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BIOMASS REMOVAL PLAN

for Baleh Hydroelectric Project

Final Report
Rev 2.0

Prepared by:

CHEMSAIN

June 2022

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EXECUTIVE SUMMARY

PHONE

WEBSITE

Executive Summary

1 Biomass Removal Plan Main Recommendations

No.	Description	Recommendation
1.	**Phase 1: Salvage Logging**	The document "*Salvage Logging Guideline Specifically for Areas that will be Inundated by the Baleh HEP Project (Revised)*" by the Forest Department Sarawak shall be strictly adhered to when carrying out Phase I.
2.	**Phase 2: Biomass Removal**	**Areas/ Volume to be Cleared** The plan recommends the clearing from the dam to the confluence of Sg. Mengiong, with a 100 m buffer along Btg. Baleh. The nett area to be cleared is around 9,478 ha. The estimated volume of biomass to be cleared excluded salvage logging, is about 2,188,028 m^3, with a remaining biomass of 20,587,239 m^3 of biomass left for inundation.
3.	**Phase 2: Recommended Non-burning Disposal Method**	In terms of simplicity and cost effectiveness, **wood chipping** is the recommended non-burning method for the biomass removal works.
4.	**Phase 2: Recommended Burning Disposal Method**	**Controlled burning of biomass** is the recommended disposal method. As a reiteration, controlled burning on-site is the most common method used for biomass removal internationally, due to its low cost and logistic simplicity. Controlled burning, however, requires prior permission from the NREB under The Natural Resources and Environment Ordinance (NREO), 1993 – Section 30(1)(a), & Section 30(2).

2 Introductory Information

2.1 Baleh Hydroelectric Project (HEP)

The Baleh HEP is located on the Baleh River at about 105 km from Kapit Town in Kapit Division, and about 3 km upstream of the confluence of the Baleh and Putai Rivers.

The 188 m high Concrete Faced Rockfilled Dam (CFRD) is projected to generate 8,076 GWh of electricity per year on average of which 941 MW is firm energy. The total installed energy capacity of Baleh Hydroelectric Project's (HEP) power station is projected to be 1,285 MW.

The main dam civil construction works, electrical and mechanical works are expected to continue until Q2 of Year 2027. Unit 1 commercial operation is scheduled in Q3 of Year 2026.

The Baleh HEP reservoir is scheduled to start impoundment in Q1 of Year 2025 and will take about 21 months to reach the minimum operating level (MOL) 205 m asl, scheduled in Q4 of Year 2026. The reservoir will take about another 1.5 years to reach the full supply level (FSL) 220 m asl.

2.1.1 Biomass Removal Plan

Biomass removal is one of the measures to minimise deterioration of water and atmospheric quality due to greenhouse gases released from the submerged biomass in the reservoir. Based on the Natural Resources and Environment Board SEIA's approval condition, under Approval Condition Clause 2.4 (h), "*A detailed Biomass Removal (BRP) must be prepared and to manage reservoir clearing operations*".

2.1.2 Objective of Study

- Establish a plan detailing the scope, methodologies, locations, and guidelines for the clearing of such biomass,
- To provide detailed guidelines for the biomass removal contractors and/or forest concessionaires performing the salvage logging.

Additionally, this study covers the social aspects of the clearing. It must be ensured that all social, traditional, and cultural impediments are respectfully addressed.

2.1.3 Biomass Removal Plan Phases

The removal of biomass from the reservoir is divided into two (2) separate phases, i.e., Phase 1, Salvage Logging and Phase 2, final Biomass Removal.

Salvage Logging (Phase 1)

Baleh Hydroelectric Project (HEP) overlaps with commercial timber concessions, who have the legal right to extract commercial timber before or during the clearing process. This extraction is referred to as Salvage Logging.

Biomass Removal (Phase 2)

Phase 2 of biomass removal, normally after salvage logging has been completed, concerns the complete removal of the remaining biomass within certain areas of the reservoir, regardless of whether the biomass is of commercial or non-commercial value.

2.2 Project Proponent and Study Team

Project Proponent	Study Team
SEB Power Sdn. Bhd. is the Project Proponent for the Baleh HEP as well as the biomass removal scope of work. The contact details for the Proponent are: **SEB Power Sdn. Bhd.** Level 6, Menara Sarawak Energy, No. 1, The Isthmus, 93050 Kuching, Sarawak. **Contact Person: Ir. Tan Hang Kiak (General Manager, Baleh HEP)**	In compliance with the environmental laws and NREB's requirement, the Project Proponent has appointed Chemsain Konsultant Sdn. Bhd. (CKSB) **Chemsain Konsultant Sdn. Bhd.** 172, Rock Road, 93200 Kuching, Sarawak. Tel.: 082 – 548 366 Fax: 082 – 548 388 / 399 Email: consult@chemsain.com **Contact Person: Ir. Brian S.H. Chong (Director)**

3 Legislative Requirements and Legal Framework

3.1 Legislative Requirements & Legal Frameworks

Below is a list of state environmental legislation which requires the BRP to be approved by NREB. The Specific Approval Conditions under the SEIA's requirements are:

Clause 2.4 Ecological Impact – *Item (h)*

Clause 3.2 Impact on Navigation and Accessibility item *(d)*

Clause 3.4 Greenhouse Gases

Clause 3.6 Soil Erosion and Sedimentation of the Reservoir – Item *(a)*

Clause 3.7 Water Quality – *item (c)*

3.1.1 Legal and Institutional Framework

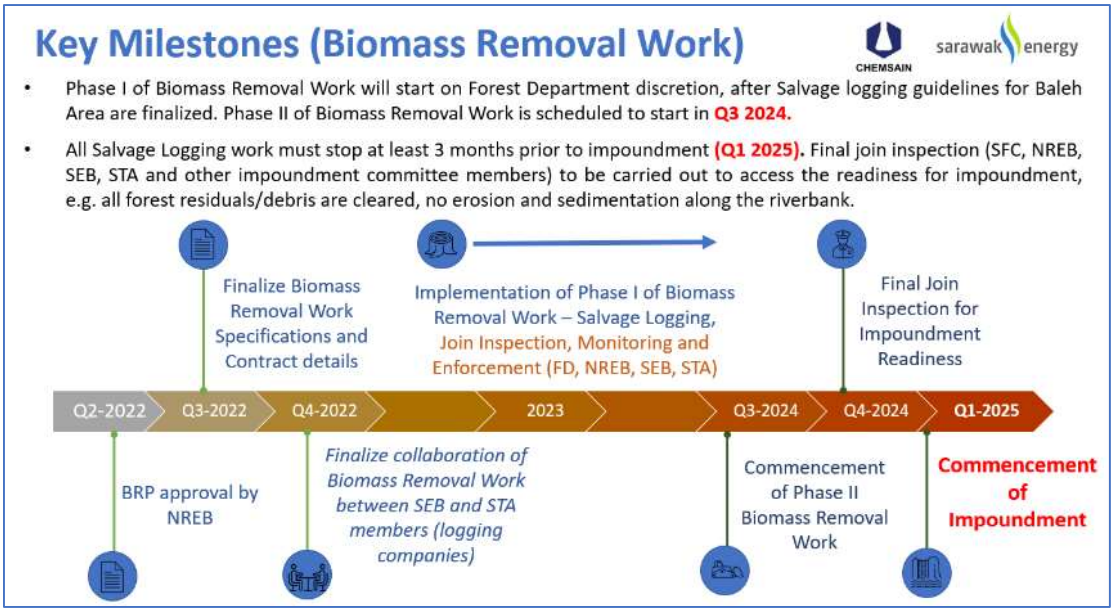
- The Biomass Removal Plan is a requirement under the SEIA approval conditions for the overall Baleh HEP EIA and falls thus under the auspices of the Natural Resources and Environment Board and the *Natural Resources and Environment Ordinance*.
- The area to be cleared is currently under the Forest Department Sarawak, who has licensed the areas to forest concessionaires who manage the areas on behalf of the Department.
- Requirements of environmental audit and the audit process shall be detailed out in the BRP in accordance with the requirements of the Natural Resources and Environment (Audit) Rules, 2008 and the Guidelines for Natural Resources and Environment (Audit) Rules, 2008.
- Removal of vegetation, including protected species or species of high conservation value is under the conditions of the *Wild Life Protection Ordinance (1998)* section 30 (2).

- The Wild Life Protection Ordinance (1998) also regulates dealing with wild animals as it forbids any activity that cause unnecessary suffering, pain or discomfort to any wild animal.

4 Biomass Removal Considerations

4.1 Timing

Major milestones for the components of the BRP are listed below along with their respective duration dates.

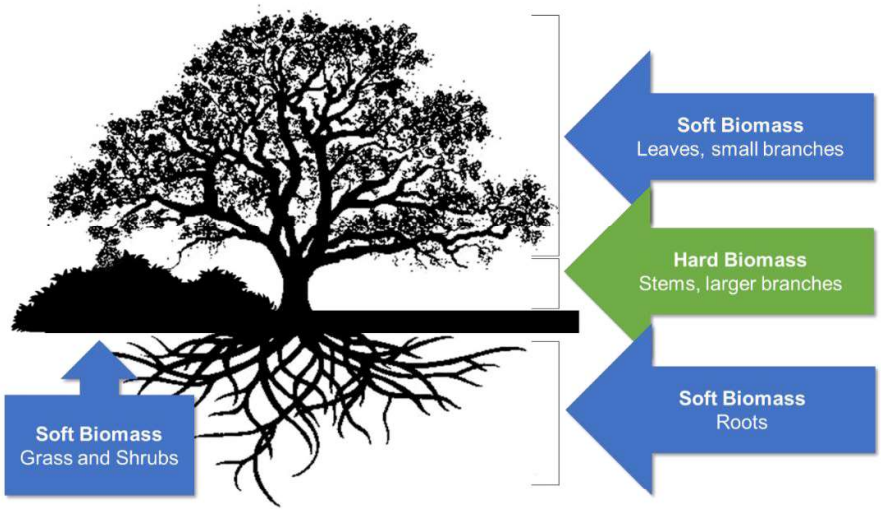


Regrowth

It is highly essential that the biomass removal works be completed no longer than six (6) months prior to impoundment. This is to prevent excess regrowth of flora within the Baleh HEP reservoir footprint and thus potentially contribute to an increase in biomass that will be inundated.

4.2 Biomass

Biomass is often distinguished as hard or soft biomass where hard biomass refers to stems and larger branches, whereas soft biomass refers to roots (below-ground biomass), twigs and smaller branches as well as herbivorous plants.



4.3 Soil Considerations

The following subsections cover the slope stability, skeletal soils (soil erodibility) and buffer zones.

Reservoir Slope Stability

Slope Class	Area (ha)	Percentage of Area (%)	Logging Method (Salvage Logging Guideline, 2021)
> 45°	286	0.5	Very steep: no logging permitted
35° to 45°	8,727	15.6	Steep: skyline/ cable system
< 35°	47,073	83.9	Normal logging with tractor and skid trails
Total	56,086	100.0	

Buffer Zones

The proposed width of river buffers during salvage logging was adopted from the Department of Irrigation and Drainage's river reserve guideline as shown below. The proposed buffer width is measured between the top edge of the riverbank at left and right side.

- River width between 5 m to 10 m: 10 meters buffer
- River width between 10 m to 20 m: 20 meters buffer
- River width larger than 20 m: 40 meters buffer
- Sg. Baleh, Sg. Mengiong, Sg. Melatai & Sg. Entulu: 50 meters buffer

4.4 Clearing Options

4.4.1 Salvage Logging

Salvage logging is considered as the Phase 1 of biomass removal work which involves partially removing vegetation/biomass in the reservoir area, for both active and dead storage zone. The activity is aimed to minimise economic waste of resources during the actual biomass clearing works.

4.4.2 Available Clearing Scenarios

From an environmental point of view, it is desirable to clear all vegetation immediately before inundation. This would minimise build-up and release of greenhouse gases and contribute to maintenance of the water quality in general.

The model framework for biomass removal is thus:

1. No removal of biomass at all;
2. Total removal of biomass;
3. Partial removal of biomass at a level where current water quality in the long run may be maintained.

4.4.3 Potential Area for Biomass Removal

4.4.3.1 Drawdown Zone

The drawdown zone is defined as the area at the edge of a body of water that is frequently exposed to the air due to changes in water level and is mainly the 205-220 m asl level as this is the levels where the HEP may be operational.. The area within this zone should be considered a priority for clearing for both navigational safety reasons and for water quality reasons.

4.4.3.2 Hypolimnion Zone

The hypolimnion zone or layer, is anything deeper than about 20 metres from the surface or at least <180 m asl due to the water level fluctuations.

4.5 Potential of Floating Debris

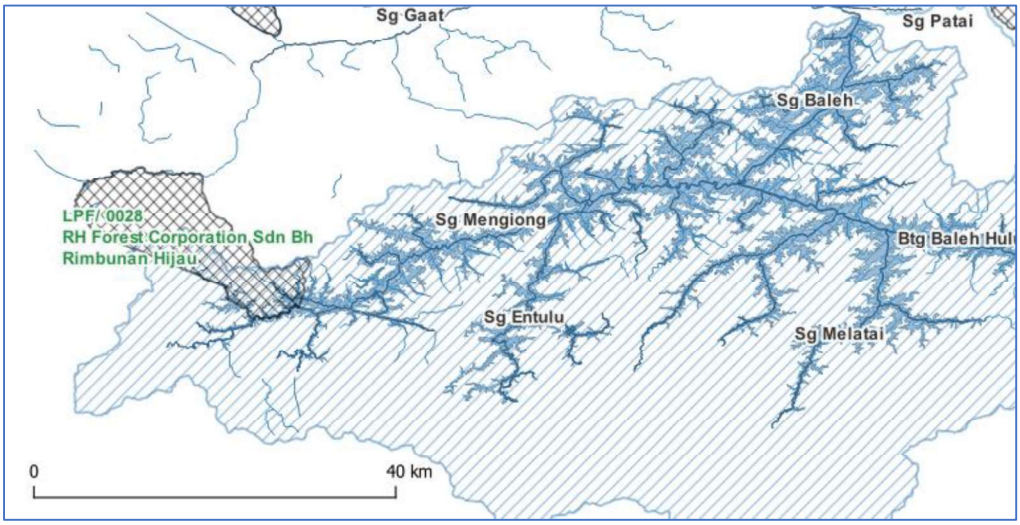
Any debris left by the biomass clearance activities will present a risk of floating debris. This may occur during any stages of the salvage logging or during the pre-inundation clearing.

4.6 Forest Harvest Activities

The entire catchment upstream of the dam is currently under forestry concessions, fourteen (13 timber licenses for natural forest management and one license for planted forest). Most areas have been harvested at least once but several places multiple times. There are indications on LiDAR and satellite imagery (Google Earth) that forest harvesting in some areas is quite intensive leaving large proportions of the ground openly exposed.

The main concern related to forestry operations will be

- land use conversion from natural forest to plantation forest;
- road construction; and
- harvest operations in general.



Planted Forest Concession

Summary of Chapter 4, Chapter5 and Chapter 6

4.0 Methodologies	5.0 Data and Information	6.0 Model Outputs and Analysis
Priority Stakeholder Engagement	**Legal Requirements** • EIA approval conditions – Overarching legal requirement. • Natural Resources and Environment (Audit) Rules, 2008 • Guidelines for Natural Resources and Environment (Audit) Rules, 2008. • Salvage Logging Guideline Specifically for Areas that will be Inundated by the Baleh HEP Project (Revised) • Forest Ordinance 2015 • The Sarawak Rivers Ordinance 1993 • Sarawak Forestry Corporation Ordinance 1995, Wild Life Protection Ordinance 1998	**Modelling not applicable**
	Conservation Areas and Water Catchments Legally Protected Areas *Heart of Borneo Initiative* The southern part of the reservoir is within the Heart of Borneo Initiative, which is a transboundary landscape conservation cooperation between Sarawak, Sabah, Indonesia and Brunei. *Baleh National Park* The Baleh National Park (approximately 70,000 ha) covers southern banks of the extreme eastern tip of the reservoir along Btg Baleh. The forest is a former timber concession. Riparian Reserves All rivers in the study area are administratively protected by riparian reserves in line with the standard Department of Irrigation and Drainage Malaysia requirements. Water Catchment Areas The entire Baleh catchment is part of the gazetted Kapit Water Catchment Area. With no settlement within the study area, there are no functioning gravity feed water systems except where they are established for timber camps. Cultural Heritage Some identified cultural heritage assets within the Baleh HEP water catchment and nearby areas may potentially be affected by biomass removal activities.	**Modelling not applicable**
	Flora and Fauna Flora The original primary vegetation of the entire area is lowland mixed dipterocarp forest. There are no significant areas of any other primary forest type. There are no wet areas near rivers or streams where riverine vegetation or freshwater swamps normally are found. The only exception to this is the single tree line of Dipterocarpus oblongifolius (Ensurai) that line particularly Btg Baleh Fauna The data use for this report is obtained from the 2013 Terrestrial Fauna report for Baleh HEP Dam SEIA. For the SEIA, sampling was conducted at a total of 54 stations, 27 in 2009 and 27 in 2012.	**Modelling not applicable**

4.0 Methodologies	5.0 Data and Information	6.0 Model Outputs and Analysis
Priority Stakeholder Engagement	**Demography and Social Aspects** Demography The main communities which are likely to be affected by the biomass removal activities are those found in Entawau-Merirai and Lg. Singut groups. The Entawau-Merirai groups are Iban dominated whereas the Singut groups are mainly Kenyah. Cultural or Traditional Aspects of the Clearing The focus is on the cultural heritage assets within the Baleh HEP water catchment and immediate to the Baleh HEP dam site which could be affected the biomass removal activities All twelve (12) identified and noted cultural assets are within areas involved in biomass removal activities, and currently as they are (*in situ*). Hence, necessary actions to be taken to protect the identified cultural assets, from activities which will cause their disturbance, destruction or desecration, until the actions planed in CHMP be carried out / implemented. Socio-economic Aspect of Clearing • The livelihood of the peoples residing in the communities within and in the vicinity of Baleh HEP depends largely on natural resources. • Farming activity is mostly subsistent hill rice farming which still practised by many households in Rantau Penora and Lg. Singut. Some of the farmed lands and fallowed areas (temuda) are found in the areas which could be directly affected by the biomass removal activities • Many households from both Entawau-Merirai and Lg. Singut communities involved in fishing and hunting as well as collections of other forest products. • Timbers are extracted for longboat and house construction. • Some members of the communities are also directly employed in logging operations in Baleh. • Land transport is preferable by locals for traveling in Baleh, be their own transport or hitch-hiking pickup trucks/lorries of logging companies. However, water transport remains an important mode of local transportation. • Only Entawau people served with treated water from JBALB.	**Modelling not applicable**
Geographic Information System (GIS)	**Study Boundary** Catchment Area: 5,550 km^2 Maximum Inundation Area: 592 km^2 (Excluding Islands) Outer Perimeter: 5,474 km	**Modelling not applicable**
	Topography • Baleh catchment is dominated by a series of northeast-southwest low mountain ranges with slopes mostly below 30°. • About 100 tributaries draining into to Btg. Baleh and Sg. Mengiong within the inundation area and having drainage areas larger than 1,000 ha. • The entire area surrounding the future reservoir is currently covered with a dense network of logging roads and tracks. • Thirteen (13) camp areas have been identified within the area to be inundated or so close that they cannot be deemed safe. • There is no other major infrastructure in the area.	**Modelling not applicable**

4.0 Methodologies	5.0 Data and Information	6.0 Model Outputs and Analysis
Geographic Information System (GIS)	**Land Cover and Biomass Estimation** Hard and Soft Biomass Derived hard and soft biomass values for each land cover type 153 t/ha and 22 t/ha respectively. Above Ground Biomass The average above ground biomass has been estimated to 227.8 ± 32.4 t/ha for logged over mixed dipterocarp forest in Sarawak. Below Ground Biomass Values of below-ground biomass for each land cover type were weighted by their relative proportions of the reservoir area to calculate a total below-ground biomass value of 16 t/ha Forest Areas • All primary forest is lowland dipterocarp forest, and no other distinct forest type has been detected. 39,594 ha have been classified as having higher stocking/closed canopy, while 12,076 ha have been classified as lower stocking due to an open canopy. • No large-scale establishment of industrial forest plantations have been detected within the area to be inundated from the available resources even though one concession is licensed to do so. • Salvage logging has at the time of writing been ongoing for some time and has produced 2,284,737 m^3 or 127.6 m^3/ha. Agricultural Areas Active agricultural areas have been minimal and have thus been excluded from the biomass estimation. Herbivorous Vegetation 232 ha have been classified as herbivorous vegetation, which primarily covers grass areas along roads and at old landings. These have been excluded from biomass estimations. Non-vegetated Areas The non-vegetated areas in the study zone consists of, water surfaces, camps, roads, and landings.	**Modelling not applicable**
	Land Use Forestry Concessions The inundation zone of the Baleh HEP is mainly predominated by forestry concessions. The concessions are separated by blocks and are distributed within and surrounding the area Logging Camps, Workshops and Major Bridges Prior to SEB's acquisition of the catchment for the Baleh HEP, the camps were previously operational and occupied. Occupancy and operation have since halted, and the camps are now largely abandoned. The structures, however, remain intact and is distributed sparsely within and surrounding the Baleh HEP area Settlements There are no known settlements within the area of inundation of the Baleh HEP. The closest settlement available to the Baleh HEP is Ng. Entawau, followed closely by Lg. Singut to the east. Agriculture There is currently no agricultural land use within the Baleh HEP area of inundation. Water Intake Points As there are no settlements within the Baleh HEP inundation zone, there are no water known water intakes within the area. The nearest water intake would be the Ng. Entawau water intake, under the management of JBALB. The intake, however, is slightly more than 10 km downstream of the Baleh HEP construction site.	**Modelling not applicable**

4.0 Methodologies	5.0 Data and Information	6.0 Model Outputs and Analysis
Modelling	**BioREM** **Spatial Options for Biomass Clearance** *CK01: Epilimnion Clearing* In this option total clearing is confined to the 180-220 m asl belt, which is slightly wider than the conventional draw-down zone. Areas lower than this may be subjected to salvage logging. The area for complete clearance is 47% of the total reservoir footprint. *CK02: Hypolimnion Clearing.* In this option, all areas below 180 m asl, or 52% of the reservoir footprint, shall be cleared totally while the epilimnion belt may be subjected to salvage logging. *CK03: Limited total clearing* In the limited total clearing the area between the dam and the confluence with Sg. Mengiong and the remaining main stems and major tributaries shall be totally cleared. The remaining areas may be subjected to salvage logging. In this scenario, 68% of the area shall be totally cleared. *CK01A: Mixed clearing* In this mixed clearing scenario, the area from the dam to the confluence with Sg. Mengiong shall be totally cleared. Along the main stems of Sg. Mengiong and Upper Btg. Baleh as well as along main tributaries, only the epilimnion belt shall be completely cleared. **Final Clearing Scenario** Based on the modelling results and including technical, administrative and economic considerations, scenario SEB01 has been defined. ***SEB01**: Dam Area with 100 m Buffer Clearing* For this option, the area between the dam and the confluence with Sg. Mengiong shall be totally cleared, leaving a 100 m buffer strip along both sides of Btg. Baleh. In this scenario, 16% of the reservoir area shall be totally cleared. The objectives of scenario SEB01 are to: • minimise the total volume/area to be cleared since the epilimnion water quality seems to be not proportional to the level of dissolved oxygen. • reduce the total volume/area to be cleared due to challenging terrain of the reservoir area. • minimise build-up of methane but still meeting the International Hydropower Association's (IHA) Hydropower Sustainability Guidelines for GHG emission, 100 g CO_2e/kWh. • maintain options for multiple use of the reservoir in areas near the dam. Clearing of the navigation routes were omitted in SEB01 as river transport to and from timber camps currently is rare and also considered undesirable from a HEP point of view and also due to security concerns as the area is near the international border to Indonesia. River transport to Lg. Singut is considered of dwindling importance since most transport to that community now follows logging roads. In addition, Public Work Department (JKR) will construct a new access road from Lg. Singut to Lg. Busang, through Mantan Camp. Scenario SEB01 also meets the IHA Guidelines for GHG emission (100 g CO_2e/kWh) at 83.1 g CO_2e/kWh. Thus, SEB01 scenario is the preferred clearing model as it satisfies the environmental requirements as well as technical and financial limitations.	**Biomass Removal Modelling Summary (BioRem)** BioRem modelling indicates that the filling and operation of the proposed Baleh reservoir is likely to result in poor reservoir water quality within the short-term. Hypolimnion water is predicted to become anoxic under all modelling scenarios due to the low turnover rate of the reservoir (412 – 1,383 days) and levels of residual biomass left within the reservoir footprint. Out of the eleven (11) scenarios run using BioRem, a total of four (4) scenarios seems to be the most optimum. These are BR1, CK03, BR3 and SEB01. • **Scenario BR1** (30% hard biomass removal, 0% soft biomass removal) represents the best scenario for water quality with approximately 90% oxygen saturation in the epilimnion five years after reservoir filling • **Scenario CK03** (68% hard and soft biomass removal) represents a good scenario for water quality and comparable (low) GHG emissions to BR2. It will, however present both technical and financial challenges. • **Scenario BR3** (30% hard biomass removal, 50% soft biomass removal) likely represents an optimal scenario for moderate biomass removal that results in good water quality outcomes and lower GHG production. • **Scenario SEB01** (10% hard biomass removal, 10% soft biomass removal) represents a good scenario for water quality as the epilimnion DO level is comparable to Scenario BR1. However, taking into account of both technical and financial challenges, the reduced biomass removal results in increased GHG emissions, lower than the baseline scenario and Scenario BR1. **Summary of Reservoir Limnology Assessment** The morphology of the Baleh reservoir shows good potential for mixing and water quality conditions in the long term, based on the size, volume, surface and contributing area of the proposed reservoir. However, in the short term, the following issues will require management to ensure that reservoir water quality is optimised: • Adoption of good forestry practices and roading stormwater controls to prevent sediments and nutrients entering the reservoir. • Removal of existing forest biomass within the reservoir footprint. • Management of hydropower discharges to retain maximum reservoir volume during the year. Summary of METABOLAK Model Results The proposed Baleh reservoir is likely to be a moderate to high nutrient reservoir system, with winter sunlight the likely limiting factor for algal productivity in the reservoir nutrient system, depending on Reservoir depth. This assessment supports that of the BioRem results, which predicts the reservoir is likely to experience *Mesotrophic conditions*: having moderate levels of biological activity and fair water quality, to *Eutrophic conditions*: having high levels of biological activity and poor water quality.

<table>
<tr><th>4.0 Methodologies</th><th>5.0 Data and Information</th><th>6.0 Model Outputs and Analysis</th></tr>
<tr><td rowspan="2">Modelling</td><td></td><td>It is recommended that upstream forestry and roading practices be undertaken using good practice forestry methods, and stormwater from roads is also managed using good practice for stormwater treatment and management, to help minimise nutrient loading on the reservoir over time. Elevated sedimentation levels from poor forestry and roading practices can reduce the operational life of the reservoir by reducing the available reservoir volume.

<u>Standing Biomass Volume to be Cleared</u>

<table>
<tr><th rowspan="2">Land Cover</th><th colspan="2">Area</th><th>Baseline AGB</th><th colspan="2">Salvage Logging</th><th>Residual AGB</th><th>Area Weighted Residual AGB</th></tr>
<tr><th>ha</th><th>%</th><th>m³/ha</th><th>Harvest m³/ha</th><th>Residual m³/ha</th><th>t/ha</th><th>t/ha</th></tr>
<tr><td>MDF High Volume</td><td>39,594</td><td>69</td><td>433</td><td>127.6</td><td>305.4</td><td>183</td><td>126</td></tr>
<tr><td>MDF Low Volume</td><td>12,076</td><td>21</td><td>325</td><td>127.6</td><td>197.4</td><td>118</td><td>25</td></tr>
<tr><td>Recently Logged</td><td>3,727</td><td>6</td><td>338</td><td>127.6</td><td>210.4</td><td>126</td><td>8</td></tr>
<tr><td>River</td><td>979</td><td>2</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Secondary Forest</td><td>733</td><td>1</td><td>70</td><td>0</td><td>70</td><td>42</td><td>1</td></tr>
<tr><td>Other*</td><td>506</td><td><1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Total</td><td>57,615</td><td>100</td><td></td><td></td><td></td><td></td><td>159</td></tr>
</table>
</td></tr>
<tr><td><u>Erosion Modelling and Sediment Yield</u>

<u>Universal Soil Loss Equation (USLE)</u>

Soil erosion assessment was conducted using Universal Soil Loss Equation (USLE). Sediment yield at the dam outlet can come from any part of the dam catchment area, hence the entire catchment of Baleh HEP of 5,625 km2 was used in the modelling.

The annual soil loss for BRP scenario was calculated and map was generated based on the input of R, K, LS, C, and P factors produced.</td><td><u>Erosion Modelling Output</u>

<u>BRP Scenario</u>

The BRP scenario simulated in this Study is based on Forest Management Mapping (2009) from Forest Department of Sarawak.

The derived soil erosion rate for the BRP scenario is 27 t/ha/yr and is considered ‘moderate’ soil erosion ranking. This soil erosion rate is equivalent to 15 million t/yr of soil loss for the proposed Baleh HEP catchment.

<u>Estimation of the Sediment Delivery Ration (SDR)</u>

SDR is defined as the fraction between sediment transport and gross erosion that is transported for a given time interval. Based on the comparison of SDR derived from the previous studies, SDR for Baleh HEP catchment was assumed to be 35% and was used for subsequent analysis.

<u>Sediment Yield Estimate</u>

For the sediment load estimation with SDR of 35%, the sediment load and sediment yield calculation for BRP is 5.3 million t/year and 9.45 t/ha/year respectively.</td></tr>
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<table>
<tr><th>4.0 Methodologies</th><th>5.0 Data and Information</th><th>6.0 Model Outputs and Analysis</th></tr>
<tr><td rowspan="2">Modelling</td><td><u>MIKE HYDRO RIVER</u>
Water quality analysis was carried out to assess the impact of biomass removal activities on the water quality of Btg. Baleh downstream of the Baleh HEP. The critical parameter due to biomass removal activities is the total suspended solids (TSS) before the impoundment of the dam.
The river water level, flow and velocity time series are the main outputs from the MIKE Hydro River model.

<u>MIKE Advection-Dispersion (AD)</u>
The TSS modelling was carried out using the MIKE-11 AD module, coupling with MIKE Hydro River Module. The MIKE11 AD module is based on the one-dimensional (1-D) equation of conservation of mass of dissolved and suspended material.
TSS pollutograph along the river is the main output from the MIKE AD model.</td><td><u>Water Hydraulics and Quality Modelling: MIKE11/MIKE AD</u>
The Advection Dispersion (AD) modules in MIKE11 was employed for the WQ modelling and TSS parameter was simulated. The modelling has adopted the 1-year daily flow series before the dam impoundment. Two scenarios have been conducted, assuming with and without the implementation of BMP.
Under 1-year daily flow series before the dam impoundment without the implementation of BMP, the maximum TSS concentration would exceed the threshold limit of Class V along Btg. Baleh during wet seasons while the minimum TSS concentration is within the Class III range during dry season. If BMP is in place to control the TSS concentration at 300 mg/L, the maximum TSS concentration along Btg. Baleh would drop to Class IV.</td></tr>
<tr><td>Hydrology</td><td><u>Flow</u>
<table><tr><th>Sub-catchment</th><th>Catchment Area (km^2)</th><th>Area Ratio</th><th>1990 Average Flow (m^3/s)</th></tr><tr><td>C1 (Dam Inflow)</td><td>5,625</td><td>1.00</td><td>604</td></tr><tr><td>C2 (Sg. Putai)</td><td>735</td><td>0.13</td><td>79</td></tr><tr><td>C3 (Entawau WTP)</td><td>39</td><td>0.01</td><td>4</td></tr><tr><td>C4 (Btg. Baleh, before Sg. Merirai confluence)</td><td>200</td><td>0.04</td><td>21</td></tr><tr><td>C5 (Sg. Merirai)</td><td>729</td><td>0.13</td><td>78</td></tr><tr><td>C6 (Btg. Baleh, before Sg. Gaat)</td><td>267</td><td>0.05</td><td>29</td></tr><tr><td>C7 (Sg. Gaat)</td><td>823</td><td>0.15</td><td>88</td></tr><tr><td>C8 (Upper Sg. Gaat)</td><td>829</td><td>0.15</td><td>89</td></tr><tr><td>C9 (Sg. Mujong and Sg. Melinau confluence)</td><td>1,261</td><td>0.22</td><td>135</td></tr><tr><td>C10 (Sg. Mujong)</td><td>789</td><td>0.14</td><td>85</td></tr><tr><td>C11 (Btg. Baleh)</td><td>272</td><td>0.05</td><td>29</td></tr><tr><td>C12 (Btg. Baleh)</td><td>83</td><td>0.01</td><td>9</td></tr><tr><td>C13 (Sg. Suit)</td><td>662</td><td>0.12</td><td>71</td></tr><tr><td>C14 (Btg. Baleh, up to confluence)</td><td>34</td><td>0.01</td><td>4</td></tr></table></td><td>Modelling not applicable</td></tr>
<tr><td></td><td><u>Water Yield</u>
With the release of 250 m^3/s during the impoundment, the effect on water yield to the Entawau WTP is insignificant</td><td>Modelling not applicable</td></tr>
</table>

<table>
<tr><th>4.0 Methodologies</th><th>5.0 Data and Information</th><th>6.0 Model Outputs and Analysis</th></tr>
<tr><td>Hydrology</td><td><u>Existing Water Quality</u>
<table>
<tr><th colspan="2">SEB Stations</th><th>TSS (mg/L)</th></tr>
<tr><td rowspan="3">1434SEB001
Baleh Damsite</td><td>Max</td><td>756</td></tr>
<tr><td>Avg.</td><td>326</td></tr>
<tr><td>Min</td><td>248</td></tr>
<tr><td rowspan="3">1434SEB002
Putai</td><td>Max</td><td>510</td></tr>
<tr><td>Avg.</td><td>116</td></tr>
<tr><td>Min</td><td>11</td></tr>
<tr><td rowspan="3">1433SEB001
Mengiong</td><td>Max</td><td>774</td></tr>
<tr><td>Avg.</td><td>348</td></tr>
<tr><td>Min</td><td>91</td></tr>
<tr><td rowspan="3">1341SEB001
Long Singut</td><td>Max</td><td>560</td></tr>
<tr><td>Avg.</td><td>201</td></tr>
<tr><td>Min</td><td>65</td></tr>
</table></td><td>Modelling not applicable</td></tr>
</table>

7 Biomass Removal Plan

7.1 Phase I: Salvage Logging

As conversion to a hydroelectric reservoir carries some environmental considerations, a specific set of guidelines has been issued by the Forest Department Sarawak: "*Salvage Logging Guideline Specifically for Areas that will be Inundated by the Baleh HEP Project (Revised)*".

The Guideline includes specific procedures for the removal of all logging residues, off-cuts, and remnants from the felling site in order to reduce the risk of these materials floating down to the dam site as a result of heavy rain and flooding.

7.2 Phase II: Clearance of Non-Commercial Biomass

The removal of biomass by SEB and it's contractors is the final phase of the Biomass Removal Plan before the commencement of inundation.

7.2.1 Prevention of Floating Debris

If clearing and removal works are performed satisfactorily to a tee, there should not be any remnant biomass of significant size within the area of inundation. However, to further prevent the prevalence of floating debris, the installation of log booms shall be done at the downstream end of the catchments for major river systems within each coupe as a safeguard.

7.3 Ecological Management

7.3.1 Wildlife Management

The topic of wildlife rescue and general management is governed by the Law of Sarawak Chapter 26: Wild Life Protection Ordinance 1998.

A wildlife rescue plan is required for animals that encounter difficulties in relocating to a safe area, especially during the clearing and inundation phases of the Baleh HEP. The following factors should be within consideration in the plan:

1. Formation and Training of Wildlife Rescue Team
2. Identification of Release Sites
3. Timing of Rescue
4. Animal Capture, Handling, Data Collection and Release
5. Post-release Monitoring

7.3.1 Flora Management

Relevant government agencies such as the Forest Department Sarawak, the Sarawak Forest Corporation, and the Biodiversity Centre must be given an opportunity to collect specimens for *ex-situ* gene pool conservation in accordance with the WiMOR programme.

7.4 Monitoring Recommendations

7.4.1 Objective of Monitoring

The monitoring programme, which may be subcontracted to third parties, shall focus on:

1. Contractor compliance; and
2. Residual impact monitoring, i.e., effectiveness of the prescribed protective or remedial measures.

The monitoring shall be bi-weekly, by physical site visit, aerial survey, drones, satellites or other remote sensing techniques or a combination of these monitor compliance regarding spatial extent of clearing as well as chosen technologies and methodologies including establishment of and maintenance of log-booms. The findings from the bi-weekly monitoring activity shall be summarised in the quarterly reporting.

Where failures are detected, SEB will immediately cause remedial actions to be taken. Similarly, where prescribed measures have proven ineffective, SEB shall impose improved methodologies on the contractors.

The focus of monitoring will move with the progress of work while maintaining observations in completed areas.

7.4.2 Compliance Monitoring

The compliance monitoring shall focus on:

- Whether areas set aside for clearance have been cleared.
- Whether areas >45° have been totally excluded from all activities.
- Whether areas of slopes >35° have been excluded from clearing.
- Whether areas of slope 35°–45° have been excluded from ground-based harvesting methods during salvage logging.
- Whether debris has been sufficiently removed/burned.
- Whether there is any floating debris that needs removal from the rivers.

Compliance monitoring shall be a constantly ongoing activity during the salvage logging and subsequent clearing phases.

7.4.3 Environmental Monitoring and Audits

Monitoring programme to be carried during the biomass removal will be carried out at all stages to ensure the environment quality is maintained.

The programme for monitoring will identify:

- The type of monitoring required (e.g., water quality measurement, slope stability);
- The locations of monitoring stations (e.g., water quality) or monitoring areas (e.g., compliance, floating debris);
- The parameters to be maintained (e.g., dissolved oxygen, turbidity in rivers); and
- The frequency of monitoring.

7.4.4 Real Time Water Quality Monitoring

Water quality shall be monitored regularly, at least during the first 5 years after initial inundation.

Permanent monitoring stations are recommended to be established at the following locations:

1. One kilometre downstream of the confluence between Btg. Baleh and Sg Putai
2. At the upstream side of the dam
3. 100 m downstream of the confluence between Btg. Baleh and tributaries having catchment areas exceeding 9,000 ha. The sampling shall take place midstream of the reservoir.
4. 100 m downstream of the confluence between Sg. Mengiong and tributaries having catchment areas exceeding 9,000 ha. The sampling shall take place midstream of the reservoir.

Stations 1 and 2 shall be monitored daily while stations 3 and 4 shall be monitored bi-weekly

7.4.5 Salvage Logging Monitoring

This guideline includes provisions (Section 7 of the guideline) for monitoring of management and effectiveness of the log-and-debris booms.

That monitoring will be carried out by the Forest Department Sarawak after the cutting block has been closed and until the inundation has reached full supply level.

SEB's aerial/remote sensing bi-weekly monitoring shall also cover areas under active salvage logging. It will include monitoring of slope limitation, method limitations and debris accumulation. The findings from the bi-weekly monitoring activity shall be summarised in the quarterly reporting.

Since the active logging areas will be moving, focus for monitoring will also move. Monitoring of the closed areas will be synchronised with the monitoring by the Forest Department Sarawak.

7.4.6 Reporting

A brief note containing monitoring results and assessment of the results shall be submitted to the dam management immediately after the results are provided.

Results from all monitoring shall be summarised in quarterly reports. SEB, which without delay shall make these reports available to the Sarawak Rural Water Supply Department, NREB, district office and Ministry of Utility and Telecommunication (MUT).

8 Environmental Management

8.1 Environmental Impact and Mitigation Measures

Several environmental impacts due to the biomass removal works were assessed, identified and duly listed within this section of the Biomass Removal Plan. The listed measures enable SEB and the authorities to monitor the biomass removal performance in addressing environmental issues. The identified impacts and their objectives are summarised and coupled with their reference in the following table:

Summary of Environmental Impacts

Identified Impact	Description	Mitigation Measure Reference in BRP
Sedimentation and Erosion Impacts	As the biomass removal activities involve large scale felling of timbers as well the clearing of vegetation at hilly elevations, this will usually result in increased soil erosion and sedimentation occurrence into receiving waterways, such as the Btg. Baleh. Thusly, the primary identified impact would be sedimentation and erosion impacts. Although these impacts are unavoidable due to the nature of the biomass removal and the subsequent inundation of the Baleh HEP, measures may be taken to mitigate such impacts.	• Contractors performing Salvage Logging activities shall strictly adhere to all items included in the Salvage Logging Guidelines issued by the Forest Department Sarawak. This includes adhering to guidelines concerning construction/maintenance of roads, trails and landings. • To re-use and maintain existing logging roads, as much as possible. This also includes re-using all road accessories including all river/stream crossings and side drains between slopes and the roads. • No heavy machinery shall be allowed within any buffer zones and no logs shall be skidded across any stream. • Salvage logging activities be performed while maintain the buffer specifications in the Salvage Logging Guidelines. • Carry out bi-annual monitoring of water quality throughout the Project duration according to the criteria of the Internal Environmental Compliance Audit.

Identified Impact	Description	Mitigation Measure Reference in BRP
Water Quality Impacts	Other than the above sedimentation and erosion impacts, water pollution may arise from various other sources during the biomass removal works. To name a few: • Oil and grease from leakage, spills, cleaning, and sloughing • Domestic wastes and sewage from temporary quarters or camps • Floating debris generated from cutting and felling activities.	• In case of oil leakage, stop the leakage immediately by removing the machinery from the site or to carry out on-site emergency repair. • Carry out the close supervision of refuelling (trucks, machinery, portable tanks) in a designated area. • No raw or untreated sewage discharge into existing water body is allowed. • Keep the waterways clean from any kind of earth spoils or waste. • Carry out bi-annual monitoring of water quality throughout the Project duration according to the criteria of the Internal Environmental Compliance Audit
Green House Gas (GHG) and Air Quality Impacts	Residual biomass generated from the removal works will release significant amounts of GHG and other noxious gases such as carbon dioxide (CO_2), hydrogen sulphide (H_2S), methane (CH_4) etc. Coupled with emissions from machineries and equipment, excess emissions contribute greatly to global climate change and potential serious health impacts.	• The Proponent and Contractor should adhere to all application requirements of the Environmental Quality (Control of Emission from Diesel Engines) Regulations, 1996. • Vehicles and associated equipment should be properly maintained through regular servicing to reduce the emission of pollutants. • Controlled burning should be performed in contrast to general open burning to minimise harmful emissions. • If controlled burning is opted, SEB or relevant contractors must comply with the terms and conditions set by the NREB • Any complaints from the nearby communities or workers on air quality should be immediately investigated and necessary action should be taken.
Health and Safety Impacts	Accidents can have several human effects, including death, permanent disability, temporary disability, minor injuries and / or psychological disturbances. Lack of safety gear or equipment, awareness and experiences could contribute to the hazard-risk at the site of operations as well as to the general public.	• Prepare and establish a health and safety plan for the general operation of the Baleh HEP area. • Incorporate safety procedures and regulation into contract agreement with contractors and subcontractors. • Set up an Occupational, Safety and Health committee to plan, implement, enforce and evaluate all safety and health promotion programme. • Follows the rules and regulations under the Laws of Malaysia, Factories and Machinery Act 1967 (Act 139) and Occupational Safety and Health Act 1994 (Act 514).

Identified Impact	Description	Mitigation Measure Reference in BRP
		• Provide workers with suitable personal protective equipment (PPE) such as gloves, hard hats, safety boots, earmuffs, safety harness, face masks or respirators, etc.
Ecological Impacts	As the biomass removal activity covers a wide area, various wildlife and their respective habitats are bound to be affected. Proper wildlife management should be considered to allow the wildlife in the affected area to have the best possible chance at survival in their relocation Aquatic life is impacted by biomass removal works as the eventual erosion and natural decomposition of vegetation will cause sedimentation and eutrophication.	• Biomass removal works shall only be performed within the boundaries and buffers set within the biomass removal plan. • Workers shall be prohibited and prevented from hunting, trapping and killing protected and totally protected animals, as per the requirement of the Wild Life Protection Ordinance 1998. • Vehicles exiting the working areas should be inspected randomly for the illegal possession of wildlife. The authorities (SFC and FDS) shall also be informed if such possessions have been found. • Minimise stream disturbance in areas that not intended to be inundated as these will serve as gene pools for macro invertebrates. • Fishing activities within the Baleh HEP area shall be prohibited to all workers, and all staff of SEB and contractors.
Socioeconomical Impacts	The biomass removal activities may adversely affect the livelihoods of the local communities, both directly and indirectly alike. Through destruction or disturbance of cultural heritage, forest/ aquatic resources, and navigation. Additionally, disturbance of the soil surfaces may bring about diseases and burnings may cause wildfires. Fortunately, the biomass removal works may also bring about opportunities and benefits. These are mostly via employment and business opportunities.	• Recruitment policy should prioritise local residents who are interested to work in biomass removal works whenever applicable, especially in the semi- and low-skilled job categories. • Local communities should be allowed to utilise/collect less valuable timbers/ biomass and other useful forest products within areas to undergo biomass removal activities. • Notify local communities of the lesser value timbers and other residual biomass they can use/collect/utilise. • Workers should be educated of customs and way of life of the local communities. These customary ways of life must be respected and upheld. • Any complaints from residents or members of public shall be immediately investigated and necessary action should be taken

8.2 Floating Debris Management

The issue of floating debris is primarily an issue for the dam operator and only to a minimal degree an issue for the communities downstream of the dam.

During the period, where the dam is under construction, it is in SEB's best interest to maintain log booms, steel mesh filters or similar measures at the diversion tunnel entries to prevent blockage. These measures shall be seen as an extra precaution in addition to preventive measures set up by the clearing contractors.

When inundation starts, the diversion tunnels will be blocked and soon the former tunnel entries will be deep under water. No floating debris can during inundation pass through the tunnels or otherwise pass the dam.

During operation, SEB will maintain measures to prevent logs from entering the ungated spillway.

The bi-weekly monitoring activities shall cover throughout the reservoir area to monitor the occurrence of floating debris. SEB shall thereafter ensure, that the designated contractors for clearing or salvage logging can immediately remove the debris before it creates any risk or damage. The findings from the bi-weekly monitoring activity shall be summarised in the quarterly reporting.

Quarterly joint monitoring by SEB, FDS, NREB and SRB shall be implemented to ensure compliances with all relevant requirements.