REPORT ON THE ASSESSMENT OF WATER QUALITY IN DERAMAKOT FOREST RESERVE 2016

by

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INTRODUCTION

Environmental baseline sampling was carried out to characterize the water quality of 5 rivers in Deramakot FR, namely Sg. Rawog, Sg. Mannan, Sg. Tangkulap Kecil, Sg. Balat and Sg. Deramakot as of 13th April 2016 (Table 1).

LOCATION OF STUDY AREA

A total of 5 sampling points represent the project watershed and its sub-catchment areas which predominantly drain through the project site. These sampling points are labelled W1 to W5 (Figure 1). All the headwaters of these rivers derived from within Deramakot itself, except for part of Rawog River derived from adjacent oil palm estate in the north. The chemical analyses and water quality classes for all parameters tested for the sampling points in the project area are listed in Table 2.

Table 1 The geographical location and site description of water quality sampling in Deramakot SFM Project Area.

Sample Point No.	Location	Surrounding Condition	Prevailing Weather conditions (24 hours)	Date of Sampling	GPS Location	
					North	East
W1	Rawog River	Secondary forest	Clear weather during sampling period.	18th April 2016	05°26.223’	117°25.559’
W2	Mannan River (Basecamp)	Secondary forest		13th April 2016	05°21.955’	117°26.239’
W3	Tangkulap Kecil River	Secondary forest		18th April 2016	05°19.445’	117°22.113’
W4	Balat River	Secondary forest		13th April 2016	05°19.556’	117°35.351’
W5	Deramakot River	Secondary forest		13th April 2016	05°17’05.16”	117°32’35.47”

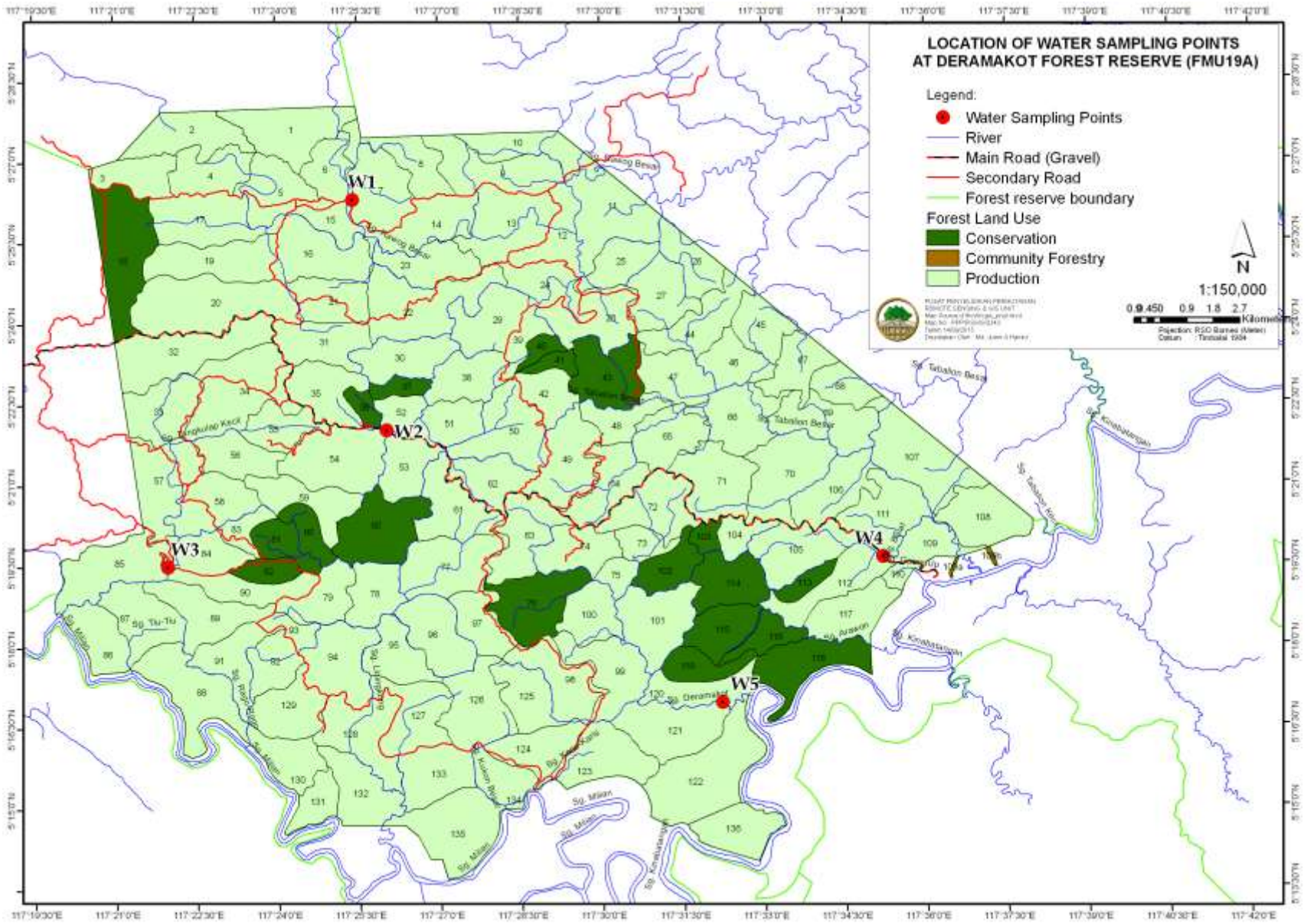

Figure 1 The location of 5 water sampling points W1 – W5 to assess river water quality in Deramakot Forest Reserve, Sabah.

RESULTS

Water Quality

The chemical analyses and water quality classes for all parameters tested for the sampling points in the project area are listed in Table 3.

Table 2. The results of chemical analyses and water quality classes for all parameter tested for sampling location W1, W2, W3, W4, W5 in Deramakot Project Area. Note: Biological Oxygen Demand (BOD in mg/l), Chemical Oxygen Demand (COD in mg/l), Ammoniacal Nitrogen (AN in mg/l), Suspended Solid (SS in mg/l), Dissolved Oxygen (DO in mg/l), fecal coliform (MPN/100mL), total coliform (MPN/100mL), and oil & grease (mg/l).

Parameters Tested	Sampling Location					NWQSM *
	W1	W2	W3	W4	W5	
Biological Oxygen Demand (BOD in mg/l)	1.00	1.00	1.00	1.00	1.00	Class I for all sampling points
Suspended Solid (SS in mg/l)	17	15	5	5	81	W1- W4: Class I W5 : Class II
Chemical Oxygen Demand (COD in mg/l)	12.5	25.0	18.8	10.0	25.0	W1, W3 & W4 : Class I W2 & W5 : Class IIB
Ammoniacal-Nitrogen (as N_3-N in mg/l)	0.05	0.05	0.05	0.05	0.05	Class I for all sampling points
Dissolved Oxygen (DO in mg/l)	6.62	6.52	5.14	6.79	6.42	Class IIB for all sampling points
Oil & Grease (mg/l)	1.50	1.50	1.50	1.50	1.50	Class I for all sampling points
Total Coliform Count (MPN/100mL)	460	1700	1100	330	490	Class I for all sampling points
Fecal Coliform Count (MPN/100mL)	79	1300	23	330	490	W1& W3 : Class I W2, W3 & W5 : Class IIB
pH value	5.84	5.63	5.79	6.31	6.06	W1, W2 & W3: Class III W4& W5: Class II

∗ National Water Quality Standards for Malaysia

(i) pH Value

The concentration range of hydronium ions suitable for the existence of most biological life is narrow, typically between pH 6 to 9. The water pH levels for 3 sampling points were ranged between 5.63 to 5.84 and classified under Class III water for the National Water Quality Standards for Malaysia. For two (2) sampling points are classified under Class I of NWQSM.

(ii) Suspended Solid

Suspended solid (SS) is an indicator of the amount of land disturbance within the catchment area and relates to the erosion that took place nearby sampling area or upstream. All sampling point W1 – W4 registered SS levels categorized as Class I under the National Water Quality Standards for Malaysia. Only W5 sampling point registered the highest SS levels and categorized as Class II. Part of the upper catchment of W1 is originated from oil palm estate that can be elucidated having low structural diversity that eventually may influence increase surface runoff and soil erosion during rainy season.

(iii) Biological Oxygen Demand (BOD)

This parameter is a measure to indicate the presence of organic waste in the river. All sampling points registered BOD levels within Class I under the National Water Quality Standards for Malaysia.

(iv) Chemical Oxygen Demand (COD)

This parameter is an indicator of organics in the water and usually used in association with BOD. Three (3) sampling points registered COD levels as Class I under the National Water Quality Standards for Malaysia. Only W2 and W5 sampling point is classified under Class IIB.

(v) Dissolved Oxygen (DO)

DO is an essential indicator in supporting aquatic life. It measures the amount of oxygen (O_2) that is dissolved in the water. All sampling points registered DO levels as Class IIB as stipulated under the National Water Quality Standards for Malaysia.

(vi) Ammoniacal-Nitrogen (as N_3-N)

This parameter is an indicator of pollution from excessive usage of ammonia rich fertilizers and often used as a measure of the health of water in natural bodies such as rivers or lakes, or in manmade water reservoirs. All sampling points registered AN levels as Class I under the National Water Quality Standards for Malaysia.

(vii) Oil and Grease

The presence of oil and grease in water bodies leads to the formation of oil layer, which causes significant pollution problem such as reduction of light penetration and photosynthesis. It further hinders oxygen transfer from atmosphere to water medium and this leads to decreased amount of dissolved oxygen (DO) at the bottom of the water thus adversely impacted of aquatic life in water. This parameter aims to test whether in general there has been indiscriminate dumping of oils or oily waste in to the water bodies. All sampling points showed levels of oil and grease below measurable ranges (<1.5 mg/l) that indicates near natural background levels.

(viii) Total Coliform Count (TCC)

The term total coliform count (TCC) refers to a numerical count that generally includes both fecal and non-fecal coliforms, and is used to highlight bacterial contamination of the waters.

All sampling points in Deramakot registered TCC levels under Class I as stipulated under the National Water Quality Standards for Malaysia .

(ix) Fecal Coliform Count (FCC)

The term refers to a subset numerical count of total coliform, primarily comprising fecal coliform bacteria that originates from the guts of warm-blooded animals and humans, and is used as an indicator of fecal matters. Two (2) sampling points registered FCC levels under Class I while other three (3) sampling points registered FCC levels for water under Class IIB of the National Water Quality Standards for Malaysia.

Synthesis of assessment

In general, the tests for water quality sampled from the various local rivers are considerably clean. All rivers indicated no trace of oil and grease and harmful level of ammonium nitrate (indicator of extreme used of fertilizer). Total suspended solid levels complied with the standards set for water under Class I of the National Water Quality Standards for Malaysia, except for point W5 that show the levels under Class II, indicating impact of soil erosion is at the minimal level. The pH for all rivers generally complied with the standards set for water under Class I and Class III of the NWQSM. The acceptable limit for river water pH is 6 to 9, thus for the pH of W1, W2 and W3 sampling point having low pH could be because the effect of rain. No indications of organic pollution in all sampling point as the BOD for all sampling point are under Class I of NQWSM. The COD for all rivers generally complied with the standards set for water under Class I and Class IIB of the NWQSM. The COD correlates with the DO and this shown in the result where all sampling points are Class I for DO result. Although part of Rawog River derived from adjacent oil palm estate, there is no indication of excessive usage of ammonia rich fertilizers, shown by Ammoniacal- Nitrogen (as N_3-N) result which complied with the standards under Class I of the National Water Quality Standards for Malaysia. Based on the total and faecal coliform counts, the bacterial contamination level in all sampling points are low and showing no sewerage problem especially in sampling point W2 where the Deramakot Forestry Office and living quarters are located. These results should be expected for rivers draining from catchment areas without forest harvesting activities. This favourable finding may elucidate that sustainable forest management practices in Deramakot could maintain or enhance environmental quality of the area even with timber extraction activities is on-going periodically.

Water Quality Index (WQI)

The results of water quality index for W1to W5 sampling points are listed in Table 3.

Table 3. The water quality index (WQI) for W1to W5 sampling points in Deramakot Project Area. (Note: DO % saturation values were calculated based on dissolved oxygen saturation factor of 8.26 mgL^{-1} at temperature 25° C).

Attributes	Sampling Point				
	W1	**W2**	**W3**	**W4**	**W5**
DO%	80.11	78.90	62.20	82.16	77.69
BOD	1	1	1	1	1
COD	12.5	25.0	18.8	10.0	25.0
SS	17	15	5	5	81
pH	5.84	5.63	5.79	6.31	6.06
NH3-NL	0.2	0.05	0.05	0.05	0.05
SIDO	89	88	68	91	87
SIBOD	96	96	NA	96	96
SICOD	82	69	74	86	69
SIAN	95	95	95	95	95
SISS	88	89	95	95	92
SIpH	88	84	87	95	92
WQI	90	87	85	93	83
CLASS	**II**	**II**	**II**	**I**	**II**
WQ STATUS	**Clean**	**Clean**	**Clean**	**Clean**	**Clean**

Based on the river water quality index, only sampling points W4 falls within Class I and other four (4) W1, W2, W3, and W5 falls within Class II all are categorized as clean river. Comparing the river water quality index from years before, the result shows that there's improvement for all sampling point except for D2 sampling point which show slightly deteriorated in WQI from Class I to Class II. Nevertheless all sampled rivers are categorized as clean water and able to use for human livelihood and consumption (Table 3).

For future undertaking, it is recommended that the management team to install signage in all river crossing areas to prevent visitors or passerby traversing from dumping waste into the watercourse. The management team should periodically brief departmental, adjacent communities and contract workers on this matter to protect the river water quality. The management also may need to carry out periodic inspection and monitoring on existing sewage and septic tanks in all office and living quarters within the FMU to prevent deterioration of the waste treatment system.

REFERENCES

Department Of Environment Malaysia (DOE), 2011. Malaysia Environmental Quality Report 2011. http://www.doe.gov.my/webportal/en/penerbitan-jas/

http://www.wepa-db.net/policies/law/malaysia/eq_surface.htm

APPENDIX I

METHODOLOGY

Sampling Method and Parameters Tested for Chemical Analyses

Grab sampling technique was used to collect all water samples. All samples were collected in a polyethylene and amber glass bottles for analysis. The samples were preserved accordingly and sent to Chemsain Konsultant Sdn. Bhd (an accredited laboratory), for analysis within 24 hours of collection. Parameters tested are according to the DOE Water Quality Index (WQI) with additional other physical and microbiological analysis of the waters. The parameters tested were concentration of hydrogen ion (pH), Biological Oxygen Demand (BOD in mg/l), Chemical Oxygen Demand (COD in mg/l), Ammoniacal Nitrogen (AN in mg/l), Suspended Solid (SS in mg/l), Dissolved Oxygen (DO in mg/l), fecal coliform (MPN/100mL), total coliform (MPN/100mL), and oil & grease (mg/l). The results for all parameters tested by Chemsain Konsultant Sdn. Bhd are listed in Appendix II.

Water Quality Index

Water Quality Index (WQI) is used to determine the water quality status and to classify the rivers based on WQI and the Interim National Water Quality Standards for Malaysia (INWQSM). It also provides a convenient means of summarizing water quality data for sampled river water. The existing WQI equations are proposed by the Department of Environment Malaysia. DOE river water monitoring programme was practised in Malaysia since the year 1978. Water quality data were used to determine the water quality status weather in clean, slightly polluted or polluted category and to classify the rivers in Class I, II, III, IV or V based on Water Quality Index (WQI) and National Water Quality Standards for Malaysia (NWQS).

The results of the water quality sampling receive from Chemsain Konsultant Sdn. Bhd (an accredited laboratory) for sampling points namely W1 and W6 was calculated using the Water Quality Index (WQI) to determine the status and classify the rivers. The formulas used in the calculation of WQI are:

$$\mathbf{WQI = 0.22SIDO+0.19SIBOD+0.16SICOD+0.16SISS+0.15SIAN+0.12SI\ pH} \quad (1)$$

where, WQI = Water quality index; SIDO = Sub-index of DO; SIBOD = Sub-index of BOD; SICOD = Sub-index of COD; SIAN = Sub-index of AN; SISS = Sub-index of TSS; SIpH = Sub-index of pH.

Sub-index for DO (in % saturation):

$SIDO = 0$ for $DO < 8$ (2a)

$= 100$ for $DO > 92$ (2b)

$= -0.395 + 0.030DO^2 - 0.00020DO^3$ for $8 < DO < 92$ (2c)

Sub-index for BOD:

$SIBOD = 100.4 - 4.23BOD$ for $BOD < 5$ (3a)

$= 108e^{-0.055BOD} - 0.1BOD$ for BOD > 5 (3b)

Sub-index for COD:

SICOD $= -1.33COD + 99.1$ for COD < 20 (4a)

$= 103e^{-0.0157COD} - 0.04COD$ for COD > 20 (4b)

Sub-index for AN:

SIAN $= 100.5 - 105AN$ for AN < 0.3 (5a)

$= 94e^{-0.573AN} - 5 | AN - 2 |$ for 0.3 < AN < 4 (5b)

$= 0$ for AN > 4 (5c)

Sub-index for SS:

SISS $= 97.5e^{-0.00676SS} + 0.05SS$ for SS < 100 (6a)

$= 71e^{-0.0016SS} - 0.015SS$ for 100 < SS < 1000 (6b)

$= 0$ for SS > 1000 (6c)

Sub-index for pH:

SIpH $= 17.2 - 17.2pH + 5.02pH^2$ for pH < 5.5 (7a)

$= -242 + 95.5pH - 6.67pH^2$ for 5.5 < pH < 7 (7b)

$= -181 + 82.4pH - 6.05pH^2$ for 7 < pH < 8.75 (7c)

$= 536 - 77.0pH + 2.76pH^2$ for pH > 8.75 (7d)

APPENDIX II

CHEMSAIN KONSULTANT SDN BHD *(130904-U)*
Lots 2 & 7, Lorong Suria, Off Lorong Buah Duku 1, Taman Perindustrian Suria,
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TEST REPORT

* NOT FOR ADVERTISEMENT PURPOSES *

Customer	:	Jabatan Perhutanan Sabah PPP Sepilok, PS 1407, 90715 Sandakan, Sabah.	Lab No. Type (No.) of Sample Date Received Date of Report	: : : :	CK/CL405/1290/16 River Water (3) 14th April 2016 28th April 2016
Attn	:	Ms. Noor Azmizah Bt. Andaman	Service Order	:	-

Lab No.:	1290-1	1290-2	1290-3	*Test Method*
Parameter(s)	Sg. Mannan II Date: 13/04/16 Time: 4.30 pm	Sg Dermakot Date: 13/04/16 Time: 2.30 pm	Sg. Balat Date: 13/04/16 Time: 3.50 pm	
pH Value @ 25°C	5.63	6.06	6.31	*APHA 4500H+ B, 2012*
Biochemical Oxygen Demand in 5 days @ 20°C, mg/L	<1.00	<1.00	<1.00	*APHA 5210 B & 4500-O G, 2012*
Total Suspended Solids, mg/L	15.0	81.0	<5.00	*APHA 2540 D, 2012*
Dissolved Oxygen, mg/L	6.52	6.42	6.79	*APHA 4500-O G, 2012*
Oil & Grease, mg/L	<1.50	<1.50	<1.50	*APHA 5520 B, 2012*
Chemical Oxygen Demand, mg/L	25.0	25.0	<10.0	*APHA 5220 C, 2012*
Ammoniacal-Nitrogen (as NH_3-N), mg/L	<0.05	<0.05	<0.05	*APHA 4500 NH_3 F, 2012*

Date of commencement of BOD_5 analysis: 14th April 2016

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TEST REPORT

* NOT FOR ADVERTISEMENT PURPOSES *

Lab No.: CK/CL405/1355/16

Lab No.:	1355-3	*Test Method*
Parameter(s)	Sg. Rawog Date: 18/04/16 Time: 12.45 pm	
pH Value @ 25°C	5.84	*APHA 4500H ` B, 2012*
Biochemical Oxygen Demand in 5 days @ 20°C, mg/L	<1.00	*APHA 5210 B & 4500-O G, 2012*
Suspended Solids, mg/L	17.0	*APHA 2540 D, 2012*
Dissolved Oxygen, mg/L	6.62	*APHA 4500-O G, 2012*
Oil & Grease, mg/L	<1.50	*APHA 5520 B, 2012*
Chemical Oxygen Demand, mg/L	12.5	*APHA 5220 C, 2012*
Ammoniacal-Nitrogen (as NH_3-N), mg/L	<0.05	*APHA 4500 NH_3 F, 2012*

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TEST REPORT

* NOT FOR ADVERTISEMENT PURPOSES *

Lab No.: CK/CL405/1355/16

Lab No.:	1355-5	*Test Method*
Parameter(s)	Sg. Tangkulap Kecil Date: 18/04/16 Time: 2.30 pm	
pH Value @ 25°C	5.79	*APHA 4500H+ B, 2012*
Biochemical Oxygen Demand in 5 days @ 20°C, mg/L	<1.00	*APHA 5210 B & 4500-O G, 2012*
Suspended Solids, mg/L	<5.00	*APHA 2540 D, 2012*
Dissolved Oxygen, mg/L	5.14	*APHA 4500-O G, 2012*
Oil & Grease, mg/L	<1.50	*APHA 5520 B, 2012*
Chemical Oxygen Demand, mg/L	18.8	*APHA 5220 C, 2012*
Ammoniacal-Nitrogen (as NH_3-N), mg/L	<0.05	*APHA 4500 NH_3 F, 2012*

Date of commencement of BOD_5 analysis: 19th April 2016

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TEST REPORT

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Customer	:	Jabatan Perhutanan Sabah PPP Sepilok, PS1407, 90715 Sandakan, Sabah.	Lab No.	:	CK/ML405/1291/16
			Type (No.) of Sample	:	River Water (3)
			Date Received	:	14th April 2016
			Date of Report	:	22nd April 2016
Attn	:	Ms. Noor Azmizah Bt Andaman	Service Order	:	-

Lab No.:	1291-1	1291-2	1291-3	*Test Method*
Parameter	Sg. Dermakot Date: 13/04/16 Time: 02.30 pm	Sg. Balat Date: 13/04/16 Time: 03.30 pm	Sg. Mannan II Date: 13/04/16 Time: 04.30 pm	
Total Coliform Count MPN/100mL, 35±0.5°C/48 h	4.9×10^2	3.3×10^2	1.7×10^3	*APHA 9221B, 2012*
Fecal Coliform Count MPN/100mL, 44.5±0.2°C/24 h	4.9×10^2	3.3×10^2	1.3×10^3	*APHA 9221E, 2005*

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TEST REPORT

* NOT FOR ADVERTISEMENT PURPOSES *

Customer	:	Jabatan Perhutanan Sabah PPP Sepilok, PS1407, 90715 Sandakan, Sabah.	Lab No. Type (No.) of Sample Date Received Date of Report	: : : :	CK/ML405/1356/16 River Water (5) 19th April 2016 27th April 2016
Attn	:	Ms. Noor Azmizah Bt Andaman	Service Order	:	-

Lab No.:	1356-1	1356-2		*Test Method*
Parameter	Sg. Rawog Date: 18/04/16 Time: 12.48 pm	Sg. Tangkulap Kecil Date: 18/04/16 Time: 2.36 pm		
Total Coliform Count MPN/100mL, 35±0.5°C/48 h	4.6×10^2	1.1×10^3		*APHA 9221B, 2012*
Fecal Coliform Count MPN/100mL, 44.5±0.2°C/24 h	79	23		*APHA 9221E, 2003*

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APPENDIX III

i. National Water Quality Standards For Malaysia
ii. Water Classes And Uses
iii. DOE Water Quality Classification Based On Water Quality Index
iv. DOE Water Quality Index Classification
v. WQI Formula And Calculation

Source from: Department Of Environment Malaysia (DOE), 2011. Malaysia Environmental Quality Report 2011. http://www.doe.gov.my/webportal/en/penerbitan-jas/

APPENDIX III (i)

ANNEX

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III#	IV	V
Al	mg/l		-	(0.06)	0.5	
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (IV)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	0.2	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pb	mg/l		0.05	0.02* (0.01)	5	
Mn	mg/l		0.1	0.1	0.2	
Hg	mg/l		0.001	0.004 (0.0001)	0.002	
Ni	mg/l		0.05	0.9*	0.2	
Se	mg/l		0.01	0.25 (0.04)	0.02	
Ag	mg/l		0.05	0.0002	-	
Sn	mg/l		-	0.004	-	
U	mg/l		-	-	-	
Zn	mg/l		5	0.4*	2	
B	mg/l		1	(3.4)	0.8	
Cl	mg/l		200	-	80	
Cl_2	mg/l		-	(0.02)	-	
CN	mg/l		0.02	0.06 (0.02)	-	
F	mg/l		1.5	10	1	
NO_2	mg/l		0.4	0.4 (0.03)	-	
NO_3	mg/l		7	-	5	
P	mg/l		0.2	0.1	-	
Silica	mg/l		50	-	-	
SO_4	mg/l		250	-	-	
S	mg/l		0.05	(0.001)	-	
CO_2	mg/l		-	-	-	
Gross-α	Bq/l		0.1	-	-	
Gross-β	Bq/l		1	-	-	
Ra-226	Bq/l		< 0.1	-	-	
Sr-90	Bq/l		< 1	-	-	
CCE	µg/l		500	-	-	-
MBAS/BAS	µg/l		500	5000 (200)	-	-
O & G (Mineral)	µg/l		40; N	N	-	-
O & G (Emulsified Edible)	µg/l		7000; N	N	-	-
PCB	µg/l		0.1	6 (0.05)	-	-
Phenol	µg/l		10	-	-	-
Aldrin/Dieldrin	µg/l		0.02	0.2 (0.01)	-	-
BHC	µg/l		2	9 (0.1)	-	-
Chlordane	µg/l		0.08	2 (0.02)	-	-
t-DDT	µg/l		0.1	(1)	-	-
Endosulfan	µg/l		10	-	-	-
Heptachlor/Epoxide	µg/l		0.05	0.9 (0.06)	-	-
Lindane	µg/l		2	3 (0.4)	-	-
2,4-D	µg/l		70	450	-	-
2,4,5-T	µg/l		10	160	-	-
2,4,5-TP	µg/l		4	850	-	-
Paraquat	µg/l		10	1800	-	-

NATURAL LEVELS OR ABSENT

LEVELS ABOVE IV

Notes :

* = At hardness 50 mg/l $CaCO_3$
\# = Maximum (unbracketed) and 24-hour average (bracketed) concentrations
N = Free from visible film sheen, discolouration and deposits

APPENDIX III (i & ii)

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	µS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	%	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000)a	5000 (20000)a	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

Notes :

N : No visible floatable materials or debris, no objectional odour or no objectional taste
* : Related parameters, only one recommended for use
** : Geometric mean
a : Maximum not to be exceeded

WATER CLASSES AND USES

CLASS	USES
Class I	Conservation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
Class IIA	Water Supply II – Conventional treatment required. Fishery II – Sensitive aquatic species.
Class IIB	Recreational use with body contact.
Class III	Water Supply III – Extensive treatment required. Fishery III – Common, of economic value and tolerant species; livestock drinking.
Class IV	Irrigation
Class V	None of the above.

APPENDIX III (iii & iv)

DOE WATER QUALITY CLASSIFICATION BASED ON WATER QUALITY INDEX

SUB INDEX & WATER QUALITY INDEX	INDEX RANGE		
	CLEAN	SLIGHTLY POLLUTED	POLLUTED
Biochemical Oxygen Demand (BOD)	91 - 100	80 - 90	0 - 79
Ammoniacal Nitrogen (NH_3-N)	92 - 100	71 - 91	0 - 70
Suspended Solids (SS)	76 - 100	70 - 75	0 - 69
Water Quality Index (WQI)	81 - 100	60 - 80	0 - 59

DOE WATER QUALITY INDEX CLASSIFICATION

PARAMETER	UNIT	CLASS				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/l	< 0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	> 2.7
Biochemical Oxygen Demand	mg/l	< 1	1 – 3	3 – 6	6 – 12	> 12
Chemical Oxygen Demand	mg/l	< 10	10 – 25	25 – 50	50 – 100	> 100
Dissolved Oxygen	mg/l	> 7	5 – 7	3 – 5	1 – 3	< 1
pH	-	> 7.0	6.0 – 7.0	5.0 – 6.0	< 5.0	> 5.0
Total Suspended Solid	mg/l	< 25	25 – 50	50 – 150	150 – 300	> 300
Water Quality Index (WQI)		> 92.7	76.5 – 92.7	51.9 – 76.5	31.0 – 51.9	< 31.0

APPENDIX III (v)

WQI FORMULA AND CALCULATION

FORMULA

WQI = (0.22 * SIDO) + (0.19 * SIBOD) + (0.16 * SICOD) + (0.15 * SIAN) + (0.16 * SISS) + (0.12 * SIpH)

where;

SIDO = Subindex DO (% saturation)
SIBOD = Subindex BOD
SICOD = Subindex COD
SIAN = Subindex NH_3-N
SISS = Subindex SS
SIpH = Subindex pH
$0 \leq WQI \leq 100$

BEST FIT EQUATIONS FOR THE ESTIMATION OF VARIOUS SUBINDEX VALUES

Subindex for DO (in % saturation)

$SIDO = 0$	for $x \leq 8$
$SIDO = 100$	for $x \geq 92$
$SIDO = -0.395 + 0.030x^2 - 0.00020x^3$	for $8 < x < 92$

Subindex for BOD

$SIBOD = 100.4 - 4.23x$	for $x \leq 5$
$SIBOD = 108 * \exp(-0.055x) - 0.1x$	for $x > 5$

Subindex for COD

$SICOD = -1.33x + 99.1$	for $x \leq 20$
$SICOD = 103 * \exp(-0.0157x) - 0.04x$	for $x > 20$

Subindex for NH_3-N

$SIAN = 100.5 - 105x$	for $x \leq 0.3$
$SIAN = 94 * \exp(-0.573x) - 5 * \lvert x - 2 \rvert$	for $0.3 < x < 4$
$SIAN = 0$	for $x \geq 4$

Subindex for SS

$SISS = 97.5 * \exp(-0.00676x) + 0.05x$	for $x \leq 100$
$SISS = 71 * \exp(-0.0061x) - 0.015x$	for $100 < x < 1000$
$SISS = 0$	for $x \geq 1000$

Subindex for pH

$SIpH = 17.2 - 17.2x + 5.02x^2$	for $x < 5.5$
$SIpH = -242 + 95.5x - 6.67x^2$	for $5.5 \leq x < 7$
$SIpH = -181 + 82.4x - 6.05x^2$	for $7 \leq x < 8.75$
$SIpH = 536 - 77.0x + 2.76x^2$	for $x \geq 8.75$

Note:
* means multiply with