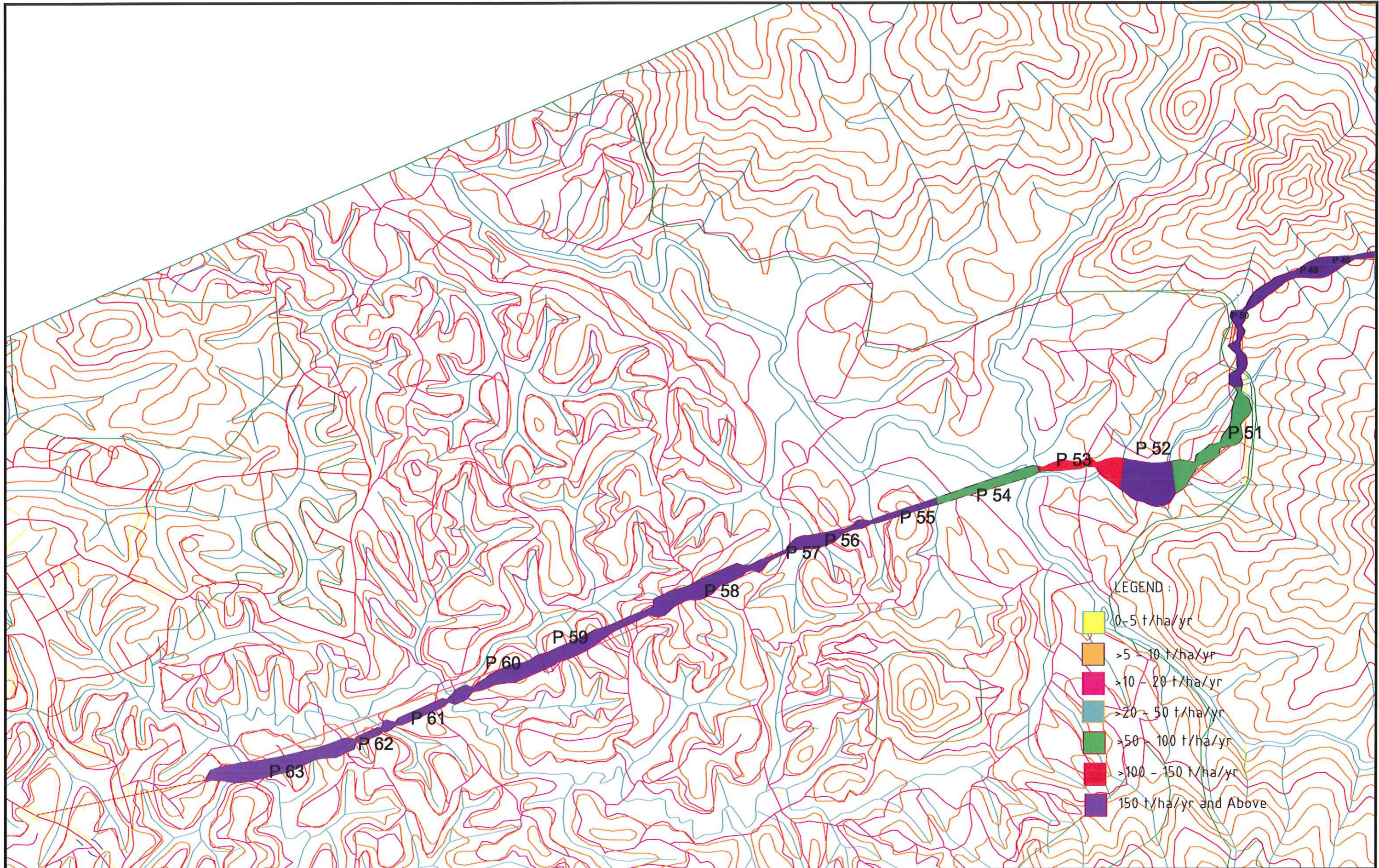
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			DILUKIS OLEH : DA DISEMAK OLEH : Iv. ADMAN ABU BAKAR DILULUSKAN OLEH : Iv. ADMAN ABU BAKAR P.Eng., MEM. CPSWQ.	NO. 67-2, JALAN SP 3/1, BUKITIN 2, TANJUNG SEPAT, PUNJUNG, 43000 BINTU REBANG, SELANGOR DARUL EHSAN TEL: 60-3-8913208 FAX: 60-3-8913248		TAJUK LUKISAN : Figure 5.4.4b : SERA Map During the Construction Stage Without Control Measures (P10 to P18)
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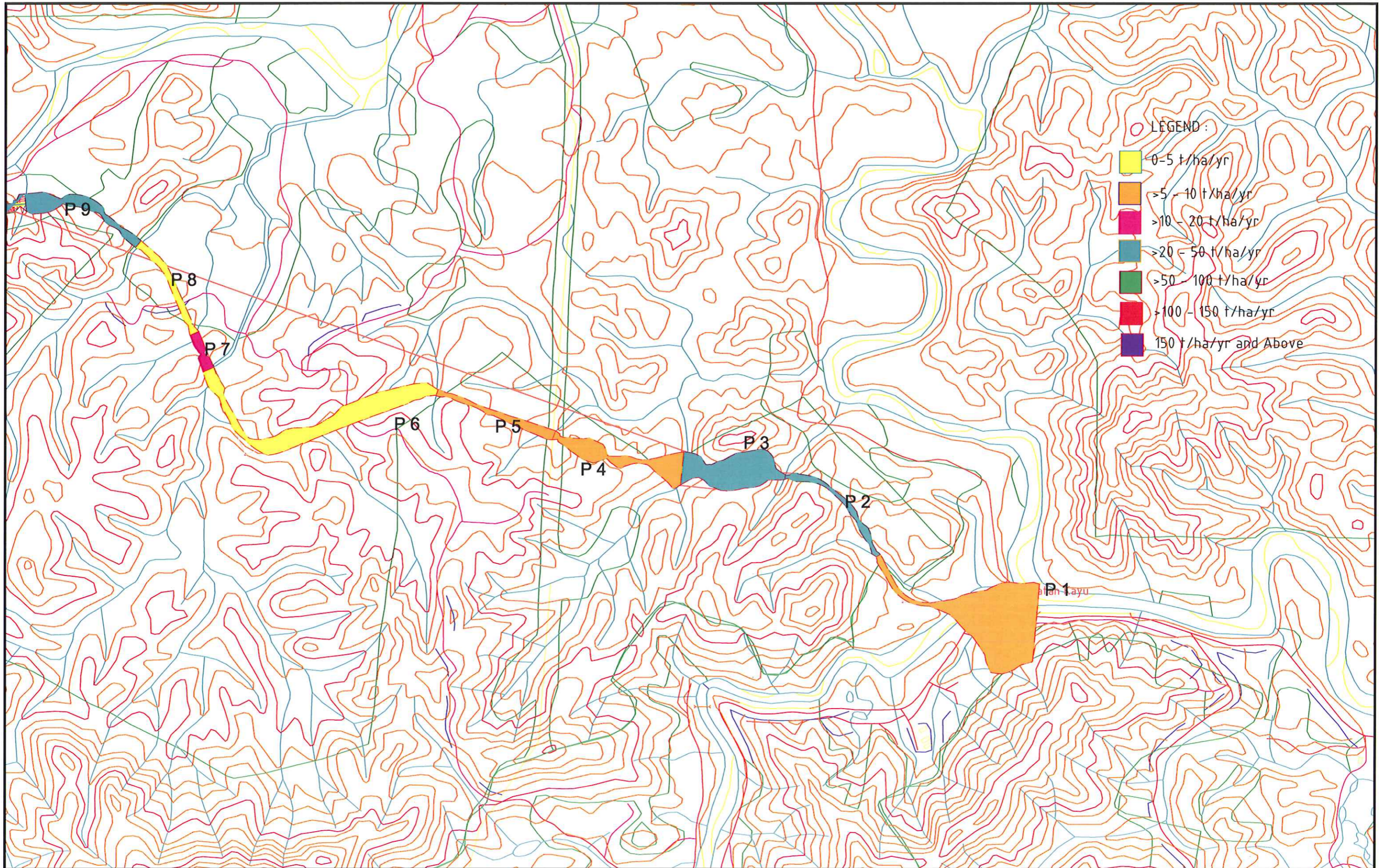
Tarikh	Butiran	Rujukan	DIREKA OLEH : DA DILUKS OLEH : DA DILULUSKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MEd., CPSWG.	PERUNDING ALAM SEKITAR :  GUNUNG-GALANG CORPORATION BHD. (091174-P) NO. 63-3, JALAN GP 5/A, BUKIT KEM 8 42000 BUKIT KEM, SELATAN DAHAR, DAHAR TEL: 03-8941038 FAKS: 03-8942288	PEMILIK PROJEK :  JABATAN KERJA RAYA MALAYSIA	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK) TAJUK LUKISAN : Figure 5.4.4c : SERA Map During the Construction Stage Without Control Measures (P19 to P33) TARIKH: 0605 2013 BIL. LUKISAN: PEIA/SGLJ/06/13/SERA/C/WOC/03 REV. MUKASURAT: 50-20d-11
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Tarikh	Butiran	Rujukan	DIREKA OLEH : DA	PERUNDING ALAM SEKITAR :  GUNUNG-GAMANG CORPORATION BHD. (091174-W)	PEMILIK PROJEK :  JABATAN KERJA RAYA MALAYSIA	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK)
			DILUKIS OLEH : DA	DIREKSI PERUMPAHAN DAN BERSEKUTUAN 43300 BBN KEDAH, BELAKAW DUFRA, DUFRA TEL: 05-36413308 FAX: 05-3642348		TAJUK LUKISAN : Figure 5.4.4d : SERA Map During the Construction Stage Without Control Measures (P34 to P50)
			DILULUSKAN OLEH : Iv. AZMAN ABU BAKAR P.Eng., MEM., CPSMO.			TARIKH: OGOS 2013
	PINDAAN		Scale 1:3000 UKURAN			BIL. LUKISAN: PEA/SGLI/G0/13/SERA/C/WOC/04
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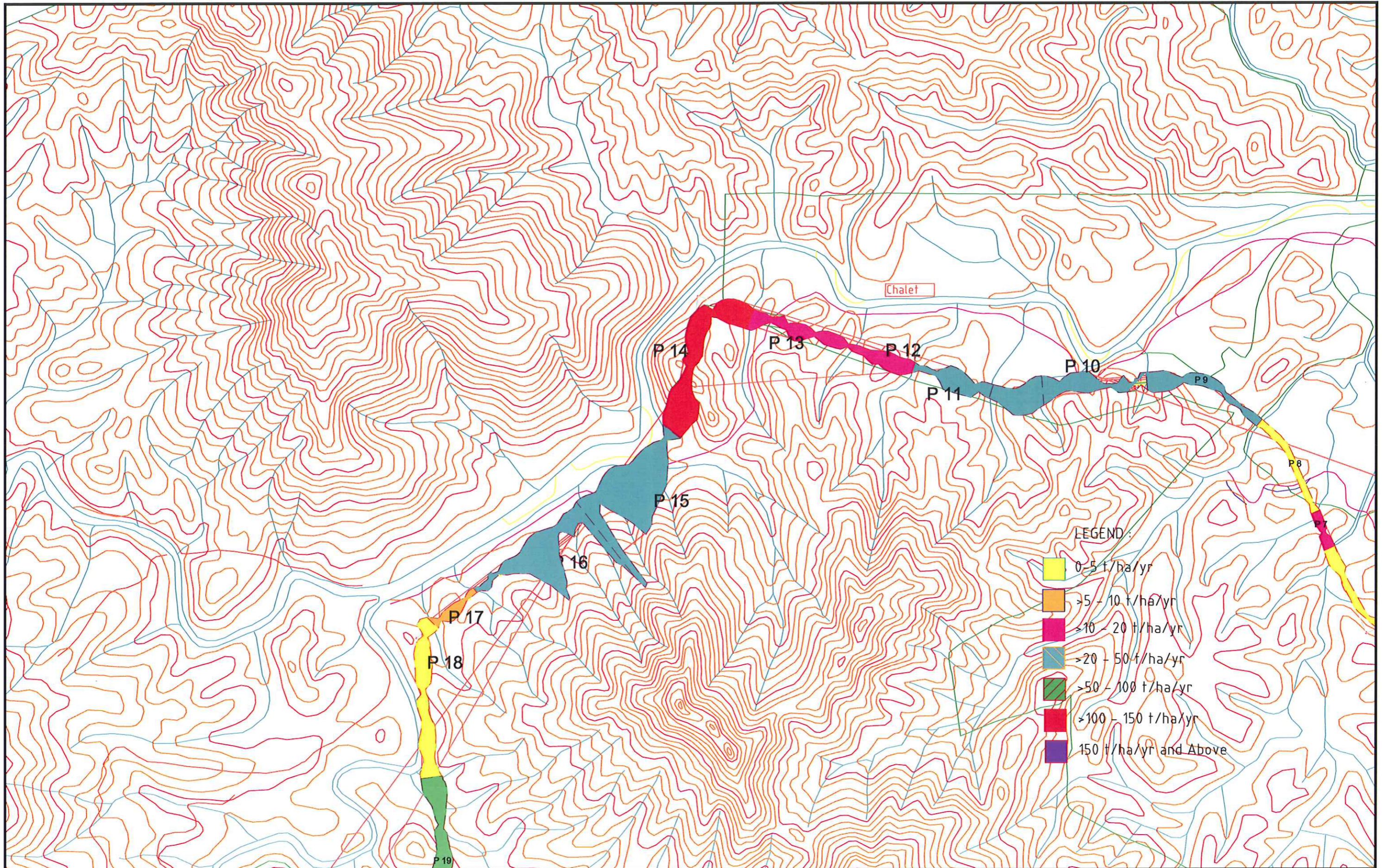
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			DILUKIS OLEH : DA	DISEMAK OLEH : Ir. AZMAN ABU BAKAR		TAJUK LUKISAN : Figure 5.4.4e : SERA Map During the Construction Stage Without Control Measures (P51 to P63)	
			DILULUSKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MEM, CPSM.			TARIKH: OGOS 2013	
	PINDAAN		Scale 1:3000 UKURAN			BIL. LUKISAN: PEA/SGJ/09/13/SERA/c/woc/05	REV. MUKASURAT: 5-20d-v





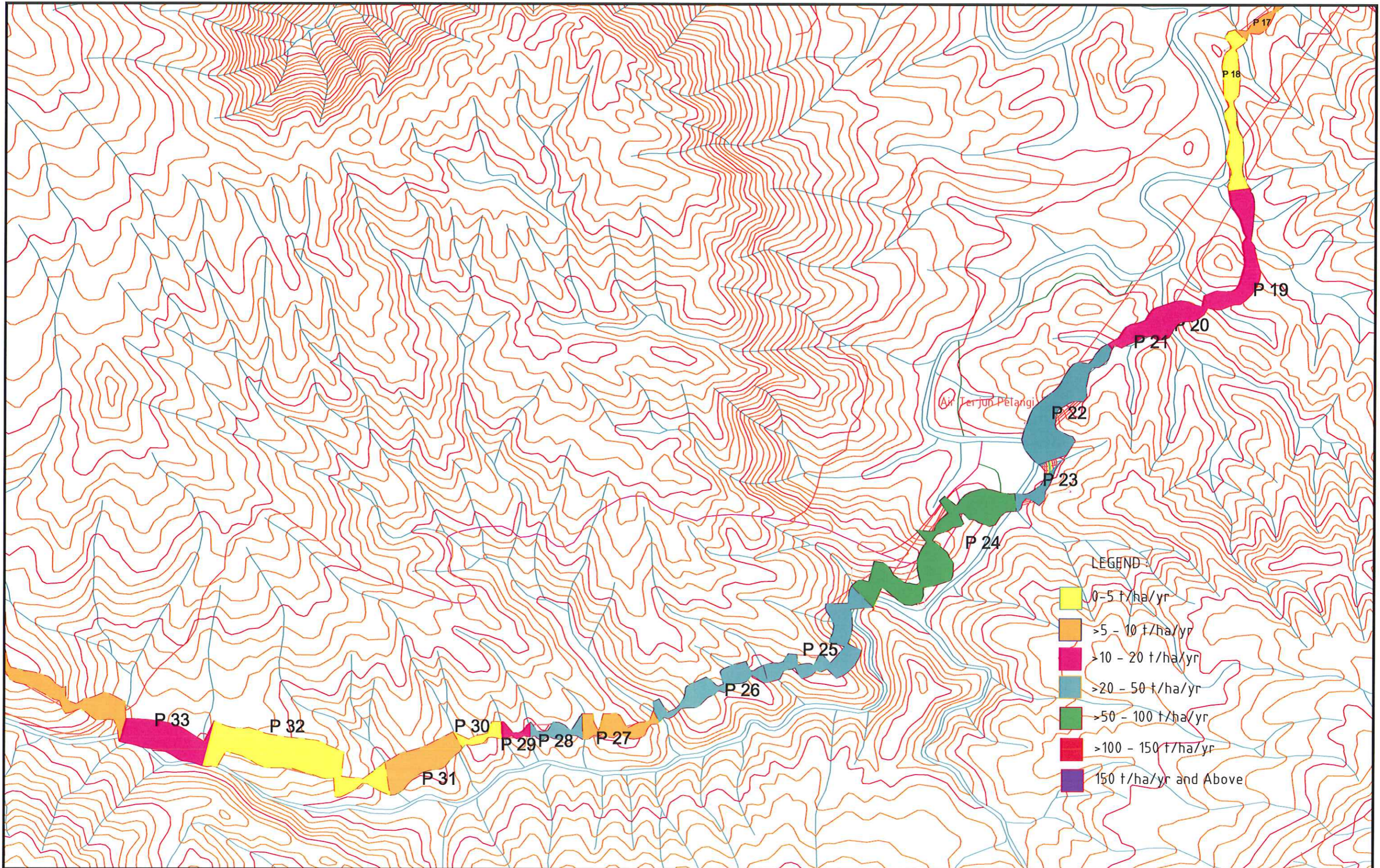
LEGEND :

	0-5 t/ha/yr
	>5 - 10 t/ha/yr
	>10 - 20 t/ha/yr
	>20 - 50 t/ha/yr
	>50 - 100 t/ha/yr
	>100 - 150 t/ha/yr
	150 t/ha/yr and Above

Terikh	Burhan	Rujukan	DIREKA OLEH : DA	PERUNDING ALAM SEKITAR :  GUNUNG-BANJARI CORPORATION BDN. BHD. (191174-2)	PEMILIK PROJEK :  JABATAN KERJA RAYA MALAYSIA	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK)	
			DILUKIS OLEH : DA	DISEMAK OLEH : v. AZMAN ABU BAKAR		TARIKH LUKISAN : Figure 5.4.5a : SERA Map During the Construction Stage With Control Measures (P1 to P9)	
			DILULUSKAN OLEH : v. AZMAN ABU BAKAR P.Eng., MEM, CPSWG.	NO. 81-5, JALAN BP 1/1, BUKIT D. 43300 BUKIT SERAPONG, SELANGOR DARUL BAHU TEL: 63-89415328 FAX: 63-8942448		TARIKH: 0605 2013	BIL. LUKISAN: PEIA/SGLJ/G0/13/SERA/C/WC/01
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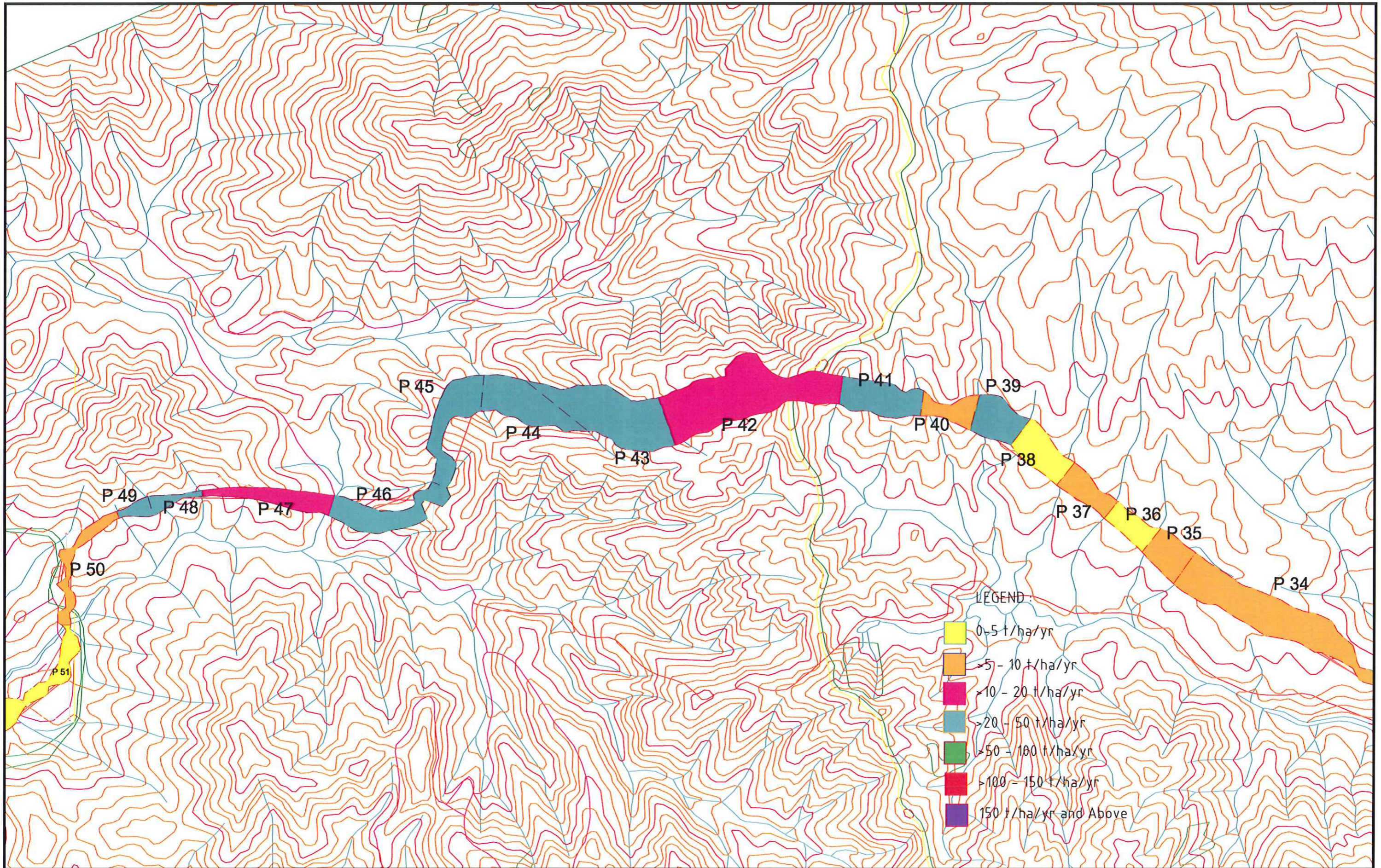
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			DILUKS OLEH : DA	DISEMAK OLEH : Iv. AZMAN ABU BAKAR		TAJUK LUKSAS : Figure 5.4.5b : SERA Map During the Construction Stage With Control Measures (P10 to P18)
			DILULUSKAN OLEH : Iv. AZMAN ABU BAKAR P.Eng., MEd, CPSWQ.			TARIKH: 0605 2013
			Scale 1:5000 UKURAN			BIL. LUKSAS: PEIA/SGLJ/00/13/SERA/C/WC/02
						REV. MUKASURAT: 5-204-II



LEGEND :

- 0 - 5 t/ha/yr
- >5 - 10 t/ha/yr
- >10 - 20 t/ha/yr
- >20 - 50 t/ha/yr
- >50 - 100 t/ha/yr
- >100 - 150 t/ha/yr
- 150 t/ha/yr and Above

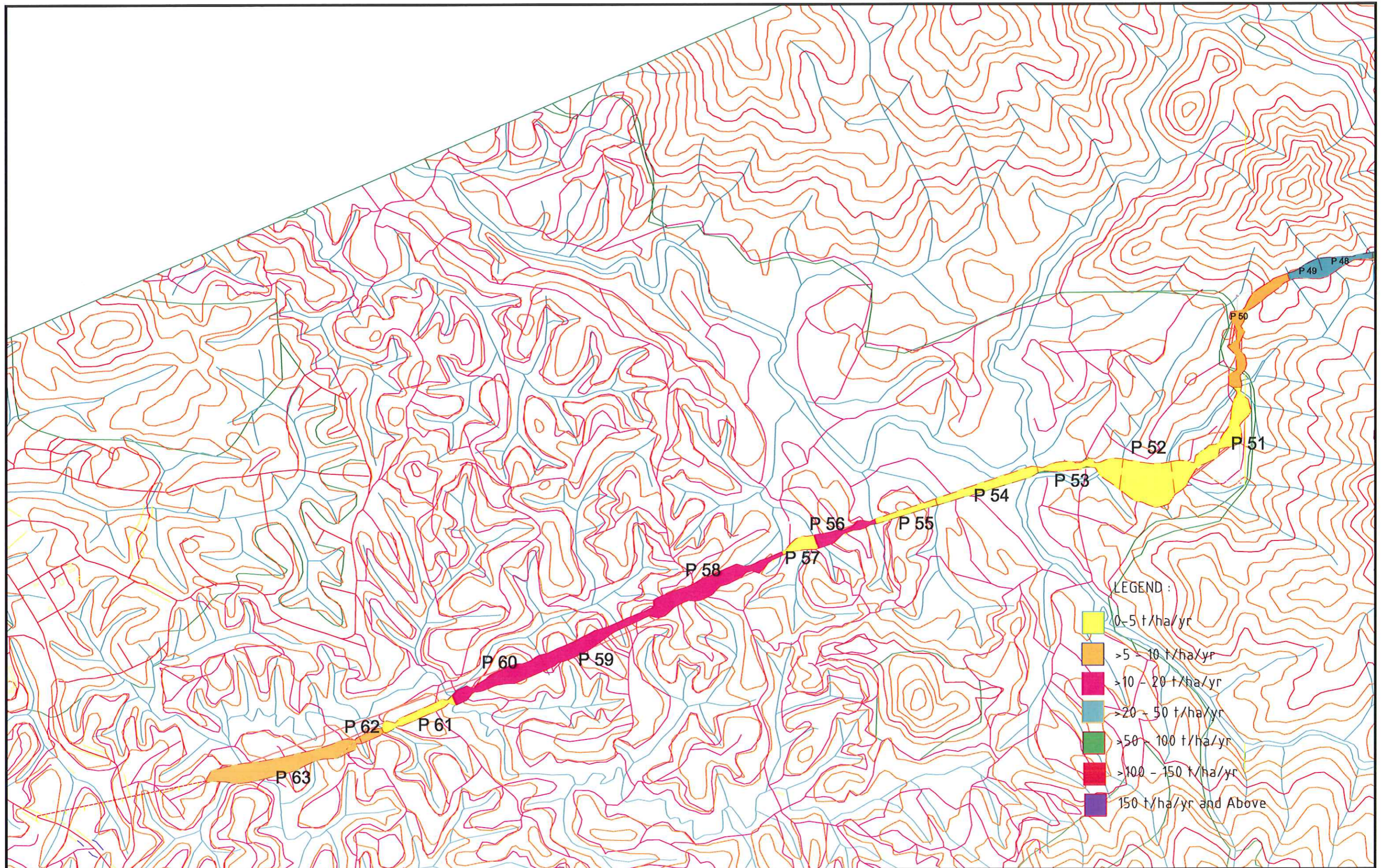
Tarikh	Butiran	Rujukan	DIREKA OLEH : DA DILUKIS OLEH : DA DILULUSKAN OLEH : I. AZMAN ABU BAKAR P.Eng., MEM, CPSWG.	PERUNDING ALAM SEKITAR :  GUNUNG-BAHARU CORPORATION BHD. (011124-0) NO. 63-5, JALAN 88 S/1, 80300 A, TANGKAP PERANG, MUKOH BUKA, DUN TEL: 62-8413208 FAX: 62-842548	PEMILIK PROJEK :  JABATAN KERJA RAYA MALAYSIA	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK) TAJUK LUKISAN : Figure 5.4.5c : SERA Map During the Construction Stage With Control Measures (P19 to P33)
	PINDAAN		Scale 1:3000 UKURAN			TARICAH : 0005 2013 BIL. LUKISAN : PEA/SGLJ/00/13/SERA/C/WC/03 REV. : MUKASURAT : 5-20a-II



LEGEND :



- 0-5 t/ha/yr
- >5 - 10 t/ha/yr
- >10 - 20 t/ha/yr
- >20 - 50 t/ha/yr
- >50 - 100 t/ha/yr
- >100 - 150 t/ha/yr
- 150 t/ha/yr and Above

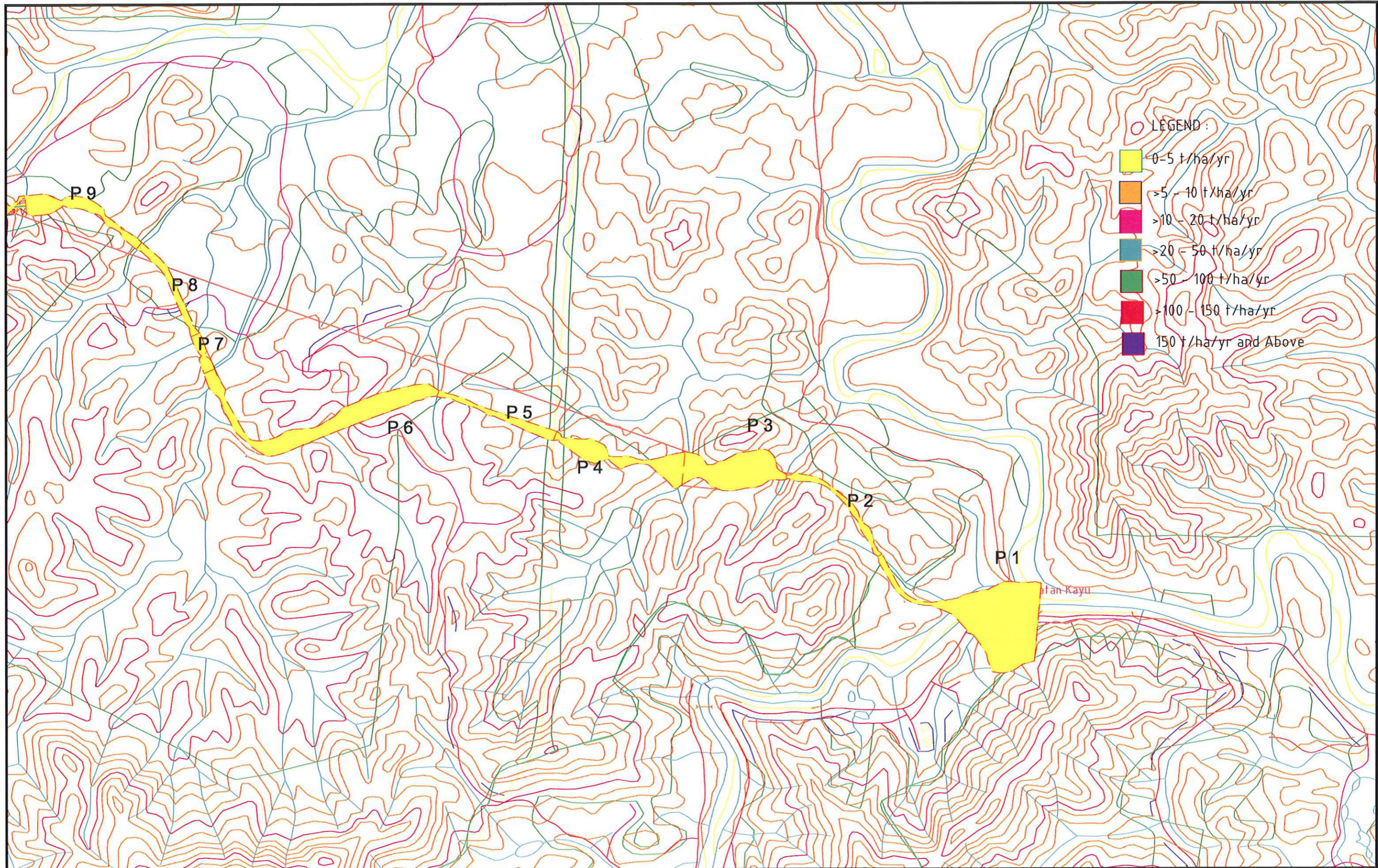
Tarikh	Butiran	Rujukan	DIREKA OLEH : DA DILUKIS OLEH : DA DISEMAK OLEH : Iv. AZMAN ABU BAKAR DILULUSKAN OLEH : Iv. AZMAN ABU BAKAR P.Eng., MIDA, CPSWQ.	PERUNDING ALAM SEKITAR :  <b>GUNUNG-GAJAH</b> GUNUNG-GAJAH CORPORATION SDN. BHD. (011174-P) <small>NO. 65-B, JALAN SP 5/1, BUKIT TIKH 2,          42000 BUKIT KEMuning, SELANGOR DARUL EHSAN          TEL: 60-3-6418208 FAX: 60-3-6422488</small>	PEMILIK PROJEK :  <b>JABATAN KERJA RAYA MALAYSIA</b>	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK)		
			Scale 1:3000 UKURAN			TAJUK LUKISAN : Figure 5.4.5d : SERA Map During the Construction Stage With Control Measures (P34 to P50)		
	PINDAAN					TARIKH: 0005 2013	BL LUKISAN: PEIA/SQA/JG/06/13/SERA/C/WC/04	REV. : MUKASURAT: 5-20a-IV





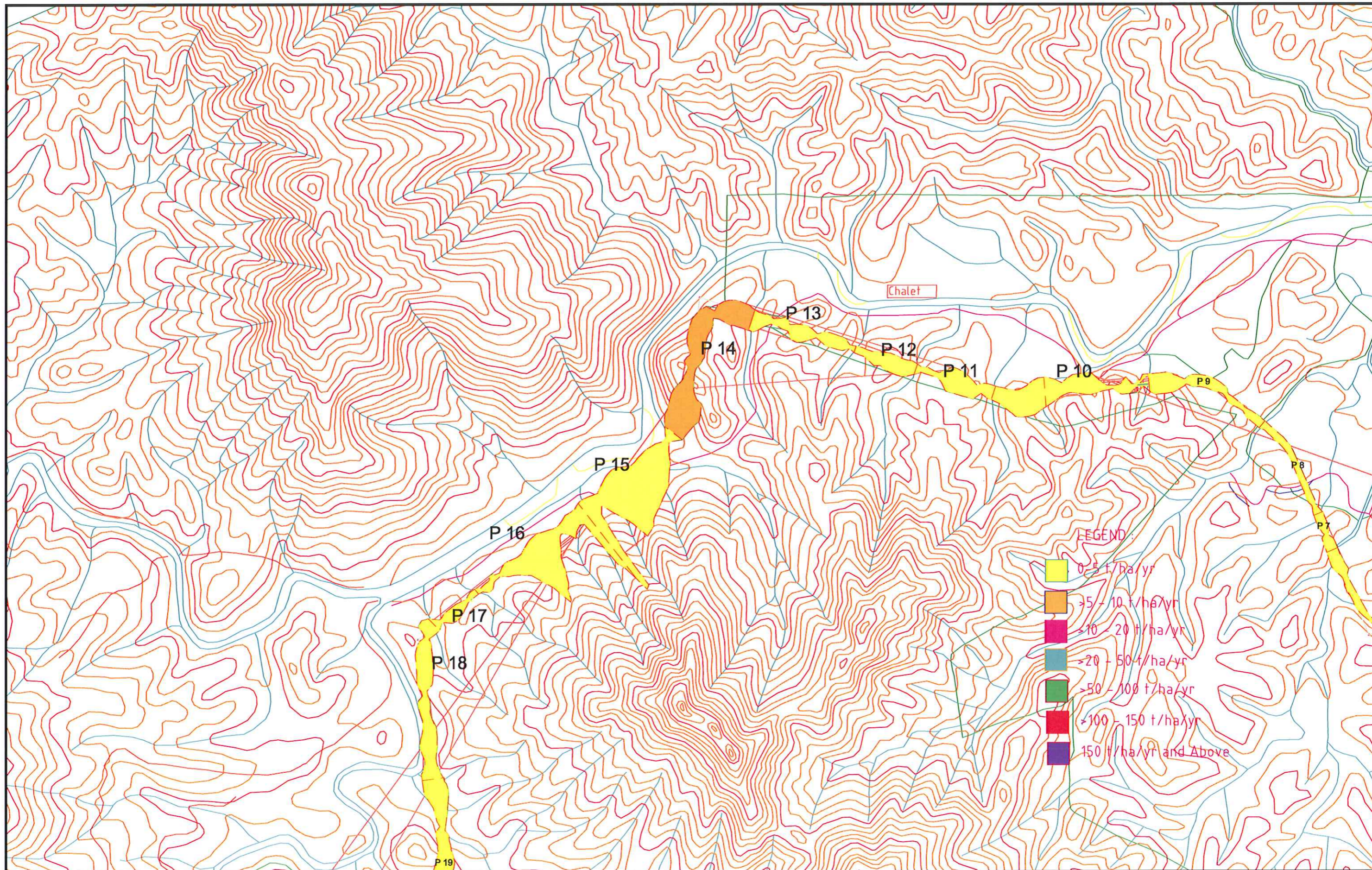
LEGEND :

- 0-5 t/ha/yr
- >5 - 10 t/ha/yr
- >10 - 20 t/ha/yr
- >20 - 50 t/ha/yr
- >50 - 100 t/ha/yr
- >100 - 150 t/ha/yr
- 150 t/ha/yr and Above

Tarikh	Bulatan	Rujukan	DIREKA OLEH : DA DILUKIS OLEH : DA DISEMAK OLEH : v. AZMAN ABU BAKAR DILULUSKAN OLEH : v. AZMAN ABU BAKAR P.Eng., MDM, CPSWO.	PERUNDING ALAM SEKITAR :  GUNUNG-GAJAH CONSERVATION CORPORATION BHD. (1991174-9) NO. 33-2, JALAN GP 7/A, BUKIT 2, TAMBUK BERINGIN, SEREMBAN, NEGERI SEMBILAN, 70100 TEL: 03-89413208 FAX: 03-89423488	PEMILIK PROJEK :  <b>JABATAN KERJA RAYA MALAYSIA</b>	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK) TAJUK LUKISAN : Figure 5.4.5e : SERA Map During the Construction Stage With Control Measures (P51 to P63)		
	PINDAAN		Scale 1:3000 UKURAN			TARICHI: 0605 2013	BIL. LUKISAN: PEM/SGLJ/00/13/SERA/C/WC/05	REV. MUKASURAT: 5-20a-v

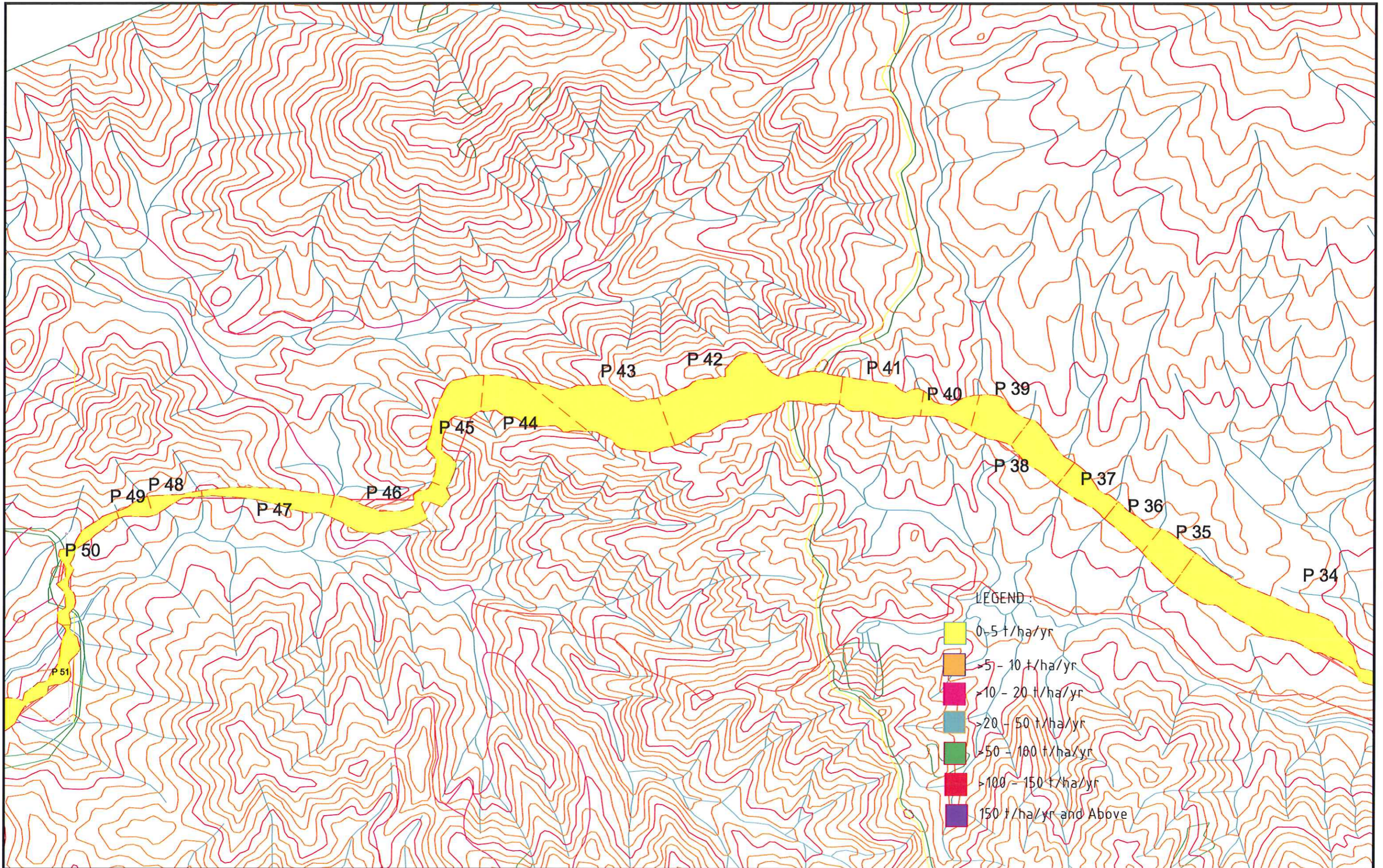



Terikh	Butiran	Rujukan	DIREKA OLEH : DA	PERUNDING ALAM SEKITAR :  GUNUNG-GAJAH CORPORATION SDN. BHD. (091174-9) NO. 63-3, JALAN GP 5/1, BLOK D1 2, TUNJUNG SELATAN, SELANGOR DARUL EHSAN, TEL: 03-89415308 FAX: 03-89423489	PEMLIK PROJEK :  JABATAN KERJA RAYA MALAYSIA	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK)
			DILUKIS OLEH : DA	DISEMAK OLEH : Ir. AZMAN ABU BAKAR		TAJUK LUKISAN : Figure 5.4.6a : SERA Map During the Post Development Stage With Control Measures (P1 to P9)
			DILULUSKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MEM., CPSWG.			TARIKH: 0605 2013
	PINDAAN		Scale 1:3000 UKURAN			BIL. LUKISAN: PEIA/SGLJ/OG/13/SERA/POST/WC/01
						REV. : MUKASURAT: 5-20f-1

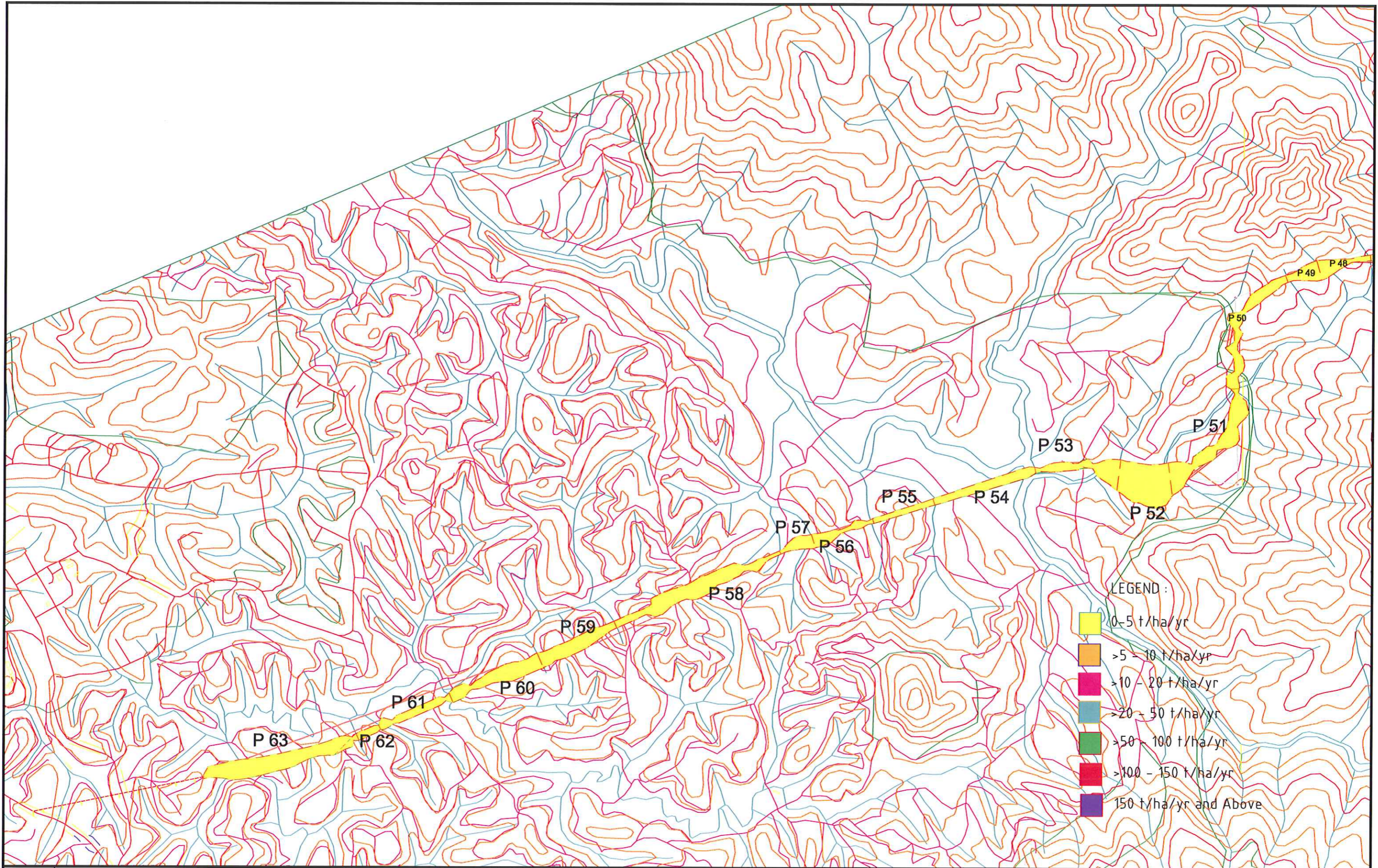


Tarikh	Butiran	Rujukan	DIREKA OLEH : DA	PERUNDING ALAM SEKITAR :	PEMILIK PROJEK :	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK)
			DILUKIS OLEH : DA	 GUNUNG-BAHARU GUNUNG-BAHARU CORPORATION SDN. BHD. (0191714-9)	 JABATAN KERJA RAYA MALAYSIA	TAJUK LUKSAN : Figure 5.4.6b : SERA Map During the Post Development Stage With Control Measures (P10 to P18)
			DISEMAK OLEH : Ir. AZMAN ABU BAKAR	NO. 81-3, JALAN SP 5/1, 802001 A, ALYON BUKU BARU, SELANGOR DARUL BAHU TEL: 03-89413328 FAX: 03-89423488		TARIKH: 0605 2013
			DILULUSKAN OLEH : Ir. AZMAN ABU BAKAR P.Eng., MEM. CPSIQ.	Scale 1:3000 UKURAN		DIL. LUKSAN: PEIA/SRLJ/Ga/13/SERA/POST/WC/02
	PINDAN					REV. MUKASURAT: 50-201-1





Tarikh  	Butiran    PINDAAN	Rujukan  	DIREKA OLEH : DA DILUKIS OLEH : DA DISEMAK OLEH : Ir. AZMAN ABU BAWAR DILULUSKAN OLEH : Ir. AZMAN ABU BAWAR P.Eng., MDM, CPSWG.	PERUNDING ALAM SEKITAR :  GUNUNG-GANANG CORPORATION BDN. BHD. (091174-9) <small>NO. 67-B, JALAN BP 5/1, BLOK D1 &amp; 2          TINGKAT 5, KAWASAN PERINDUSTRIAN          KUALA BANGSAWAN, SELANGOR DARUL EHSAN          TEL: 03-89113328 FAX: 03-8942108</small>	PEMILIK PROJEK :   JABATAN KERJA RAYA MALAYSIA	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT (REKABETUK) TAJUK LUKISAN : Figure 5.4.6d : SERA Map During the Post Development Stage With Control Measures (P34 to P50) TARIKH: OGOS 2013 BIL. LUKISAN: PEIA/SGLJ/06/13/SERA/POST/wc/04 REV. MUKASURAT: 5-20f-iv
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Tarikh	Butiran	Rujukan	DIREKA OLEH : DA DILUKIS OLEH : DA DISEMAK OLEH : K. AZMAN ABU BAKAR DILULUSKAN OLEH : K. AZMAN ABU BAKAR P.Eng., MEd., CPSW.	PERUNDING ALAM SEKITAR :  <b>GUNUNG-GANANG</b> GUNUNG-GANANG CORPORATION BDM. BHD. (019174-9) 80, 82-3, JALAN GP 1/1, BLOK D1 3, 43000 BERKAMPUNG, SELANGOR DARUL BAHU TEL: 03-89413328 FAX: 03-89423488	PEMILIK PROJEK :  <b>JABATAN KERJA RAYA</b> <b>MALAYSIA</b>	PEIA FOR MEMBINA JALAN DARI SUNGAI LEMBING KE JERANTUT(REKABETUK) TAJUK LUKISAN : Figure 5.4.6e : SERA Map During the Post Development Stage With Control Measures (P51 to P63) TARIKH: Ogos 2013 BIL. LUKISAN: PEIA/SGLJ/GG/13/SERA/POST/WC/05 REV. : MUKASURAT: 5-20f-v
	PINDAAN		Scale 1:3000 UKURAN			

**Table 5.4.5: Summary of Estimated Disturbed Area from the Project (cont.)**

No.	Sub-Catchment	Parcel	Disturbed Area (ha)
8.	SC 8	8	1.982
9.	SC 9	9	1.181
10.	SC 10	10	10.108
11.	SC 11	11	13.582
12.	SC 12	12	9.728
13.	SC 13	13	3.255
14.	SC 14	14	2.301
15.	SC 15	15	3.044
16.	SC 16	16	2.51
17.	SC 17	17	5.753
18.	SC 18	18	5.776
19.	SC 19	19	1.37
20.	SC 20	20	9.3
21.	SC 21	21	7.419
22.	SC 22	22	13.421
23.	SC 23	23	1.629
24.	SC 24	24	9.54
25.	SC 25	25	3.004
26.	SC 26	26	1.484
27.	SC 27	27	0.684
28.	SC 28	28	2.178
29.	SC 29	29	3.022
30.	SC 30	30	4.888
31.	SC 31	31	3.374
32.	SC 32	32	24.198
33.	SC 33	33	6.468
34.	SC 34	34	14.573
35.	SC 35	35	5.36
36.	SC 36	36	3.592
37.	SC 37	37	4.793
38.	SC 38	38	4.157
39.	SC 39	39	3.808
40.	SC 40	40	3.239
41.	SC 41	41	6.926
42.	SC 42	42	8.521
43.	SC 43	43	14.594
44.	SC 44	44	19.17
45.	SC 45	45	6.823
46.	SC 46	46	4.438
47.	SC 47	47	1.582
48.	SC 48	48	1.11
49.	SC 49	49	4.607
50.	SC 50	50	7.571
51.	SC 51	51	1.074
52.	SC 52	52	2.614
53.	SC 53	53	1.486
54.	SC 54	54	7.174

**Table 5.4.5: Summary of Estimated Disturbed Area from the Project (cont.)**

No.	Sub-Catchment	Parcel	Disturbed Area (ha)
55.	SC 55	55	4.424
56.	SC 56	56	3.243
57.	SC 57	57	2.847
58.	SC 58	58	6.004
59.	SC 59	59	1.113
60.	SC 60	60	1.157
61.	SC 61	61	6.503
62.	SC 62	62	0.525
63.	SC 63	63	1.493

#### **5.4.4 PROPOSED SITE ACTIVITY**

Site activities generally include the following:

- Preservation of buffer strip (Green buffer) - a minimum 5 m from the existing river or stream.
- Installation of erosion control BMPs, including rerouting of surface water run-on at the Project site.
- Construction of temporary sediment pond.
- Soil excavation and stockpiling; and transport to approved stockpile or disposal/filling areas.
- River/ Channel diversion
- Desilting or desludging works on existing sedimentation pond.
- Installation of permanent BMPs.
- Replanting or turfing within the sites.

#### **5.4.5 PRELIMINARY ACTIVITY**

##### **A Staging**

A small area will be set aside for parking of equipment, and provision of amenities such as drinking water, and portable toilet for the construction workers.

##### **B Re-routing of Surface Runoff**

During the construction activity, surface water run-on will be dammed and conveyed around the Project site using a temporary drain, and discharged to a silt trap or sediment pond at downslope of the Project site in every Phase to ensure stream flow is maintained during construction. Check dams will likely be constructed from sandbags unless there is substantial surface water flow, in which case other methods (e.g., large rock, sheet pile, etc.) will be employed as needed. Pumps will be used, as needed if diversion cannot be achieved through gravity flow alone. Following completion of the construction phase, the check dams will be removed and flow will be returned to new permanent drain that will be constructed during the phases or stages.

#### 5.4.6 DESIGN CRITERIA

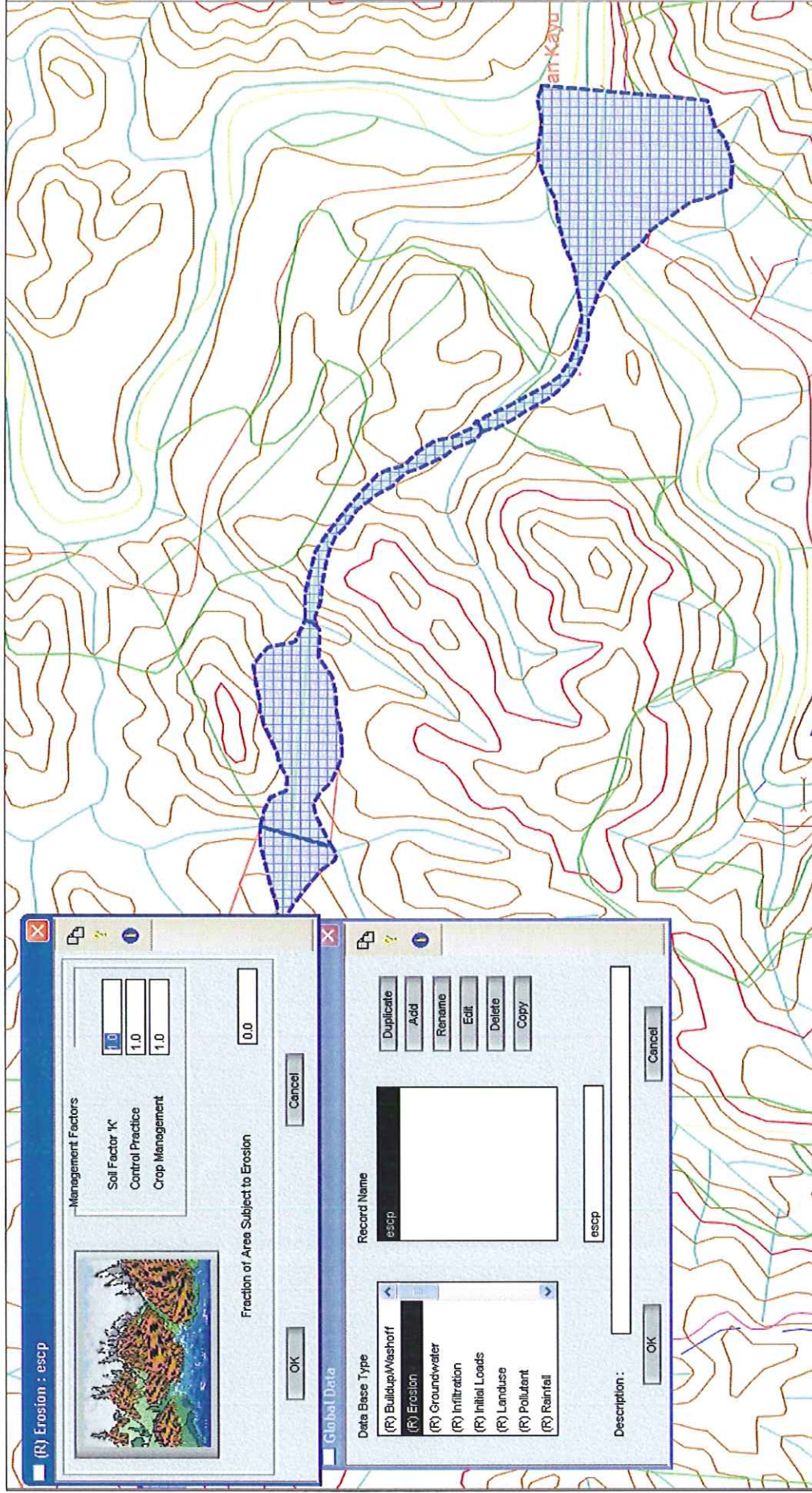
The design criteria for sediment control structures are summarised in **Table 5.4.6**.

**Table 5.4.6: Sediment Control Structures – capacity Requirements**

Sediment Control Structure	Function	Design Capacity
Upslope diversion drains	Reduce runoff from undisturbed areas onto disturbed areas	Peak flow calculated for 1 in 2 year ARI
Downslope collection drains	Intercept and convey disturbed area runoff water to sediment dams	Peak flow calculated for 1 in 2 year ARI
Sediment Pond	Containment of sediment-laden runoff from disturbed areas with more than 150 m <sup>3</sup> /yr estimated soil loss	Settling Zone: Capacity to store the runoff produced from the 3 months ARI design storm Sediment Storage Zone: Two month calculated soil loss estimated using RUSLE
Sediment fences	Retention /filtration of suspended sediments	Limit flow to 50 L/s in design 1 in 2 ARI

The 3 months ARI design storm will be based on IDF Sungai Lembing. It was used in calculating the silt trap settling zone capacity; and was calculated to be 40 mm from the average of values for Kuantan. The calculated soil loss based on the soils assessments are modelled based on estimated parameters for Revised Universal Soil Loss Equation (RUSLE) while the soil yield is performed by using the Modified Universal Soil Loss Equation (MUSLE) formula. **Figure 5.4.7** show the model on the RUSLE for the Project site.

Figure 5.4.7: The Model of Erosion by RUSLE for the Project



## 5.5 IMPACTS ON HYDROLOGY AND DRAINAGE

### 5.5.1 HYDROLOGIC AND HYDRAULIC MODELLING

In the assessment, XP-Storm Water Management Model (SWMM) is used to analyse the hydrologic and hydraulic behaviour of present catchment characteristics and to simulate flooding scenarios due to future development. The calibrated model is used to predict the impact of future development on the flow hydrographs.

#### A. Hydrologic Modelling

The purpose of hydrologic modelling is to estimate flow hydrograph from the tributary catchment for various Average Recurrence Interval (ARI). The estimated flow hydrograph serves as an input to the hydraulic modelling of the study area. The hydrologic model in XP-SWMM is available in the runoff mode.

The catchment was divided into several sub-catchments which are represented as nodes in XP-SWMM. Selections of nodes are based on the consideration of certain aspects of the catchment characteristics and locations where determination of flow is required. Each sub-catchment is given an identification (ID) number and provided with a link number for connectivity among the nodes.

#### B. Hydraulic Modelling

The objective of the hydraulic modelling is to perform hydraulic routing of flood flow in the drainage system, which uses the upstream inflow hydrograph generated from the runoff mode. The hydraulic flow routing model in XP-SWMM is called EXTRAN and is available under the hydraulic mode. The simulated water surface profile and discharge determine which area is prone to flooding under various scenarios. The modelling scenarios include existing and future conditions of the study area plus existing and future flood mitigation facilities. The scenarios considered in this study are as follows:

- Existing condition.
- Future condition with mitigation measures.

EXTRAN can model the water surface profile along channels and flood plains in drainage systems. The EXTRAN model uses fully a dynamic flood routing technique based on the St. Venant equation. The model is based on gradually varied one-dimensional flow.

The Project will definitely change the streamflow at its outlet. Land cover changes from pervious to impervious will result in increase of surface runoff. As specified in the Urban Stormwater Management Manual for Malaysia (MSMA) by the DID, the developer is responsible in controlling the increase of surface runoff. The design storm selected for this study depends on the time of concentration of the study area ( $t_c$ ) which was estimated by using the Barnsby William formulae as given below:

$$t_c = \frac{F_c \cdot L}{A^{1/10} S^{1/5}}$$

where;

- $t_c$  = the time of concentration (minute)
- $F_c$  = a conversion factor, 58.5 when area  $A$  is in  $\text{km}^2$ , or 92.5 when area is in ha
- $L$  = length of flow path from catchment divide to outlet (km)
- $A$  = catchment area ( $\text{km}^2$  or ha)
- $S$  = slope of stream flow path (m/km).

The closest IDF curve available for this study area is in Sungai Lembing. The design storm hyetograph of 2, 5, 10, 20, 50 and 100 years ARI will be used.

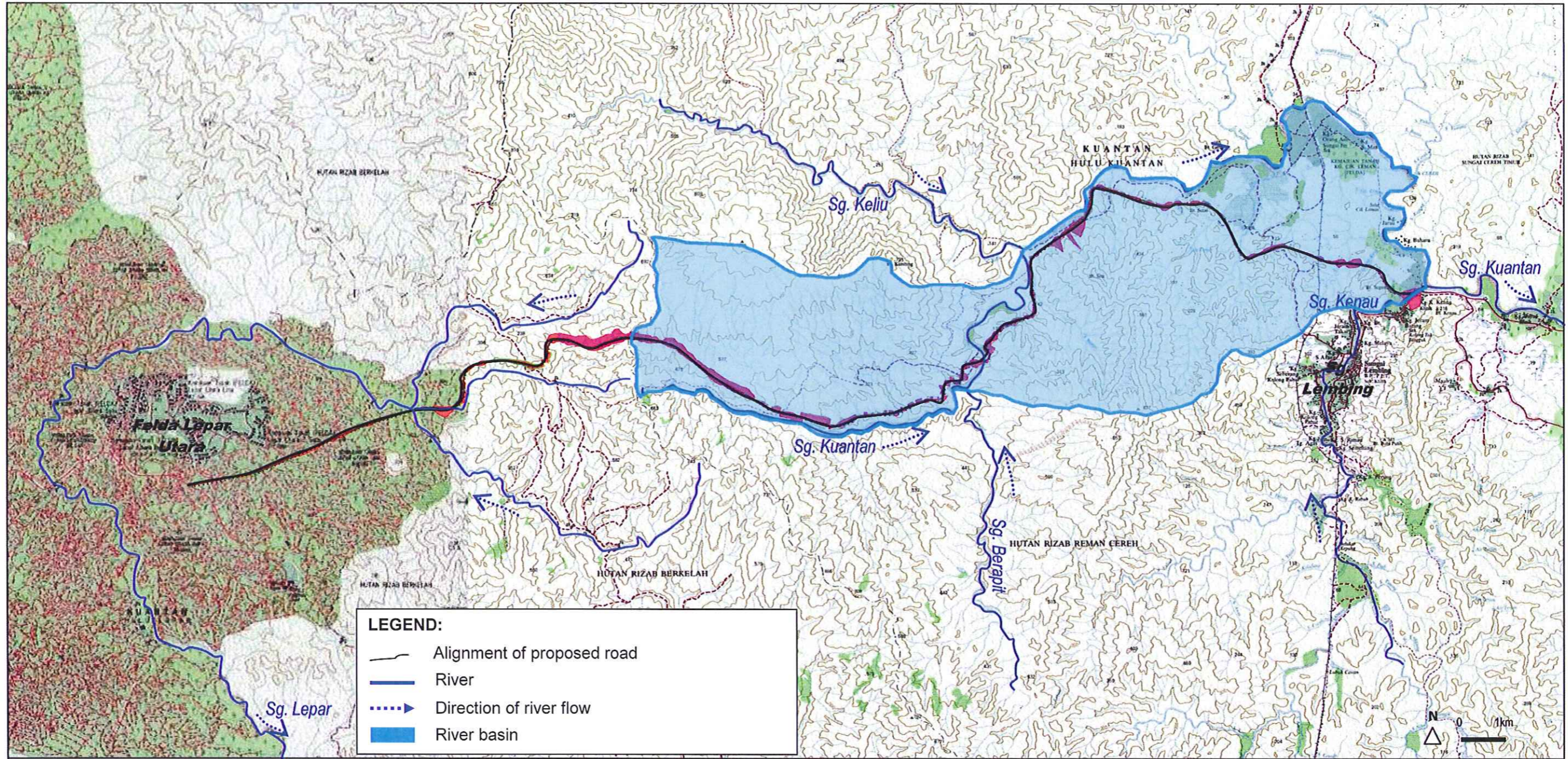
### 5.5.2 STUDY AREA AND CATCHMENT

The construction activities will give temporary impact on the change of land use to give way for the construction of the Project. Stormwater which originates from the Project site is generally regulated and discharged into the nearest drain or stream.

Modelling of runoff from the development of the proposed road to the nearest monsoon drain (stream or channel) or downstream area was conducted. The model for the catchment that contributes to the surface runoff flow into Sg. Kuantan from the Project site is shown in **Figure 5.5.1** while **Figure 5.5.2** shows the catchment that contributes the surface runoff into Sg. Pahang through Sg. Lepar. By mimicking pre-development conditions, mitigation measures should be considered to control the flow by gradual release of runoff into the downstream drainage system before allowing it to flow into Sg. Kuantan and Sg. Pahang.

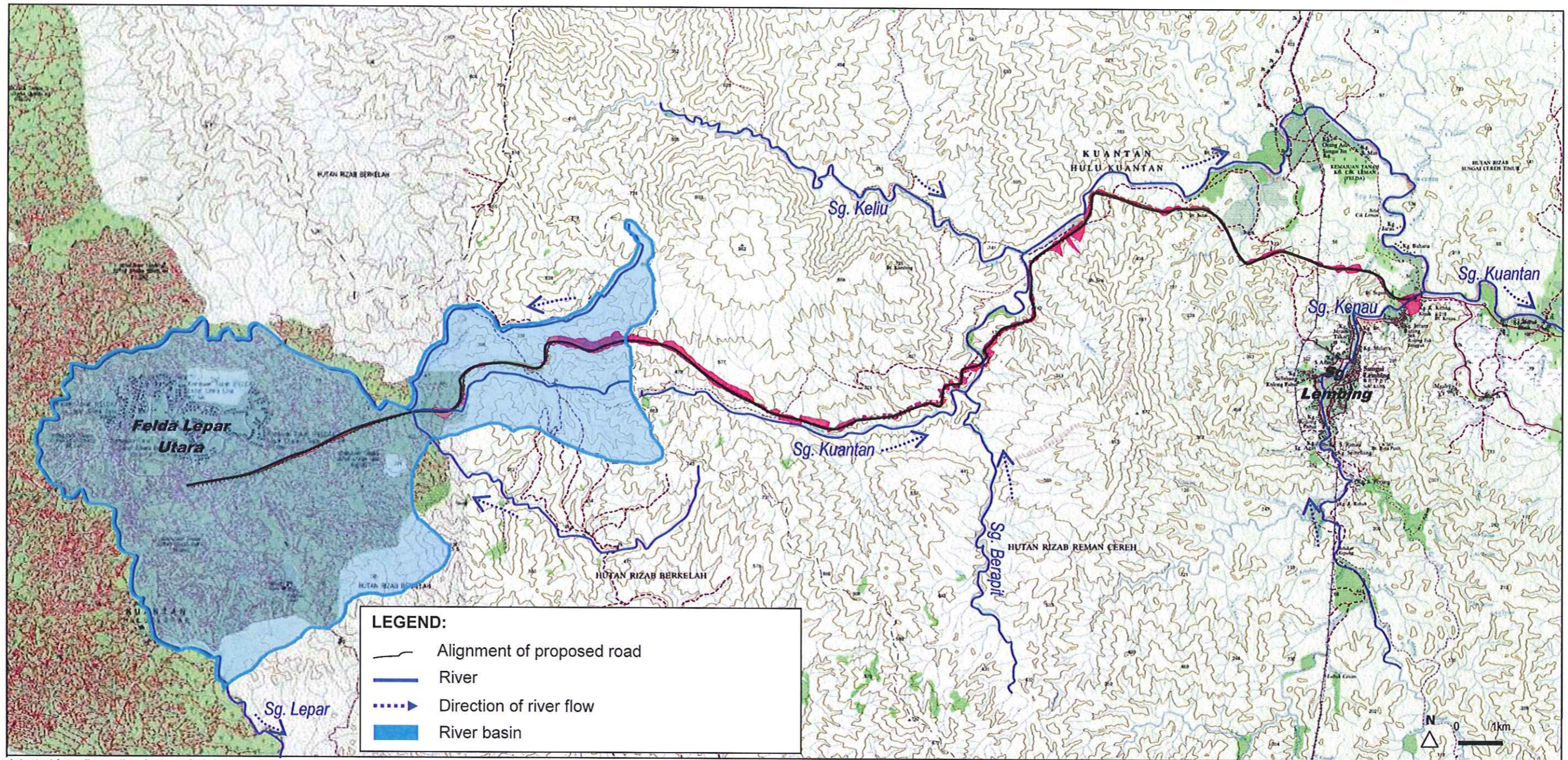
MSMA requires that the post-development flow at the outlet must be equal to or less than the pre-development level. Post-development surface water modelling was used to determine the peak discharge from the study area using the SWMM routing method. The overall catchment area of the Project is about 350.895 hectares (**Figure 5.5.3**) and is subdivided into 63 sub-catchments to allow better representations of the catchment characteristics (**Figures 5.5.4 – 5.5.10**). This is also to provide more accurate and reliable representations of the sub-catchments. The model simulated a 100 ARI, 24-hour storm to obtain a peak discharge rate. A different percentage impervious area of up to 90% for each sub-catchment was used for the post development analysis because the Project site will be developed with a road and its ancillary works.

Figure 5.5.1: Catchment that Contributes to the Surface Runoff into Sg. Kuantan River Basin from the Project Site



Adapted from Perunding Azman, Ooi dan Rao (2013)

Figure 5.5.2: The Catchment that Contributes to the Surface Runoff into Sg. Kuantan through Sg. Lepar



Adapted from Perunding Azman, Ooi dan Rao (2013)

Figure 5.5.3: Modelling of the Hydrologic and Hydraulic Flow for the Project Using XP-SWMM

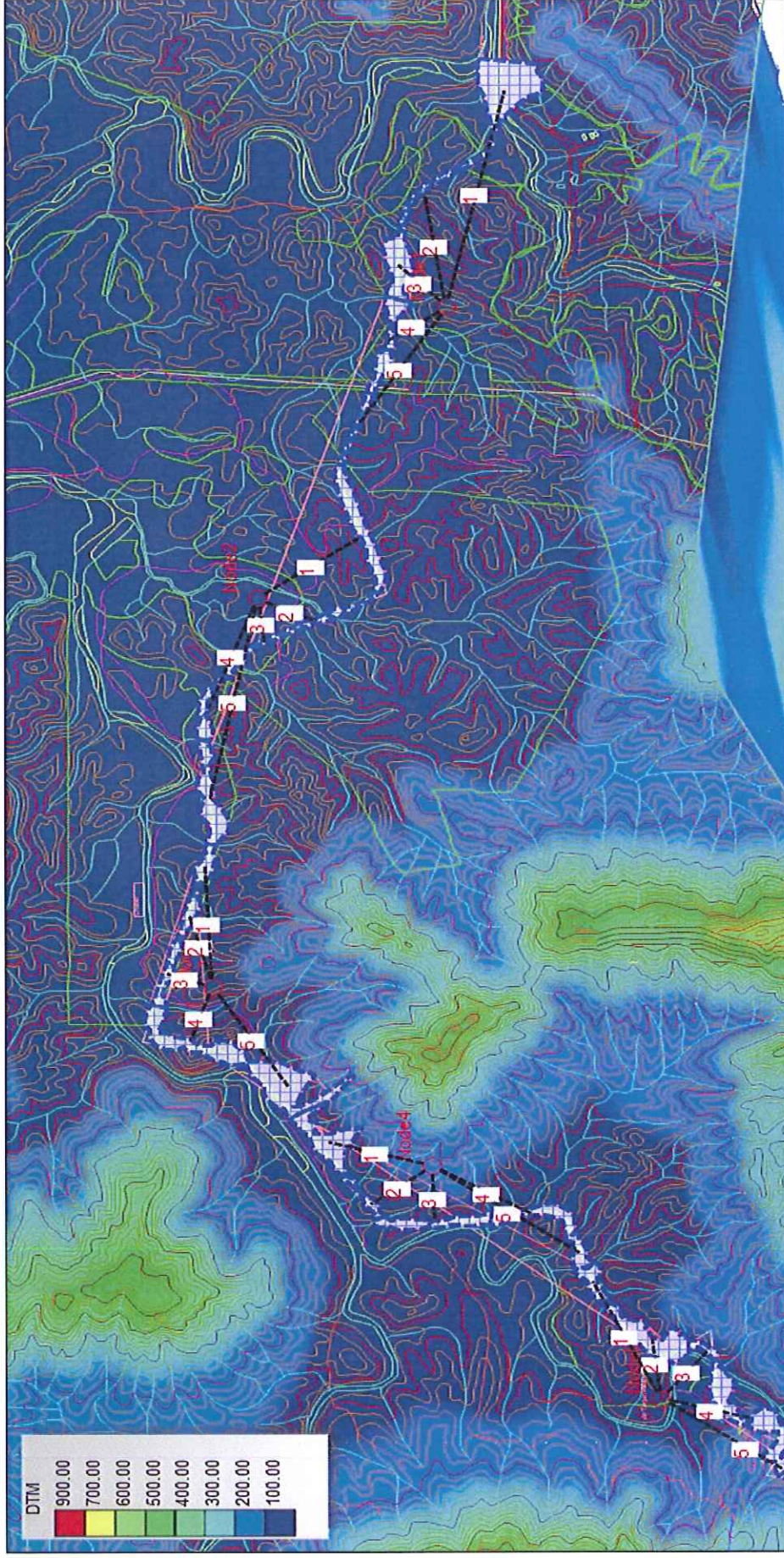


Figure 5.5.4: Sub-Catchment 1 to 7

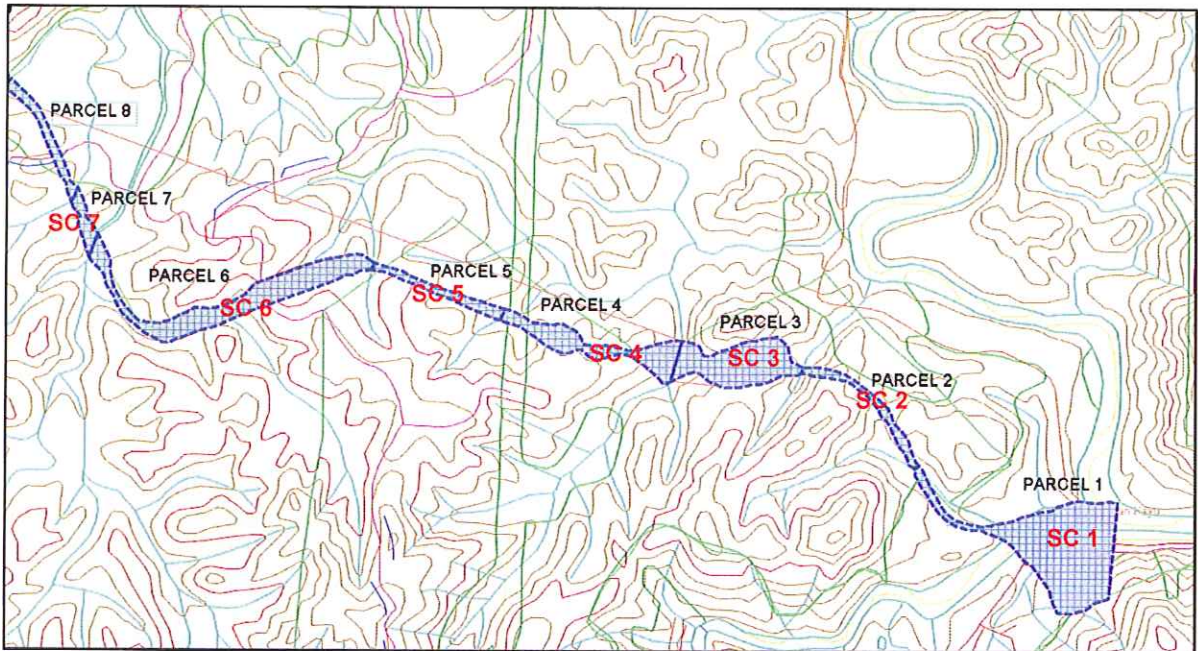


Figure 5.5.5: Sub-Catchment 8 to 18

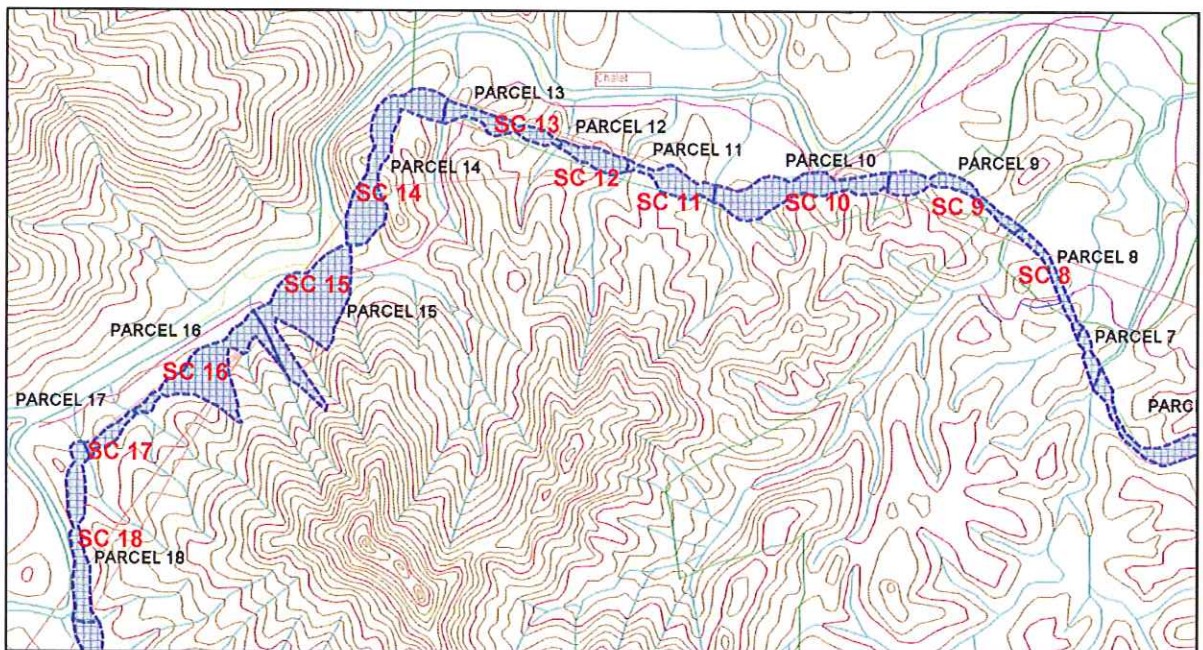


Figure 5.5.6: Sub-Catchment 19 to 24

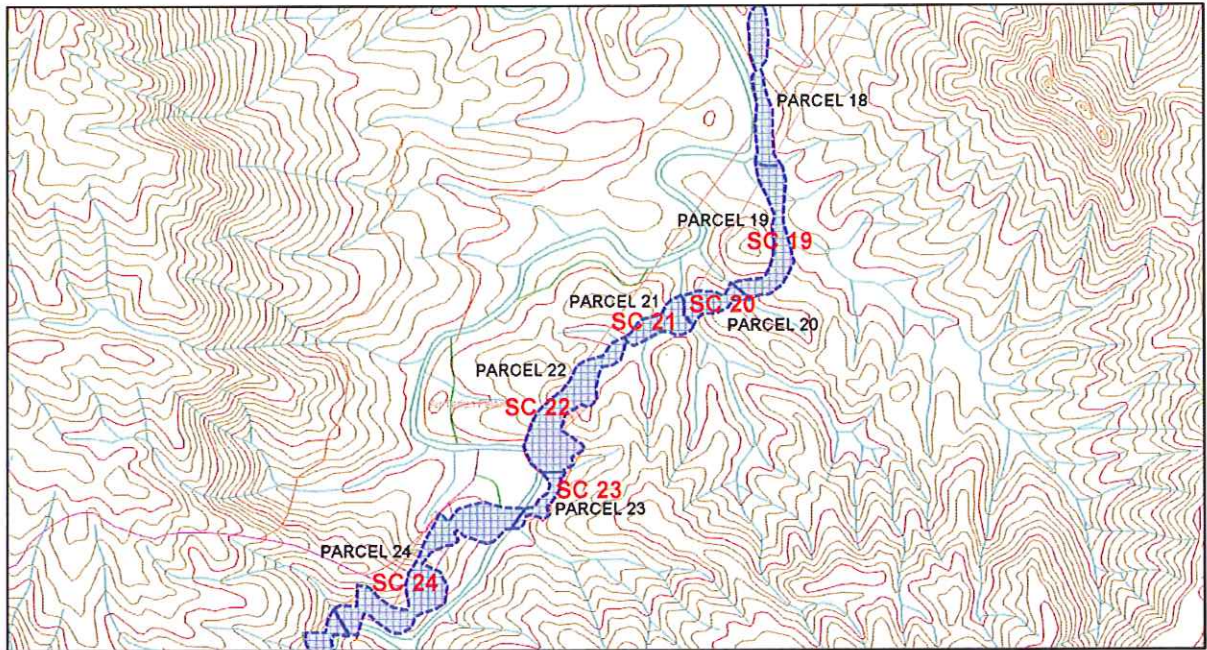


Figure 5.5.7: Sub-Catchment 25 to 34

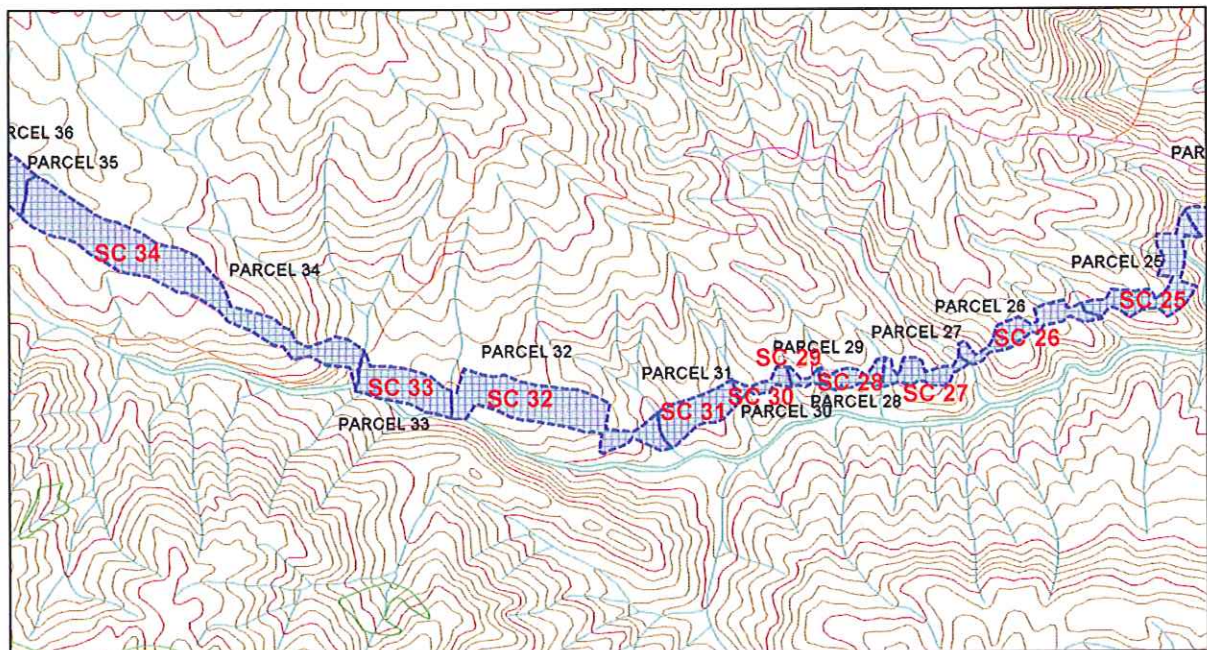


Figure 5.5.8: Sub-Catchment 35 to 45

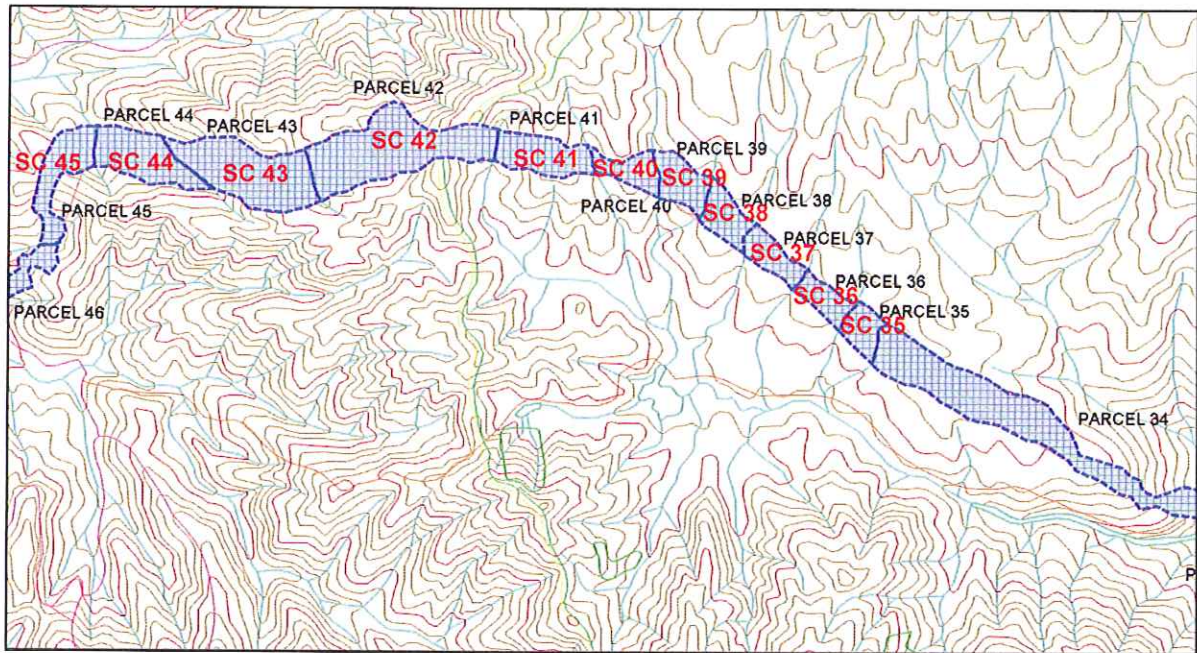
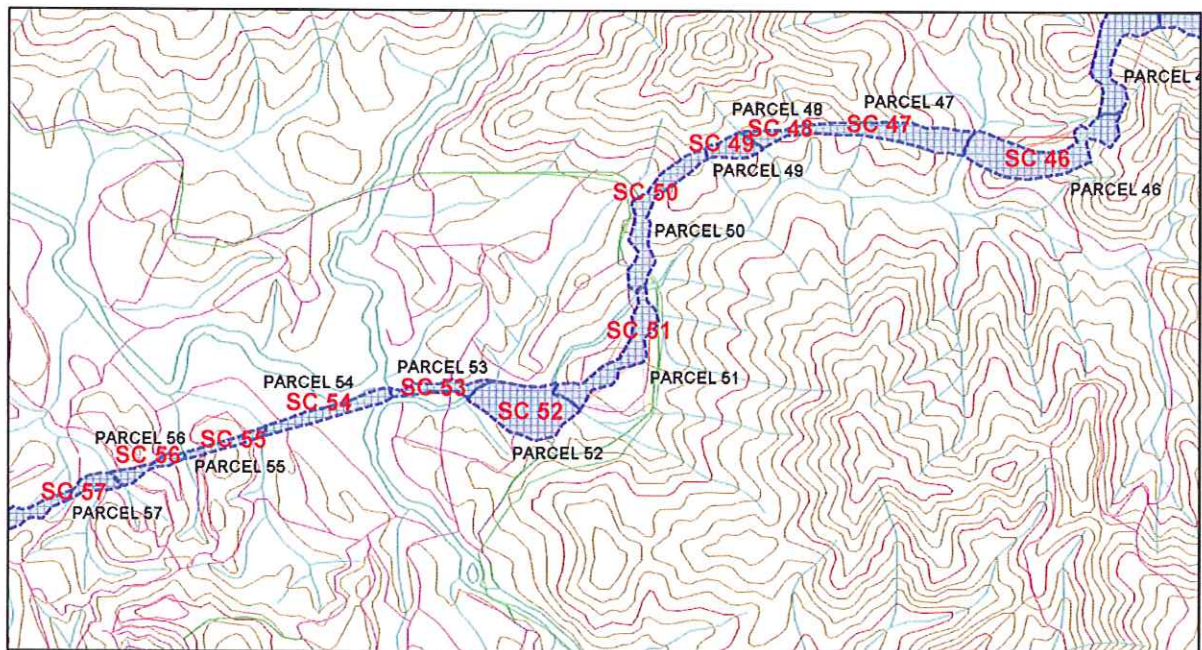
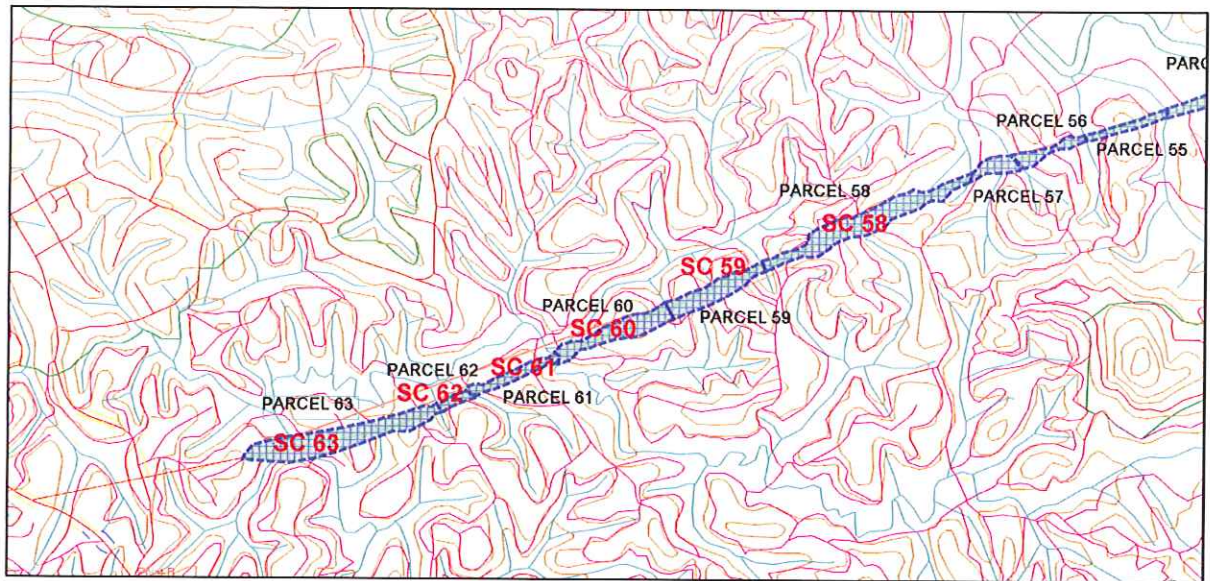


Figure 5.5.9: Sub-Catchment 46 to 57



**Figure 5.5.10: Sub-Catchment 58 to 63**

### 5.5.3 HYDROLOGIC MODELLING

The stormwater within the catchment area originates from the surrounding area with an elevation of about 980 m and ends at the outlet where the elevation is about 20 m. It flows through the Project site and empties itself into Sg. Kuantan and Sg. Pahang. Sub-catchment 1 to 42 is within the Sg. Kuantan River Basin while Sub-catchment 43 to 63 will lead the surface runoff discharge into Sg. Lepar which is one of the tributary of the Sg. Pahang River Basin.

Land cover that changes from pervious to impervious will result in an increase of surface runoff which eventually increases flow volume and velocity. In anticipation of the increase in surface runoff, the layout design of the Project should allocate areas for retention ponds (dry) or wetlands to manage on-site stormwater and act as silt traps during the construction period.

Hydrologic losses for the area are on Uniform Loss Model by MSMA. The initial loss is assumed to be 10 mm/hr and the continuing loss is assumed to be 6.5 mm/hr for the pervious area. It is also assumed that the pre-development land cover consists of 10% impervious ground and the post-development consists of 80% - 90% impervious ground for the Project. The transformation of effective rainfall to the outlet area will be based on the XP-SWMM Runoff Routing Method.

The simulated results from the modelling for the pre-development conditions are shown in **Tables 5.5.1 to 5.5.6** for various ARIs. **Tables 5.5.7 to 5.5.12** show the results of modelling for post development in various ARIs. The results show that the increase in runoffs will potentially cause occurrences of flood at downstream of the study area. Mitigation measures should be considered to control the flow by gradual release of runoff into the downstream drainage system. The estimated peak flow of the study area for the proposed condition without any mitigations measures is 171.303 m<sup>3</sup>/s (100 ARI with 90% impervious area).

**Table 5.5.1: Result of Modelling for Pre-Development for 2 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	72.250	2.065
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	72.250	1.330
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	72.250	4.008
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	72.250	2.809
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	72.250	6.175
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	72.250	3.240
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	72.250	12.296
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	72.250	5.175
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	72.250	14.813
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	72.250	3.987
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	72.250	1.080
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	72.250	3.269
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	72.250	2.008
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.2: Result of Modelling for Pre-Development for 5 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	86.250	2.716
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	86.250	1.750
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	86.250	4.912
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	86.250	3.452
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	86.250	7.530
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	86.250	3.925
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	86.250	15.265
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	86.250	6.272
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	86.250	17.956
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	86.250	4.844
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	86.250	1.422
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	86.250	4.095
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	86.250	2.553
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.3: Result of Modelling for Pre-Development for 10 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	97.800	3.206
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	97.800	2.071
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	97.800	6.065
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	97.800	4.275
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	97.800	9.226
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	97.800	4.778
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	97.800	18.831
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	97.800	7.636
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	97.800	21.860
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	97.800	5.917
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	97.800	1.679
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	97.800	5.095
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	97.800	3.201
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.4: Result of Modelling for Pre-Development for 20 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	102.375	3.520
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	102.375	2.272
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	102.375	6.297
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	102.375	4.440
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	102.375	9.566
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	102.375	4.948
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	102.375	19.531
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	102.375	7.909
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	102.375	22.640
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	102.375	6.131
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	102.375	1.844
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	102.375	5.290
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	102.375	3.326
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.5: Result of Modelling for Pre-Development for 50 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	120.750	4.481
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	120.750	2.902
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	120.750	7.712
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	120.750	5.453
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	120.750	11.615
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	120.750	5.970
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	120.750	23.708
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	120.750	9.542
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	120.750	27.315
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	120.750	7.424
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	120.750	2.349
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	120.750	6.460
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	120.750	4.073
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.6: Result of Modelling for Pre-Development for 100 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	147.500	6.046
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	147.500	3.933
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	147.500	8.668
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	147.500	6.139
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	147.500	12.987
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	147.500	6.651
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	147.500	26.470
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	147.500	10.631
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	147.500	30.431
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	147.500	8.289
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	147.500	3.171
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	147.500	7.233
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	147.500	4.562
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.7: Result of Modelling for Post-Development for 2 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	72.250	3.712
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	72.250	2.438
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	72.250	4.383
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	72.250	3.105
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	72.250	6.557
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	72.250	3.383
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	72.250	13.481
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	72.250	5.407
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	72.250	15.478
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	72.250	4.198
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	72.250	1.956
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	72.250	3.727
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	72.250	2.349
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.8: Result of Modelling for Post-Development for 5 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	86.250	4.620
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	86.250	3.070
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	86.250	5.372
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	86.250	3.850
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	86.250	7.939
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	86.250	4.064
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	86.250	16.207
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	86.250	6.496
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	86.250	18.594
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	86.250	5.068
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	86.250	2.430
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	86.250	4.491
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	86.250	2.824
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.9: Result of Modelling for Post-Development for 10 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	102.375	5.678
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	102.375	3.815
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	102.375	6.899
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	102.375	4.902
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	102.375	10.040
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	102.375	5.085
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	102.375	20.302
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	102.375	8.128
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	102.375	23.266
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	102.375	6.384
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	102.375	2.982
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	102.375	5.641
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	102.375	3.535
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.10: Result of Modelling for Post-Development for 20 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	120.750	6.891
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	120.750	4.681
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	120.750	8.473
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	120.750	6.045
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	120.750	12.171
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	120.750	6.107
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	120.750	24.403
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	120.750	9.760
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	120.750	27.939
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	120.750	7.711
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	120.750	3.611
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	120.750	6.796
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	120.750	4.245
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.11: Result of Modelling for Post-Development for 50 ARI**

Name	Subcatchment	Hydrology Methods	Total Rainfall mm	Max Flow cms
Node1	1	SWMM Meth	147.500	8.982
Node1	2	SWMM Meth		
Node1	3	SWMM Meth		
Node1	4	SWMM Meth		
Node1	5	SWMM Meth		
Node2	1	SWMM Meth	147.500	6.090
Node2	2	SWMM Meth		
Node2	3	SWMM Meth		
Node2	4	SWMM Meth		
Node2	5	SWMM Meth		
Node3	1	SWMM Meth	147.500	9.913
Node3	2	SWMM Meth		
Node3	3	SWMM Meth		
Node3	4	SWMM Meth		
Node3	5	SWMM Meth		
Node4	1	SWMM Meth	147.500	7.415
Node4	2	SWMM Meth		
Node4	3	SWMM Meth		
Node4	4	SWMM Meth		
Node4	5	SWMM Meth		
Node5	1	SWMM Meth	147.500	13.605
Node5	2	SWMM Meth		
Node5	3	SWMM Meth		
Node5	4	SWMM Meth		
Node5	5	SWMM Meth		
Node6	1	SWMM Meth	147.500	6.788
Node6	2	SWMM Meth		
Node6	3	SWMM Meth		
Node6	4	SWMM Meth		
Node6	5	SWMM Meth		
Node7	1	SWMM Meth	147.500	27.140
Node7	2	SWMM Meth		
Node7	3	SWMM Meth		
Node7	4	SWMM Meth		
Node7	5	SWMM Meth		
Node8	1	SWMM Meth	147.500	10.849
Node8	2	SWMM Meth		
Node8	3	SWMM Meth		
Node8	4	SWMM Meth		
Node8	5	SWMM Meth		
Node9	1	SWMM Meth	147.500	31.054
Node9	2	SWMM Meth		
Node9	3	SWMM Meth		
Node9	4	SWMM Meth		
Node9	5	SWMM Meth		
Node10	1	SWMM Meth	147.500	8.601
Node10	2	SWMM Meth		
Node10	3	SWMM Meth		
Node10	4	SWMM Meth		
Node10	5	SWMM Meth		
Node11	1	SWMM Meth	147.500	4.729
Node11	2	SWMM Meth		
Node11	3	SWMM Meth		
Node11	4	SWMM Meth		
Node11	5	SWMM Meth		
Node12	1	SWMM Meth	147.500	7.567
Node12	2	SWMM Meth		
Node12	3	SWMM Meth		
Node12	4	SWMM Meth		
Node12	5	SWMM Meth		
Node13	1	SWMM Meth	147.500	4.719
Node13	2	SWMM Meth		
Node13	3	SWMM Meth		

**Table 5.5.12: Result of Modelling for Post-Development for 100 ARI**

Name	Subcatchment	Total Rainfall mm	Hydrology Methods	Max Flow cms
Node1	1	171.125	SWMM Meth	10.788
Node1	2		SWMM Meth	
Node1	3		SWMM Meth	
Node1	4		SWMM Meth	
Node1	5		SWMM Meth	
Node2	1	171.125	SWMM Meth	7.381
Node2	2		SWMM Meth	
Node2	3		SWMM Meth	
Node2	4		SWMM Meth	
Node2	5		SWMM Meth	
Node3	1	171.125	SWMM Meth	11.603
Node3	2		SWMM Meth	
Node3	3		SWMM Meth	
Node3	4		SWMM Meth	
Node3	5		SWMM Meth	
Node4	1	171.125	SWMM Meth	8.713
Node4	2		SWMM Meth	
Node4	3		SWMM Meth	
Node4	4		SWMM Meth	
Node4	5		SWMM Meth	
Node5	1	171.125	SWMM Meth	15.777
Node5	2		SWMM Meth	
Node5	3		SWMM Meth	
Node5	4		SWMM Meth	
Node5	5		SWMM Meth	
Node6	1	171.125	SWMM Meth	7.809
Node6	2		SWMM Meth	
Node6	3		SWMM Meth	
Node6	4		SWMM Meth	
Node6	5		SWMM Meth	
Node7	1	171.125	SWMM Meth	31.250
Node7	2		SWMM Meth	
Node7	3		SWMM Meth	
Node7	4		SWMM Meth	
Node7	5		SWMM Meth	
Node8	1	171.125	SWMM Meth	12.481
Node8	2		SWMM Meth	
Node8	3		SWMM Meth	
Node8	4		SWMM Meth	
Node8	5		SWMM Meth	
Node9	1	171.125	SWMM Meth	35.727
Node9	2		SWMM Meth	
Node9	3		SWMM Meth	
Node9	4		SWMM Meth	
Node9	5		SWMM Meth	
Node10	1	171.125	SWMM Meth	9.945
Node10	2		SWMM Meth	
Node10	3		SWMM Meth	
Node10	4		SWMM Meth	
Node10	5		SWMM Meth	
Node11	1	171.125	SWMM Meth	5.673
Node11	2		SWMM Meth	
Node11	3		SWMM Meth	
Node11	4		SWMM Meth	
Node11	5		SWMM Meth	
Node12	1	171.125	SWMM Meth	8.727
Node12	2		SWMM Meth	
Node12	3		SWMM Meth	
Node12	4		SWMM Meth	
Node12	5		SWMM Meth	
Node13	1	171.125	SWMM Meth	5.429
Node13	2		SWMM Meth	
Node13	3		SWMM Meth	

The post-development peak flow (100 ARI) exceeds the pre-development peak flow (2 ARI) by 109.048 m<sup>3</sup>/sec (Table 5.5.13). Retention ponds are proposed to bring down the post-development flow to the proposed pre-development level. During the operational stage, dry retention ponds will be used to provide temporary storage for excess runoff during a storm event. The silt traps proposed during construction stage should be converted to dry retention ponds for the proposed stormwater management. Stormwater from the study area would flow into the dry retention pond, while the outflow from the pond will flow into the nearest stream or river.

**Table 5.5.13: Maximum Flow for Pre and Post Project Developments (m<sup>3</sup>/s)**

Catchment	Pre-Development	Post-Development
	2 ARI	100 ARI
Project site	62.255	171.303

The retention pond should be designed to accommodate a storm of 20-year ARI, while the spillway should be able to cater for a 100 year storm. The stormwater management should be designed to comply to the MSMA requirement where the post-development runoff should not be exceeding the pre-development runoff. In the operational stage, surface runoff could be controlled by construction of a proper drainage system and discharged into several small dry retention ponds that are converted from the proposed silt traps in the Erosion and Sediment Control Plan for every sub-catchments. These will then be discharged into the nearest stream or river.

## 5.6 IMPACT ON AQUATIC BIOLOGICAL RESOURCES

Impacts do not necessarily lead to environmental crises. It actually depends on how the development is to be carried out. In some cases, there are significant adverse impacts that cannot be avoided, even after all the feasible mitigation measures have been implemented. Other adverse impacts are reduced or avoided by the implementation of mitigation measures. In some cases the impact is adverse, but not significant, and generally do not require mitigation measures. Projects can also have beneficial impacts that improve environmental conditions around the project site.

The various activities associated with development and operation of the Project will invariably bring about environmental impacts on different aspects of the terrestrial and aquatic environments depending on their extent, intensity and timing. The impacts on the aquatic biological resources that may potentially occur are discussed below.

### 5.6.1 CONSTRUCTION STAGE

#### A. Loss of Riparian Habitat

Land use would be altered as a result of site-clearing and earthwork. This could affect the riparian habitat, particularly at those construction areas adjacent to the river (Sg. Kuantan and Sg. Lepar).

#### B. Soil Erosion

Uncontrolled soil erosion can cause landslide, increase in sedimentation of downstream water bodies as well as flooding. Where fish and other aquatic organisms are concerned, high suspended sediment concentrations within rivers can clog gills or cause gill abrasion, which may increase susceptibility to disease (Marks and Rutt, 1997). It can also clog spawning gravels, which reduces available habitat and affects fish reproduction by lowering dissolved oxygen levels (Theurer *et al.*, 1998). Sediment that smothers the riverbed can also affect the aquatic fauna especially the sessile organisms, hence reducing their abundance and diversity in the area (Donohue *et al.*, 2003; Alin *et al.*, 1999).

#### C. Deterioration of Water Quality

Road construction alters the hydrology of watersheds through changes in water quantity and quality, stream channel morphology and groundwater levels. Where a road crosses a river/ stream, engineers usually divert, channelise, or alter the river/ stream. Culverts and bridges alter flow patterns and can restrict fish passage. Channelisation removes natural diverse substrate materials, increases sediment loads leading to high suspended solids in waterway, creates a shifting bed load inimical to bottom-dwelling organisms, simplifies current patterns, lowers the river/ stream channel, reduces the stability of banks and exacerbates downstream flooding.

Increased sediment loads in river/ streams have been reported to reduce light penetration, thereby suppressing photosynthetic activity of phytoplankton, algae, and

macrophytes. This leads to fewer photosynthetic organisms available to serve as food sources for many invertebrates. As a result, overall invertebrate numbers also decline, leading to decreases in fish populations (Redding and Midlen, 1991).

In addition, surface runoff for road construction may contain sufficient petroleum drippage plus spillage materials (including toxic and hazardous materials), which can affect the aquatic ecology. An ecotoxicology study indicated that acute toxicity for zooplankton, *Daphnia magna* occurs after 4-days exposure of 9.8% cutback (i.e. diluted) bitumen with kerosene at levels above 100 mg/l (Herrington *et al.*, 2006).

#### **D. Noise and Vibration**

During the construction stage, heavy equipment such excavators, power shovels, dumpers, compacters, loaders, etc. are used. This will caused considerable vibration in nearby areas (river/ stream). They will also produce excessive noise levels. This will disturb the natural surroundings and creates unfavourable conditions for the aquatic organisms.

The degree to which an individual fish will be affected when exposed to sound is dependent on several factors such as species of fish, fish size, presence of a swimbladder, physical condition of the fish, peak sound pressure and frequency, shape of the sound wave (rise time), depth of the water around the pile, depth of the fish in the water column, amount of air in the water, bottom substrate composition and texture, effectiveness of bubble curtain sound/pressure attenuation technology and presence of predators (NOAA Fisheries, 2011).

Depending on these factors, effects on fish can range from changes in behaviour to immediate mortality. Short-term exposure to peak sound pressure levels above 190 dB(A) is sufficient to damage the auditory system in many fishes (Hastings, 2002). However, 155 dB(A) may be sufficient to shock small fish. Small fish are more prone to injury by intense sound than larger fish of the same species (Yelverton *et al.*, 1975).

### **5.6.2 POST-CONSTRUCTION STAGE**

#### **A. Stormwater Runoff**

Freshwater organisms below road stormwater outfalls are exposed to pulses of contaminants following rainfall events. They may be exposed to a first flush which containing significant organic and inorganic pollutants and other suspended matter (Gjessing *et al.*, 1984). This may be followed by lower level prolong exposure. For example, a study undertaken by Kennedy (2003) indicated that the concentrations of copper (3.2 – 9.7 mg/l) and zinc (33 – 170 mg/l) in urban and roadway stormwater exceeded the US EPA acute criteria (USEPA, 2002) and ANZECC water quality guidelines for freshwater (ANZECC, 2000).

Stormwater from roads also contains a wide range of organic compounds. Many contaminants are present as a result of their emission from a number of sources associated with motor vehicles such as tyre and brake-pad wears as well as exhaust

emission. Compounds present on road surfaces and in stormwater include volatile organic compounds (VOCs) and a wide range of semi-volatile organic compounds (SVOCs). However, VOCs are commonly present in stormwater at low concentrations. Their road transport source is principally the evaporation from fuel and loss through the exhaust system. The polycyclic aromatic hydrocarbons (PAHs) are the most well understood group of SVOCs and have been measured in stormwater (Moncrieff and Kennedy, 2002).

Both petrol and diesel fuel contain a very wide range of VOCs and SVOCs. A study undertaken by Yang *et al* (1998) indicated that diesel fuels contained 8.74 mg/l zinc, 1.93 mg/l lead, 17.5 mg/l nickel, 22.4 mg/l chromium, 4.22 mg/l copper and 0.30 mg/l cadmium. In addition, Mi *et al.* (2000), Yang *et al.* (1998) and Lee *et al.* (1995) reported PAHs compounds in petrol and diesel (Table 5.6.1). In this respect, the leakages of the heavy metals and PAHs to the adjacent river could potentially affect the aquatic organisms.

**Table 5.6.1: PAH Compounds in Petrol and Diesel**

Parameter	95 unleaded Petrol (mg/l)	Diesel (mg/l)		
	Lee <i>et al.</i> (1995)	Lee <i>et al.</i> (1995)	Yang <i>et al.</i> (1998)	Mi <i>et al.</i> (2000)
Naphthalene	1576 ± 110	776 ± 9.19	17.1	81.1
Acenaphthylene	70.0 ± 46.4	1564 ± 685	110	81.3
Acenaphthene	125 ± 54.9	1681 ± 371	207	53.6
Fluorene	15.5 ± 12.5	973 ± 80.8	296	36.3
Phenanthrene	3.83 ± 4.77	556 ± 65.5	52.2	11
Anthracene	8.63 ± 6.88	499 ± 102	26.4	10.3
Fluoranthene	3.59 ± 1.88	367 ± 199	3.8	5.47
Pyrene	1.58 ± 1.87	320 ± 308	0.816	0.83
Cyclopenta[c,d]pyrene	0.19 ± 0.05	60.8 ± 61.7	6.32	0.19
Benzo[a]anthracene	0.29 ± 0.25	197 ± 228	0.029	0.63
Chrysene	0.15 ± 0.03	188 ± 242	0.0287	0.43
Benzo[b]fluoranthene	0.13 ± 0.07	12.8 ± 17.4	0.0024	0.97
Benzo[k]fluoranthene	0.10 ± 0.12	115 ± 140	0.102	0.16
Benzo[e]pyrene	0.09 ± 0.01	17.0 ± 19.8	0.439	0.05
Benzo[a]pyrene	0.15 ± 0.10	3.14 ± 3.42	0.0126	1.78
Perylene	0.16 ± 0.04	5.05 ± 4.16	0.0076	0.04
Indeno[1,2,3,-cd]pyrene	1.65 ± 0.18	1.70 ± 0.49	0.0062	0.69
Dibenzo[a,h]anthracene	0.35 ± 0.12	1.97 ± 2.62	1.59	0.97
Benzo[b]chrycene	0.61 ± 0.01	1.80 ± 2.02	0.0053	0.09
Benzo[g,h,i]perylene	0.99 ± 0.13	1.82 ± 2.06	0.0053	0.4
Coronene	0.18 ± 0.24	0.61 ± 0.56	0.0059	0.02
<b>Total</b>	<b>1,809 ± 91.5</b>	<b>7,341 ± 1491</b>	<b>721</b>	<b>285</b>

## **5.7 IMPACT ON FOREST AND FLORA SPECIES**

### **5.7.1 PRE-CONSTRUCTION STAGE**

The pre-construction stage will involve site investigations and collection of environmental and geotechnical samples. No significant impact to the forest and flora species is anticipated.

### **5.7.2 CONSTRUCTION STAGE**

From the preliminary design, the road construction will affect a linear strip of 60 m width for a length of 35 km, more or less, of the forested area. All the plant species found within this strip will be cleared off and the site levelled to the desired road formation. Therefore, total loss of the plant species contained therein is anticipated.

The plant species within the orchards, *belukar* and oil palm estates are common landscape species which are not accorded with high conservation or scientific value. However, the forested area within the Reman Cereh and Berkelah Forest Reserves as a whole contains many species of plants with a high level of biodiversity. After preliminary analysis of the flora species, none of them are considered rare or otherwise endangered; thus making the existing flora community scientifically irrelevant. All of these plant species can readily be found in similar habitats elsewhere.

The concern is not on the forest area directly affected by the Project, but more towards the forest areas beyond the road corridor. The Forest Reserves traversed by the road are currently remote without established means of public access. With the road construction, it creates permanent access to the hinterland of these Forest Reserves, thereby increasing the opportunity for illegal harvesting of the forest produces.

### **5.7.3 POST-CONSTRUCTION STAGE**

During the post-construction stage, the road is completed and opens for public usage. The traffic volume is expected to be low to moderate and the usage of the road itself will not cause any impact to the forest or flora diversity. However, due to the accessibility, it provides easy access for hunters or poachers to enter the previously remote forest areas for hunting of wildlife or collection of forest produces.

## 5.8 IMPACT ON WILDLIFE

### 5.8.1 RAPID ASSESSMENT ON SECTIONS OF THE PROPOSED ROAD

A rapid assessment was conducted to assess the various potential impacts on wildlife along the three sections of the proposed road. The findings are presented in an assessment matrix (**Table 5.8.1**) which highlighted the stretch of road and the key impacts that are most important for wildlife and where mitigation measures are warranted.

The assessment differentiated the differences in the level of significance of the potential environmental impacts for the three stretches of road assessed. The most significant findings are:

- i. Section 1 has an access road and the impacts will not be new. In addition, the *Orang Asli* of Kg. Sungai Jin have decimated local wildlife populations. The impact on wildlife along this stretch is not significant and does not warrant further assessment.
- ii. Section 2 within the RCBFR is clearly the stretch of road that is most important and should be the main focus of detailed assessment and designing of mitigation measures for wildlife.
- iii. Section 3 is within the oil palm plantation which is a monoculture crop and has an extensive network of roads. The impact on wildlife within the plantation is not significant and also does not warrant further assessment.

Notwithstanding the assessment, it should be noted that even the hunting or a single road kill of an endangered species – immaterial of in which stretch it occurs, may be viewed as a significant loss among conservationists. Thus the best and most practicable mitigation measures should be applied throughout this Project.

From a conservative view point, all species that occur in the lowland dipterocarp forest have been either recorded in the past, during the current study or expected to be discovered within the RCBFR which is contiguous with the greater Taman Negara forest complex to the north. Thus for the road design, no species should be excluded and the design should cater for a diverse range of species.

The riparian habitat supports a rich diversity of wildlife particularly large mammals like ungulates and has been recognised as a natural conduit for regular wildlife movements. Taking note that a considerable stretch of the proposed road runs along the river banks of Sg. Kuantan and Sg. Lepar, it is imperative that adequate river and riparian reserve be provided for to allow local wildlife to continue using this habitat for movement whilst minimising the potential for crossing and collision.

**Table 5.8.1: Rapid assessment matrix of road section against potential impacts on wildlife**

No	Environmental Impact	Proposed Sungai Lembing – FLU4 Road			Key Issue Score
		Section 1: Orchard (Sungai Lembing)	Section 2: Forest (Reman Cereh & Berkelah FRs)	Section 3: Oil Palm Plantation (FLU4)	
1	Loss of habitat	This orchard provides foraging ground for wildlife species at the edge of the forest. About 12 ha will be affected and the loss of habitat in this common Malaysian rural landscape is acceptable.	About 156 ha of forest within the ROW will be lost. However, from a macro perspective this habitat loss is not critical within the Berkelah and Reman Cereh FRs.	About 42 ha will be affected. The forest habitat has earlier been cleared and converted to oil palm plantations.	3
	<i>Impact Rating</i>	1	2	0	
2	Forest fragmentation	The habitat is already fragmented.	The core area of contiguous forest within the CFS will be segregated.	Not applicable.	4
	<i>Impact Rating</i>	1	3	0	
3	Barrier to wildlife & road kills	A road already exists and the impacts have already been occurring. Increase in traffic will increase road kills.	This is a new stretch of road transecting a contiguous forest rich in wildlife. This will introduce a barrier to wildlife movement & a new cause of mortality on wildlife.	The road already exists within the plantation and impacts are already occurring for species that enter from the forest. Increase in traffic will increase road kills.	5
	<i>Impact Rating</i>	1	3	1	
4	Hunting for game	No change in hunting pressure is expected as the area is already readily accessible.	A large tract of relatively inaccessible forest area will be made readily accessible to hunting parties from Kuantan, Maran, Jerantut and other towns.	Not applicable as hunting is prohibited within FLU.	4
	<i>Impact Rating</i>	1	3	0	
5	Risk of poaching	No change in existing situation.	Similar to hunting, the road will provide easy access for poachers to access game in a large tract of forest.	Not applicable within the plantation.	4
	<i>Impact Rating</i>	1	3	0	
6	Subsistence hunting	The wildlife in the vicinity of Sungai Lembing have already been decimated by the Semaq Beri and Jakun <i>Orang Asli</i> at Kg. Sungai Jin.	The accessibility will allow the local <i>Orang Asli</i> to venture further into the forest and exert pressure on wildlife populations.	Not applicable at the plantation	2
	<i>Impact Rating</i>	0	2	0	

**Table 5.8.1: Rapid assessment matrix of road section against potential impacts on wildlife (Cont.)**

No	Environmental Impact	Proposed Sungai Lembang – FLU4 Road			Key Issue Score
		Section 1: Orchard (Sungai Lembang)	Section 2: Forest (Reman Cereh & Berkelah FRs)	Section 3: Oil Palm Plantation (FLU4)	
7	Increase human – wildlife conflict	Conflict with elephant is already occurring annually.	The road itself does not create conflict. However, if the road paves the way for opening of forest land along the road then it will lead to conflict. This is beyond the scope of this EIA.	Conflict with tiger and elephant are already reported in the past due to land clearing for oil palm plantation establishment. Impact of road is not significant.	2
	<i>Impact Rating</i>	0	2	0	
	<b>Key Road Section Score</b>	5	18	1	
	<b>Significance</b>	Stretch of road where impacts are already occurring and will likely to be more frequent. Assessed as <b>not significant</b> .	Most important stretch where wildlife will be subjected to various impacts. Impacts potentially <b>very significant</b> .	Stretch of road where impact on wildlife is <b>not significant</b> .	

Note: Environmental Impact and level of significance rating as follows:

Impact/ Significance	Impact Rating	Significance Rating	
		Rating	Key Issue Score
High	3	15-21	7-9
Moderate	2	8-14	4-6
Low	1	1-7	1-3
Not Applicable	0	0	0

## 5.8.2 IMPACT ASSESSMENTS

### A. HABITAT LOSS AND FRAGMENTATION

Wildlife habitat along the road alignment corridor will be permanently lost together with the wildlife that it supports. For the 26 km of road through the forest, the maximum total area of forest that will be lost if the entire 60 m ROW is cleared is 156 ha. Although this represents a permanent loss of forest within the RCBFR, when comparing the size of the forest that needs to be cleared against the total area of forest within the RCBFR, the loss is not considered significant. It is inevitable and a linear strip of habitat will be permanently lost if this Project proceeds.

Poorly planned roads dissect forests areas and cause fragmentation of contiguous forests. Wildlife habitat loss and fragmentation are exacerbated by other development activities that often follow new road constructions. This is a common occurrence when new roads are constructed in undeveloped areas. The control of change of land use in the future is beyond the control of the Project Proponent. However, as the RCBFR are within the Central Forest Spine (CFS), it is likely that conservation policies will be enforced to prevent continual habitat loss and fragmentation of the forest.

It is evident that the proposed road alignment lies within the core area of the Central Forest Spine (CFS) that includes the Berkelah Forest Reserve and Reman Cereh Forest Reserve. Although the alignment is not within the critical primary or secondary linkage areas, it is within the core CFS area of the secondary linkage CFS2-SL1 Hutan Simpan Lepar – Hutan Simpan Berkelah which is a High Conservation Value Habitat (HCVH) (**Figure 5.8.1**). The objective of the CFS secondary linkage CFS2-SL1 is to maintain connectivity between the Taman Negara forest complex with the Tasik Chini – Bera forest complex. The proposed road alignment clearly cuts right across the core area of CFS2-SL1.

It is imperative for the success of the CFS master plan that the proposed road does not become a barrier to wildlife movement and severe or hinder the free movement of wildlife between the Greater Taman Negara forest complex and the Task Chini – Bera forest complex. Designing and incorporating effective wildlife crossings is a key issue that is of utmost importance for the Project and the Project Proponent must strictly adhere to the requirements and guidelines set out in the CFS master plan.

### B. ROADS AS A BARRIER TO WILDLIFE

Poorly designed roads can form a barrier to free and safe movement of various species of wildlife. Examples include:

- Road that have a wide section of forest cleared will become a barrier for arboreal species (like gibbons) or shy forest species that may not readily cross the gaps created by roads.
- Steep and large cuts in hilly terrain often make the slopes impassable to wildlife and act as a barrier to free movement.
- Steep and high embankments may also be a barrier to small species like tortoises.

- Small size culverts may prevent or limit some species from utilising them.
- Fencing, guard rails, pipelines and road side furniture could hinder the movement of some species of wildlife.

Whilst some design features may render roads 'unfriendly' for wildlife movement, roads rarely form a barrier that totally prohibits wildlife from crossing. Wildlife species will find points along the roads where they can cross, albeit at the risk of being hit by passing vehicles and ending up as a road kill.

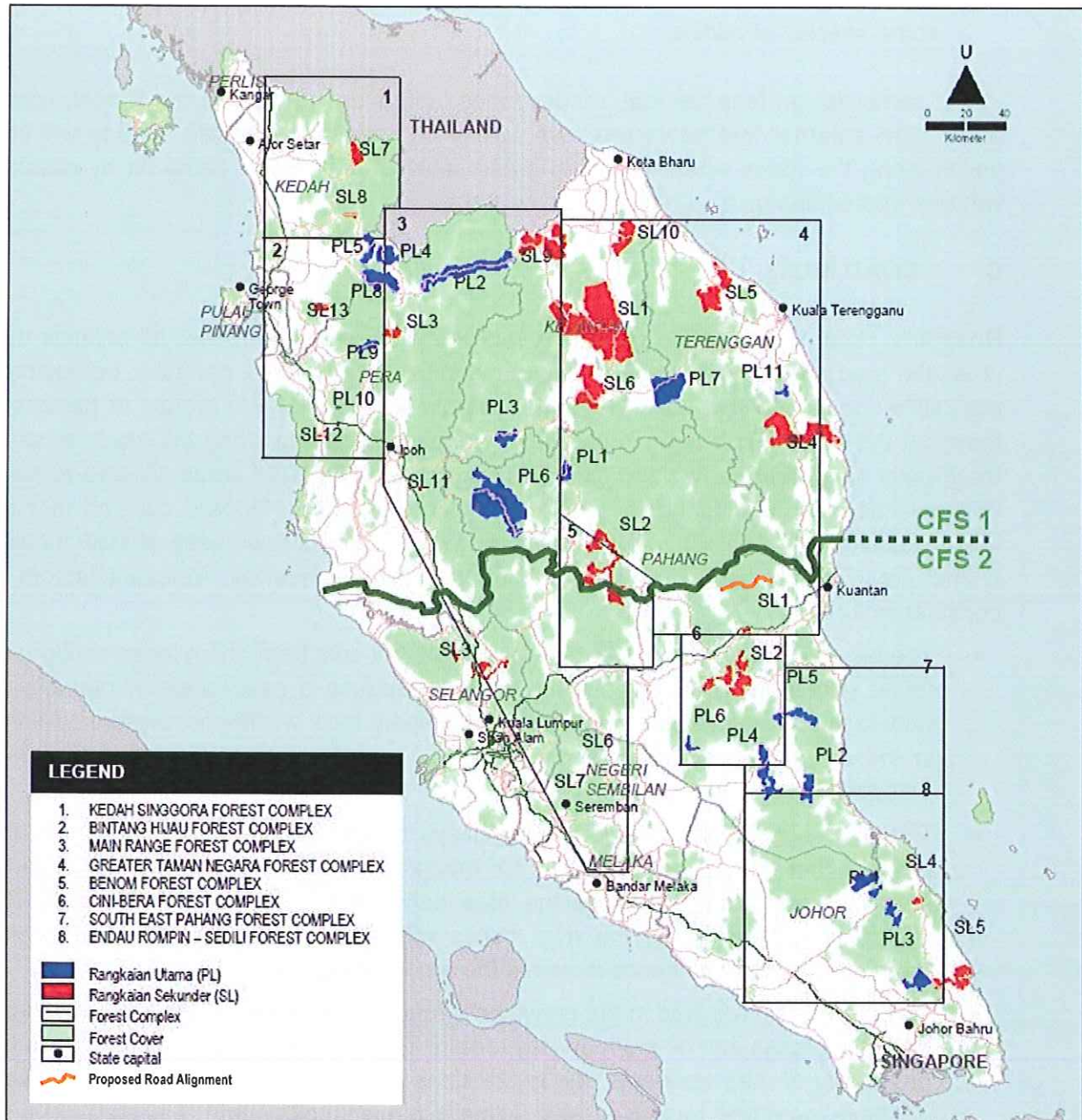
### C. ROAD KILLS

Road kills occur when wildlife get hit by vehicles when crossing roads. All animals that cross the road are at risk but slow moving and small (e.g. tortoise, pangolin, porcupines, etc.) slithering or crawling animals as well as animals that move in groups or herds are the most vulnerable. This is an impact that is already occurring along the roads close to the Project site, particularly along stretches that traverse forested areas. Wildlife species observed as road kills during the site visit include wild boar, leopard cat and monitor lizard. According to PERHILITAN Pahang, there were also a few cases of slow moving animal, i.e. Tapir getting killed along the East Coast Expressway. Relevant factors to consider include:

- The alignment at section 2 will be a new road that cuts through an intact contiguous forest (albeit being logged over). This will introduce a new cause of mortality to wildlife in this isolated area and inevitably impact local wildlife populations. Wildlife in the area have not been exposed to nor learnt how to avoid being hit when crossing roads.
- The road alignment runs along the valleys of Sg. Kuantan and Sg. Lepar and crosses these rivers as well as their tributaries which are the habitats of large mammals that also criss-cross the area between the river and the forests. The alignment running along the river banks will increase the probability of wildlife crossing the road and hence increase the probability of road kills.
- The hilly terrain resulted in the preliminary road design speed to be low, i.e. 70km/h on flat stretches and 40 km/h on hilly terrain. This is advantageous as it reduces the probability of road accidents due to collisions with wildlife. Both wildlife and drivers will have more time to take evasive action to prevent collisions.
- The new road is aligned right through the core area of the CFS that is contiguous with Taman Negara to the north. This forest habitat is very rich in wildlife and thus poses a risk of causing road kills. The confirmed presence of internationally threatened and locally protected species makes any loss from road kill more significant.

As the road traverses a forest that is rich in wildlife biodiversity, it is important that the detailed design include mitigation measures for safe crossings that cater to large mammals as well as small slithering species. These measures should be provided throughout the length of the road to facilitate usage by local wildlife species and populations.

Figure 5.8.1: Central Forest Spine - Primary and Secondary Linkage



Source: JPBD (2010a)

## D. ACCESSIBILITY FOR HUNTING AND POACHING

This new road will provide easy access to remote and previously inaccessible areas within the heart of the RCBFR. This will make wildlife populations within these remote forested areas accessible to hunters and possibly poachers. The new road will undoubtedly cause an increase in hunting pressure. It should be noted that the forests within the vicinity of the proposed alignment are already criss-crossed by a network of logging roads and the area is most easily accessed via four-wheeled drive (4WD) vehicles especially at the stretches of forests near to Sungai Lembing and FLU. According to a logging truck driver at the Berkelah FR, the existing logging roads can be used for travel from FLU to Jengka and onwards to Sungai Lembing. Old bridges of previous logging concessions had been dismantled to limit accessibility to the forest but 4WD vehicles could cross shallow stretches of river. Some hunting and trapping were already evident in the study area and were recorded during the site survey.

### a. Hunting within FLU4

Hunting is prohibited in the FLU estates and signboards prohibiting hunting within the plantations are clearly displayed at entry points to the estates. According to the locals, hunting was not carried out at the FLU4 area by the local settlers which are predominantly Malay. However, an empty cartridge was found at the boundary of the plantation at FLU4 and the forest. According to the locals, armed *Ikatan Relawan Rakyat Malaysia* or Volunteers of Malaysian People (RELA) members assist in patrolling the estate boundary and may occasionally fire shots to drive away animals.

### b. Hunting Activity in the Sungai Lembing Area

Hunting was being carried out at the forest fringes in Sungai Lembing. Hunting of Wild Pig was reportedly being carried out in the forests and oil palm estates surrounding Sungai Lembing. A local hunter reportedly acted as a guide for groups of hunters from Kuantan who frequented the area via the main access point from Sungai Lembing. The hunting parties entered the forests using 4WD vehicles via the extensive networks of abandoned logging roads in the area. Dogs were not used during hunting.

### c. Subsistence Hunting by the Semoq Beri of Kg. Sungai Jin

There were approximately 400 Semoq Beri *Orang Asli* in Kg. Sungai Jin and subsistence hunting was carried out occasionally or opportunistically. There were also Jakun in the same village but they have converted to Islam and would not be hunting wild boar, lizards and snakes or amphibians. The orchards and forests surrounding Sungai Lembing have been subjected to continuous subsistence hunting and it was evident that wildlife in this area have been decimated. Interviews with the *Orang Asli* revealed the following:

- As commonly practiced by the *Orang Asli*, most wildlife species were hunted and consumed including wild boars, mouse deers, porcupines, scaly ant eaters, civets, squirrels, monkeys, Argus pheasants, wild fowls, hornbills, monitor lizards, snakes, etc. As such, wildlife in the area have become depleted and are difficult to find. Hunting methods described included traditional blowpipes, setting traps, hitting with

parang or sticks. None of the villagers have guns and they are aware that hunting for consumption is legal but selling bush meat is illegal.

- The *Orang Asli* children commonly go into the forests with catapults or slingshots and bring back anything they can hit. These are usually birds or small animals.
- The absence of or very scarce wildlife recorded in the nearby area provided evidence that the local wildlife in the vicinity of Sungai Lembing have been severely decimated due to hunting by the *Orang Asli*.
- Some of the *Orang Asli* rear dogs but the dogs were not used for hunting.
- There are gibbons and monkeys being kept as pets including the Long-tailed Macaque and Pig-tailed Macaque.

Increased accessibility afforded by the new road with result in the impact caused by subsistence hunting to expand to a wider area and into the heart of the RCBFR. This could prove to be a potentially significant adverse impact to wildlife within the forest reserves.

#### **d. Trapping Birds**

There were local villagers who poached White Rumped Shama (*Copsychus malabaricus*) in the accessible sections of the forests using mist nets. One poacher was observed retrieving his catch during the site survey. A bird of this species is sold for RM 50 per bird and other species that were caught that did not have a ready market were released. Based on the information from the poacher, this activity did not appear to be widespread.

#### **e. Poaching**

Poaching still occasionally occurs in the forests adjacent to and also recently within Taman Negara. Poaching activity can vary from an individual who hunts occasionally either without a license; or who shoot a protected species that he comes across on a hunting trip; to syndicates that hunt and trap wildlife in organised and systematic groups. Increased accessibility will expose wildlife to greater hunting pressure and possibly poaching. The latter type of poachers clearly poses a greater risk to wildlife within the RCBFR when the road is completed. The new road will increase the risk of poaching in the remote area where prized, rare and engendered species may be targeted.

#### **f. Hunting by Construction Workers**

During the construction phase, construction workers may hunt, kill, trap or capture Totally Protected or Protected wildlife for consumption, for sale or to be kept as pets which run counters to the current wildlife conservation efforts as well as JKR policies. This impact has occurred on other construction projects adjacent to forested areas and could potentially occur. Proper education and control measures need to be implemented to prevent this from occurring.

## E. INCREASE IN HUMAN – WILDLIFE CONFLICT

Human-wildlife conflict is caused by wildlife competing with humans for habitat which results in crop damage; or taking or consumption or loss of livestock; or wildlife causing nuisance to villages or settlements. Human – wildlife conflicts that have already been occurring within the study area are as follows:

- Human–Elephant conflicts were occurring where the Cereh Herd regularly raided crops along Sg. Kuantan. On the other end of the road, the Lepar Herd intruded into FLU5 as well as FLU10 and damaged young palms.
- Human–Tiger conflict was apparently rare in the area. There was only one recent case of a tiger taking a cow calf at FLU1. There were no reports of Tiger-human conflict at the Sungai Lembing area including from the nearby deer farm (DWNP, 2013). There were no incidents of Tiger taking any of the goats or cows roaming within FLU4.
- Human–Monkey conflict: Pig-tailed Macaque were damaging young palms and causing nuisance at FLU4.

Construction and operation of the new road is not anticipated to have a significant impact on the existing human – wildlife conflicts. However if the improved accessibility results in more people stopping along the riparian forests to fish and picnic, human-wildlife contacts will likely increase.

## 5.9 IMPACT ON SOCIO-ECONOMY

The impacts of the Project are based on the findings of the survey and field visits. The following discussions elaborate the potential socio-economic impacts.

### 5.9.1 DISPLACEMENT OF RESIDENTS

The proposed road is not expected to result in displacement of any resident within the Felda settlement. Based on the proposed alignment, no relocation of any permanent structure is required. Similarly, no permanent structure within the Sungai Lembing section will be affected.

### 5.9.2 DISPLACEMENT OF BUSINESSES

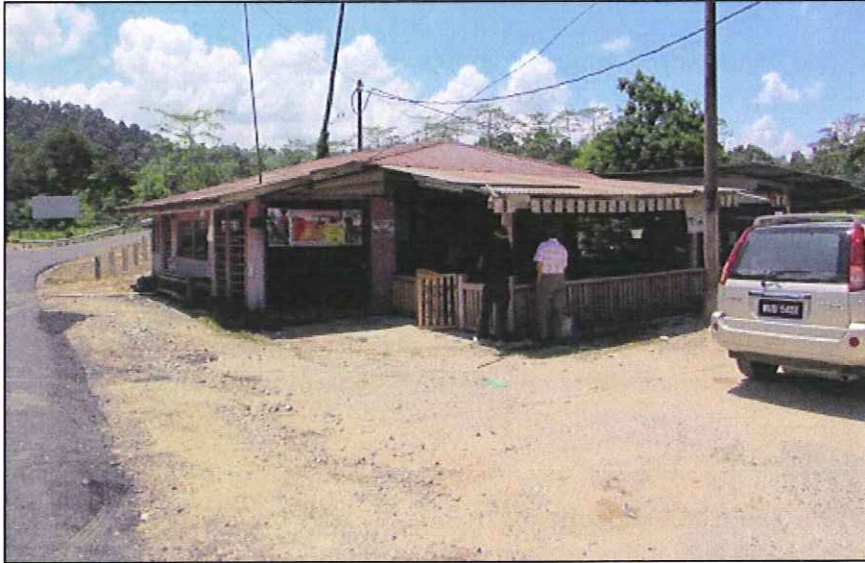
Similar to the impact on residents, the proposed road will not displace any of the existing businesses. All business activities at Felda Lepar Utara are located within the settlement area. Other businesses are located elsewhere, which is quite a distance from the Lepar Utara 2 and 4 settlements (i.e. outside the 5 km radius of the proposed road).

The only business establishment located near the proposed road end is the Felda Lepar Utara palm oil mill, Kilang Sawit Lepar Utara 4 (**Plate 5.9.1**). However, the proposed road is not expected to run through the palm oil mill area or somewhere near.



**Plate 5.9.1:** Kilang Sawit Lepar Utara 4.

At Sungai Lembing, the only existing business structure with probable direct impact from the proposed road is the food stall/restaurant located by the road near the steel bridge crossing the Sg. Kenau river to the Sg. Jin *Orang Asli* village (**Plate 5.9.2**). As such, this study proposes that the road should start some distance away from this stall/ restaurant; preferably 100 m away to avoid the anticipated inconvenience to the locals. In this case, this stall/ restaurant will be spared.



**Plate 5.9.2:** Stall/restaurant near the steel bridge to the Sg. Jin village.

### 5.9.3 DISPLACEMENT OF COMMUNITY FACILITIES

No community facility is located along the proposed road corridor. Thus the Project will not result in any displacement of community facility. The nearest facility is a mosque located on the opposite road from the stall/ restaurant at the steel bridge in Sungai Lembing.

### 5.9.4 IMPACT ON RESIDENTS

The proposed road has no direct impact on the residents at both ends since the Project does not involve any relocation or resettlement. However, 12 Felda settlers may be affected as the new road will cut across some portion of their assigned lands. Currently, the palms are still young and not in production since the land has just been replanted a few years ago (**Plate 5.9.3**).



**Plate 5.9.3:** New oil palm tree.

At Sungai Lembing, five landowners may be affected as the road will traverse their farmlands. The *Orang Asli* are also of concern since the road will affect their so-called "source of livelihood" (foraging areas) when part of the forest is cleared.

**a. Felda Lepar Utara**

**i. Shorter travel distance to Kuantan**

The findings of the study indicate some of the settlers travel frequently to Kuantan. The proposed road will shorten their travel distance and travel time to Kuantan.

**ii. More traffic**

Traffic using the current road between the palm oil mill and the junction to Jerantut/ Maran is expected to increase with the proposed road.

**iii. Better road condition**

The settlers and palm oil mill workers expect that the current road leading to their settlements (i.e. Lepar Utara 2 and 4) will be improved once the proposed road is ready. The palm oil mill workers who use the road regularly will have better travelling experience compared to the existing road condition.

**iv. Psychological Impact**

No negative psychological impact is expected since the Project will not interfere or disrupt the human environment of the community; no land/ physical acquisition that require relocation or resettlement. The only probable impact, if any, is on the 12 settlers whose land (small portion) is affected (probably need to be acquired to make way for the road).

**b. Sungai Lembing**

The propose road is not expected to have significant impact on the residents within the Sungai Lembing villages and town. In the short and medium term, traffic volume for using this road as an alternative to Jerantut or from Jerantut is not expected to swell.

**i. Shorter travel distance to Jerantut**

Likewise, the findings of the study indicate the proposed road will shorten the distance and thus travel time to Jerantut. However, the study has no indication of locals in Sungai Lembing as frequent travellers to Jerantut. Nevertheless, the road will benefit the locals and also others from Kuantan or further north (i.e. Kuala Terengganu) to Jerantut. From this end of the road, the impact is not significant in the short and medium term.

**ii. More traffic**

Since the road leads to shorter travelling distance between Kuantan and Jerantut, more traffic is expected to run through the Kuantan - Sungai Lembing road. No serious negative impact is anticipated although increased traffic normally leads to increased traffic risk. However, increase traffic also leads to opportunities; in this case road side

business (food and services). However, no direct impact on locals is expected since most of the settlements are not located along the Lepar Utara - Sungai Lembing - Kuantan route.

**iii. Better road condition**

The current Kuantan - Sungai Lembing road requires improvement. The Project provides an indication for this road to experience some roadwork and improvement. This will improve traveling experience along the road.

**iv. Orang Asli "Source of Livelihood"**

Although the road has no direct impact on the *Orang Asli* settlement, it however will somewhat affect the area where the *Orang Asli* claim as their foraging area (*kawasan rayau*), i.e. where they use to seek forest resources for some of their income and food.

However, there is no certainty to the level of significance this may be, since the actual foraging area is huge. Probably mobile animals will go deeper into the jungle and this may result in further journey by the *Orang Asli* to hunt for their food.

Another fear among the *Orang Asli* is that the road may disrupt the forest environment and affect wild animals. There is a possibility of wild animals attacking their farm for food once the road is built as the animal may have problems traversing around due to road traffic.

**v. Psychological Impact**

No negative psychological impact is also expected within this social environment since the Project will not interfere or disrupt the human environment of the community; no land/ physical acquisition that require relocation or resettlement.

**5.9.5 IMPACT ON BUSINESS/ SERVICES**

The road is not expected to have any significant impact on existing business activities and services. Business activities within Lepar Utara 2 and 4 service the daily needs of the locals (**Plate 5.9.4**). For other higher order goods, their next option is Pusat Bandar Jengka. Others may opt for Jerantut or Maran. Some residents indicate periodic travel to Kuantan. In normal circumstance, traffic using the proposed road is not expected to divert to this settlement. Only if traffic volume is high, some of the locals may establish retail businesses or food stalls along the main road to Jerantut/ Maran (probably at the entry point to the settlement).



**Plate 5.9.4:** Sundry shop in Felda Lepar Utara 2.

### 5.9.6 IMPACT ON COMMUNITY SERVICES

#### a. Felda Lepar Utara

Among the community facilities are primary school, religious school (**Plate 5.9.5**), mosque, clinic, community hall and playground. The Project has no impact on these facilities as none is affected for relocation. The expected increase in traffic that passes along the main road is not expected to use these facilities.

The mosque in Lepar Utara is located some 1 km from the main road. Normally, this will not attract travellers to stop for their prayers. The only possibility is traffic diverting to Felda Lepar Utara 2 and 4 settlements on Friday for afternoon prayer. However, the probability is low and the number is also low to have any impact on the crowd for Friday prayer.

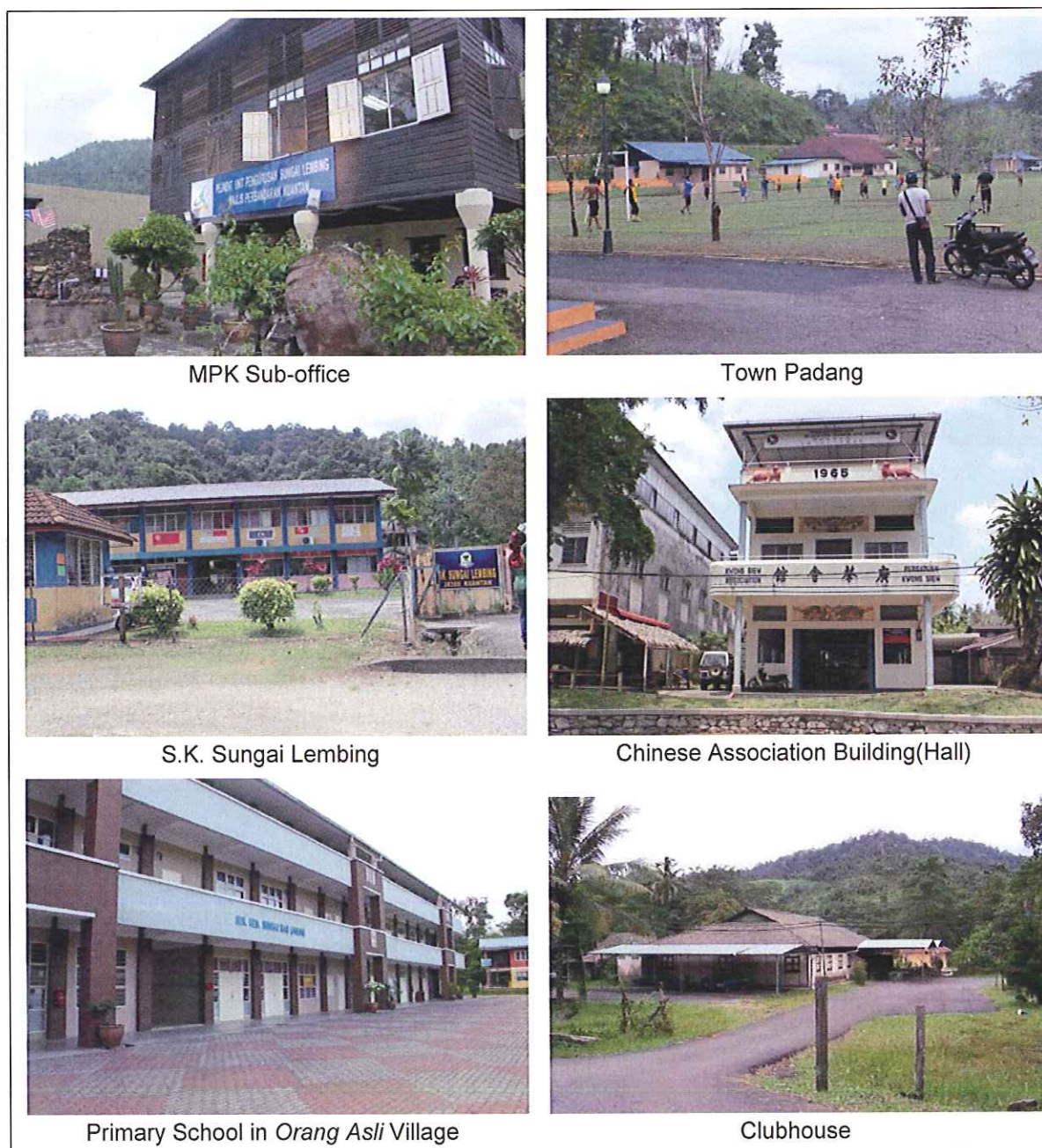
Since the Project will not lead to displacement of any community facilities, it is thus anticipated that the Project will not leave any significant impact on community services.



**Plate 5.9.5:** Sekolah Agama Felda Lepar 4.

## b. Sungai Lembing

There are more community facilities in Sungai Lembing; including mosque, surau, Chinese temples, community halls, playing field, museum, clinic, Bomba, police station, mukim central offices (i.e. *Kompleks Penghulu*), public library, kindergarten, primary schools, secondary school, club house and recreational area (**Plate 5.9.6**).



**Plate 5.9.6:** Community facilities in Sungai Lembing

These facilities are located mainly within Sungai Lembing town which is more than 2 km from the Project starting point. In normal circumstance, travellers will not seek for such facilities or divert to the Sungai Lembing town unless there is a need to do so. Thus, no significant impact is expected from the anticipated traffic due to the proposed road as no interruption or change in demand for community services is anticipated.

The community mosque is located outside the Sungai Lembing town, about one kilometre from the proposed road starting point. Likewise at Felda Lepar, most travellers are not expected to divert 1 km from their route to stop at the mosque. Some may though as a stopover for prayer and rest. Other community facilities are located in the Sungai Lembing town, some 2 km away.

#### **5.9.7 IMPACT ON COMMUNITY**

The proposed road is not expected to bear any significant impact on the community living in settlements in the vicinity of the proposed road. No disruption on community environment within the Felda Lepar Utara settlements is anticipated. Current community shall remain and no significant impact is expected as a result of more traffic along the main road.

Similarly, no disruption on the community environment within Sungai Lembing's various communities is anticipated. The current community shall remain and no significant impact is expected as a result of more traffic along the main road. Even the *Orang Asli* community environment shall remain uninterrupted.

#### **5.9.8 IMPACT ON SOCIO-CULTURAL ACTIVITIES**

No significant impact on socio-cultural activity is anticipated. The study area is not known for any special event related to socio-cultural activities. The proposed road is also not expected to have any negative impact on current socio-cultural activities of the adjacent communities.

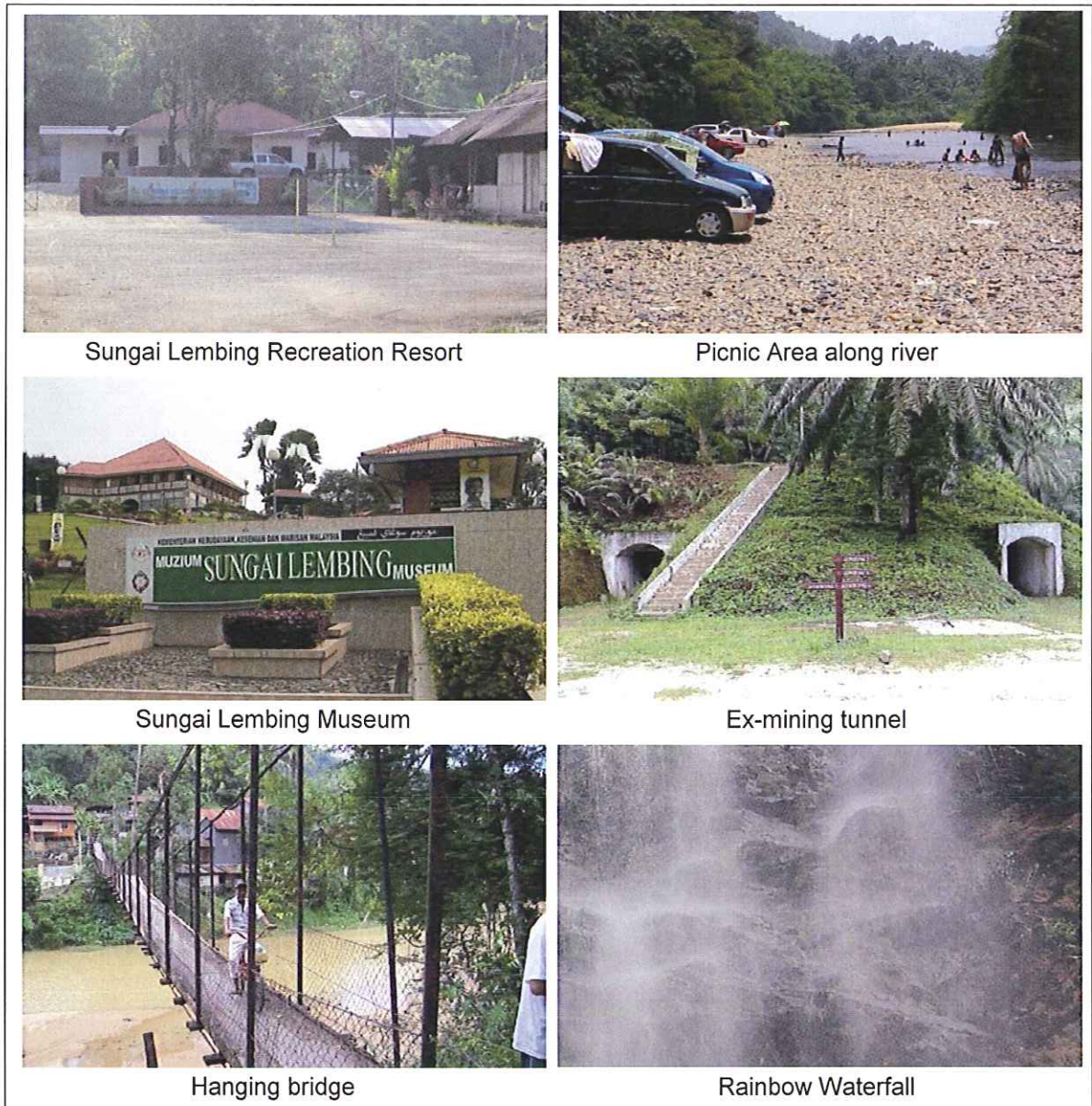
Sungai Lembing is known for its harmonious socio-cultural environment where the Malays and Chinese appreciate each other community's social culture. The proposed road is not expected to change this harmonious environment.

#### **5.9.9 IMPACT ON TOURISM**

Tourism for Felda Lepar Utara is out of the question. There is nothing that attracts tourist to this area now and nothing will in the future. This area has no tourism resources. Thus, the proposed road will have no impact on tourism within this area.

The followings are said to be tourist attractions in Sungai Lembing: Sungai Lembing Town Club House, Old Cinema, Mining Museum, Old Mine Shaft, Tok Tangkok Tunnel, Paddock Creek, Bukit Panorama Hill, Pesona Resort, Mount Tapis/ Rainbow Waterfall, Hot Springs, Sungai Jin River, Deer Farm and Sungai Mas *Orang Asli* Settlement (Plate 5.9.7).

There is a home-stay programme in Sungai Lembing. From a business point of view, this programme is not an outstanding venture. The venue is located some 2 km from the proposed road. Thus, travellers are not expected to notice the existence of the programme. Moreover, such a programme is more effective through direct promotion and advertisement.



**Plate 5.9.7:** Recreational and tourist attractions in Sungai Lembang.

Our assessment is; most of the tourist sites/ attractions show that they are not popular since it does not receive much attention. Moreover, we do not find any promotional items of these sites either on the internet or by tourist agencies. Even if traffic along the proposed road may pick-up later, we do not anticipate significant change in tourism at these sites.

However from a recreational point of view, the waterfall and hot springs do receive frequent nature tourists and picnickers. Nevertheless, the study does not anticipate significant change in demand for such attractions due to the proposed road.

The study views Sungai Lembang museum, the mining shaft and the tunnel as a good attractions. However, our finding indicates that this museum, and the mining shaft and tunnels are not attracting tourists. The homestay operator conducts scheduled visits to these sites but not many of his clients are interested.

This study thus concludes that the proposed road is not expected to have a significant impact on tourism in Sungai Lembing.

#### **5.9.10 CONCLUSION**

This study concludes that the proposed road has no direct impact that will significantly change the human environment of the study area. The impact probability on the *Orang Asli* due to the road cutting across their so-called foraging area (*kawasan rayau*) is small and not significant.