A HEALTH IMPACT ASSESSMENT (HIA) REPORT IN SUPPORT OF A SECOND SCHEDULE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR THE PROPOSED EXPANSION OF AN ALUMINIUM SMELTING PLANT ON LOT 36, SAMALAJU INDUSTRIAL PARK, BINTULU, SARAWAK

SUBMITTED TO

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Chapter 1

EXISTING PUBLIC HEALTH STATUS

1.1 Community Morbidity Statistics

Data on disease cases related to air pollution, water pollution, animal vectors and reservoirs and skin diseases were requested from Klinik Kesihatan Nyalau for a period of one year from January to December 2017. Of these only disease cases related to air pollution and skin diseases were reported at the clinic throughout 2017. Klinik Kesihatan Nyalau is about 11 km northeast of the proposed project site.

Table 1.1 gives disease cases related to air pollution seen at Klinik Kesihatan Nyalau in 2017. Respiratory diseases normally aggravated by air pollution as represented by upper respiratory tract infection and asthma made up 27.3% of all adult cases and 77.3% of all children cases seen at the clinic. These figures seem rather high, which means that the population may be susceptible to the impact of air pollution. Cardiovascular diseases which may be worsen by air pollution as represented only by hypertension made up 20.3% of all adult cases. Air pollution tends to impact children through respiratory diseases and adults through cardiovascular diseases. No disease case related to water pollution, animal vectors and reservoirs was seen at the clinic.

Table 1.2 indicates skin diseases seen at Klinik Kesihatan Nyalau in 2017. Among these, only urticaria and disorders of skin appendages were reported at the clinic. They made up only 1.6% of all adult cases and 4.7% of all children cases. We can see that the percentages of skin diseases seen at the clinic were very minimal. Of all these skin diseases, dermatitis and eczema, urticaria and erythemas are allergic forms of skin reactions that may be exacerbated by allergens and irritants that may be present in air or water. Among these, only urticaria cases were reported.

Table 1.1 : Disease cases related to air pollution seen at Klinik Kesihatan Nyalau.

Year	Month	Conj.		URTI		Inf.		Asth.		TB		Pneu.		Bron.		Emphy.		Lung Ca		HF		HPT		IHD		CVA		*Total (all patients)	
		A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C
2017	J	0	0	17	5	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	101	17
	F	0	0	26	15	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	216	24
	M	0	0	30	12	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	119	28
	A	0	0	19	32	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	0	0	0	142	38
	M	0	0	32	11	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	105	15
	J	0	0	37	10	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	37	0	0	0	0	0	133	15
	J	0	0	16	13	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	37	0	0	0	0	0	123	17
	A	0	0	66	17	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	193	24
	S	0	0	53	26	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0	151	42
	O	0	0	46	20	0	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	133	26
	N	0	0	45	20	0	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	0	0	0	144	25
	D	0	0	32	25	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	105	24
Total		0	0	419	206	0	0	35	22	0	0	0	0	0	0	0	0	0	0	0	0	338	0	0	0	0	0	1665	295

Conj. : Conjunctivitis
URTI : Upper respiratory tract infections
Inf. : Influenza
Asth. : Asthma
TB : Tuberculosis
Pneu. : Pneumonia
Bron. : Chronic bronchitis
Emphy. : Emphysema
Lung Ca : Lung cancer
HPT : Hypertension
HF : Heart failure
IHD : Ischaemic heart disease
CVA : Cerebrovascular accident/stroke

*Total (all patients) : Total attendance of all patients at the clinic during that month.

A: Adult
C: Children

Table 1.2 : Skin disease cases seen at Klinik Kesihatan Nyalau.

Year	Month	Cutan.		Cell.		Derm.		Psor.		Urti.		Dis.		Eryth.		Rad.		*Total (all patients)	
		A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C
2017	Jan	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	101	17
	Feb	0	0	0	0	0	0	0	0	1	3	0	1	0	0	0	0	216	24
	Mar	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	119	28
	Apr	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	142	38
	May	0	0	0	0	0	0	0	0	5	2	0	0	0	0	0	0	105	15
	June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133	15
	July	0	0	0	0	0	0	0	0	5	3	0	0	0	0	0	0	123	17
	Aug	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	193	24
	Sep	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	151	42
	Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133	26
	Nov	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	144	25
	Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	105	24
Total		0	0	0	0	0	0	0	0	24	13	2	1	0	0	0	0	1665	295

Cutan. : Cutaneous abscess/furuncle & carbuncle
Cell. : Cellulitis
Derm. : Dermatitis and eczema
Psor. : Psoriasis
Urti. : Urticaria
Dis. : Disorders of skin appendages
Eryth. : Erythemas
Rad. : Radiodermatitis & other radiation-related disorders of the skin & subcutaneous tissue

*Total (all patients) : Total attendance of all patients at the clinic during that month.

A: Adult
C: Children

Table 1.3 shows the prevalence rates of selected environment-related notifiable communicable diseases in the District of Bintulu in 2017. The prevalence rates of most of the diseases are below the national prevalence rates in 2016, except for malaria and leptospirosis, which are transmitted by mosquitoes and rodents, respectively.

Table 1.3 : Prevalence rates of selected notifiable communicable diseases in the District of Bintulu in 2017.

Disease	**No. of Cases**	**Prevalence Rates in 2017 (per 100,000 population)**	**Prevalence Rates for Malaysia in 2016 per 100,000 population)[a]**
Waterborne and Foodborne Diseases	0	0	
Cholera	0	0	0.54
Typhoid	0	0	0.57
Hepatitis A	0	0	0.27
Dysentery	0	0	0.40
Poliomyelitis	0	0	0
Food poisoning	12	4.73	55.21
Vectorborne and Zoonotic Diseases	0	0	
Dengue fever	73	28.80	318.13
Dengue haemorrhagic fever	0	0	2.01
Chikungunya	0	0	-
Malaria	61	**24.06**	7.27
Filariasis	0	0	-
Typhus	0	0	0
Rabies	0	0	0
Leptospirosis	70	**27.61**	16.69

Population of the District of Bintulu in 2017 is 253,500.
Source : [a] Ministry of Health Malaysia. 2017. Health facts 2017.

1.2 Workers' Health and Safety Records

The impacts of the proposed project on workers' health are not included in this HIA, as it is not within the scope specified in the Guidance Document. However, due to the request from the Sarawak Health Department, we reviewed some of the medical records of employees of the existing plant.

As of March 2019, Phases 1 and 2 of the existing PMB Aluminium Smelter has a total of 2,675 current employees, comprising 2,505 males and 170 females. Some 46% of the employees are locals while 54% are foreigners. For the Phase 3 PMB smelter expansion, an estimated 1,220 new employees will be recruited, giving a total of 3,895 employees. PMB is in the midst of increasing the percentage of local employees.

The breakdown of employees by Section/Department are as follows :

i) **Administration** : Human resource, data management, finance, communications and public relation, IT, and purchasing) : 120 employees.
ii) **Production House** : Anode rodding, electrolysis, and cast house) : 1,733 employees.
iii) **Production Support** : Logistics and maintenance : Logistic, power distribution, facilities and services, electrolysis support, environmental health and safety, quality, workshop, production planning and general building infrastructure maintenance) : 785 employees.
iv) **Auxiliary Police**: 37 employees.

Table 1.4 gives the employees' health complaints for 2018, as reported by PMB Aluminium Smelter's workers' health services. A total of 5,225 health complaints were received from the employees in 2018. The most common complaints were cough, headache, influenza, fever, toothache and skin itchiness, with 809, 762, 728, 661, 225 and 209 complaints, respectively. These are common health problems that may not be work-related.

Table 1.5 shows employees' accident summary for 2018. The accidents which seems to result in the longest medical leave are fractures of the wrist, shoulder and humerus bones. Another common accidents are burns of the face and eye area, wrist, hand, arm, foot, abdomen and chest. Also common are lacerations of the face, scalp, palm, finger, thigh and knee. It seems that work accidents are quite common at the electrolysis and cast house sections of the smelter. Therefore, improvement to the work environment, workers' job safety training, and the use of personal protective equipment (PPE) must be promoted to reduce future work accidents.

Table 1.4 : Employees' health records for 2018, as reported by PMB Aluminium Smelter's workers' health services.

No.	Complaints	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1	Flu/Unable to clear plegm	55	66	46	71	51	51	53	54	65	43	53	120	728
2	Cough	63	112	64	72	59	54	63	42	60	40	56	124	809
3	Fever	56	90	59	72	36	20	42	37	49	34	51	115	661
4	Headache	89	73	72	68	62	72	52	15	60	54	56	89	762
5	Body pain	13	20	27	7	16	7	9	7	4	13	13	22	158
6	Back pain	23	13	7	14	7	11	9	13	18	7	10	16	148
7	Chest pain	2	2	1	5	3			2	3	1	3	1	23
8	Elbow pain				1									1
9	Neck pain				1					2				3
10	Shoulder Pain							5	3	1				9
11	Joint pain						1							1
12	Muscle Pain				11			4	4	11			17	47
13	Muscle Cramp	2		5					1	2				10
14	Facial pain					1					2			3
15	Leg/foot/knee pain			4	1	4	1		4	1	1	1		17
16	Ankle sprain	1	1	1						1			1	5
17	Abdominal Discomfort/ Heartburn	1	14	2		9	2	9	3		1			41
18	Abdominal Pain/ Stomachache	11		9	10	5	8	4	6	10	25	20	10	118
19	Diarrhoea/Loose Stool	17	13	16	16	17	27	13	8	17	8	5	19	176
20	Skin Itchiness	9	13	13	7	16	11	18	45	21	26	15	15	209
21	Allergy	27	21	10	13	16	9	9		2		14	4	125
22	Gastric Pain/ Gastritis/ Epigastric Pain	14	13	10	15	18	11	18	5	3	3	23	14	147
23	Sore Throat	3	8	16	9	13	6	5	9	16	3	9	15	112
24	Dysuria	6	4	2	4		3	2	5	6		2	9	43
25	Sob / Asthma		1					3	2	2	2	6	9	25
26	Wound													0
27	Dry Eye/ Itchyness		1	2							2		10	15
28	Toothache	24	14	22	15	25	17	20	16	20	11	22	19	225
29	Vomiting		6		2		2	2		2	4		4	22

No.	Complaints	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
30	Constipation	3	1	2	2	2	2	3	2	3	1	4	4	29
31	Malaise				2		1		1		2		3	9
32	Carbuncle										1		2	3
33	Oral Sore / Ulcer	6	3	1		3	1	3	1	1	2	7	2	30
34	Eye Redness	3	1		1		2						2	9
35	Eye Pain	2	6	1			3	4	6	16	15	20	1	74
36	Ear Pain / Ear Discharge	1	2	1	1	3	2	4	3	4	3	1	2	27
37	Epistaxis				1						3			4
38	Gum Pain												2	2
39	Gum Swollen	1	3		2		2					1		9
40	Motion Sickness												1	1
41	Chalazion			3		1	4				2		1	11
42	Eczema												1	1
43	Soft Tissue Injury	2								3		4	20	29
44	Abscess		1	2		2	4	6	9	2	9	4	1	40
45	Nausea	2			2	2	3	4		2	6			21
46	Dysmenorrhea/ Menstrual Pain	1	1	3			1	2	1				2	11
47	Dizziness		9	8	11	12	1	3	1	4	1			50
48	Insect Bite	3		1	2			1		6	2			15
49	STO		1	1										2
50	Fungal infection	4			2	4			2					12
51	Haemorrhoid				1		1		2			1		5
52	Gout	2		1					3	1	1			8
53	Dehydration						1		1			1		3
54	Enlargement/swollen of lymph node	1							1					2
55	Wound dressing	2						2	6	2		1		13
56	Boil	6	2		1		1							10
57	Wind trapped	1												1
58	Migraine	1	1	1	4		1	1	3	3			1	16
59	Numbness			1										1
60	Abrasion/laceration wound	1	1	1			1		3		4	2		13
61	Osteoporasis			1										1

No.	Complaints	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
62	Burn						2				1			3
63	Pain over lower/upper extremity	6	2		3	2	8	7	2	8	19	7	1	65
64	Swollen Limb		3							2	3			8
65	Loss of appetite				1	1	1			1	1			5
66	Tonsillitis		1		1									2
67	Discharge at finger					1								1
68	Blister									3	2			5
69	Chill and rigor		1							2				3
70	URTI		2							1				3
71	UTI				1					2				3
72	Blurry vision		1							1	1			3
73	Shingles		1								1			2
74	Pimples										3			3
75	Urticaria										5			5
76	Post syncopal										1			1
77	Nail prick										1			1
78	Lethargic	1										2		3
79	Tachycardia			1										1
80	Orchitis										1			1
81	Rhinorrhea												2	2
TOTAL		465	528	417	452	391	355	380	328	443	371	414	681	5225

Table 1.5 : Employees' accident summary for 2018.

No.	Date	Department	Injury	Medical Leave	FAC	Minor	Major	Years of Service
1	7 January, 2018	Electrolysis	Laceration wound over right eyebrow	0		1		>3 years
2	8 January, 2018	Electrolysis	Avulsion injury over right 4th finger	0	1			2 - 3 years
3	11 January, 2018	Cast House	Blister wound at left ring finger	0	2			<1 year
4	12 January, 2018	Electrolysis	Fracture at right wrist	30			1	2 - 3 years
5	17 January, 2018	Electrolysis	Fracture at few location of the body part	60			2	2 - 3 years
6	24 January, 2018	Cast House	2nd Degree Burn at left palm	0	3			<1 year
7	26 January, 2018	Anode Rodding	Soft Tissue Injury at Left Wrist	0	4			>3 years
8	8 February, 2018	Electrolysis	Laceration wound	2		2		1 - 2 years
9	26 February, 2018	Cast House	Punctured wound at left foot	0		3		1 - 2 years
10	27 February, 2018	Electrolysis	2nd degree burn	0	5			<1 year
11	2 March, 2018	Electrolysis	Dislocation with fracture at left shoulder	60			3	<1 year
12	6 March, 2018	Cast House	Deep laceration wound at upper lips	8			4	>3 years
13	8 March, 2018	Cast House	2nd and 3rd degree burn at left wrist	7			5	<1 year
14	10 March, 2018	Cast House	Deep dermal burn at chest area	7			6	<1 year
14	10 March, 2018	Cast House	mild ear pain	0			6	>3 years
14	10 March, 2018	Cast House	mild ear pain	0			6	<1 year
15	10 March, 2018	Electrolysis	second degree burn over right hand	3		4		<1 year
16	12 March, 2018	QAQC	Superficial second degree burn at left thumb	0	6			<1year
17	14 March, 2018	Electrolysis	1st degree burn at face region	0	7			<1year
17	14 March, 2018	Electrolysis	1st degree burn at eye area, swollen and redness at upper left eye lid	0	7			>3 years
18	16 March, 2018	Electrolysis	Laceration wound at right middle finger	2		5		2 - 3 years
19	28 March, 2018	Cast House	Laceration wound at left index finger	0		6		1 - 2 years
20	29 March, 2018	PPC	1st degree burn at left side of frontal and swollen at left eyelid	0	8			2 - 3 years

No.	Date	Department	Injury	Medical Leave	FAC	Minor	Major	Years of Service
21	31 March, 2018	Cast House	1st degree burn at left side index finger	0	9			<1 year
22	2 April, 2018	Cast House	2nd degree of burn at right arm	14			7	1 - 2 years
23	11 April, 2018	Carbon Dust Recovery	Left midshaft humerus closed fracture	60			8	2 - 3 years
23	11 April, 2018	Carbon Dust Recovery	Deep laceration wound over left palm	14			8	<1 year
24	16 April, 2018	Cast House	1-2% first degree of burn on left side of clavicle	0	10			<1 year
25	18 April, 2018	Transport & Workshop	Swollen at 4th and 5th right finger	0	11			<1 year
26	20 April, 2018	Cast House	Fracture of left radius and radial styloid	60			9	<1 year
27	23 April, 2018	Cast House	Superficial laceration wound with nail avulsion	0		7		<1 year
28	25 April, 2018	Flouride Warehouse	Open Fracture of right distal phalanx of middle finger	9			10	<1 year
29	30 April, 2018	Cast House	Laceration wound at right thigh	0		8		> 3 years
30	2 May, 2018	Human Resources Administration	Swollen at right knee	0			11	2 - 3 years
30	2 May, 2018	Anode Rodding	Laceration and abrasion wound over left side of face	5			11	>3 years
31	2 May, 2018	Fume Treatment	Swollen at right knee	2		9		<1 year
32	10 May, 2018	Cast House	Left thermal eye injury	4		10		2 - 3 years
33	12 May, 2018	Production Planning Control	Deep laceration wound over left left index finger	0		11		>3 years
34	13 May, 2018	Cast House	Soft Tissue Injury at distal Metatarsal region of left foot	4		12		>3 years
35	18 May, 2018	Cast House	second degree burn at right hand	0		13		<1 year
36	18 May, 2018	Anode Rodding	Superficial multiple laceration wound at right ring finger	0		14		2 - 3 years
37	19 May, 2018	Anode Rodding	Right side of eye irritation	0	12			>3 years
38	19 May, 2018	Transport & Workshop	Nail pricked at right toe	0	13			>3 years
39	22 May, 2018	Mechanical Anode Repair	Swollen and abrasion wound over both lower limb	0	14			1 - 2 years
40	29 May, 2018	Cast House	2nd to 3rd degree burn at upper back and right armpit area	14			12	<1 year

No.	Date	Department	Injury	Medical Leave	FAC	Minor	Major	Years of Service
41	30 May, 2018	Fabrication	Laceration wound at left index finger	0		15		2 - 3 years
42	2 June, 2018	Cast House	Laceration wound at left small finger	0	15			<1 year
43	4 June, 2018	Anode Rodding	Sprain at left foot	0	16			>3 years
44	4 June, 2018	GBIM	Nail pricked at left foot	0	17			>3 years
45	9 June, 2018	Cast House	Right ankle 3-4 deep dermal burn	3		16		<1 year
46	14 June, 2018	Cast House	1st to 2nd degree of burn at left side of neck area	0	18			<1 year
47	15 June, 2018	Anode Rodding - Anode Repair	1-2 % deep dermal burn at right upper hand	0	19			>3 years
48	16 June, 2018	Cast House	Soft Tissue Injury	3		17		1 -2 years
49	22 June, 2018	Electrolysis	Laceration wound over scalp	4		18		>3 years
50	25 June, 2018	Electrolysis	Laceration wound at right hand and Left knee soft tissue injury	4		19		2 - 3 years
51	27 June, 2018	Quality	Superficial laceration wound at right middle finger	0	20			2 - 3 years
52	27 June, 2018	Electrolysis	1st to 2nd degree of burn over multiple abdomen and both side of hand	0	21			>3 years
53	5 July, 2018	Cast House	2nd degree burn at right arm and back	0	22			<1 year
54	13 July, 2018	Cast House	Swollen and small cut wound at left index finger	0	23			2 - 3 years
55	30 July, 2018	Cast House	1st degree burn over left pad of foot	0	24			>3 years
56	11 August, 2018	Cast House	Nail bed injury with total nail avulsion of right index finger	6			13	<1 year
57	16 August, 2018	Fume Treatment	Abrasion wound at right knee region	0	25			<1year
58	18 August, 2018	Cast House	Right knee soft tissue injury	3		20		1 -2 years
59	18 August, 2018	Cast House	Left foot soft tissue injury	1		21		1 -2 years
60	29 August, 2018	Cast House	Second degree thermal burn at left hand and left knee region	14			14	1 -2 years
61	07 September , 2018	Cast House	Facial injury with laceration wound over left cheek, upper lip and lower lip	3		22		<1 year
62	08 September, 2018	Electrolysis	Punctured wound over left foot plantar due to rusty nail	0	26			2-3 years

No.	Date	Department	Injury	Medical Leave	FAC	Minor	Major	Years of Service
63	14 September, 2018	Electrolysis	Deep dermal burn over left lower foot 1.75%	31			15	>3 years
64	17 September, 2018	Electrolysis	Pain over both eye	0	27			1-2 years
65	18 September, 2018	Electrolysis	Facial chemical first degree burn	2		23		2-3 years
66	25 September, 2018	Electrolysis	Crush wound over left ring finger	30			16	> 3 years
67	25 September, 2018	Electrolysis	Superficial burn over right forearm	0	28			<1 year
68	08 October, 2018	Carbon Export	1cm laceration wound at left phalanx middle finger	0	29			<1 year
69	12 October, 2018	Cast House	Soft tissue injury with abrasion wound at left elbow	0	30			<1 year
70	20 October, 2018	Anode Rodding	Soft tissue injury with minor abrasion at middle and ring finger proximal phalnges	0	31			>3 years
71	25 October, 2018	Logistic	Soft tissue injury	4		24		<1 year
72	27 October, 2018	Cast House	Abrasion wound over middle proximal finger	0	32			<1 year
73	1 November, 2018	Electrolysis	Soft tissue injury over right forearm	0	33			2-3 years
74	7 November, 2018	Cast House	Right Trichiasis, Left Corneal abrassion, Left periorbital skin abrasion	14			17	<1 year
75	8 November, 2018	Cast House	Crushed bimalleolar injury with open ankle dislocation and multiligament tear	23			18	2-3 years
76	8 December, 2018	Fume Treatment	Rib fracture secondary to blunt force trauma	14			19	>3 years
77	12 December, 2018	Cast House	First Degree Burn over right side of thigh and right thumb	0	34			<1 year
78	20 December, 2018	Cast House	Bilateral conjunctivitis	0	35			1-2 years
79	20 December, 2018	Cast House	Laceration wound over left index finger	0	36			<1 year
80	22 December, 2018	Fume Treatment	Soft Tissue Injury	0		25		<1 year

Chapter 2

HEALTH IMPACT ASSESSMENT

Health impact assessment (HIA) is the process of estimating the potential impact of a chemical, biological, physical or social agent on a specified human population system under a specific set of conditions and for a certain time frame (EnHealth Council, 2001; DOE, 2012). The main approach in this HIA is to assess the impacts of the proposed expansion of an aluminium smelting plant on Lot 36 in the Samalaju Industrial Park, Bintulu Division, Sarawak, on the health of residents of affected communities within the vicinity of the proposed project that may emanate from environmental impacts. The HIA reported here is based on the Guidance Document on HIA in EIA by the Department of Environment Malaysia (DOE, 2012). The impacts of the proposed project on workers' health are not included in this HIA, as it is not within the scope specified in the Guidance Document. However, due to the request from the Sarawak Health Department, we reviewed some of the medical records of employees of the existing plant, as reported in Chapter 1.

Health risk assessment (HRA) is a component of HIA. There are two forms of HRA, namely qualitative and quantitative HRA. Qualitative HRA merely characterizes or compares the hazard of a chemical relative to others, or in comparison to reference values or standards, or defines the hazard in only qualitative terms such as mutagen or carcinogen, which connotes certain risk or safety procedures. In qualitative HRA, only subjective and comparative assessment of environmental hazards are attempted without generating any quantitative estimate of the risks involved.

Quantitative HRA is a methodological approach in which the toxicities of a chemical are identified, characterized, analyzed for dose-response relationships, and the data generated are applied to a mathematical model to produce a numeric estimate representing a guideline or decision concerning allowable exposure (James, 1985). Quantitative HRA generates a numerical measure of the risk or safety of a chemical exposure. The numerical measure of the risk generated is compared against a guideline value or an acceptable risk level. When conducting a quantitative HRA, there are two categories of risks being assessed, namely non-carcinogenic and carcinogenic health risk.

For the purpose of this HRA, only qualitative HRA was employed. There are 6 steps involved in the HRA methodology.

2.1 Issues Identification

This first step explores the source-pathway-receptor link, the component of each is essential in the expression of risk. Health impacts are mainly secondary impacts upon the human community that emanate from primary impacts upon the physical (air, water and soil); biological (animals and plants) and social environments. In the case of this proposed project, the main health impacts will emanate from human exposure to air pollutants that will be released during the construction and operational phases of the proposed project. The major pathway for human exposure to the released air pollutants during the construction and operational phases will be through direct inhalation. Indirect exposure to air pollutants through

the ingestion route is highly unlikely in this case. The proposed project site is surrounded by oil palm plantation and palm oil mill. It is unlikely that the pollutants may accumulate in the oil palm and palm oil products. Therefore, there is no potential of human health risk from the consumption of contaminated palm oil.

As the plant operations will involve only dry processes, no wastewater will be generated. The water used in the cooling system will also be recycled. Sewage from the plant will go to a centralised sewage treatment system.

2.2 Hazard Identification

This second step in HRA involves the identification of potential environmental hazards and characterization of their innate adverse toxic or health effects. The purpose is to scope for potential environmental and health hazards that may emanate from the operation of the proposed project. The review indicated that the major environmental hazards from the proposed project will be mainly particulate and gaseous air pollutants during its construction and operational phases.

2.2.1 Project Construction Phase

It is estimated that about 1,220 workers will be employed during the proposed project construction phase. Some of these workers might be Malaysians and foreigners from outside of Sarawak. Most of them will not be staying at the project site but will be housed at nearby area such as Samalaju New Township or nearby villages. A small number of workers will be staying at the temporary workers' camp on-site to guard their equipment and machineries. The temporary on-site workers' camp will be provided with proper sanitation facilities like drinking water, toilet and garbage disposal.

Workers who are not properly screened for infectious diseases may transmit them to the local population. These workers who will be mostly young males may present an increased risk in the transmission of sexually-transmitted diseases (STD). Common STDs includes human papillomavirus (HPV) infection, trichomoniasis, chlamydia, herpes simplex virus (HSV) infection, gonorrhea, syphilis, human immunodeficiency virus (HIV) infection and hepatitis B. In 2008, 31.5% of malaria cases were imported cases among foreigners (Ministry of Health, 2008). Immigrants who are likely to harbour malarial parasites can reintroduce the disease to previously malaria-free areas because the vectors may still be present there. Other diseases that may be brought in by foreign workers are tuberculosis, dengue fever and chikungunya.

According to the air quality modeling study (Chapter 7, Section 7.4), potential air quality impact during the project construction phase will be mainly due to fugitive dust. This shall be considered temporary and minimal as the work area is within the existing plant premise which involves minimal earthwork. Fugitive dust which is generally heavier is usually found concentrated at or near to ground level. As such, air pollution during this stage is anticipated to be known as a nuisance and localised within the project site. Hence, the potential impact will be towards the on-site receptor (the workers), if no proper control measure is implemented on-site. However, the nearest human receptors; namely Samalaju Lodge and Samalaju Local Camp which are located about 0.4 km to the south should not be affected. Besides fugitive dust, trace amount of carbon monoxide and dark smoke will be emitted from transportation and

machineries. Nevertheless, this impact is insignificant as the emissions are source-limited and occur only during usage.

2.2.2 Project Operational Phase

2.2.2.1 Air Pollutants during the Project Operational Phase

During the project operational phase, fume generated during the electrolysis process in the Pot Room Building will be treated in the Fume Treatment System (FTS), whereby the fume will be channeled into a dry alumina scrubber for removal of fluorides, and then the enriched alumina dust (AlF3) will be collected in a Pulse-Jet Bag Filter and used back as a feed material in the smelting process. For the existing Phase 1 and Phase 2 operations, 6 FTS and 17 Pulse-Jet Bag Filters have been strategically installed. For the Proposed Phase 3 operation, another 3 FTS and 7 Pulse-Jet Bag Filters will be designed and installed. The air pollutants generated will be respirable particulate (PM10), sulphur dioxide (SO_2), hydrogen fluoride (HF) and total fluoride (TF).

2.2.2.3 Health Hazards of the Air Pollutants Generated

Particulate matter, especially the fraction known as respirable particulate (PM10), with an aerodynamic diameter of 10 μm, have a great impact on human health as they can penetrate beyond the nasopharyngeal region and reach the lower human respiratory tract (Dockery and Pope, 1994; Dockery and Pope, 1996). Acute exposure may lead to asthmatic attack, respiratory infections and acute bronchitis (USEPA, 2003), as well as alveolar inflammation, increased blood coagulability and exacerbation of lung and cardiovascular diseases (Seaton *et al*., 1995).

Sulphur dioxide (SO_2) irritates the nose, throat, and airways to cause coughing, wheezing, shortness of breath, or a tight feeling around the chest. The effects of sulfur dioxide are felt very quickly and most people would feel the worst symptoms in 10 or 15 minutes after breathing it in (Department of the Environment and Heritage, 2005). It may cause bronchoconstriction and increased asthma symptoms among children, the elderly, and asthmatics (USEPA, 2013).

Hydrogen fluoride gas, even at low levels, can irritate the eyes, nose, and respiratory tract. Breathing in hydrogen fluoride at high levels or in combination with skin contact can cause death from an irregular heartbeat or from fluid buildup in the lungs. People who survive after being severely injured by breathing in hydrogen fluoride may suffer lingering chronic lung disease (CDC, 2019).

2.3 Dose-response Assessment

The probability of seeing a health effect from human exposure to a toxicant is dependent on the dose of exposure. There is only one possible human exposure route to pollutants that may originate from the proposed project, and that is inhalation exposure to air pollutants during the project construction and operational phases.

2.3.1 Inhalation Exposure to Air Pollutants

As a qualitative HRA, for comparison to standard ambient PM10 guideline values, comparison were made to the 24-hour and annual Malaysian Ambient Air Quality Standard (MAAQS) 2013 (Standard 2020) for normal project operation, and to the 24-hour MAAQS 2013 (Standard 2020) for abnormal project operation. For comparison to standard ambient SO_2 guideline values, comparison were made to the 1-hour and 24-hour MAAQS 2013 (Standard 2020) for normal project operation, and to the USEPA Acute Exposure Guideline Levels (AEGLs) for abnormal project operation. For comparison to standard ambient ambient HF guideline value, comparison was made to the 24-hour Ontario's Ambient Air Quality Criteria (OAAQC) 2012 for normal project operation. For comparison to standard ambient TF guideline value, comparison was made to the WHO's Air Quality Guidelines for Europe for normal project operation.

In quantitative HRA, for inhalation exposure to air pollutants, the non-carcinogenic dose-response relationship is reflected in the reference concentration (RfC). RfC is an estimated daily concentration of a toxicant in air, with uncertainty spanning perhaps an order of magnitude, of which an inhalation exposure to the human population including sensitive subgroups, is likely to be without an appreciable risk of deleterious effect during a lifetime of 70 years (DOE, 2012). Therefore, the RfC is described in the form of an air concentration which may be safely inhaled by an exposed person over his entire lifetime of 70 years. Where applicable, the RfC is used as a direct comparison with the exposure concentration (EC) of the air pollutant. The unit for RfC is is usually in mg/m^3. However, RfC is not available for any of the air pollutants identified for this proposed project. Therefore, no quantitative HRA can be conducted.

2.4 Exposure Assessment

2.4.1 During Project Construction Phase

2.4.1.1 Exposure to Air Pollutants

According to the air quality modeling study (Chapter 7, Section 7.4), potential air quality impact during the project construction phase will be mainly due to fugitive dust. This shall be considered temporary and minimal as the work area is within the existing plant premise which involves minimal earthwork. Fugitive dust which is generally heavier is usually found concentrated at or near to ground level. As such, air pollution during this stage is anticipated to be known as a nuisance and localised within the project site. This impact is insignificant as the emissions are source-limited and occur only during usage. Therefore, no further HRA will be conducted for air pollutant exposure during the project construction phase.

2.4.2 During Project Operational Phase

2.4.2.1 Exposure to Air Pollutants

According to the air quality modeling study (Chapter 7, Section 7.4), air pollutants that may be released from the proposed project during its operational phase include respirable particulate (PM10), sulphur dioxide (SO_2), hydrogen fluoride (HF) and total fluoride (TF). A total of 6 exposure scenarios were simulated as follows :

1. Project site
2. Samalaju Lodge and Samalaju Local Camp (~0.5 km; south)
3. Samalaju Resort Hotel (~3.0 km; south-west)
4. Samalaju Eco Park Township (~6 km; east-north-east)
5. Suburmas Workers Camp (~3.2 km; west)
6. Kg Nyalau (consisting of Kg Hulu Nyalau, Kg Nyalau Tengah and Kg Kuala Nyalau) (~10.7 km; north-east)

For each exposure scenario, two emission scenarios were simulated. The first was the normal emission scenario, whereby the air pollution control devices (APCDs), namely the fume treatment system at the electrolysis pot room building and the dust collector (pulse-jet bag filter) at the anode rodding facility and cast house, were all working normally. The second is the abnormal emission scenario, whereby there is breakdown of the APCDs).

Table 2.1 shows the exposures to PM10 during normal project operation. The predicted 24-hour and annual ambient PM10 concentrations at all the receptor locations will be below their respective MAAQS 2013 (Standard 2020) of 100 µg/m^3 and 40 µg/m^3, respectively.

Table 2.2 shows the exposures to PM10 during abnormal project operation. The predicted 24-hour ambient PM10 concentrations at the receptor locations will be below their MAAQS 2013 (Standard 2020) of 100 µg/m^3, except at the project site where it will exceed the standard.

Table 2.3 gives the exposures to SO_2 during normal project operation. The predicted 1-hour and 24-hour ambient SO_2 concentrations at all the receptor locations will be below their respective MAAQS 2013 (Standard 2020) of 250 µg/m^3 and 80 µg/m^3, respectively.

Table 2.4 gives the exposures to SO_2 during abnormal project operation. The predicted 1-hour ambient SO_2 concentrations at the project site, Samalaju Lodge and Samalaju Local Camp and Samalaju Resort Hotel will exceed the 1-hour USEPA AEGL-2 of 1,963.2 µg/m^3 for disabling health effect.

Table 2.5 gives the exposures to HF during normal project operation. The predicted 24-hour ambient HF concentrations at all the receptor locations will exceed its Ontario's Ambient Air Quality Criteria (OAAQC) 2012 of 1.72 µg/m^3. However, this is mainly due to the already high baseline HF concentration, rather than the incremental concentration from the proposed project.

Table 2.6 gives the exposures to TF during normal project operation. The predicted 24-hour ambient TF concentrations at all the receptor locations will meet its Air Quality Guidelines for Europe of 1.0 µg/m^3.

Table 2.1 : Baseline, incremental and predicted ambient respirable particulate (PM10) concentrations (µg/m^3) during normal project operation.

Receptor	Baseline concentration		Incremental concentration		Predicted ambient concentration	
	24-hour	**Annual**	**24-hour**	**Annual**	**24-hour**	**Annual**
Project site	39.0	NA	5.0	1.9	44.0	+1.9
Samalaju Lodge & Samalaju Local Camp	27.0	NA	2.5	0.5	29.5	+0.5
Samalaju Resort Hotel	19.0	NA	0	0.5	19.0	+0.5
Suburmas Workers Camp	39.0	NA	0	0.5	39.0	+0.5
Samalaju Eco Park Township	19.0	NA	0	0	19.0	+0
Kg. Nyalau	9.0	NA	0	0	9.0	+0
MAAQS 2013 (Std 2020)					100	40

NA = Not available

Table 2.2 : Baseline, incremental and predicted ambient respirable particulate (PM10) concentrations (µg/m^3) during abnormal project operation.

Receptor	Baseline concentration		Incremental concentration		Predicted ambient concentration	
	1-hour	**24-hour**	**1-hour**	**24-hour**	**1-hour**	**24-hour**
Project site	NA	39.0	971.4	80.1	+971.4	**119.1**
Samalaju Lodge & Samalaju Local Camp	NA	27.0	250.0	50.0	+250.0	77.0
Samalaju Resort Hotel	NA	19.0	250.0	25.0	+250.0	44.0
Suburmas Workers Camp	NA	39.0	100.0	25.0	+100.0	64.0
Samalaju Eco Park Township	NA	19.0	100.0	10.0	+100.0	29.0
Kg. Nyalau	NA	9.0	50.0	10.0	+50.0	19.0
MAAQS 2013 (Std 2020)					-	100

NA = Not available

Table 2.3 : Baseline, incremental and predicted ambient sulphur dioxide (SO_2) concentrations ($\mu g/m^3$) during normal project operation.

Receptor	Baseline concentration		Incremental concentration		Predicted ambient concentration	
	1-hour	24-hour	1-hour	24-hour	1-hour	24-hour
Project site	NA	<5.0	100.0	20.0	+100.0	<25.0
Samalaju Lodge & Samalaju Local Camp	NA	<5.0	100.0	0	+100.0	<5.0
Samalaju Resort Hotel	NA	<5.0	100.0	5.0	+100.0	<10.0
Suburmas Workers Camp	NA	<5.0	25.0	25.0	+25.0	<30.0
Samalaju Eco Park Township	NA	<5.0	100.0	5.0	+100.0	<10.0
Kg. Nyalau	NA	<5.0	100.0	5.0	+100.0	<10.0
MAAQS 2013 (Std 2020)					250	80

NA = Not available

Table 2.4 : Baseline, incremental and predicted ambient sulphur dioxide (SO_2) concentrations ($\mu g/m^3$) during abnormal project operation.

Receptor	Baseline concentration		Incremental concentration		Predicted ambient concentration	
	1-hour	24-hour	1-hour	24-hour	1-hour	24-hour
Project site	NA	<5.0	2,303.1	95.0	**+2,303.1**	<100.0
Samalaju Lodge & Samalaju Local Camp	NA	<5.0	2,000.0	75.0	**+2,000.0**	<80.0
Samalaju Resort Hotel	NA	<5.0	2,000.0	103.5	**+2,000.0**	<108.5
Suburmas Workers Camp	NA	<5.0	1,000.0	<25.0	+1,000.0	<30.0
Samalaju Eco Park Township	NA	<5.0	500.0	<25.0	+500.0	<30.0
Kg. Nyalau	NA	<5.0	500.0	<25.0	+500.0	<30.0
1-hour USEPA AEGL-1 (non-disabling)					523.5	-
1-hour USEPA AEGL-2 (disabling)					1,963.2	-
1-hour AEGL-3 (lethal)					78,527.6	-

NA = Not available

Table 2.5 : Baseline, incremental and predicted ambient hydrogen fluoride (HF) concentrations (µg/m^3) during normal project operational phase.

Receptor	Baseline concentration	Incremental concentration	Predicted ambient concentration
	24-hour	**24-hour**	**24-hour**
Project site	<20.0	0	<**20.0**
Samalaju Lodge & Samalaju Local Camp	<20.0	0.1	<**20.1**
Samalaju Resort Hotel	<20.0	0.1	<**20.1**
Suburmas Workers Camp	<20.0	0.05	<**20.05**
Samalaju Eco Park Township	<20.0	0	<**20.0**
Kg. Nyalau	<20.0	0	<**20.0**
OAAQC 2012			1.72

Table 2.6 : Baseline, incremental and predicted ambient total fluoride (TF) concentrations (µg/m^3) during normal project operational phase.

Receptor	Baseline concentration	Incremental concentration	Predicted ambient concentration
	24-hour	**24-hour**	**24-hour**
Project site	NA	0	0
Samalaju Lodge & Samalaju Local Camp	NA	0.1	+0.1
Samalaju Resort Hotel	NA	0.1	+0.1
Suburmas Workers Camp	NA	0.1	+0.1
Samalaju Eco Park Township	NA	0	0
Kg. Nyalau	NA	0.1	+0.1
WHO's Air Quality Guidelines for Europe			<1.0

NA = Not available

2.5 Health Risk Characterization

2.5.1 Air Pollutant Exposure Guidelines

This involves a qualitative HRA, whereby the predicted exposure levels of the concerned air pollutants were compared to local and foreign ambient air quality guidelines.

2.5.1.1 During Project Operational Phase

During normal project operation, the predicted 24-hour and annual ambient PM10 concentrations at all the receptor locations will be below their respective MAAQS 2013 (Standard 2020) (**Table 2.1**).

During abnormal project operation, the predicted 24-hour ambient PM10 concentrations at the receptor locations will be below their MAAQS 2013 (Standard 2020), except at the project site where it will exceed the standard (**Table 2.2**).

During normal project operation, the predicted 1-hour and 24-hour ambient SO_2 concentrations at all the receptor locations will be below their respective MAAQS 2013 (Standard 2020) (**Table 2.3**).

During abnormal project operation, the predicted 1-hour ambient SO_2 concentrations at the project site, Samalaju Lodge and Samalaju Local Camp, and Samalaju Resort Hotel will exceed the 1-hour USEPA AEGL-2 for disabling health effect (**Table 2.4**).

During normal project operation, the predicted 24-hour ambient HF concentrations at all the receptor locations will exceed its Ontario's Ambient Air Quality Criteria (OAAQC) 2012 (**Table 2.5**). However, this is mainly due to the already high baseline HF concentration, rather than the incremental concentration from the proposed project.

During normal project operation, the predicted 24-hour ambient TF concentrations at all the receptor locations will meet its Air Quality Guidelines for Europe (**Table 2.6**).

2.7 Summary of Assessment

During normal project operation, the predicted ambient PM10 and SO_2 concentrations at all the receptor locations will be below their respective MAAQS 2013 (Standard 2020), while the predicted ambient TF concentrations at all the receptor locations will meet its Air Quality Guidelines for Europe. However, the predicted ambient HF concentrations at all the receptor locations will exceed its Ontario's Ambient Air Quality Criteria (OAAQC) 2012. However, this high predicted ambient HF concentration is mainly due to the already high baseline HF concentration, rather than the incremental concentration from the proposed project.

During abnormal project operation, the predicted ambient PM10 concentrations at the receptor locations will be below their MAAQS 2013 (Standard 2020), except at the project site, while the predicted ambient SO_2 concentrations at the project site, Samalaju Lodge and Samalaju Local Camp, and Samalaju Resort Hotel will exceed the 1-hour USEPA AEGL-2 for disabling health effect. Therefore, to prevent any untoward health outcome, the emergency shutdown system of the plant must be activated within an hour of the emergency situation.

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