Chapter 4 Analysis of the Current Environmental Pollution Problem Caused by the Coal Mines in the Mahakam River Basin

1. The current situation of coal mines

1.1 General description of coal mines

The number of coal mines registered by the city of Samarinda and the province of Kutai Kertanegara is more than 200 including all coal mines of different stages as explained in Chapter 1 Section 7.2. These include those in all stages of General surveying, Exploration, F/S, Construction and Operation. **Table 4-1-1** shows the quantity of production and sales for each coal mine. Nine coal mines use the Mahkam River as transportation and they are of the form of Contractors and many KPs (Kuasa Pertambangan, Mining Authorization). Five coal mines that own a coal preparation plant or de-sliming plant were studied and some coal mines are producing the dirty coal.

The ratio of total coal production and domestic & exporting sales in Indonesia is between 15 to 16 % respectably in the coalmines using the Mahakam River as transporting measures

Table 4-1-1 Production and Sales of coalmines using the Mahakam River as transportation measures

(1,000t)

No	Company	Licence	Production		Sales			
					Domestic		Export	
			2004	2005	2004	2005	2004	2005
1	Anugrah Bara Kaltim, PT	KP	3,413	3,395	3		1,479	1,502
2	Bina Mitra Sumberarta, PT	KP		169				
3	Bukit Baiduri Energi, PT	KP	1,430	1,690	1,690	32	1,225	1,626
4	Fajar Bumi Sakti, PT	KP	2,113	328	78	188	864	120
5	Gunung Bayan Pratama Coal, PT	PKP2B, 2nd Generation	3,360	4,330	3,343	2,594	2	1,324
6	Jembayan Muarabara	KP		1,050				1,050
7	Kartika Selabumi Mining, PT	PKP2B, 2nd Generation	736	1,035	837	1,007		
8	Kimco Armindo, PT	KP		963				
9	Kitadin Corporation			1,604	78	571	864	1057
10	Lanna Harita Idonesia, PT	PKP2B, 3rd Generation	1,700	1,887	57		1,480	1,733
11	Mahakam Sumber Jaya, PT	PKP2B, 3rd Generation		2,304		1,006		1266
12	Mandiri Intiperkasa, PT	PKP2B, 2nd Generation	602	1,082	16		352	1,021
13	Multi Harapan Utama, PT	PKP2B, 1st Generation	1,521	897	299	242	1,002	648
14	Tanito Harum, PT	PKP2B, 1st Generation	2,256	2,403		9	3,217	4,984
15	Trubaindo Coal Mining, PT	PKP2B, 1st Generation		1,610		1,171		389
		Total	17,131	24,747	6,401	6,820	10,485	16,720
		Total in Indenesia	129,835	153,465	37125	41351	93759	107332
		Shear (%)	13.2	16.1	17.2	16.5	11.2	15.6

Mineral, Coal and Geothermal Statics 2006, by Ministry of Energy and Mineral Resources

1.2 Mining method

The mining methods are separated into underground and open cut mining in general terms. The open cut mining method is used in more then 99% of the mines in Indonesia. The main mining sequence is shown as follows and in the **figure 4-1-4.**

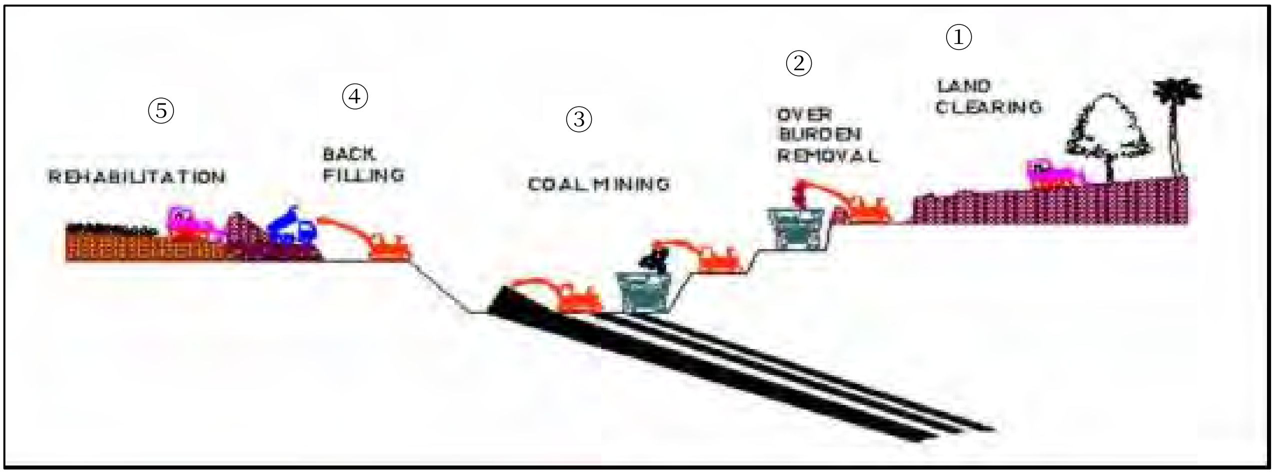
① Land Cleaning：removal of house and building and tree trimming

② Over Burden Removal：stripping

③ Coal Mining

④ Back Filling

⑤ Rehabilitation



Figures 4-1-1 The sequence of the open cut mining method

Two mines, the Pt. Kitadin and Pt. Fajar Bumi Sakti use the underground mining method also. Some coal mines in East Kalimantan are beginning to introduce a high wall mining method, which is a kind of underground mining method.

In general, an underground coal mine needs a coal preparation plant and some open cut coalmines also have them due to quality control and improvement of the coal recovery rate. There are many coal mines that are considering building a new coal preparation plant because they want to mine more coal in their mining concession area due to the limitations on expansion and difficulty in getting new concession areas due to the forest protection law. The increase in the number of a coal preparation plants has the potential to increase the environment pollution and this will be a critical issue.

1.3 General description of a coal preparation

(1) The purpose of coal preparation and its effects

Coal preparation aims to upgrade ROM (Run of Mine Coal) to tailor the specifications of the coal to meet those required by the user. The specifications address size, moisture and ash content, sulfur content and so on. The term "coal preparation" changes depending on the technology, from "Washing" to "Coal Preparation" or "Coal Improvement" and, recently, "Coal Cleaning" which is a part of CCT (Coal Cleaning Technology) in a coal chain. The coal cleaning technology includes blending, making of briquettes, and upgrading of low rank coal.

The effect of coal preparation is improvement of the calorific value by decrease of ash and moisture content and decrease of the environmental load in the burning process and ash treatment, energy saving in transporting measures and so on.

(2) Process of a coal preparation

The coal preparation technology in a coal preparation plant will be separated into blending, sizing, separation, dewatering, concentration, wastewater treatment technology and so on.

The process of coal preparation varies by the required specifications of the coal, quality of ROM and the economic situation including the coal price. In general, the following seven processes will be used together.

① ROM yard facility: Stock pile of ROM and Blending facility
② Crushing: Crushing to a particular size, Pre-separation of coal and rock
③ Sizing or Screening
④ Separation:
⑤ Concentration and Dewatering including drying
⑥ Waste water treatment and Reject treatment
⑦ Clean coal yard facility: Stock pile of cleaned coal, Blending facility

In general, only the processes ①,②,and ③ are termed “coal preparation” or the “de-sliming process”. **Figure 4-1-2** shows an outline of the coal preparation process and the product from each process. The wastewater treatment will be presented as each process needs a lot of water.

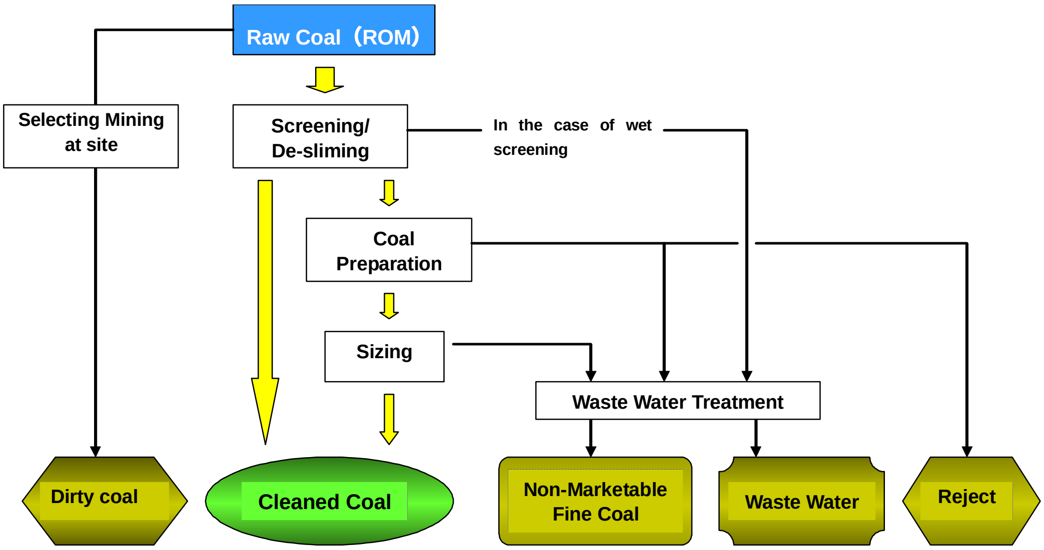


Figure 4-1-2 Out line of a coal preparation process

1.4 The source of environmental pollution due to coal production activities

The source of environmental pollution due to coal production activities are as follows,

① Discharging water from a coal preparation plant

If the TSS (Total Suspended Solids) and pH exceed the regulation limits it has the potential to contaminate the river.

② Non-marketable Fine Coal

Imperfect disposal of Non-marketable Fine Coal after the waste water treatment facility increases TSS, especially in the rainy season.

③ Sediment produced by the mining activity in open cut coal mines flows to the river.

④ Dirty Coal with high sulfur content

Dumping of high sulfur content Dirty Coal interferes with the revegetation of the mined area and also discharges acid water.

Some coal mines are exceeding the environmental limits for water quality, especially TSS, as shown in the data measured by the study team at the coal mine sites. However, the data measured at the riverside mentioned in Chapter 3-2 & 3-3 show that coal mines located along the Mahakam River do not affect water pollution significantly.

2. Current state of Coal Washeries

Table 4-2-1 presents an overview of the six coal washeries investigated in this study. The two plants that use separation receive coal from underground mines. The four remaining plants are only De-sliming※1。 Some plants have dry crushing and dry Classifying equipments side by side. As these do not generate wastewater they have been excluded from Table4-2-1.

Table 4-2-1 Overview of Investigated Coal Washeries

Washery	Capacity	Washing Process		Washing /Wastewater Turning Point	Wastewater Treatment Process	Wastewater Recycle
1 PT. Kitadin	60t/h+120t/h	Separation	Jig	**Settling Pit**	Settling Pond	**Partial**
2 PT. Fajar Bumi Sakti (FBS)	100t/h	Separation	Jig	**De-slime Screen**	Settling Pond	**Entire**
3 PT. Tanito Harum / Sebulu	125t/h	(De-slime)	(Jig※)	**Settling Pit**	Settling Pond	
4 PT. Tanito Harum / Loa Tebu 1	70t/h	De-slime	Drum-Washer	Cyclone Classifier	Settling Pond	
5 PT. Malti Harapan Utama (MHU)	400t/h	De-slime	Screen	Cyclone Classifier	Settling Pond	
6 PT. Bukit Baiduri Energy (BBE)	250t/h	De-slime	Screen	Cyclone Classifier	Settling Pond	Under Construction

※ Used for De-sliming only now

2.1 Washing Process

(1) PT. Kitadin

Fig. 4-2-1 shows a flow sheet and Figs. 4-2-2 and 4-2-3 show the equipment layout of the No.1 and No. 2 plants, respectively. After the raw coal is classified into three sizes (+50mm, 50-40mm, and –40mm), the fractions of 40mm upwards are sent to the hand picking and the fraction of 40mm or less is fed into the Jig※2 The Jig separates the raw coal into three products: clean coal, middling, and reject, according to the differences in their specific gravity. The middling is mixed with the Jig raw coal for renewed separation so that this plant actually produces two products: clean coal and reject. The clean coal that leaves the Jig is dewatered on a 1mm screen to obtain clean coal. The –1mm fraction is sent to a settling pit and the settled-out coarse-grained particles are scraped up with a bucket elevator and mixed into the clean coal. The rejects discharged from the Jig are stored in bunkers and transported on trucks. The overflow water from the settling pits is discharged as wastewater and sent to the wastewater treatment process. At this plant, a Japanese coal cleaning engineer is providing technical support and the impression is that the processes, especially the Jig separation, are run and managed splendidly

(2) PT. Fajar Bumi Sakti （FBS）

Fig. 4-2-4 shows a flow sheet and **Fig. 4-2-5** shows the equipment layout. After the raw coal has been classified into two sizes (+50mm and –50mm), the +50mm fraction passes through a hand picking and is crushed to –50mm. When there is no quality problem, it is directly classed as clean coal. Otherwise it is supplied to the Jig together with the 50mm undersize. The Jig separates the feed coal into three products: clean coal, middling, and reject. The middling is mixed with the Jig raw coal for renewed separation so that this plant actually produces two products: clean coal and reject. It is not possible to say that the Jig is properly operated. The clean coal leaving the Jig is dewatered on a 0.5mm screen to obtain clean coal. The –0.5mm fraction is sent directly to a primary settling pond doubling as a wastewater treatment process for dredging. (Before, the coarse particle is recovered in a settling pit and the overflow water of this pit is supplied to the wastewater system). The tailings discharged from the Jig are transported with a bucket elevator and stored in the open on a site immediately underneath the elevator. The debris heap is spread out with a shovel car at regular intervals. The –0.5mm fraction is directly sent to a primary settling pond of a wastewater treatment process for dredging. (Before, the coarse particles are recovered in a settling pit and the overflow water of this pit is supplied to the pondm). The reject discharged from the Jig is transported with a bucket elevator and stored in the open on a site immediately underneath the elevator.

(3) PT. Tanito Harum / Sebulu

Fig. 4-2-6 shows a flow chart and **Fig. 4-2-7** shows the equipment layout. After crushing and classifying to –50mm fraction, the product is directly treated as clean coal if there are no quality problems. Otherwise the product is sent to the Jig. While the Jig separates the feed coal into 3 products, all products are mixed into the clean coal. So that the Jig is now only used for de-sliming now. The clean coal leaving the Jig is dewatered on a 1mm screen and the oversize is sent to the clean coal and the undersize to the settling pit. The coarse particles that have settled out in this pit are then mixed into the clean coal while the overflow water is sent to the wastewater treatment process. The dredged-out coal sediment has lost its use and is deposited on a pile. The impression we had is that the factory as a whole is buried in coal sediment.

(4) PT. Tanito Harum / Loa Tebu 1

Fig. 4-2-8 shows a flow sheet and Fig. 4-2-9 shows the equipment layout. After the raw coal has been crushed to –200mm, it is sent to a drum washer to remove slime. After De-sliming, the coal is classified on a 50mm/1mm two-stage screen. The +50mm fraction is crushed and mingled with the 50 – 1mm product and the mixture is classed as clean coal. The –1mm fraction is fed to a cyclone classifier. The coarse product from the cyclone classifier is dewatered on a screen to become clean coal. The fine product is sent to the wastewater treatment process. The equipment is half-immersed in sludgy water. Our impression was that a drainage line needed to be considered.

(5) PT. Multi Harapan Utama （MHU）

Fig. 4-2-10 shows a flow sheet and **Fig. 4-2-11** shows the equipment layout. After the raw coal has been crushed to –75mm it is sent to a 50mm/1mm two-stage screen for desliming. After desliming, the +50mm fraction is crushed and mingled with the 50-1mm product to obtain clean coal. The –1mm fraction is fed to a cyclone classifier. The coarse product from the cyclone classifier is dewatered and becomes clean coal. The fine product is sent to the wastewater treatment process. This equipment was made in Australia and is compact and well managed. There is also a high level of awareness of the working environment.

(6) PT. Bukit Baiduri Energi （BBE）

Fig. 4-2-12 shows a flow sheet and **Fig. 4-2-13** shows the equipment layout. After the raw coal has been crushed to –50mm it is sent to a 1mm screen for desliming After desliming, the +1mm fraction is directly classed as clean coal while the –1mm fraction is sent to a cyclone classifier. A spiral separator is installed for the course products from the cyclone classifier. At present, however, this separator is not in use. The course product from the cyclone classifier is mingled with the +1mm clean coal after passing through a 0.5mm dewatering screen and a basket centrifuge. The fine products from the cyclone classifier, dewatering screen and busket centrifuge are sent to the wastewater treatment process. This equipment was made in Australia and is compact and well managed. There is also a high level of awareness of the working environment.

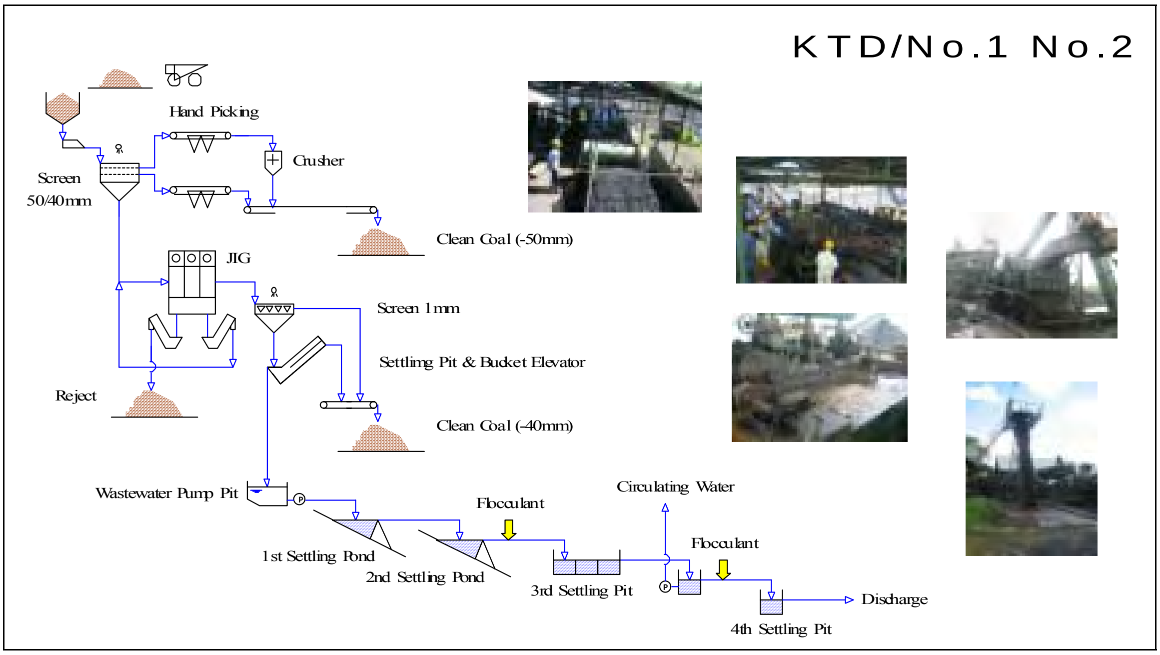
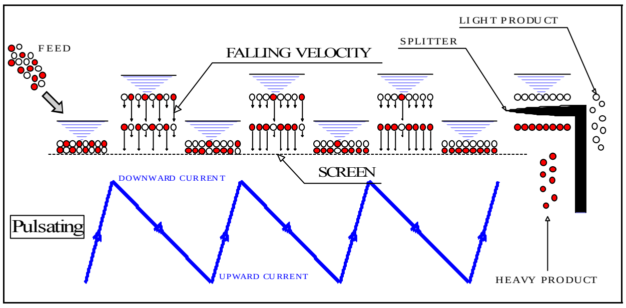


Fig. 4-2-1 Flow Sheet / Kitadin

※1 The clayey minerals in this region are water-absorbent and tend to form sludge. The open-cut coalmines use selective mining in which the majority of the rock is discarded. Nevertheless a small amount of clays mineralala are mingled with the mined coal and absorb water and form sludge in the coal storage yard. This is removed by de-sliming.

※2 A machine that separates particle clusters with a certain specific gravity and produces refined coal with certain ash content is referred to as a specific-gravity separator. The typical specific-gravity separator is a Jig. The Jig takes advantage of the fact that the settling velocity of particles in water varies with specific gravity. The Jig's coal separation process is described below (see the figure below):

(a) Water in a water tank oscillates up and down. (b) Raw coals are fed from the left side (the white one is a coal particle and the red is a reject particle). (c) Raw coal particles move up along with water and then settle down (naturally). (d) The coal particles with a greater specific gravity settle faster than those with a smaller specific gravity and heavy coal particles settled on a net. (e) The coal particles move up and down over and over again until all those particles settled down at the bottom consist chiefly of reject particles. (f) Then the floating coal and reject particles are separated from each other with a splitter and the separation of the coal particles is complete. The machine operates continuously in this way until it achieves the desired results.



Separation Process of Jig

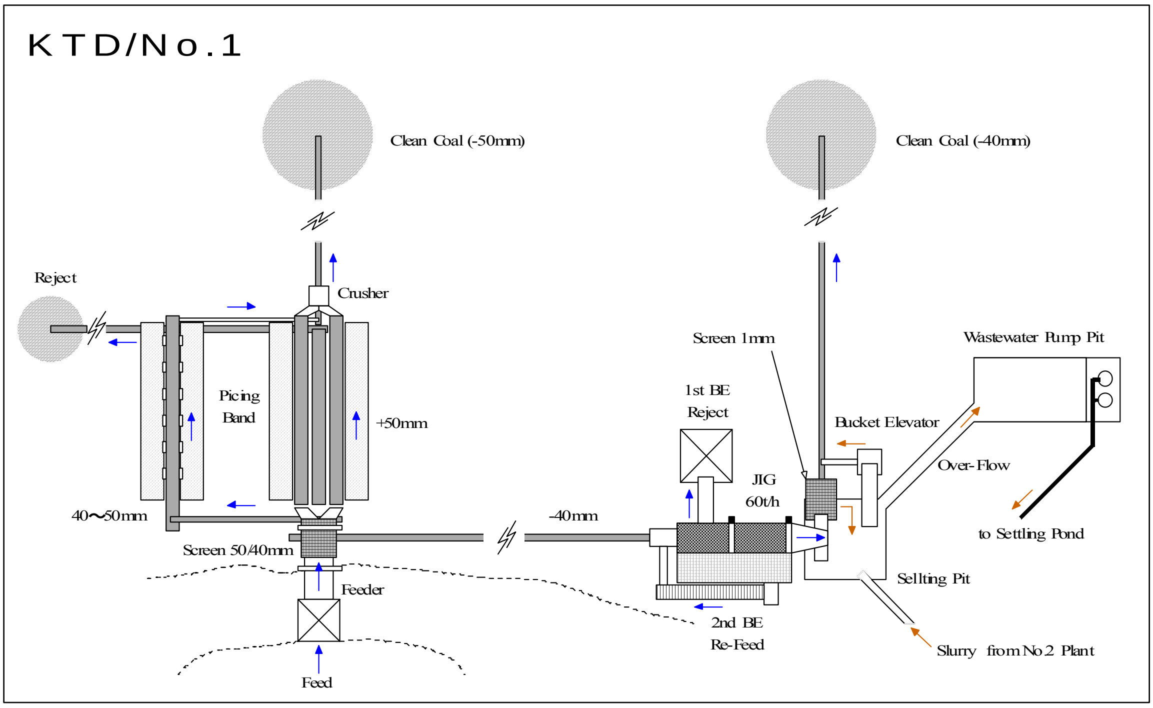


Fig. 4-2-2 Equipment Layout / Kitadin No.1 Plant

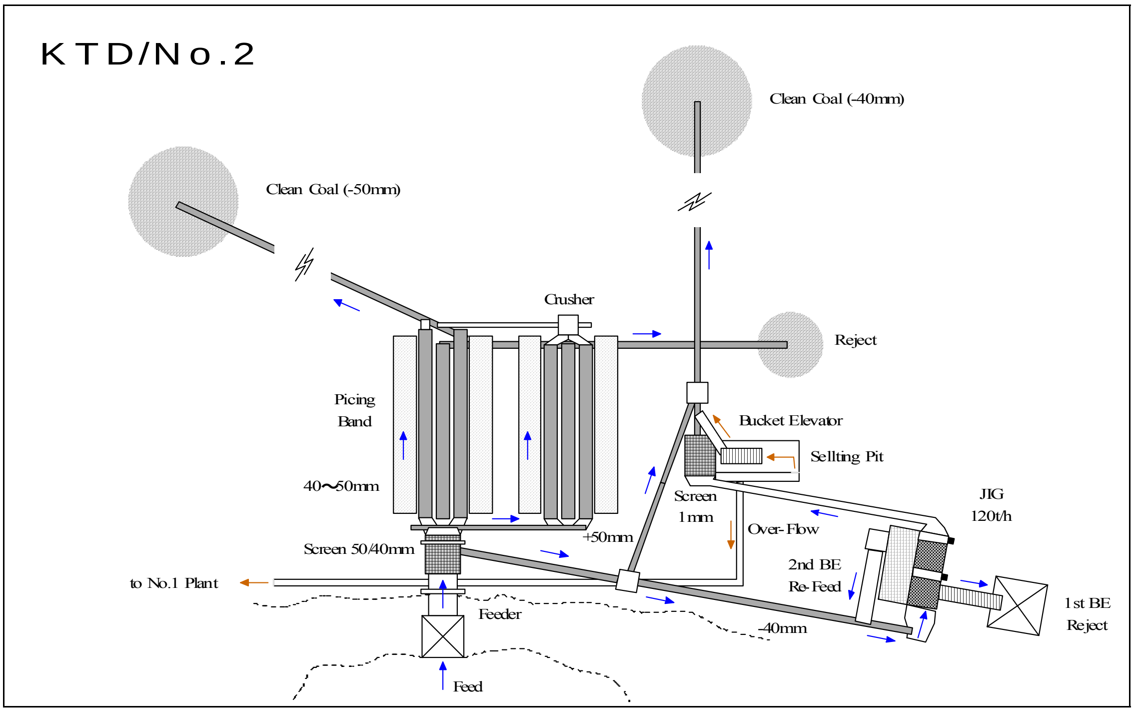


Fig. 4-2-3 Equipment Layout / Kitadin No.2 Plant

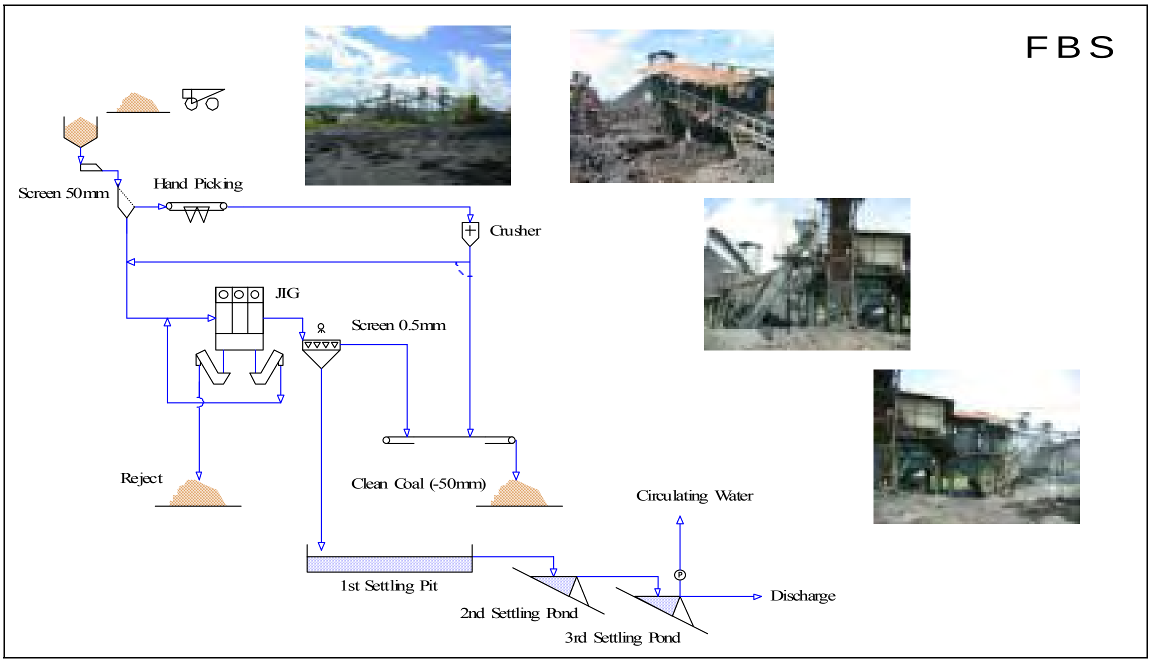


Fig. 4-2-4 Flow Sheet / FBS

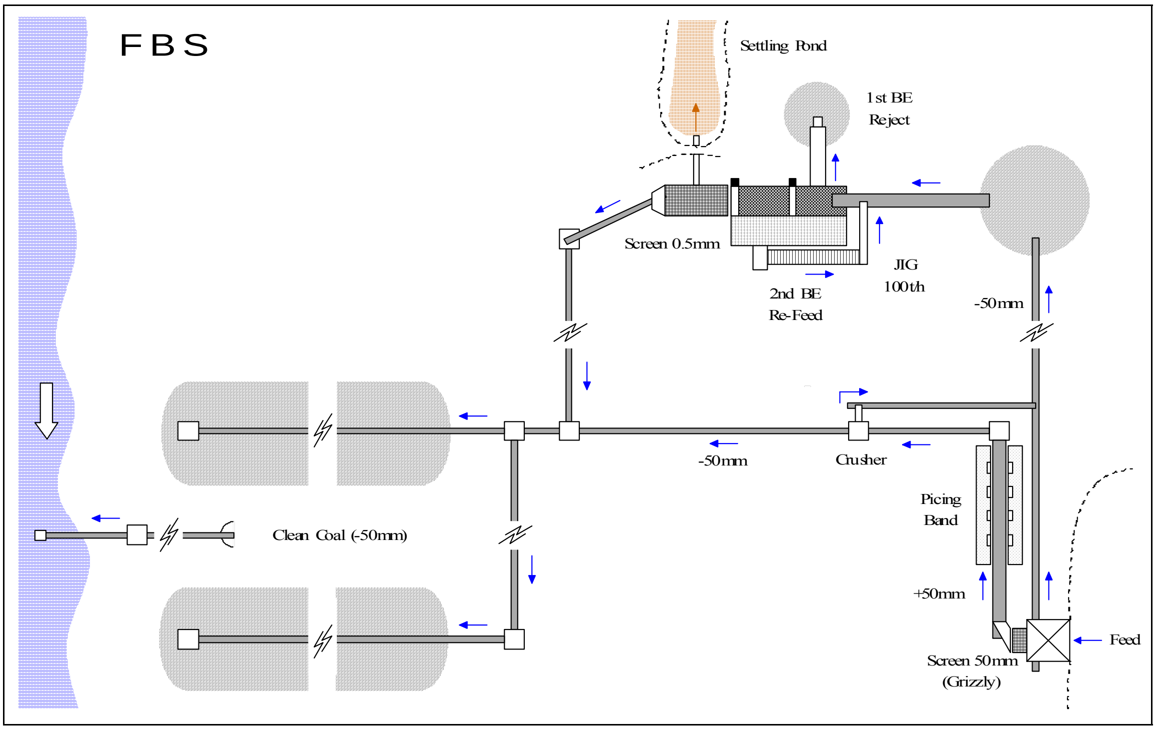


Fig. 4-2-5 Equipment Layout / FBS

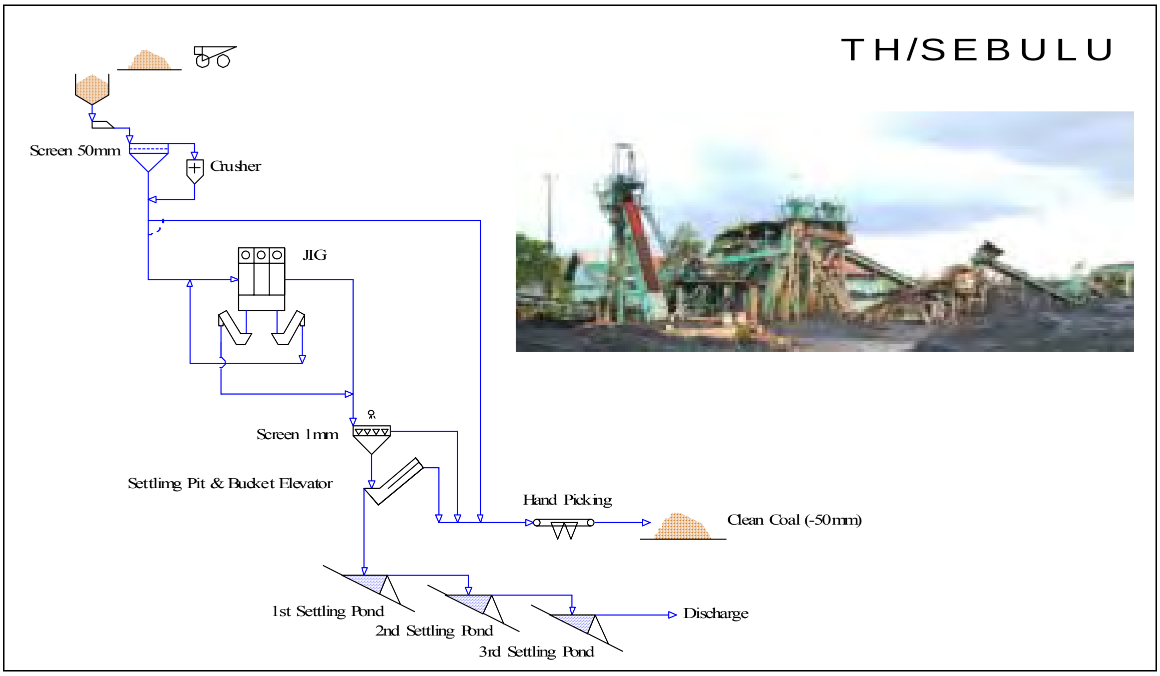


Fig. 4-2-6 Flow sheet / Sebulu

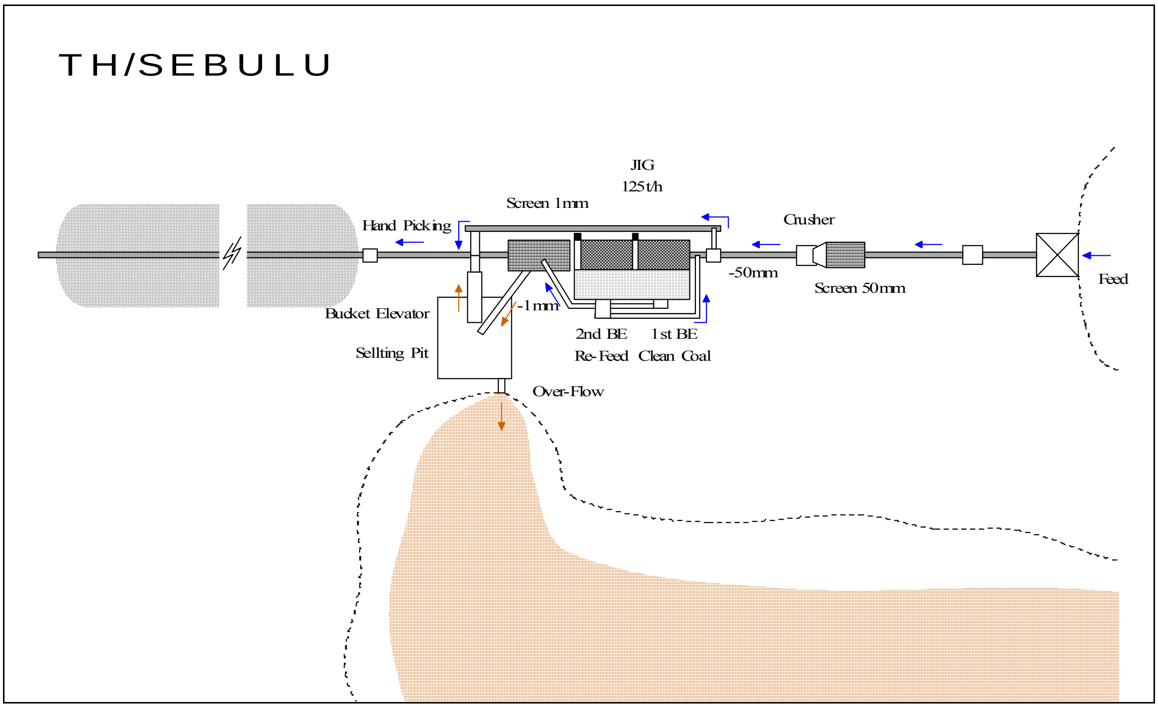


Fig. 4-2-7 Equipment Layout / Sebulu

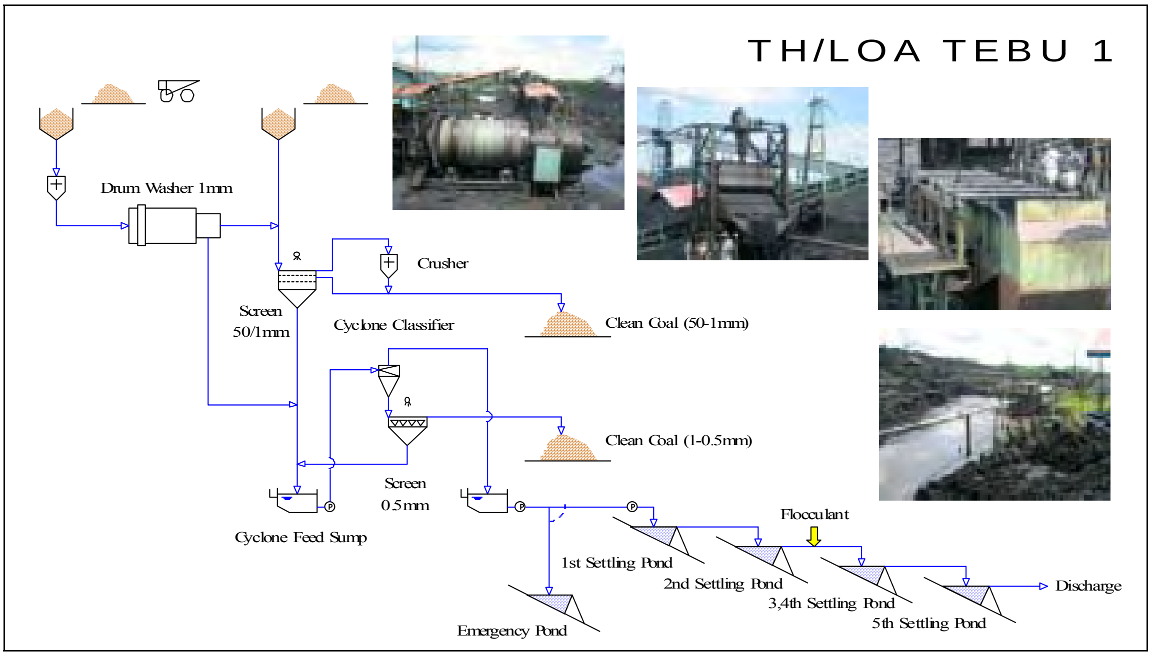


Fig. 4-2-8 Flow sheet / Loa Tebu 1

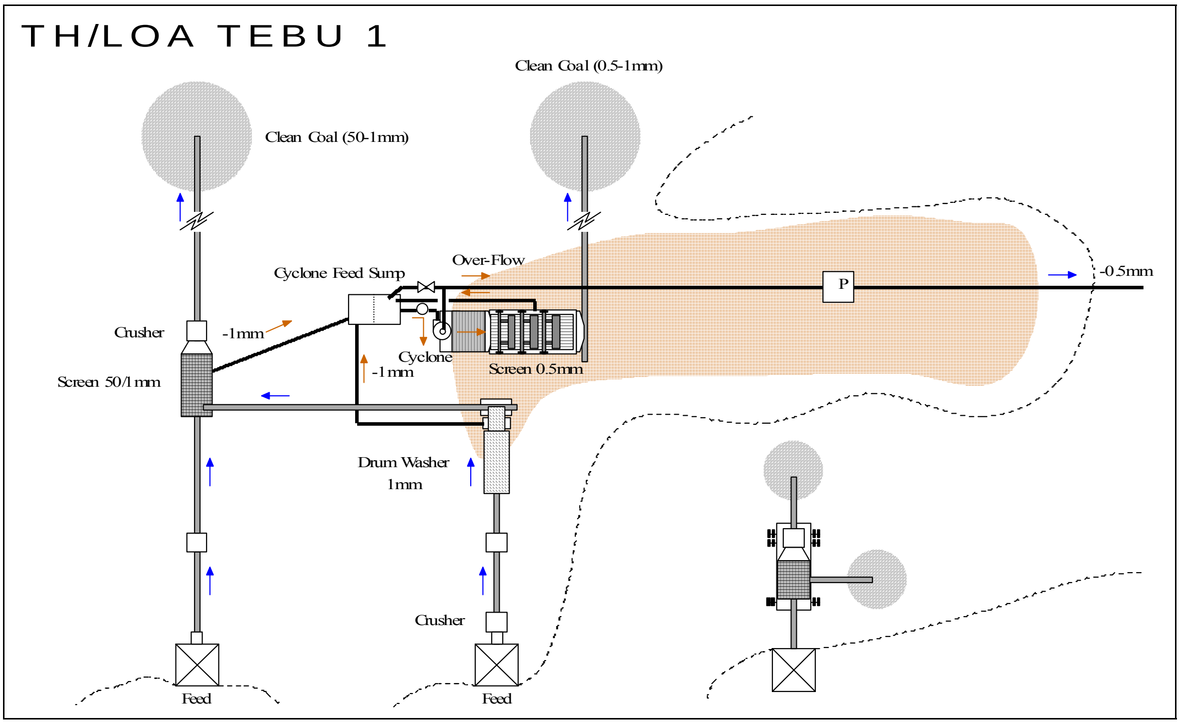


Fig. 4-2-9 Equipment Layout / Loa Tebu 1

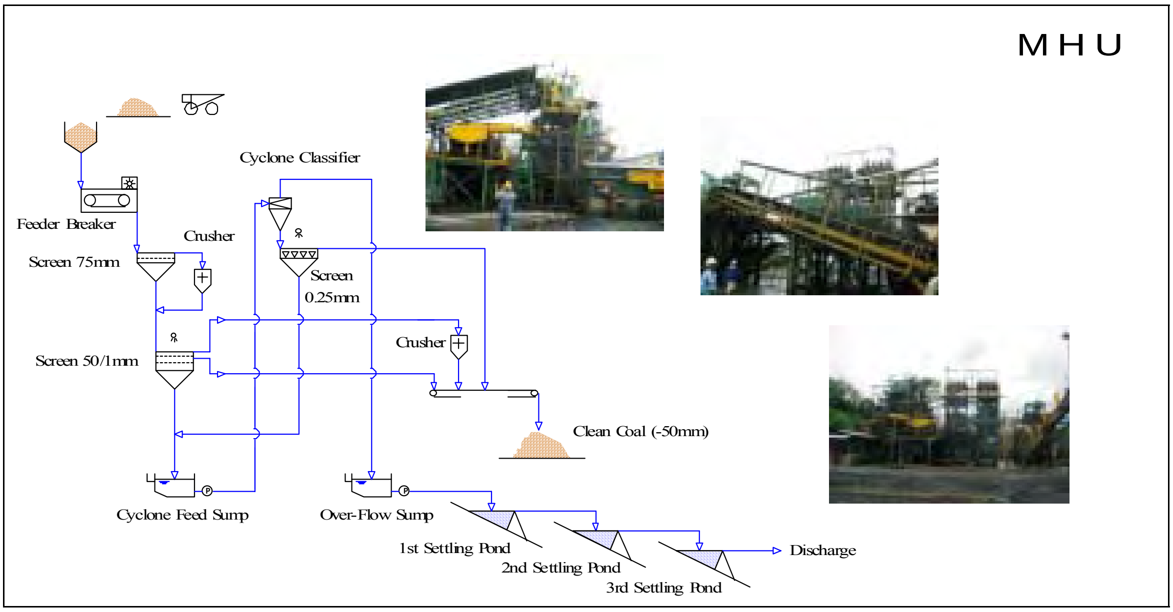


Fig 4-2-10 Flow sheet / MHU

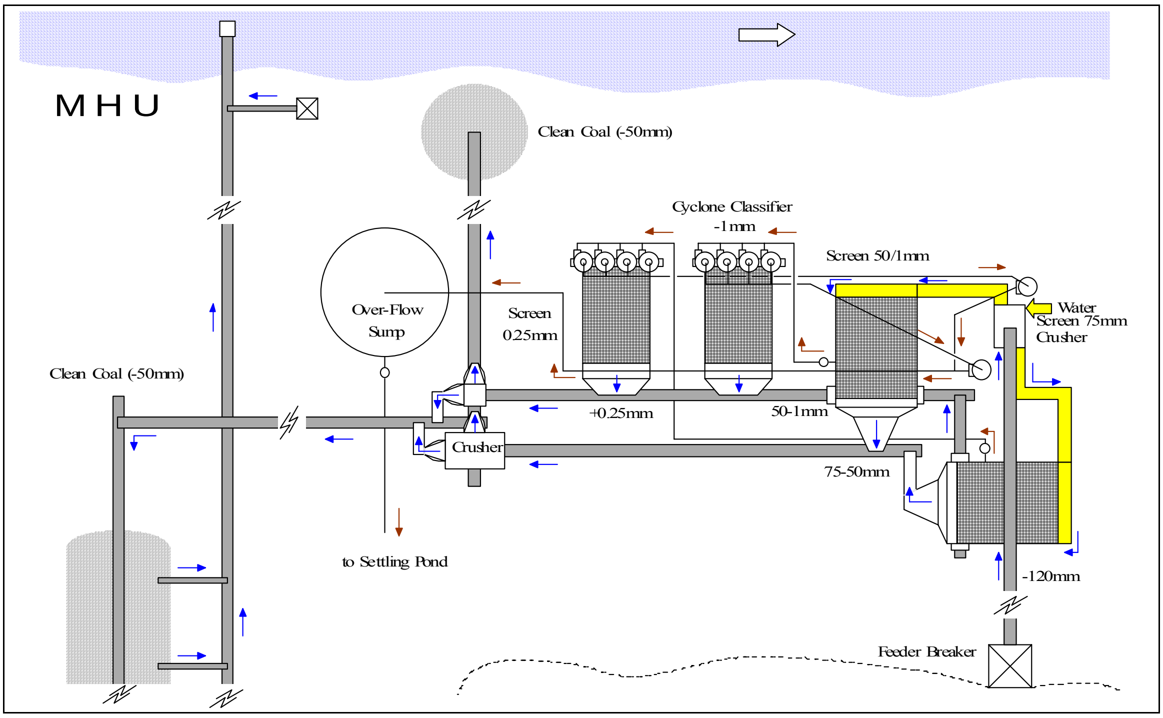


Fig. 4-2-11 Equipment Layout / MHU

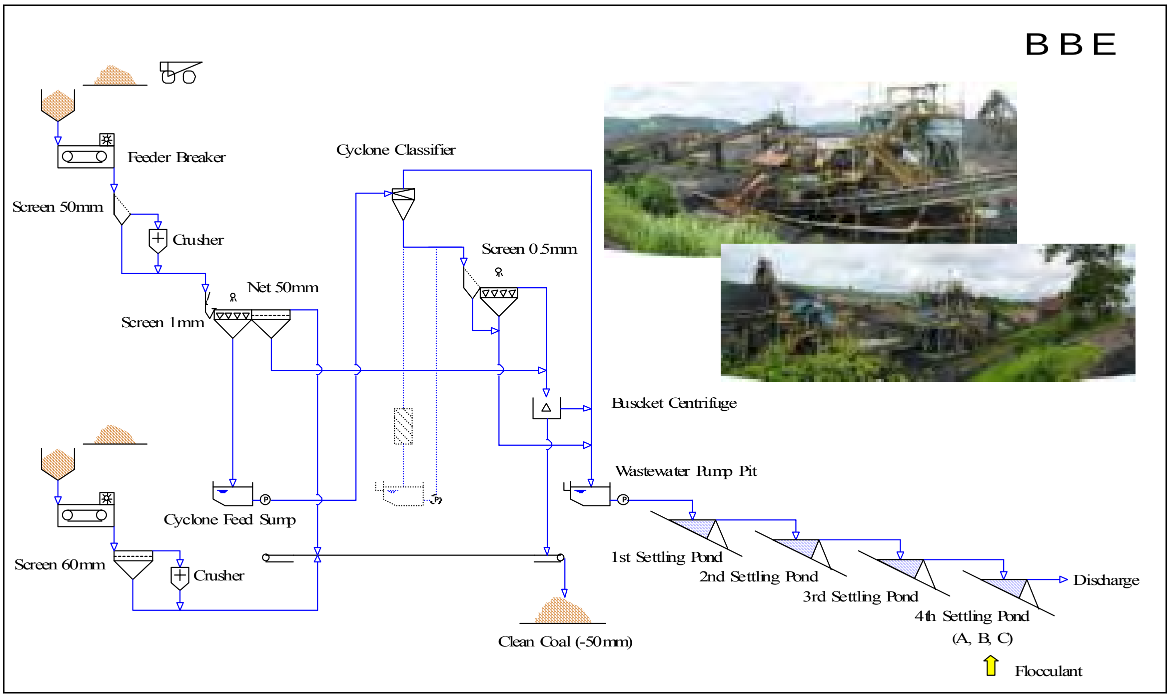


Fig. 4-2-12 Flow sheet / BBE

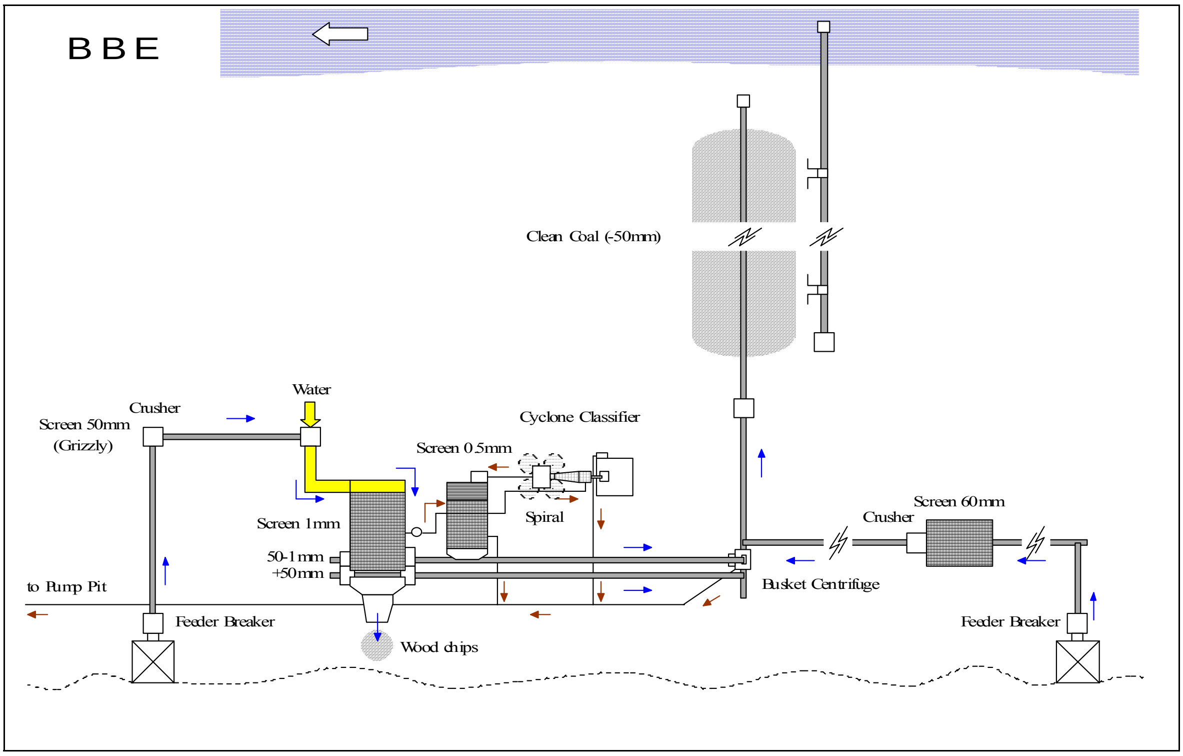


Fig. 4-2-13 Equipment Layout / BBE

2.2 Washing Process / Wastewater Treatment Process Turning point

Table 4-2-2 shows the turning points of the washing process and wastewater treatment process for the six coal washeries that were investigated. A rough grain product (an underflow product) at this turning point gets mixed with clean coal and a fine grain product (an overflow product) is fed into the wastewater treatment process. **Photo 4-2-1** shows an example of the settling pit (including a bucket elevator), while **Photo 4-2-2** shows an example of the cyclone classifier.

Table 4-2-2 Washing / Wastewater process Turning point

Washery	Turning Point		
1 PT. Kitadin	Settling Pit	+	Bucket Elevator
2 PT. Fajar Bumi Sakti (FBS)	De-slime Screen / 0.5mm		
3 PT. Tanito Harum / Sebulu	Settling Pit	+	Bucket Elevator
4 PT. Tanito Harum / Loa Tebu 1	Cyclone Classifier	+	Screen / 0.5mm
5 PT. Multi Harapan Utama (MHU)	Cyclone Classifier	+	Screen / 0.25mm
6 PT. Bukit Baiduri Energy (BBE)	Cyclone Classifier	+	Screen / 0.5mm

Photo 4-2-1 Settling Pit

Photo 4-2-2 Cyclone Classifier.

At FBS, the 0.5mm desliming screen is a turning point and particles of 0.5mm or less in grain size that have passed through the screen are fed as they are into the wastewater treatment process. This is the simplest process of its kind but it is a coarse process that allows many large grain particles to pass out into the wastewater treatment process, so this process produces the largest amount of waste water.

At Kitadin and Sebulu, particles that have passed through the desliming screen are fed into the settling pit where they are separated into underflow and overflow products. Underflow products are mixed with clean coal, while only overflow products are fed into the wastewater treatment process, thus producing a smaller amount of waste water than at FBS. However, as shown in Photo 4-2-1, the settling pit is so small that if it is poorly managed, it will be mostly filled with coal particles and become a mere gutter.

At Loa Tebu 1, MHU and BBE, cyclone classifiers are installed in place of settling pits. If it is well taken care of, a cyclone classifier can separate particles of 100μm or so in grain size into rough grain products and fine grain products. It is the most suitable equipment to separate particles in the coal washing process and the wastewater treatment process. Performance tests were conducted on the cyclone classifier at these three plants. **Table 4-2-3** shows a list of the performances of the cyclone classifiers. **Table 4-2-4** shows a table of the results of performance tests on the cyclone classifiers. **Fig. 4-2-14** shows a partition curve of the cyclone classifier. In the cyclone classifier, a specific-gravity separation phenomenon occurs and if of the same grain size, overflow products have lower ash contents.

Table 4-2-3 List of Performances of Cyclone Classifiers

Washery	Performance of Cyclone Classifier		
	D_{50}	Ep	Yield of Under-flow
4 PT. Tanito Harum / Loa Tebu 1	320μm	220μm	59%
5 PT. Multi Harapan Utama (MHU)	840μm	650μm	20%
6 PT. Bukit Baiduri Energy (BBE)	160μm	125μm	79%

Because samples were taken for only 30 minutes, these may not be representative samples. The cyclone classifier at BBE delivered the highest performance and the grain size of the particles separated by this cyclone was 160μm. The cyclone classifier at Loa Tebu 1 was apparently a home-made machine and was not expected to separate particles remarkably well but it displayed a higher-than-expected accuracy to produce separated particles of 320μm in grain size. The grain size of the particles separated by the cyclone classifier at MHU was unusually large at 840μm. Causes of this must be investigated.

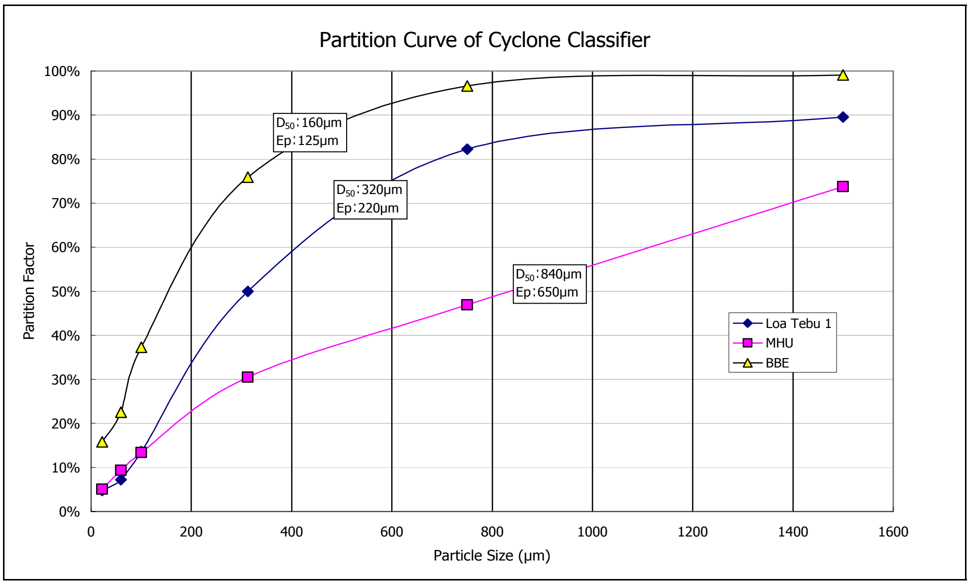


Fig. 4-2-14 Partition Curve of Cyclone Classifiers

Table 4-2-4 Results of Performance tests on Cyclone Classifiers

【Tanito/Loa Tebu 1】 (-ad)

	Feed 15-Jun-06				Under Flow 15-Jun-06				Over Flow 15-Jun-06			
	Wt%	IM%	Ash%	GCV	Wt%	IM%	Ash%	GCV	Wt%	IM%	Ash%	GCV
+1000μm	13.46		2.9	6700	12.05		3.3	6611	1.41		2.6	6669
1000 - 500	31.04		4.0	6612	25.53		4.9	6478	5.51		3.1	6628
500 - 125	39.79		9.9	6177	19.88		6.9	6311	19.92		8.5	6178
125 - 75	4.85		23.8	5035	0.66		25.4	4770	4.19		12.5	5845
75 - 44	4.08		37.4	4007	0.29		43.8	3237	3.79		23.3	4945
-44	6.77		57.6	2546	0.32		52.2	2538	6.45		51.1	2629
Total	100.00		12.15	5993	58.73		5.93	6392	41.27		16.00	5554

【MHU】 (-ad)

	Feed 16-Dec-06				Under Flow 16-Dec-06				Over Flow 16-Dec-06			
	Wt%	IM%	Ash%	GCV	Wt%	IM%	Ash%	GCV	Wt%	IM%	Ash%	GCV
+1000μm	3.65	6.7	4.8	6695	2.69	6.8	7.3	6486	0.96	4.6	2.9	6853
1000 - 500	11.42	6.8	6.5	6553	5.36	6.8	6.9	6520	6.06	5.8	4.9	6686
500 - 125	26.40	6.8	9.2	6328	8.05	7.0	12.3	6069	18.35	6.2	8.2	6411
125 - 75	10.31	6.8	15.9	5769	1.38	5.7	26.0	4927	8.93	6.2	14.3	5902
75 - 44	7.57	6.7	20.7	5369	0.71	5.1	36.4	4059	6.86	6.0	20.2	5410
-44	40.65	6.7	49.7	2950	2.04	5.4	53.1	2666	38.61	4.9	50.0	2925
Total	100.00	6.7	26.8	4864	20.24	6.6	16.1	5752	79.76	5.5	29.8	4607

【BBE】 (-ad)

	Feed 7-Dec-06				Under Flow 7-Dec-06				Over Flow 7-Dec-06			
	Wt%	IM%	Ash%	GCV	Wt%	IM%	Ash%	GCV	Wt%	IM%	Ash%	GCV
+1000μm	36.37	13.1	4.6	5867	36.04	12.8	4.4	5882	0.33	8.3	2.3	6046
1000 - 500	24.16	13.1	4.9	5843	23.34	12.6	4.9	5843	0.82	8.3	2.8	6007
500 - 125	20.83	12.8	6.1	5750	15.80	12.4	6.2	5742	5.03	10.4	4.3	5890
125 - 75	4.90	12.0	9.8	5461	1.83	11.1	14.9	5062	3.07	13.0	6.6	5711
75 - 44	3.17	11.6	12.5	5250	0.71	9.9	23.1	4422	2.45	11.1	9.5	5484
-44	10.57	7.7	39.7	3125	1.67	7.0	42.9	2876	8.91	7.8	40.2	3086
Total	100.00	12.4	9.2	5507	79.39	12.5	6.1	5748	20.61	9.6	20.7	4611

2.3 Wastewater treatment process

Table 4-2-5 shows the properties of the raw water sent to the wastewater treatment process. It is supplied at a flow rate of approximately 2-5m^3/min. and has a solids concentration of 3-8% or so. The solids are fed into the wastewater process at 4 – 20t/h. The solids have a calorific value of 3,000 – 4,000kcal/kg.

Table 4-2-5 Raw water properties of Wastewatertreatment process

	Washery	Flow rate (m^3/min)	Conc. (%)	Solid (t/h)	IM (%-ad)	Ash (%-ad)	GCV (kcal/kg-ad)
1	PT. Kitadin	5.30	4.21	13.4	5.0	49.2	2960
2	PT. Fajar Bumi Sakti (FBS)	1.85	3.08	3.4	5.3	49.3	2962
3	PT. Tanito Harum / Sebulu	No-Operating					
4	PT. Tanito Harum / Loa Tebu 1	1.96	8.24	9.7	5.7	40.2	3539
5	PT. Malti Harapan Utama (MHU)	4.53	7.31	19.9	5.7	38.9	3992
6	PT. Bukit Baiduri Energy (BBE)	4.20	2.53	6.4	7.1	33.4	3687

Table 4-2-6 shows the wastewater generating proportion. This proportion is a value obtained by dividing the solids amount given in the above table by the raw coal capacity of the washery. About 3 – 7% of raw coal is a wastewater generating rate.

Table 4-2-6 Wastewater Generating Proportion

Washery	Capacity (t/h)	Solid (t/h)	Solod / Capacity
1 PT. Kitadin	60+120	13.4	7.4%
2 PT. Fajar Bumi Sakti (FBS)	100	3.4	3.4%
3 PT. Tanito Harum / Sebulu			
4 PT. Tanito Harum / Loa Tebu 1	105 ※	9.7	9.2%
5 PT. Malti Harapan Utama (MHU)	400	19.9	5.0%
6 PT. Bukit Baiduri Energy (BBE)	250	6.4	2.6%

※ Loa Tebu 1::70t/h*150% (Over Load)

These wastewaters are treated by the natural sedimentation method in a settling pond. The solids that have settled out are regularly dredged and dried in the sun. **Table 4-2-7** shows the various data for the dredged-out sedimentation. The annual volume of deposits produced is the value obtained by the output by the abovementioned ratio of waste water and uses of deposits were based on the interviews conducted at the plants.

Table 4-2-7 Various Data for Dredged-out Sedimentation

Washery	Ammount (1000t/y)	IM (%-ad)	Ash (%-ad)	GCV (kcal/kg)	TS (%-ad)	Remarks
1 PT. Kitadin	120		19.1	4905	0.40	Waste
2 PT. Fajar Bumi Sakti (FBS)	9	5.5	33.9	4259	1.73	Waste
3 PT. Tanito Harum / Sebulu			12.7	6470	1.75	Waste
4 PT. Tanito Harum / Loa Tebu 1	148	5.9	48.1	3200	0.25	Waste
5 PT. Malti Harapan Utama (MHU)	45	6.2	27.7	4745	1.65	Waste
6 PT. Bukit Baiduri Energy (BBE)	43	7.3	37.8	3437	0.84	Waste

Dredged-out Sedimentation that contains rough grains is high in grade and the primary settling pond with numerous rough grains is producing high-grade particles. High-grade particles produced at Sebulu were attributable to the influx of coal from the coal storage yard during rainfalls. Therefore, the representative calorific value of wastewater may be 3,000-4,000 kcal/kg measured at the wastewater-producing areas in **Table 4-2-5.**

(1) PT. Kitadin

Fig. 4-2-15 shows the settling pond layout. The system consists of consecutive settling ponds 1 – 4. Most of the solids settle in the first settling pond. Periodic dredging is carried out only in the first settling pond. The dredged-out sediment is then sun-dried and discarded in its entirety. The overflow water from the first settling pond consecutively flows through the second through to the fourth settling ponds and is discharged in to the Mahakam River. At the outlet of the third settling pond, a circulated water pit is installed and a certain part of the water is sent to the coal washery for Jig washing water and the shortfall is made up by water drawn from the Mahakam River. At the overflow aperture of the second settling pond and the circulated water pit outlet, a coagulant dosing unit is provided. **Table 4-2-8** shows the properties of the raw water fed into the wastewater treatment process and **Table 4-2-9** presents the properties of the sediment. The sediment has a high calorific value of nearly 5,000kcal/kg as displayed by the sediment that had piled up near the first settling pond inlet which had been sampled.

Table 4-2-8 Raw Water of the Wastewater Treatment Process / Kitadin

	Date of Sampling	IM %-ad	Ash %-ad	GCV kcal/kg-ad	Conc. %	Flow rate m^3/min	Size Analysis	Remarks
Kitadin	14-Jun-06		49.2	2960	4.21	5.30※	○	※ Data of Kitadin

Table 4-2-9 Properties of Sediment / Kitadin

	Place of Sampling	Date of Sampling	IM %-ad	Ash %-ad	GCV kcal/kg-ad	TS %-ad	Size Analysis	Remarks
Kitadin	1st Pond Drying	14-Jun-06		19.1	4905	0.40	○	

(2) PT. Fajar Bumi Sakti （FBS）

Fig. 4-2-16 shows the settling pond layout. The system consists of three consecutive settling ponds (1 – 3). Most of the solids settle in the first settling pond. Periodic dredging is carried out only in the first settling pond. The dredged-out sediment is sun-dried and most of it is discarded. Similar to Kitadin, the settling pond of this plant also receives underground coal but there are more sandy minerals than clayey minerals. As a result, there are few fine clay particles in the wastewater and compared with other coal cleaning plants the settling properties of this coal are very favorable. Near the final discharge outlet, a circulated water pit is installed so that the entire coal washing water requirement is met with the circulated water. **Table 4-2-10** shows the properties of the raw water fed into the wastewater treatment process and **Table 4-2-11** presents the properties of the sediment.

Table 4-2-10 Raw Water of the Wastewater Treatment Process / FBS

	Date of Sampling	IM %-ad	Ash %-ad	GCV kcal/kg-ad	Conc. %	Flow rate m^3/min	Size Analysis	Remarks
FBS	10-Jul-06	5.0	43.2	3466	3.52			
	10-Jul-06	5.0	53.4	2623	2.69			
	11-Jul-06	5.4	44.8	3334	1.70			
	11-Jul-06	5.0	51.8	2755	2.27			
	12-Jul-06	4.9	53.7	2598	3.17			
	12-Jul-06	5.2	46.5	3193	4.93			
	22-Sep-06	5.0	57.5	2285	3.26	1.85		
	22-Sep-06	6.8	43.5	3442			○	
	Average	5.3	49.3	2962	3.08	1.85		

Table 4-2-11 Properties of Sediment / FBS

	Place of Sampling	Date of Sampling	IM %-ad	Ash %-ad	GCV kcal/kg-ad	TS %-ad	Size Analysis	Remarks
FBS	1st Pond Settling	15-Jun-06		41.8	3585	3.13	○	
	1st Pond Settling	7-Aug-06		27.7	4857	1.70	○	
	1st Pond Settling	22-Sep-06	5.3	48.5	3028			
	1st Pond Settling	22-Sep-06	5.3	44.0	3400			
	1st Pond Settling	22-Sep-06	5.8	45.4	3284			
	1st Pond Drying	15-Jun-06		36.2	4155	1.66	○	
	1st Pond Drying	21-Jun-06		15.9	5728	0.98	○	Inflow of coal from yard.
	1st Pond Drying	1-Aug-06		47.5	3182	2.49	○	
	Average		5.5	38.4	3902	1.99		

The underground water that flows into the FBS coalmine is pumped into the large second settling pond. As a result, there is no shortage of water for coal washing. The first settling pond is short and has the shape of a long and narrow water channel with little sedimentation. The height of the overflow of the first settling pond should be adjusted with sandbags or similar in accordance with the height to which sediment has accumulated.

(3) PT. Tanito Harumu / Sebulu

Fig. 4-2-17 shows the settling pond layout. It consists of three settling ponds (1 – 3). All of these settling ponds are dredged at regular intervals and the sediment is discarded after sun drying. At the time of the present study only dry-type classification was in operation and it was not possible therefore to see wastewater generation. **Table 4-2-12** shows the properties of the sediment. During rainfall, the sediment has a high calorific content because of the inflow of coal from the neighboring coal storage yard. The coal in this location has high sulfur content. Pyrites sulfur oxidation and rainfall leads to the formation of high-iron and acidic water. The acidity is neutralized with milk of lime (**Photos 4-2-3 and 4-2-4**).

Table 4-2-12 Properties of Sediment / Sebulu

	Place of Sampling	Date of Sampling	IM %-ad	Ash %-ad	GCV kcal/kg-ad	TS %-ad	Size Analysis	Remarks
Sebulu	1st Pond Settling	19-Jun-06		12.7	6470	1.75		

Photo 4-2-3 Hi-Fe Acidic Water

Photo 4-2-4 Neutralization

(4) PT. Tanito Harumu / Loa Tebu 1

Fig. 4-2-18 shows the settling pond layout. The system consists of five settling ponds (1 – 5) and an emergency pond. After pumping wastewater to the first pond, which is located in the hill, the wastewater then flows freely under by gravity. The large first settling pond in the hill has never been dredged. The final fifth settling pond and the emergency pond alone are dredged. The wastewater of this area also contains clayey particles that are difficult to precipitate. At the overflow aperture of the second settling pond and the inlet of the emergency-settling pond, coagulant-adding equipment is installed. **Table 4-2-13** shows the properties of the raw water of the wastewater treatment process and **Table 4-2-14** the properties of the sediment. The September 26 data for the raw water of the wastewater treatment process were obtained by continuous measurement. **Fig. 4-2-19** shows the continuous measurement data.

Table 4-2-13 Raw Water of the Wastewater Treatment Process / Loa Tebu 1

	Date of Sampling	IM %-ad	Ash %-ad	GCV kcal/kg-ad	Conc. %	Flow rate m^3/min	Size Analysis	Remarks
Loa Tebu 1	15-Jun-06		46.2	3038	7.21		○	
	19-Jun-06		43.2	3287	9.61			
	21-Jun-06		44.6	3171	13.94			
	22-Jun-06		47.9	2896	9.33			
	28-Sep-06 10:30	6.2	29.0	4470	5.22			
	28-Sep-06 11:30	5.3	40.8	3487	4.97			
	28-Sep-06 13:00	5.6	35.2	3954	6.74	1.96		
	28-Sep-06 13:30	6.0	31.8	4237	8.12			
	28-Sep-06 14:30	5.2	42.9	3312	9.02			
	Average	5.7	40.2	3539	8.24	1.96		

Table 4-2-14 Properties of Sediment / Loa Tebu 1

	Place of Sampling	Date of Sampling	IM %-ad	Ash %-ad	GCV kcal/kg-ad	TS %-ad	Size Analysis	Remarks
Loa Tebu 1	Emg. Pond Drying	15-Jun-06		35.2	4263	0.37	○	
	Last Pond Drying	15-Jun-06		36.7	4032	0.21	○	
	Last Pond Drying	1-Aug-06	5.9	59.9	2266	0.20		
	Last Pond Drying	7-Aug-06	5.8	60.4	2237	0.23		
	Average		5.9	48.1	3200	0.25		

(5) PT. Multi Harapan Utama （MHU）

Fig. 4-2-20 shows the settling pond layout. The system consists of three settling ponds (1 – 3). Most of the solids settle in the large first pond. There are no records of the ponds' having been dredged before. **Table 4-2-15** shows the properties of the raw water of the wastewater treatment process and **Table 4-2-16** the properties of the sediment. The September 25 data for the raw water of the wastewater treatment process were obtained by continuous measurement. **Fig. 4-2-21** shows the continuous measurement data. The wastewater is intermittently pumped to the first settling pond via a wastewater-collecting tank. The frequent ON/OFF cycling may be due to improper operational settings. **Fig. 4-2-22** shows the results of repeat measurements made in December. The operational settings were corrected and the frequent ON/OFF cycling no longer occurred.

Table 4-2-15 Raw Water of the Wastewater Treatment Process / MHU

	Date of Sampling		IM %-ad	Ash %-ad	GCV kcal/kg-ad	Conc. %	Flow rate m^3/min	Size Analysis	Remarks
MHU	15-Jun-06			60.4	2954	7.60			
	21-Jun-06			23.2	5110	1.76			
	25-Sep-06	13:00	6.4	23.3	5154	11.40	4.53	○	
	25-Sep-06	14:00	5.3	45.0	3342	6.64			
	25-Sep-06	15:00	5.6	38.3	3901	9.82			
	25-Sep-06	16:00	5.5	43.2	3492	6.66			
	Average		5.7	38.9	3992	7.31	4.53		

Table 4-2-16 Properties of Sediment / MHU

	Place of Sampling	Date of Sampling	IM %-ad	Ash %-ad	GCV kcal/kg-ad	TS %-ad	Size Analysis	Remarks
MHU	1st Pond Drying	15-Jun-06		29.4	4639	0.33	○	
	1st Pond Drying	7-Aug-06	6.2	26.0	4850	2.96		
	Average		6.2	27.7	4745	1.65		

The wastewater of this area also contains clayey particles that are difficult to precipitate. There is no coagulant-adding equipment. The land in this location is owned by TANITO HARUM (Mining Company). With the development of the Company's new open-cut mine the second and third settling ponds were again reduced in size (**Photo 4-2-5**). The use of coagulant-adding equipment should be considered.

Photo 4-2-5 Reclamation of Settling Pond

(6) PT. Bukit Baiduri Energy （BBE）

Fig. 4-2-23 shows the settling pond layout. The system consists of six functionally well laid-out settling ponds (1 – 6) that are periodically dredged. The sediment of the first settling pond has a coarse granularity and a high calorific value. It is deposited in large piles. During rainfall, there is danger of washout (**Photo 4-2-6**). Polymer coagulant adding equipment (**Photo 4-2-7)** is also provided and the discharge water is used for agriculture. **Table 4-2-17** shows the properties of the raw water of the wastewater treatment process and **Table 4-2-18** the properties of the sediment. The September 27 data for the raw water of the wastewater treatment process were obtained by continuous measurement. **Fig. 4-2-24** shows the continuous measurement data.

Photo 4-2-6 Large Pile of Sediment

Photo 4-2-7 Polymer Coagulant

Table 4-2-17 Raw Water of the Wastewater Treatment Process / BBE

	Date of Sampling	IM %-ad	Ash %-ad	GCV kcal/kg-ad	Conc. %	Flow rate m^3/min	Size Analysis	Remarks
BBE	20-Jun-06		16.3	5218	6.06			
	23-Jun-06		28.7	4379	3.07			
	27-Sep-06 11:00	6.9	47.8	2493	1.72	4.20		
	27-Sep-06 11:30	7.5	33.9	3578	2.72			
	27-Sep-06 13:30	7.9	33.2	3633	2.55			
	27-Sep-06 14:00	8.0	28.1	4031	2.62			
	27-Sep-06 14:30	5.4	28.4	4008	2.52			
	Average	7.1	33.4	3687	2.53	4.20		

Table 4-2-18 Properties of Sediment / BBE

	Place of Sampling	Date of Sampling	IM %-ad	Ash %-ad	GCV kcal/kg-ad	TS %-ad	Size Analysis	Remarks
BBE	1st Pond Drying	16-Jun-06		23.5	4388		○	
	2nd Pond Drying	16-Jun-06		42.0	2949		○	
	3rd Pond Drying	16-Jun-06		26.8	4133		○	
	3rd Pond Drying	2-Aug-06	7.8	39.0	3594	1.01		
	3rd Pond Drying	8-Aug-06	6.7	57.8	2120	0.67		
	Average		7.3	37.8	3437	0.84		

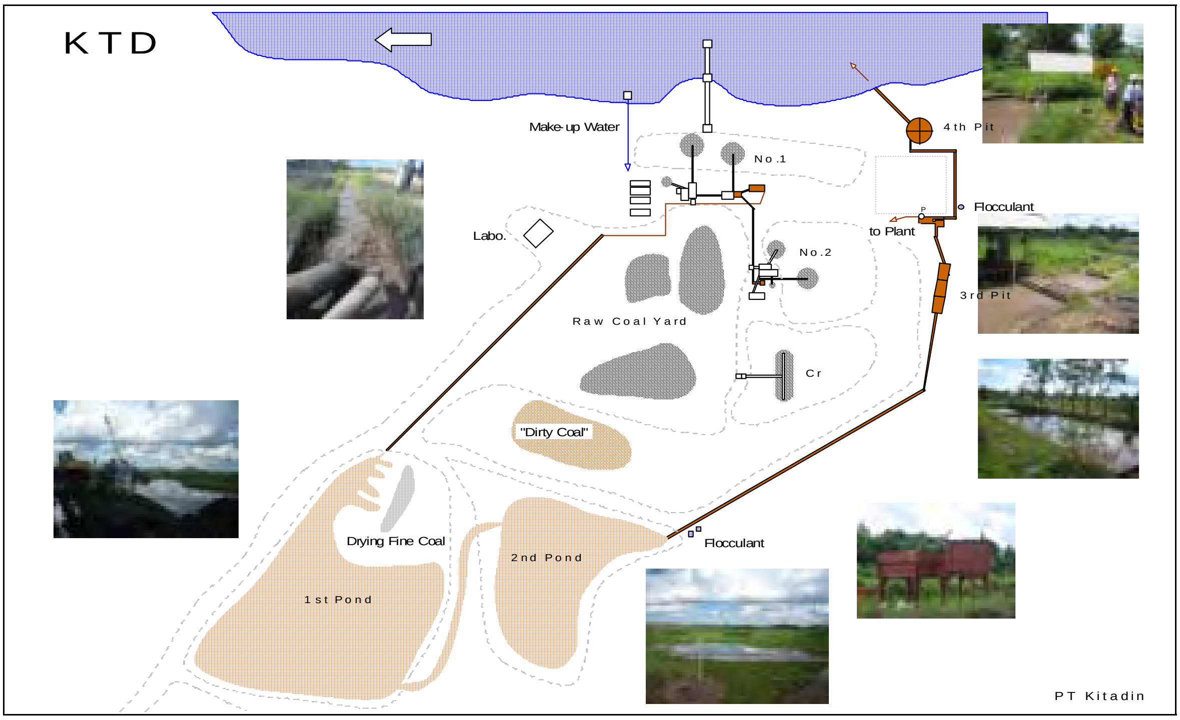


Fig. 4-2-15 Settling Pond Layout / Kitadin

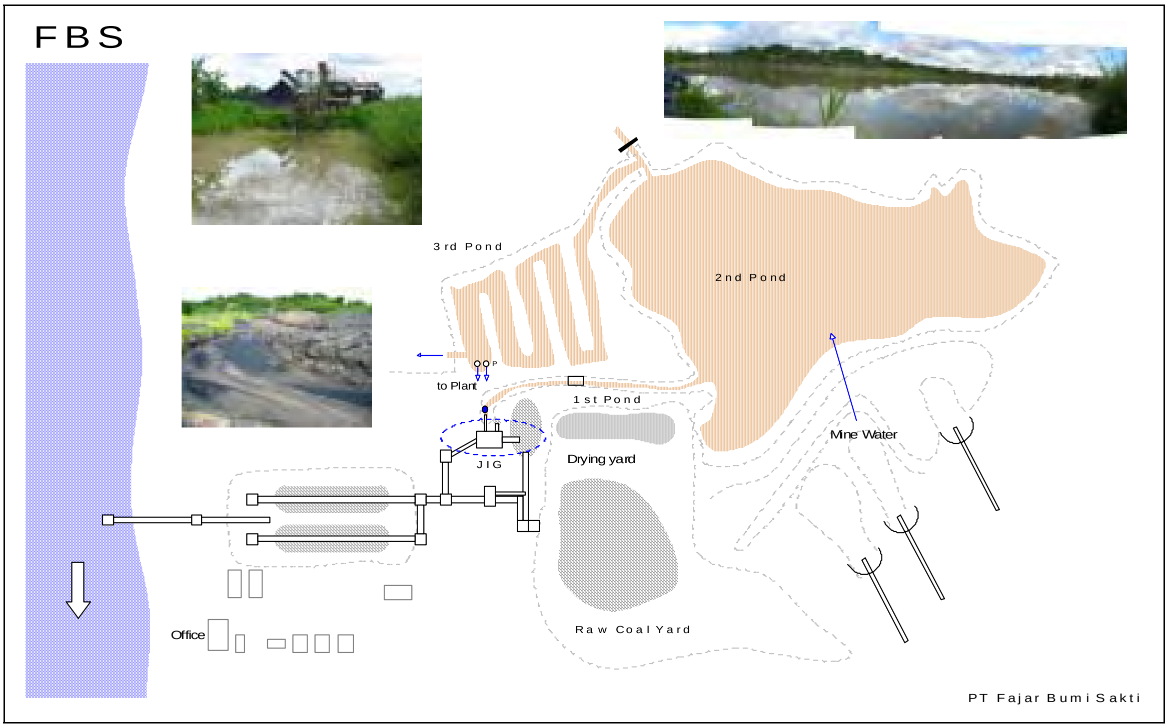


Fig. 4-2-16 Settling Pond Layout / FBS

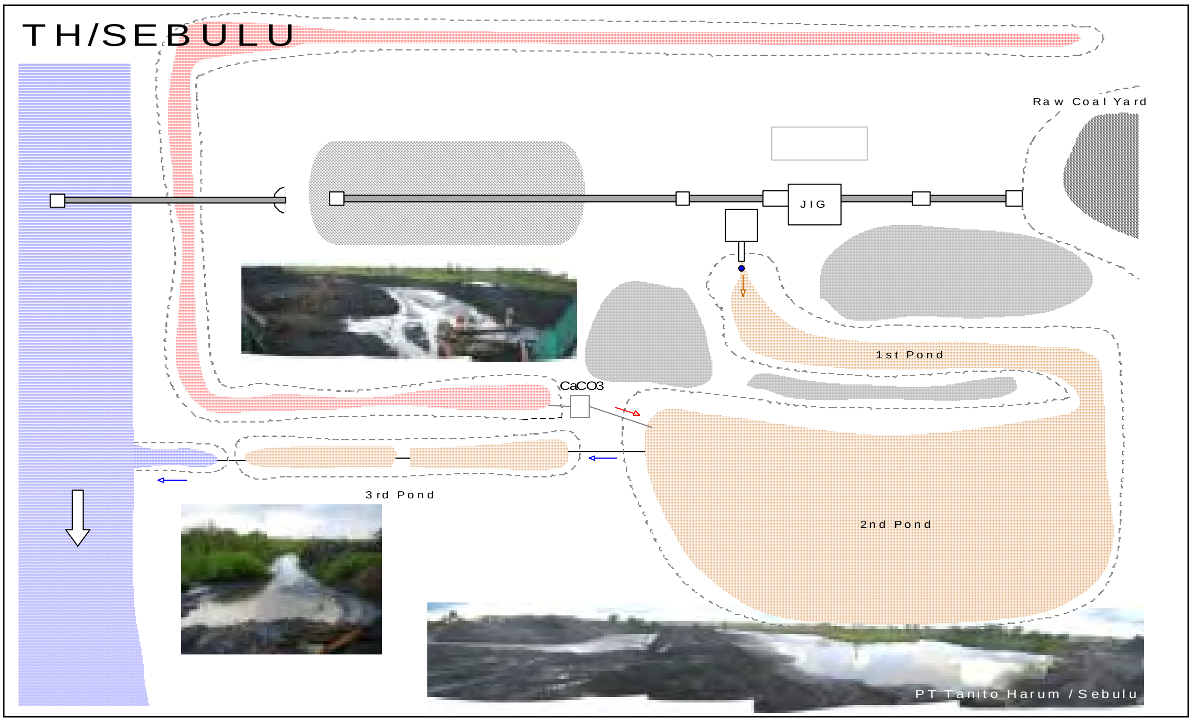


Fig. 4-2-17 Settling Pond Layout / Sebulu

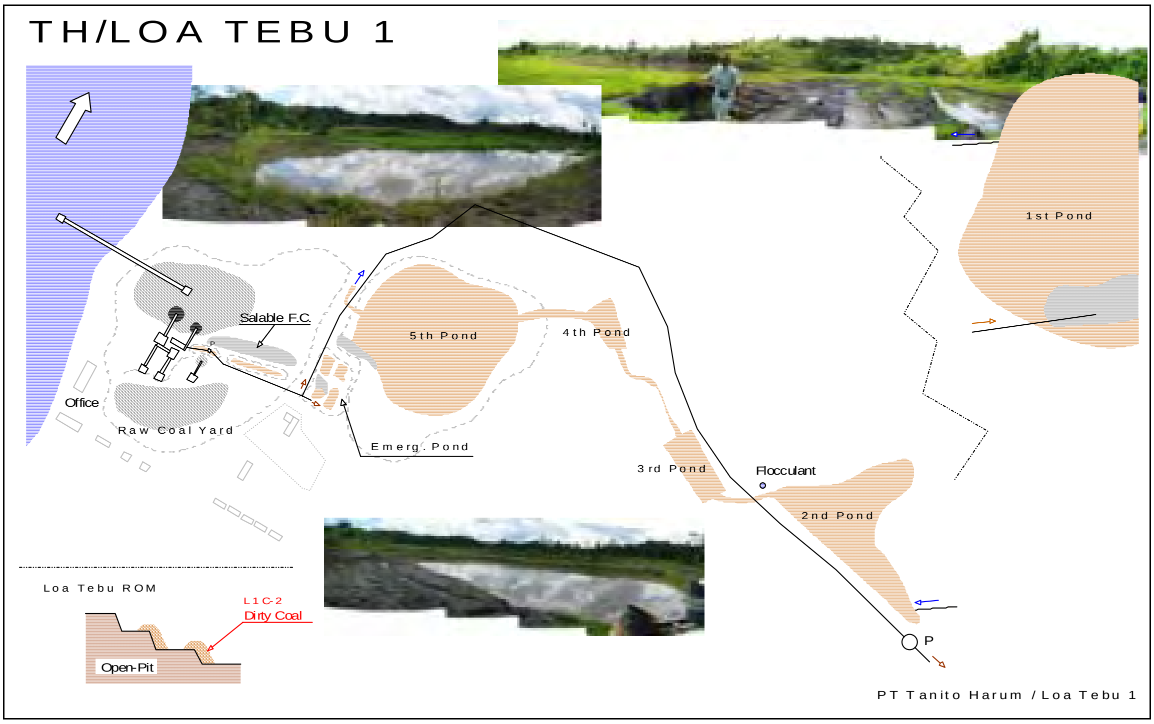


Fig. 4-2-18 Settling Pond Layout / Loa Tebu 1

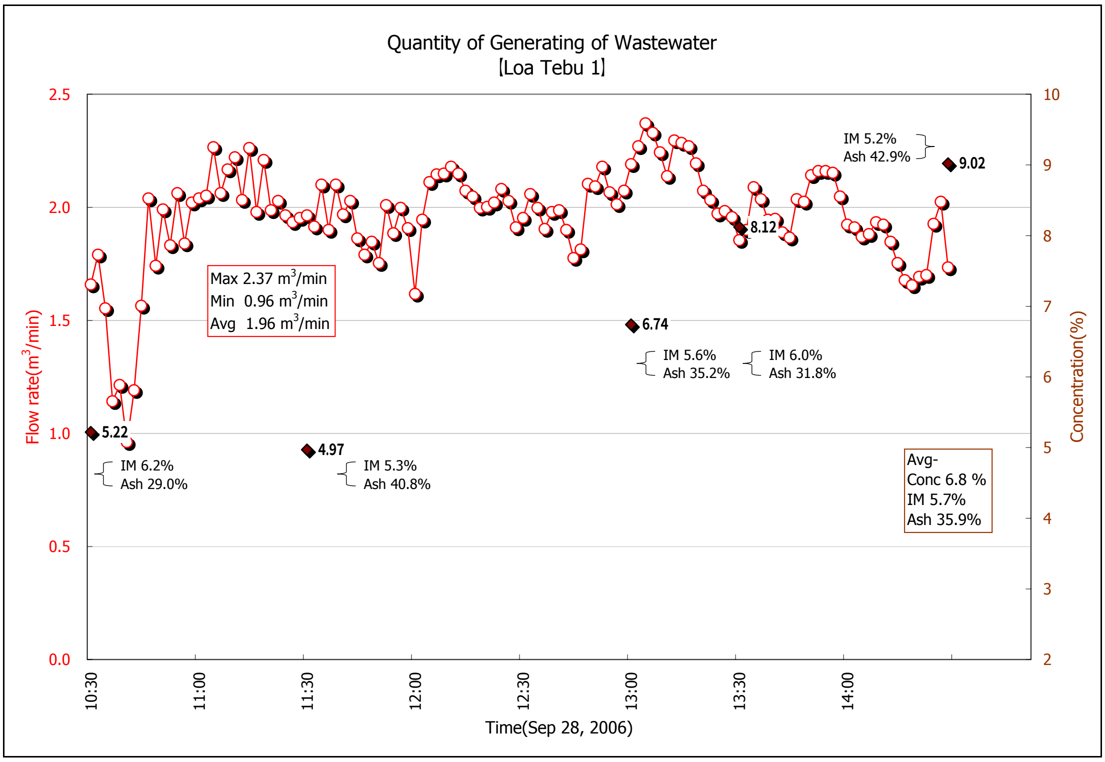


Fig. 4-2-19 Raw Water of Wastewater Treatment Process / Loa Tebu 1

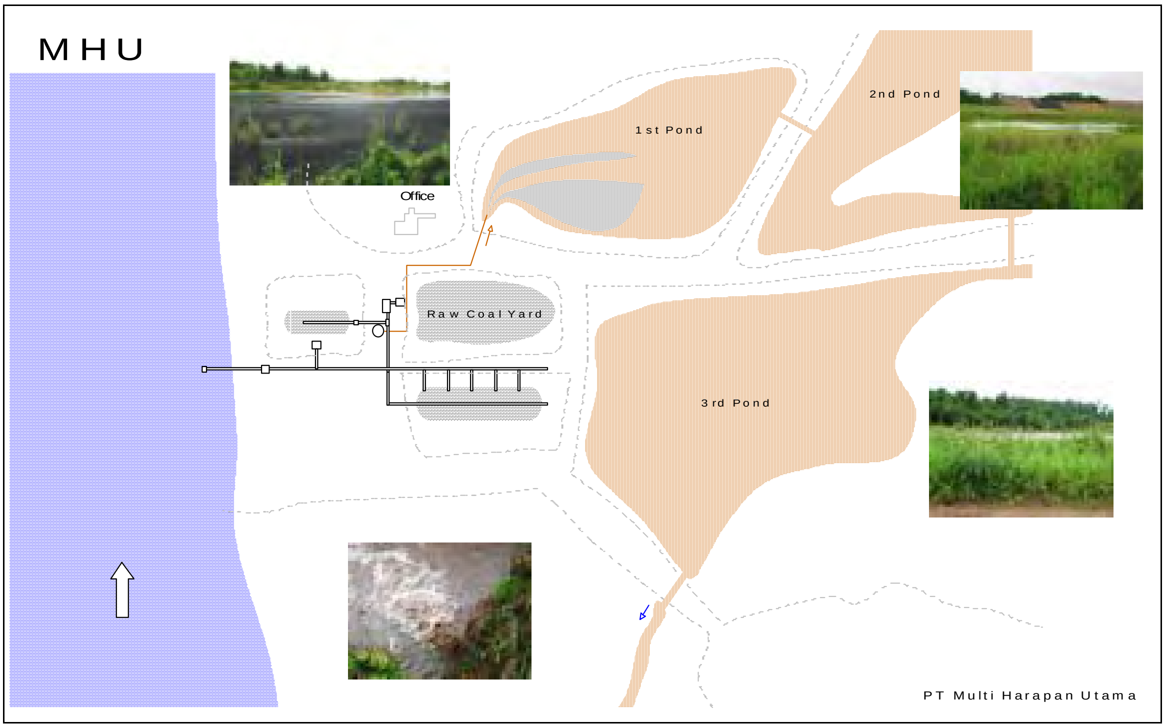


Fig. 4-2-20 Settling Pond Layout / MHU

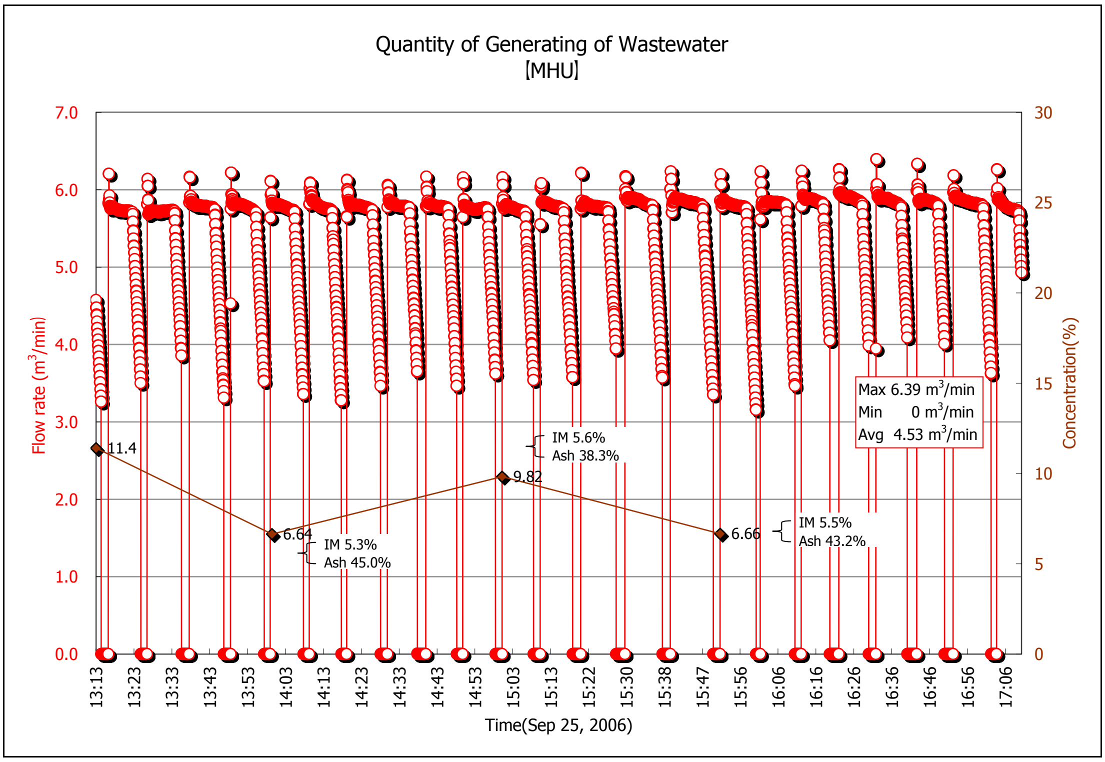


Fig. 4-2-21 Raw Water of Wastewater Treatment Process / MHU (Sep.)

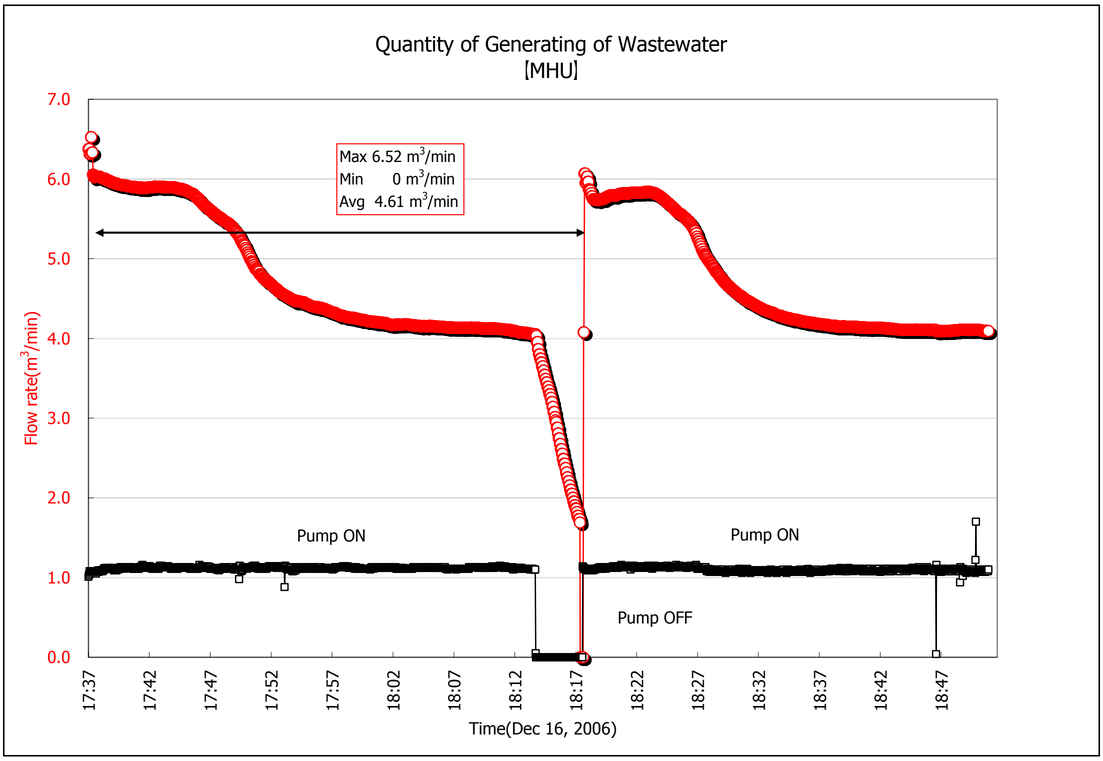


Fig. 4-2-22 Raw Water of Wastewater Treatment Process / MHU (Dec.)

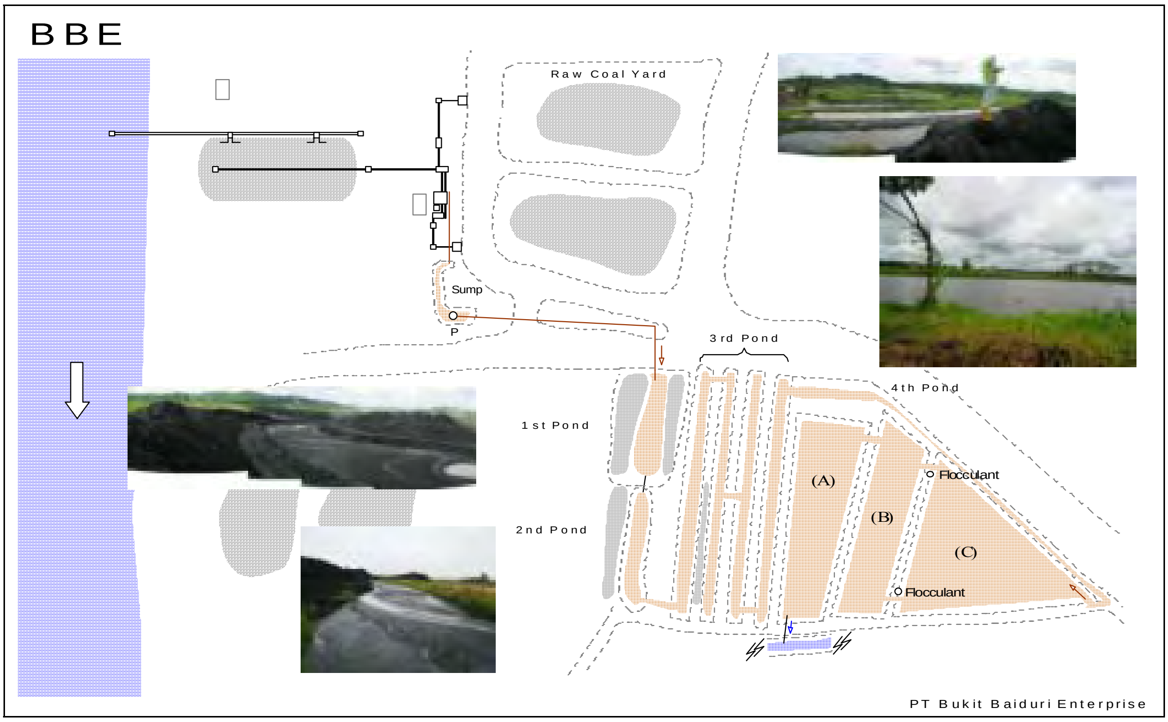


Fig. 4-2-23 Settling Pond Layout / BBE

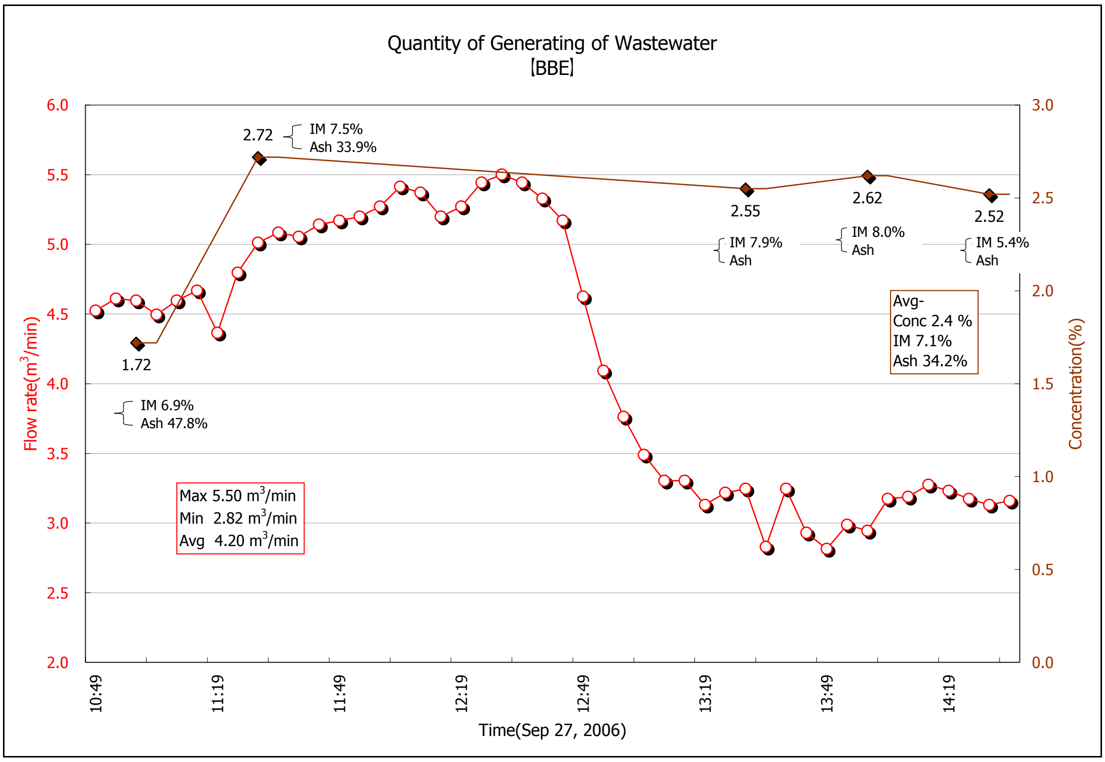


Fig. 4-2-24 Raw Water of Wastewater Treatment Process / BBE

2.4 Discharged Wastewater

(1) Properties of discharged Wastewater / excluding when raining

Table 4-2-19 gives an overview of the properties of the discharged Wastewater (excluding when raining). **Table 4-2-20** presents the measurement data for each discharged wastewater sampling (excluding when raining). In addition, since there is a case which is over an effluent standard, without using an actual name, it is expressed as A, B, C, D, E and F.

Table 4-2-19 Properties of Discharged Wastewater (excluding when raining)

Washery	SS mg/l	pH -	Fe^{ion} mg/l	Mn^{ion} mg/l	Flow rate m^3/min Measure	Flow rate m^3/min Caluc	IM %-ad	Ash %-ad	GCV kcal/kg-ad	Remarks
A	13,550					2.8	5.6	82.0	331	
B	52	7.95	≦0.5	<0.5	0.00	0.0	5.0	48.3	3044	Circulating Water
C	358	3.30	>10	<0.5	0.20			64.8	1298	Short Operating time
D	65	6.20	≦0.5	<0.5	0.18	1.8		62.5	1680	Short Operating time
E	806	6.91	≦0.5	<0.5	0.021	4.2				Short Operating time
F	88	6.66	≦0.5	<0.5	2.49	4.1	1.0	66.2	1056	

"Measure" in the flow rate column gives the actual measurement values obtained in this study. "Caluc" in the flow rate column gives the value calculated by subtracting the solids quantity from the raw water quantity of the wastewater treatment process.

Apart from the fact that the coal washing time is influenced by the quality of the raw coal, the wastewater generated in the coal washing process also takes time to flow through the wastewater treatment process until it is discharged. It is therefore believed that the calculated values provide a better picture of the real situation.

SS are actual measurement data. Because the calculated flow rate data are greater than the actually measured flow rate values in all of the factories, it is likely that flow rate measurement was somewhat too small. Apart from the A-Washery, C-Washery and E-washery, the SS values are within the effluent standard (400mg/l). Fe ion values were within the effluent standard (7mg/l), except for the C-washery, and Mn ion values were within the effluent standard (4mg/l) for all washeries. At present, only washeries A and B receive underground-mined coal. The big differences between the two are that clay minerals are included in A-washery and sandstone minerals are included in B-washery. It can be seen that sandstone minerals with no water absorption and no mud creating properties may not increase SS.

As an example of a continuous measure, **Fig. 4-2-23** (Discharged flow rate) and **Fig. 4-2-24** (Discharged quality) show the December 6 measurement data at F-washery. **Photo 4-2-8** is a view of the continuous measurement instrument arrangement. The continuous measurement methods and the measurement instruments that were used are given in the details in the Technical Transfer section that will be discussed below

Photo 4-2-8 Continuous Measurement Instrument Arrangement

Table 4-2-20 Discharged Wastewater sampling Data (excluding when raining)

Washery	Date of Sampling	SS	pH	Fe^{ion}	Mn^{ion}	Flow rate m^3/min		IM	Ash	GCV	Remarks
		mg/l	-	mg/l	mg/l	Measure	Caluc	%-ad	%-ad	kcal/kg-ad	
A	Jun-06	16,400					2.8		82.6	468	
	Sep-06	12,600						5.7	81.1	339	
		12,800						5.5	82.2	258	
		12,400						5.6	82.2	258	
	Average	13,550					2.8	5.6	82.0	331	
B	Jun-06	10	7.40	< 0.3	< 0.5	0.00		5.0	43.2	3466	Circulating Water
	Sep-06	80	7.80	< 0.3	< 0.5	0.00		5.0	53.4	2623	Circulating Water
	Dec-06 11:00		8.33	0.5	< 0.5						
	Dec-06 15:00		8.00	0.5	< 0.5						
	Dec-06 19:00		8.00	0.5	< 0.5						
	Dec-06 23:00	67	8.00	0.5	< 0.5	0.00					**24H Sampling** Circulating Water
	Dec-06 03:00		8.00	0.5	< 0.5						
	Dec-06 07:00		8.00	0.5	< 0.5						
	Dec-06 11:00		8.00	0.5	< 0.5						
	Average	52	7.95	≦0.5	< 0.5	0.00	0.0	5.0	48.3	3044	Circulating Water
C	Jun-06	320	2.80	> 10	< 0.5	0.20					
	Sep-06 12:00	475	3.80	> 10	< 0.5				64.4	1341	Short Operating time
	Sep-06 12:15	360							61.1	1667	
	Sep-06 12:30	275							69.0	886	
	Average	358	3.30	> 10	< 0.5	0.20			64.8	1298	
D	Jun-06	30	6.20	< 0.3	< 0.5						
	Jun-06	20	6.20	< 0.3	< 0.5						Short Operating time
	Jun-06	70	6.20	0.5	< 0.5						
	Sep-06	138				0.18			62.5	1680	
	Average	65	6.20	≦0.5	< 0.5	0.18	1.8		62.5	1680	
E	Jun-06	1,770	6.80	0.5	< 0.5						
	Jun-06	850	7.00	< 0.3	< 0.5						
	Jun-06	960	6.20	0.5	< 0.5						
	Jun-06	820	6.00	0.5	< 0.5						
	Sep-06	340									
	Dec-06 13:00		7.18	0.5	< 0.5						
	Dec-06 17:00		6.97	< 0.3	< 0.5						
	Dec-06 21:00		6.99	< 0.3	< 0.5						
	Dec-06 01:00		6.99								
	Dec-06 05:00		7.10	0.5	< 0.5						
	Dec-06 09:00	98	7.32			0.021					**48H Sampling** Short Operating time
	Dec-06 13:00		7.23	0.5	< 0.5						
	Dec-06 17:00		7.10	< 0.3	< 0.5						
	Dec-06 21:00		6.85	< 0.3	< 0.5						
	Dec-06 01:00		6.82	< 0.3	< 0.5						
	Dec-06 05:00		6.97	< 0.3	< 0.5						
	Dec-06 09:00		7.00								
	Average	806	6.91	≦0.5	< 0.5	0.021	4.2				
F	Jun-06	20	5.00	0.5	< 0.5						
	Jun-06	20	5.10	< 0.3	< 0.5						
	Jun-06	20	6.00	< 0.3	< 0.5						
	Sep-06	112				2.28					
	Sep-06	109						1.0	66.2	1056	
	Dec-06 11:00		7.20	0.5	< 0.5						
	Dec-06 15:00		7.46								
	Dec-06 19:00	245	7.18	0.5	< 0.5	2.70					**24H Sampling**
	Dec-06 23:00		7.30								
	Dec-06 03:00		7.29	0.5	< 0.5						
	Dec-06 07:00		7.39								
	Average	88	6.66	≦0.5	< 0.5	2.49	4.1	1.0	66.2	1056	

(2) Properties of discharged Wastewater / during rain

Table 4-2-21 shows the measured values obtained by discharged wastewater sampling during rainfalls. The results of continuous measurements conducted at C-Washery are shown in **Fig. 4-2-25** (flow rate of discharged wastewater) and in **Fig. 4-2-26** (quality of discharged wastewater). And the results of continuous measurements conducted at D-Washery are shown in **Fig. 4-2-27** (flow rate of discharged wastewater) and in Fig. **4-2-28** (quality of discharged wastewater).

Table 4-2-21 Measured values obtained by discharged wastewater sampling (during rain)

Washery	Date of Sampling	Rainfall	SS	pH	Fe^{ion}	Mn^{ion}	Flow rate m^3/min		IM	Ash	GCV	Remarks
		mm/h	mg/l	-	mg/l	mg/l	Measure	Caluc	%-ad	%-ad	kcal/kg-ad	
C	Dec-06 13:00	20	Max 395 Min 17 Avg 30	5.64	5.0	< 0.5	0.75					**24H Sampling** No-Operating
	Dec-06 17:00			4.80								
	Dec-06 21:00			3.29	> 10	< 0.5						
	Dec-06 01:00			3.21								
	Dec-06 05:00			3.20	> 10	< 0.5						
	Dec-06 09:00			3.37								
	Average	20	30	3.92	> 10	< 0.5	0.75	0.75				
D	Dec-06 14:00	19	Max 1679 Min 410 Avg 625	5.40	2.0	< 0.5	0.31					**24H Sampling**
	Dec-06 18:00			7.00	2.0	< 0.5						
	Dec-06 22:00			6.60	2.0	< 0.5				78.6	339	
	Dec-06 03:00			5.60	2.0	< 0.5				79.7	247	
	Dec-06 07:00			6.80	2.0	< 0.5						
	Average	19	625	6.28	2.0	< 0.5	0.31	> 1.8		79.2	293	

With regard to C-Washery, it was not possible to measure the rainfall volume because it was raining while the continuous measurement facilities were being installed. We had the impression that it rained for about 20 minutes. The intensity of the rain was about 20mm/h. Because the system was not in operation, the initial discharged wastewater volume was 0 but the volume increased instantly as the rain continued and reached up to 1.5m^3/min. (This too, is a predicted value.) SS also showed a rapid increase and reached 395mg/L. Yet, as soon as the rain stopped the SS level fell again. The pH value, however, continued to decrease, and reached 3.20 roughly 18 hours later. By that time, the rain puddles had disappeared and discharge stopped altogether.

With regard to the D-washery, there was a spell of rain immediately after the continuous measurement facilities had been installed. It was thus possible to actually measure the effect of rainfall. It rained for some 30 minutes or so, and the rain intensity was 19mm/h. The discharged wastewater volume increased instantly with the rainfall and reached up to 0.44m^3/h. Although the discharged wastewater volume decreased rapidly when the rain stopped, it did gradually increase again after this and started to decrease about 17 hours after the rain. SS also increased rapidly, reaching 1679mg/L. When the rain stopped, however, it decreased temporarily and then gradually increased again. While it was increasing, the measurements were stopped. Though it is therefore not clear at what time it started to decrease the high value did continue at for least about 20 hours after the rain.

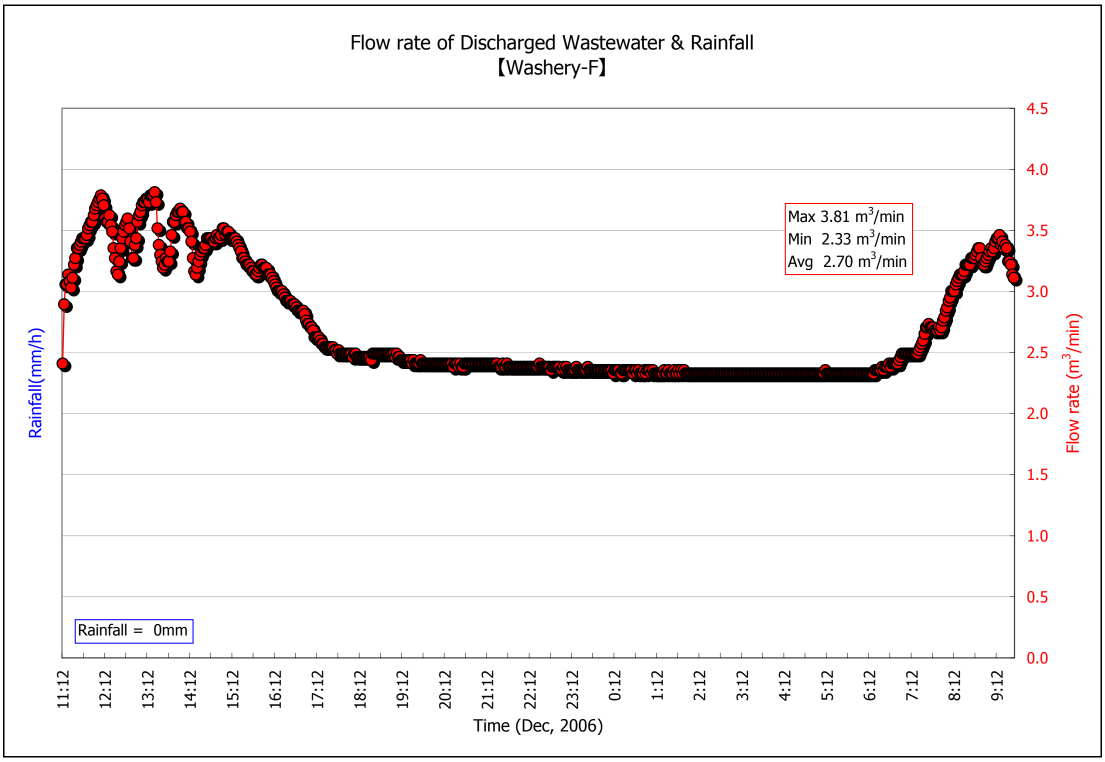


Fig. 4-2-23 Flow rate of Discharged Wastewater / F-Washery

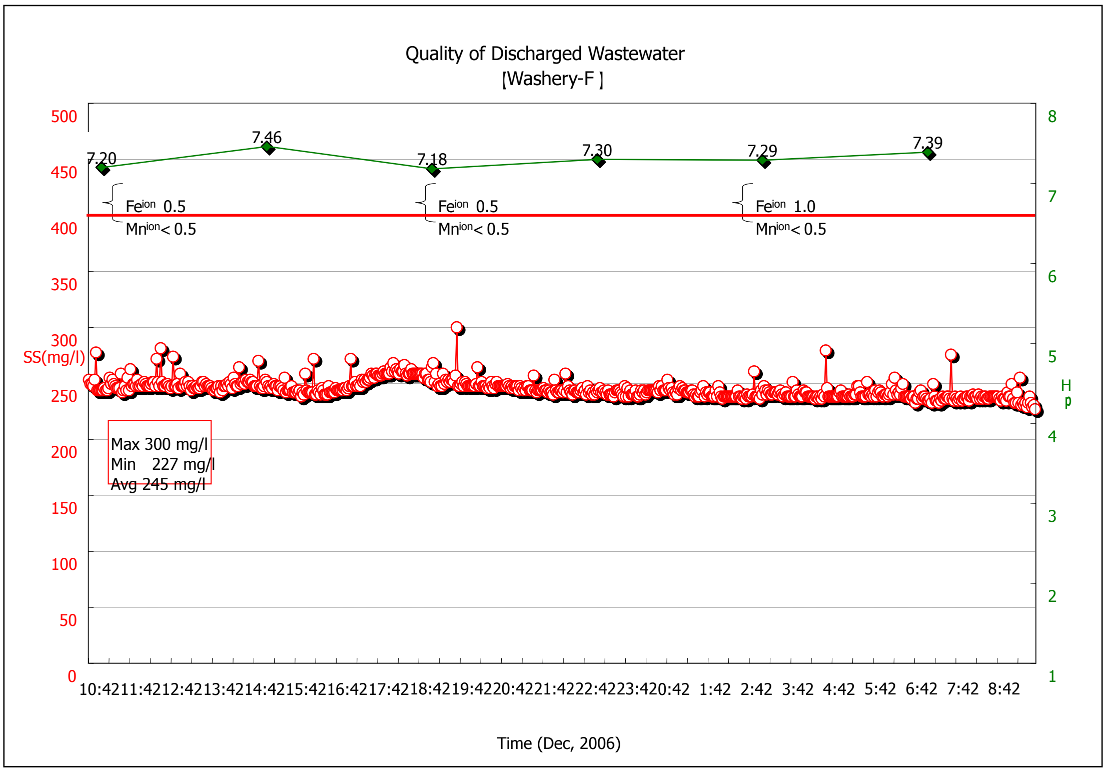


Fig. 4-2-24 Quality of Discharged Wastewater / F-Washery

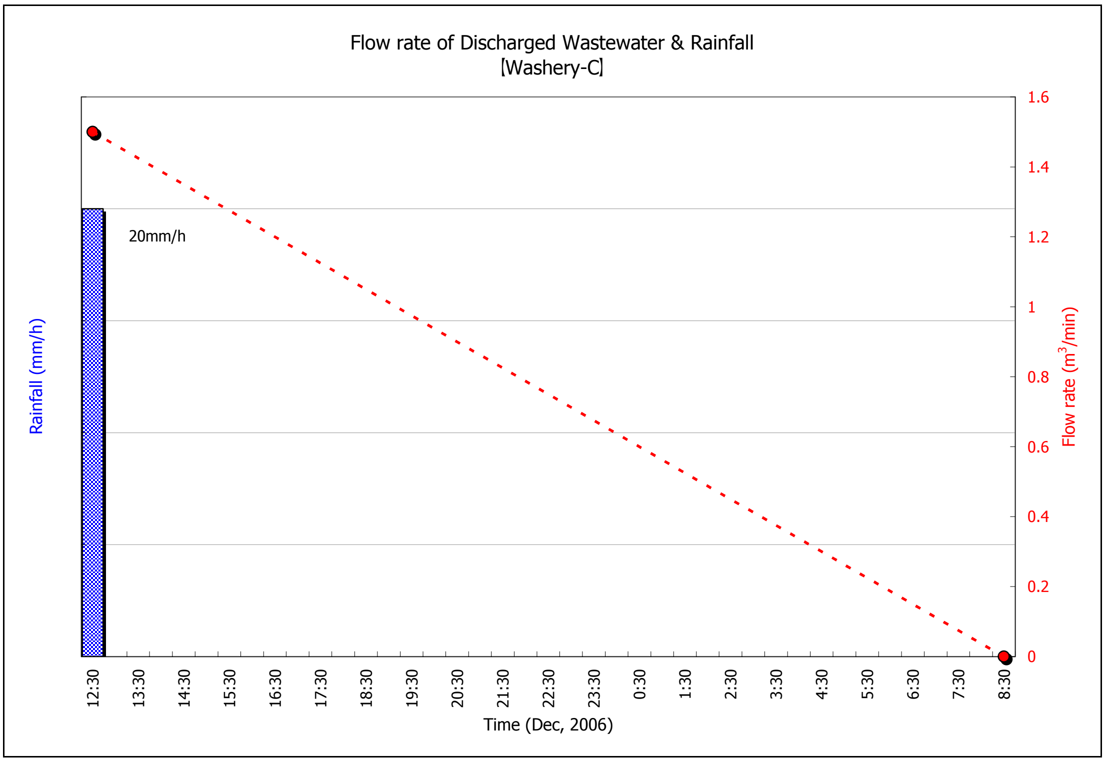


Fig. 4-2-25 Flow rate of Discharged Wastewater / C-Washery

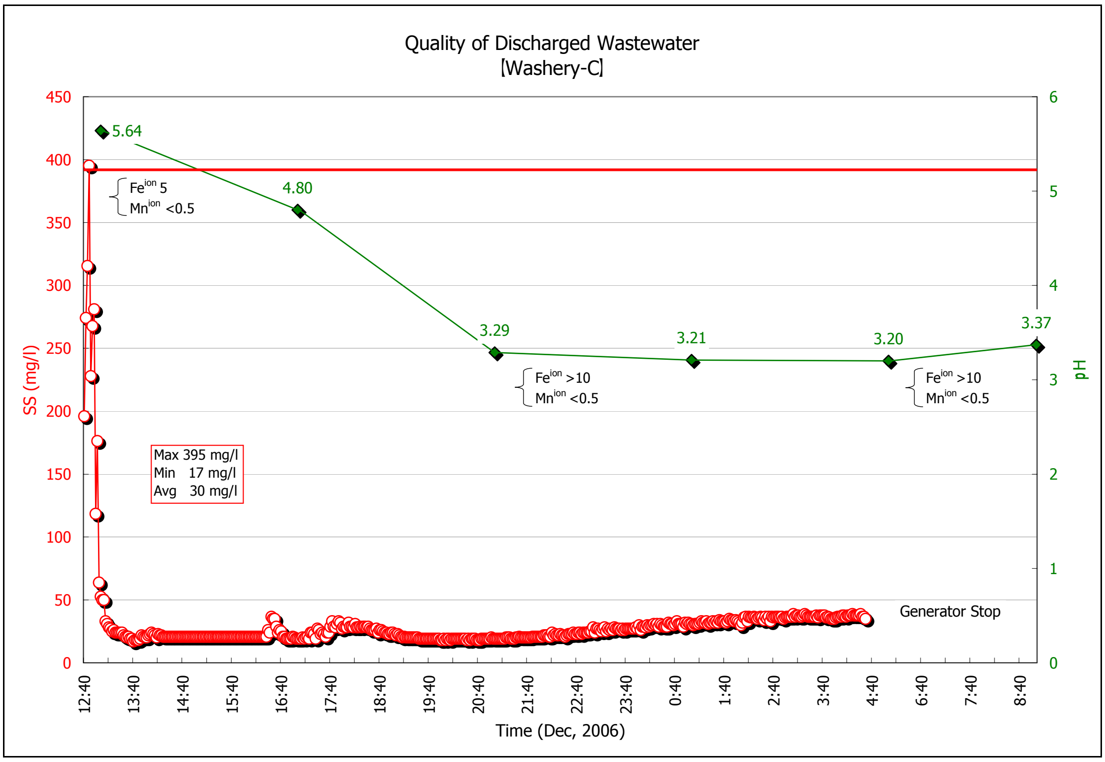


Fig. 4-2-26 Quality of Discharged Wastewater / C-Washery

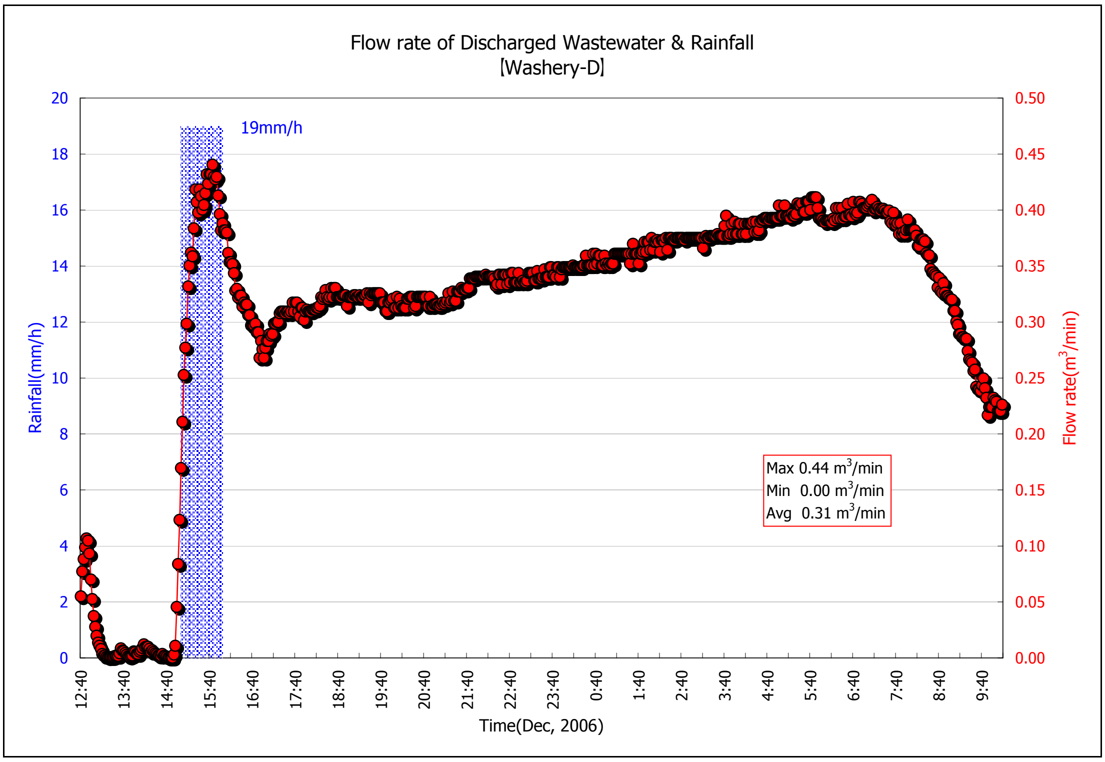


Fig. 4-2-27 Flow rate of Discharged Wastewater / D-Washery

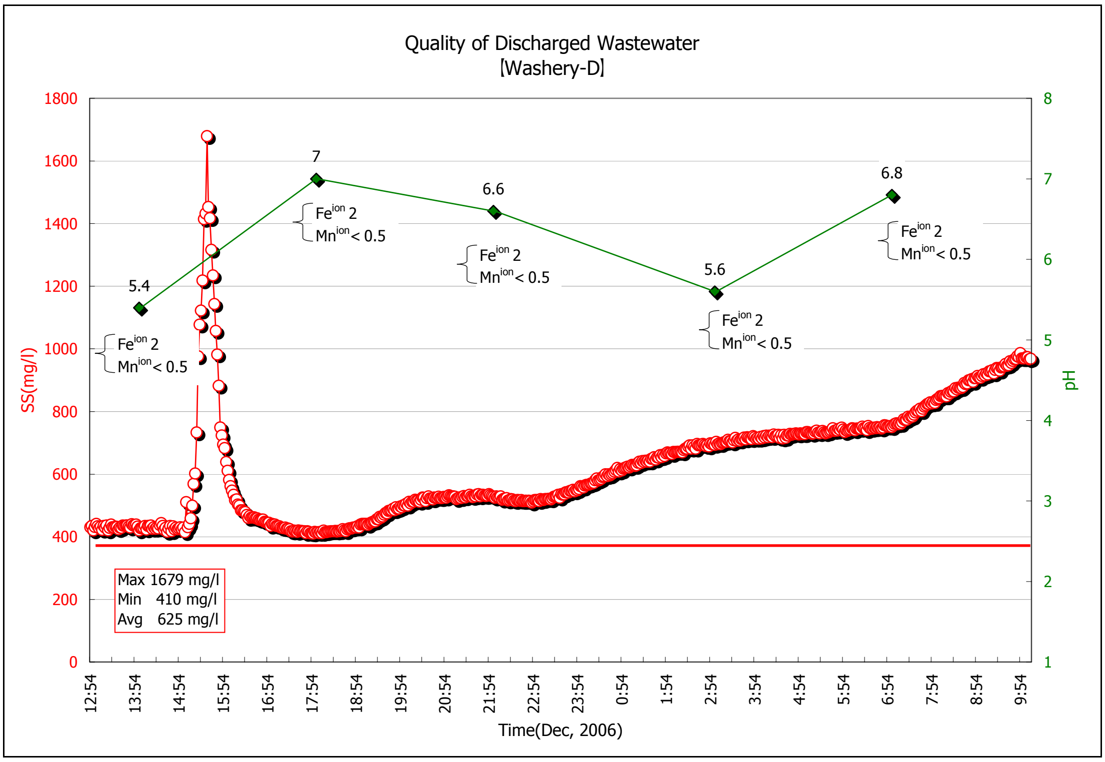


Fig. 4-2-28 Quality of Discharged Wastewater / D-Washery

(3) Forecast annual discharge amount of solids into the Mahakam River

Table 4-2-22 shows the forecast annual amount of solids discharged into the Mahakam River (excluding when raining). The values were obtained by multiplying the calculated flow rate and operating time (16h/day x 300 d/y) with the measured SS.

Table 4-2-22 Forecast annual discharge amount of solids（excluding when raining）

Washery	SS	Flow rate m^3/min		Operating Time			Discharged Solid	Remarks
	mg/l	Measure	Caluc	h/day	d/y	min/y	t/y	
A	13,550		2.8	16	300	288,000	10,920	Under-Ground
B	52	0.00	0.0				0	Under-Ground
C	358	0.20						
D	65	0.18	1.8				30	
E	806	0.021	4.2				970	
F	88	2.49	4.1				100	
Total							12,020	

Fig. 4-2-29 shows the rainfall data (1999) for the city of Samarinda as measured at the Samarinda airport. It shows how great the intensity (mm/h) of the rain was for how many hours in one year. Though it is not clear how much sediment is transported out with the wastewater during discharge at what rainfall level, it is assumed that the effect is significant when it rains at an intensity of 20mm/h. This region is apt to have rainstorms raging for a short time of about 10 or 20 minutes. After a 20mm/h rainfall for a continuous 10 minutes the airport's rain gauge recorded a value of 3.3mm/h. The duration of rainfall at an intensity of 3.3mm/h or above – that is, 105 hours/year – is the number of hours per year in which a high SS level is discharged due to rain.

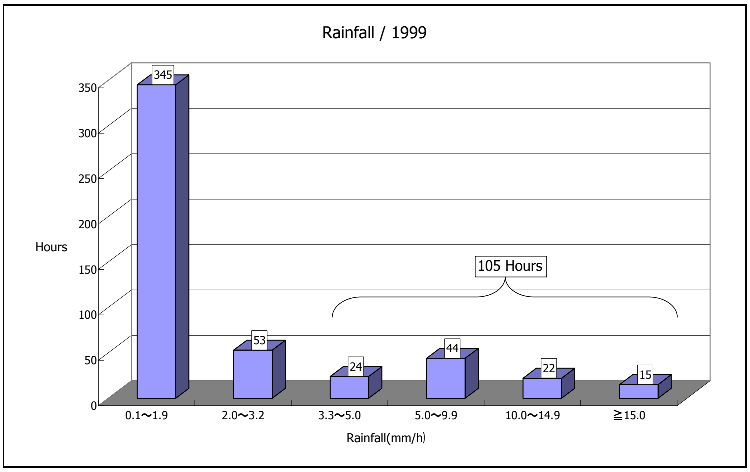


Fig. 4-2-29 the rainfall data (1999) for Samarinda City

Table 4-2-23 shows the estimated amount of solids discharged per year into the Mahakam River that becomes an addition in time of rain. The values have been determined by multiplying the calculated flow rate and the exposure time (105h/y) with the maximum SS during rainfall.

Table 4-2-23 Amount of solids discharged during of rain

Washery	SS	Flow rate m³/min		Discharge time		Discharged Solid	Remarks
	mg/l	Measure	Caluc	h/y	min/y	t/y	
A				105	6,360		
B							
C	395	1.50				3	
D	1,679	0.44	1.8			19	
E							
F							
Total						22	

The flow rates used for calculation in the table above are actual measurement data during rainfall for the C-washery (Before installation of measurement equipment, estimated values were used.) and calculated values used in the discharge prediction for the D-washery when there is no rainfall. The actual measurement value of 0.44m^3/min for D-washery is a flow rate that is far too small compared to the vast ground area of the coal washing plant (including the wastewater treatment process). Even when discharge during no-rainfall periods is concentrated to only one location, namely, the final discharge aperture, it can be surmised that during rainfalls, rain in excess of the maximum allowable retention volume from the various parts of the plant will entrain the piled up fines and cross the borders of the coal washing plant.

2.5 Others

(1)Desulfurization Effect of High Sulfur Coal Washing

High sulfur coal is currently sold unwashed. The desulfurization effect of the washing of Sebulu coal and BBE coal was estimated. The results are shown in **Table 4-2-24**. The sulfur content of particles with a specific gravity of 2.0 or more was extremely high at 22.47% for the Sebulu coal and 12.07% for the BBE coal. However, it was found that as selective coal mining is now carried out, such high specific-gravity particles are quite rarely involved, so washing is not effective in desulfurization. In the future, as the underground mining ratio increases, the current selective coal mining approach will become difficult to continue and the desulfurization effect of coal washing will become more pronounced.

Table 4-2-24 Desulfurization Effect of High Sulfur Coal Washing

[Sebulu]

	Product / un-washed 19-Jun-06				Σ↓			
	Wt%	Ash%	TS%	GCV	Wt%	Ash%	TS%	GCV
-1.2	0.19	5.8	1.76	7189	0.19	5.8	1.76	7189
1.2 - 1.3	39.86	3.0	1.98	7380	40.05	3.0	1.98	7379
1.3 - 1.4	52.36	7.0	2.56	6942	92.41	5.3	2.31	7131
1.4 - 1.5	3.52	19.2	3.41	5766	95.93	5.8	2.35	7081
1.5 - 1.6	1.75	28.5	5.40	4961	97.68	6.2	2.40	7043
1.6 - 1.8	1.58	43.5	4.98	3498	99.26	6.8	2.44	6987
1.8 - 2.0	0.54	59.7	4.41	1893	99.80	7.1	2.45	6959
+2.0	0.20	62.2	22.47	1390	100.00	7.2	2.49	6948
Total	100.00	7.2	2.49	6948				

[BBE]

	Product / un-washed 16-Jun-06				Σ↓			
	Wt%	Ash%	TS%	GCV	Wt%	Ash%	TS%	GCV
-1.2	1.39	3.3	0.42	5968	1.39	3.3	0.42	5968
1.2 - 1.3	86.10	3.5	0.58	5506	87.49	3.5	0.58	5513
1.3 - 1.4	7.92	9.0	0.70	4964	95.41	4.0	0.59	5468
1.4 - 1.5	2.66	19.1	0.81	4388	98.07	4.4	0.59	5438
1.5 - 1.6	1.13	28.4	1.02	3797	99.20	4.6	0.60	5420
1.6 - 1.8	0.62	39.1	1.94	2712	99.82	4.9	0.61	5403
1.8 - 2.0	0.12	48.2	3.00	1764	99.94	4.9	0.61	5399
+2.0	0.06	58.7	12.07	1662	100.00	4.9	0.62	5396
Total	100.00	4.9	0.62	5396				

(2) Improvement in Quality through Cleaning of Dirty Coal

At present, only Kitadin is Jig-cleaning dirty coal. **Table 4-2-25** shows the properties of dirty coal sampled at various locations and the properties of clean coal that has been Jig-cleaned. Low-grade coal of less than 2,000 kcal/kg will yield 37% clean coal of 4,300 kcal/kg through Jig-cleaning. The cleaning of dirty coal at FBS, Loa Tebu 1-(2), and Loa Tebu 1-(3) was also found effective in desulfurization.

Table 4-2-25 Improvement in Quality through Cleaning of Dirty Coal

Sp.Gr＝1.8

[Kitadin/Stock Yard of Washery]

	Ash (%-ad)	TS (%-ad)	GCV (kcal/kg)
Dirty Coal	16.9	0.43	4725

	Wt%	Ash	TS	GCV
Clean Coal	93.49	13.2	0.38	4978
Reject	6.51	69.9	1.19	1083

[**FBS**/Open Pit]

	Ash (%-ad)	TS (%-ad)	GCV (kcal/kg)
Dirty Coal	51.3	0.90	2470

	Wt%	Ash	TS	GCV
Clean Coal	38.06	17.8	0.46	5448
Reject	61.94	72.0	1.17	640

[**Loa Tebu 1 (1)**/Open Pit]

	Ash (%-ad)	TS (%-ad)	GCV (kcal/kg)
Dirty Coal	54.0	1.17	1939

	Wt%	Ash	TS	GCV
Clean Coal	37.03	26.2	1.02	4322
Reject	62.97	70.3	1.25	538

[**Loa Tebu 1 (2)**/Open Pit/Bottom]

	Ash (%-ad)	TS (%-ad)	GCV (kcal/kg)
Dirty Coal	13.8	0.62	5496

	Wt%	Ash	TS	GCV
Clean Coal	85.45	2.9	0.43	6350
Reject	14.55	77.7	1.74	477

[**Loa Tebu 1 (3)**/Open Pit/Bottom]

	Ash (%-ad)	TS (%-ad)	GCV (kcal/kg)
Dirty Coal	33.7	1.07	3756

	Wt%	Ash	TS	GCV
Clean Coal	69.24	20.2	0.63	4973
Reject	30.76	64.3	2.06	1017

[**BBE (1)**/Open +10mm]

	Ash (%-ad)	TS (%-ad)	GCV (kcal/kg)
Dirty Coal	24.8	3.01	4339

	Wt%	Ash	TS	GCV
Clean Coal	88.40	18.2	3.03	4801
Reject	11.60	75.0	2.88	816

[**BBE (2)**/Open -10mm]

	Ash (%-ad)	TS (%-ad)	GCV (kcal/kg)
Dirty Coal	26.4	3.32	4442

	Wt%	Ash	TS	GCV
Clean Coal	86.68	21.2	3.20	4965
Reject	13.32	60.2	4.09	1036

3. Generating Volume, Quality and Estimation for the Future

3.1 Non-marketable Fine Coal

(1) What is Non-marketable Fine Coal?

In general, fine coal of high moisture content collected from the wastewater treatment equipment, such as settling ponds, at the coal preparation plants (particle size: usually 1mm or less) is called Non-marketable Fine Coal. There is no commercial value in it because the fine coal with high moisture causes problems in handling. It is disposed at the mining site, or piled up around the coal preparation plant. As the rainfall often transports the fine coal to the surrounding environment, the Non-marketable fine Coal is one of the environmental pollution sources. **Photo 4-3-1** and **Photo 4-3-2** shows Non-marketable fine Coal.

Photo 4-3-1
Fine coal piled up out in the open in a settling pond

Photo 4-3-2
Non-marketable Fine Coal being recovered from a settling pond

(2) The estimated volume of Non-marketable Fine Coal

Current and estimated future volumes of Non-marketable Fine Coal generated by the five coal mines surveyed are shown in **Table 4-3-1.** Depending on the market price of coals, the life expectancy of a coal mine will be determined by its economic coal reserve. Except for Pt. Kitadin, the operating coal mines located along Mahakam River have already finalized their future coal development plans. Therefore, the coal mines have equipped themselves with their own coal washing plants for maintaining coal quality. Even after closing the existing coal mines the existing coal washing plants can be used in their current locations, or the plants can be moved to new locations, or new washing plants will be installed at new mining location as needed. As a result, it is estimated that the volume of Non-marketable Fine Coal generated will be about 300,000 tons per year for 40 years of operation as shown in the Table below.

Table 4-3-1 volume of Non-marketable Fine Coal in Generated 2005 and estimated volume for the future

Name of Coal Mine	Production	Fine Coal Ratio (%)	2005	2010	2015	2020	2025	2030	2035	2040	2045
Pt. Kitadin	Production		1,625								
	(New Mine)										
	Non marketable Fine Coal	7.4	120								
Pt.F.B.S	Production		278	600	600						
	(New Mine)					600	1,000	1,000	1,000	1,000	1,000
	Non marketable Fine Coal	3.4	9	57	20	20	34	34	34	34	34
Pt.Tanito	Production		3,222	3,000	3,000						
	(New Mine)	(9.2)				2,000	2,000	2,000	2,000	2,000	2,000
	Non marketable Fine Coal	4.6	148	138	138	92	92	92	92	92	92
Pt. M.H.U	Production		896	2,000							
	(New Mine)				2,000	2,000	2,000	2,000	2,000	2,000	2,000
	Non marketable Fine Coal	5.0	45	100	100	100	100	100	100	100	100
Pt. B.B.E	Production		1,670	2,000							
	(New Mine)				2,000	2,000	2,000	2,000	2,000	2,000	2,000
	Non marketable Fine Coal	2.6	43	52	52	52	52	52	52	52	52
		Total	366	347	310	264	278	278	278	278	278

The quantity of non marketable fine coal is based on th ratio measured on this study and shown in Table 1.2.-6
The production is predicted by the study team.

Besides the five coal mines, some other coal mines have plans for installing coal washing plants. Therefore, it is expected that the generating volume of Non-marketable Fine Coal will increase.

(3) Quality

The quality of Non-marketable Fine Coal will be different from one coal mine to another, and calorific value, ash and sulfur contents will change dramatically. The data measured during the analysis recently conducted of the fine coal samples, and their variations are shown in the Figures below together with those for Dirty Coal. Variations of calorific values of Non-marketable Fine Coal and Dirty Coal are shown by **Figure 4-3-5**, variations of ash contents of Non-marketable Fine Coal and Dirty Coal are shown by **Figure 4-3-6** and variations of sulfur contents of Non-marketable Fine Coal and Dirty Coal are shown by **Figure 4-3-7.** **Table 4-3-2** shows average quality values of Non-marketable fine coal.

Table 4-3-2. Average quality values of Non-marketable Fine Coal

	Average	Variation (1σ)
Calorific value (As Received Base)	2,929 kcal/kg	860 kcal/kg
Calorific value (Air Dry Base)	4,269 kcal/kg	1,253 kcal/kg
Total moisture content	36.2%	3.0%
Ash(Air Dry base)	33.3 %	14.9 %
Total sulfur (Air Dry Base)	1.35 %	1.1 %

(4) Grain size distribution

Grain size of the fine coal depends on the process of the coal preparation plant and wastewater treatment method. It is usually from +1,000μm (1mm) to 3,000μm (3mm) as a maximum. **Figure 4-2-1** shows average grain size distribution of the samples.

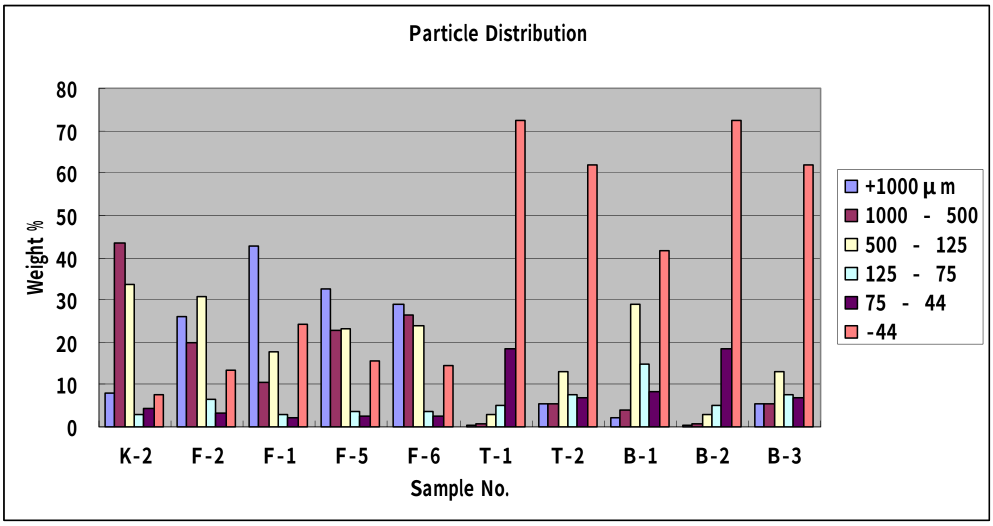


Figure 4-3-1 Grain size distributions of Non-marketable Fine Coals

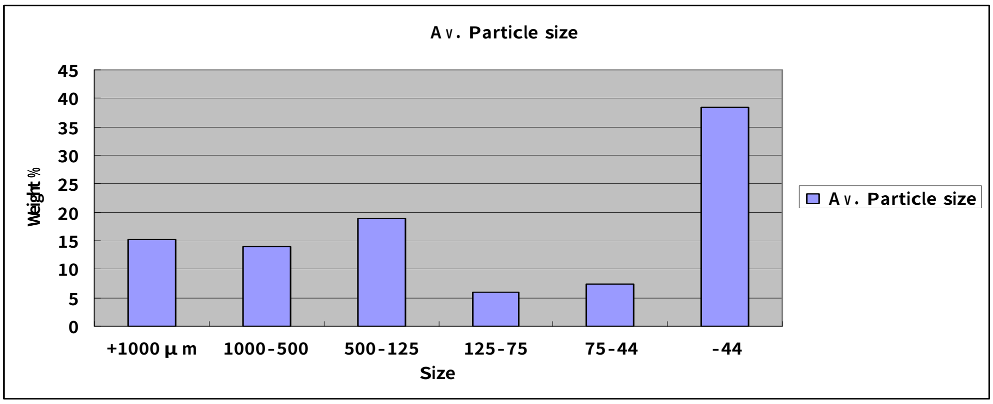


Figure 4-2-2. Average grain size of Non-marketable Fine Coals

3.2 Dirty Coal

(1) What is Dirty Coal?

Through the surveys done in this study, it is clear that the Dirty Coal disposed of at coal mine sites has the potential to become a new environmental pollutant. The Dirty Coal is being generated in significant quantities, especially at open pit mining areas. When mining coal layers in open pit areas, the upper and bottom of the coal seam, and also the inner soil layer sandwich part called a "parting" will be cleaned up for separation from coals to improve the quality of the coal to be mined. Average thickness is about 5 to 10 cm. In general, the Dirty Coal contains high ash and high sulfur, and therefore such coal has been disposed of at the mine site. Especially the Dirty Coal with high sulfur content will discharge as acid wastewater during heavy rains, and therefore cause the affected land to become acidic. This will have a negative impact on the planting of trees over the open pit areas after the mines are closed. In addition, the acid wastewater will also be discharged to surrounding areas and cause environmental pollution issues. **Photo 4-3-3** and **Photo 4-3-4** show Dirty Coal.

Photo 4-3-3
Dirty Coal removed during work for cleaning of the upper coal layer

Photo 4-3-4.
A boundary with the coal layer is shown. Dirty Coal occurs in the 5-10 cm upper layer.

(2) Quantity of Dirty Coal Generated

The quantity of Dirty Coal generated will depend on the thickness of the coal seam and the existence of a parting. Dirty Coal represents about 5% of the total coal that is mined. During the recent surveys, several coal mines were investigated for the volume of Dirty Coal that they generated. **Table 4-3-3** shows coal product quantities of the coal mines located along Mahakam River. Yellow parts in the table show the coal mines surveyed. Coal product quantity in 2005 was 24,747,000 tons, and therefore 5% will be about 1.24 million tons which was the quantity of Dirty Coal produced in the 2005. The quantity of Dirty Coal will increase in the future throughout Indonesia according to increasing coal production.

Table 4-3-3 Coal Production and Sales Volume of the Coal Mines near the Mahakam River

(1,000t/y)

No	Company	Licence	Production	
			2004	2005
1	Anugrah Bara Kaltim, PT	KP	3,413	3,395
2	Bina Mitra Sumberarta, PT	KP		169
3	Bukit Baiduri Energi, PT	KP	1,430	1,690
4	Fajar Bumi Sakti, PT	KP	2,113	328
5	Gunung Bayan Pratama Coal, PT	PKP2B, 2nd Generation	3,360	4,330
6	Jembayan Muarabara	KP		1,050
7	Kartika Selabumi Mining, PT	PKP2B, 2nd Generation	736	1,035
8	Kimco Armindo, PT	KP		963
9	Kitadin Corporation			1,604
10	Lanna Harita Idonesia, PT	PKP2B, 3rd Generation	1,700	1,887
11	Mahakam Sumber Jaya, PT	PKP2B, 3rd Generation		2,304
12	Mandiri Intiperkasa, PT	PKP2B, 2nd Generation	602	1,082
13	Multi Harapan Utama, PT	PKP2B, 1st Generation	1,521	897
14	Tanito Harum, PT	PKP2B, 1st Generation	2,256	2,403
15	Trubaindo Coal Mining, PT	PKP2B, 1st Generation		1,610
		Total	17,131	24,747
		Total production in Indenesia	129,835	153,464
		Shear (%)	13.2	16.1

Mineral, Coal and Geothermal Statics 2006, by Ministry of Energy and Mineral Resources

(3) Quality

The variation in the ash content of Dirty Coal is large, the same as in Non-marketable Fine Coal. Moisture content will be stable, excluding the effects of weather conditions. **Table 4-3-4** shows average quality of Dirty Coal.

Table 4-3-4 Average quality level of Dirty Coal

	Average	Variation (1σ)
Calorific value (As received Base)	3,840 kcal/kg	1,278 kcal/kg
Calorific value (Air Dry Base)	4,053 kcal/kg	1,349 kcal/kg
Total moisture	12 %	2 %
Ash content (Air Dry base)	30.2 %	16.5 %
Total sulfur content (Air Dry Base)	0.97 %	1.0 %

(4) Grain size distribution

As shown in **Table 4-3-3**, grain size distribution of Dirty Coal is as great as mined coal. Maximum grain size will become an important factor when utilizing Dirty Coal. The maximum grain size was about 300 mm in the small number of samples taken in this study.

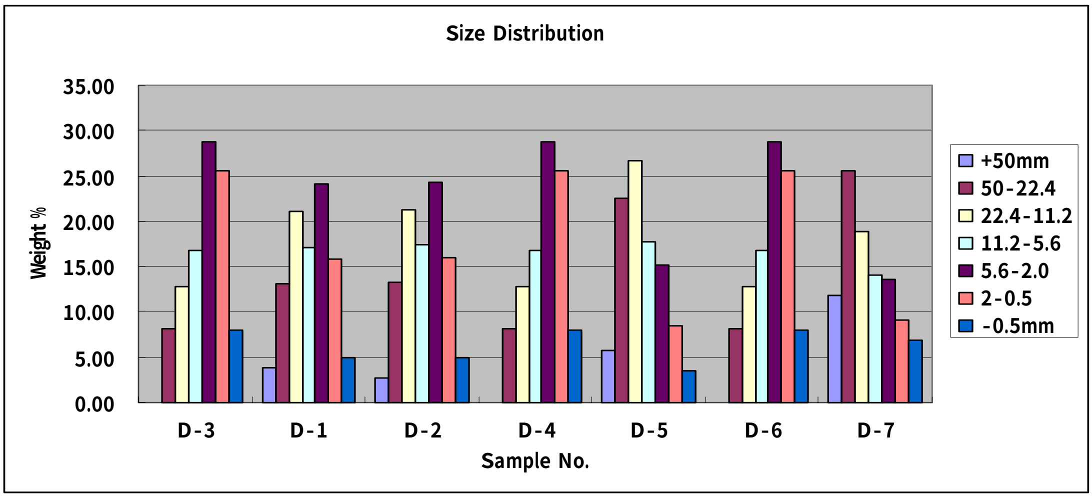


Figure 4-3-3 Grain size distribution of Dirty Coal

Figure 4-3-4 shows average grain size distribution. About 40% of the particles were larger than 10mm.

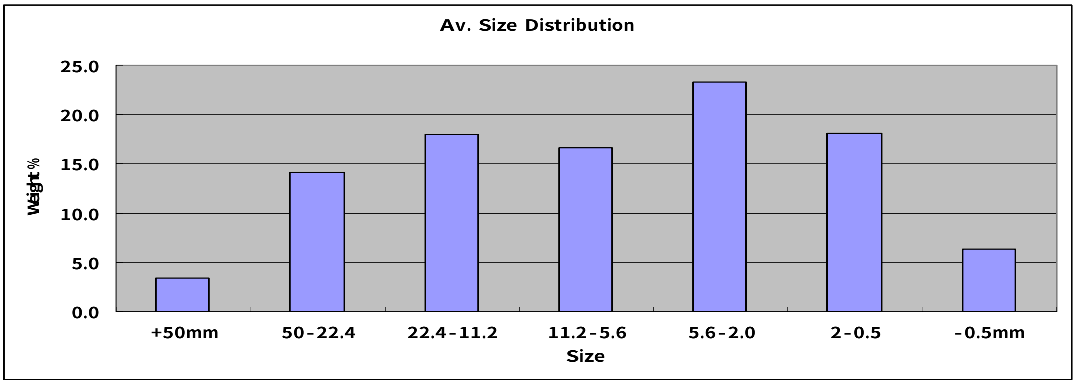


Figure 4-3-4 Average grain size distribution of Dirty Coal

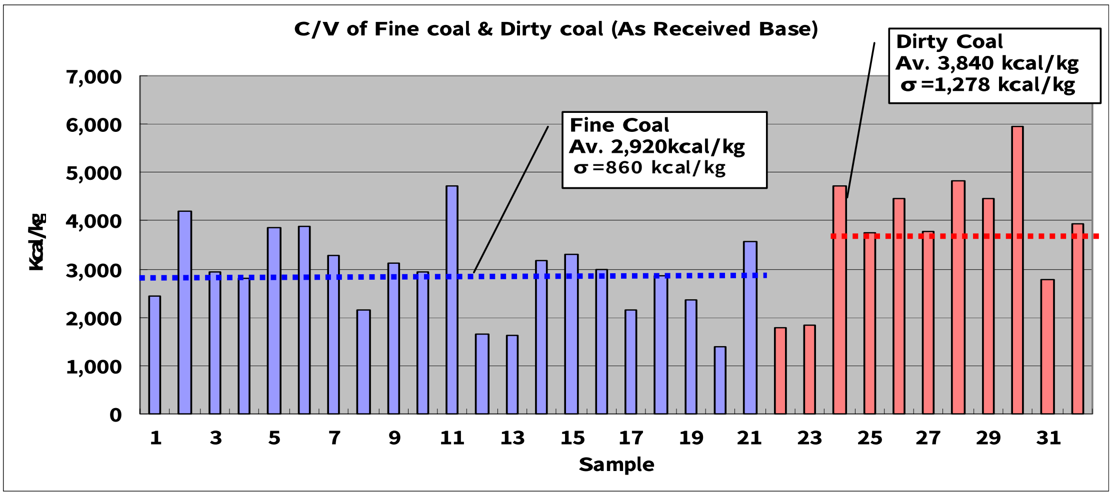


Figure 4-3-5 Changes of calorific values of Non-marketable Fine Coal and Dirty Coal

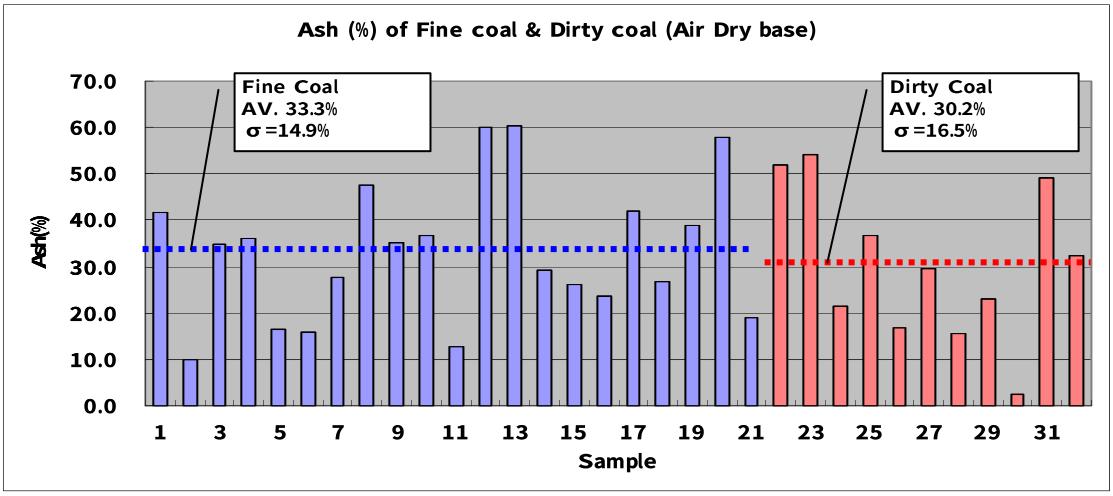


Figure 4-3-6 Changes of ash contents of Non-marketable Fine Coal and Dirty Coal

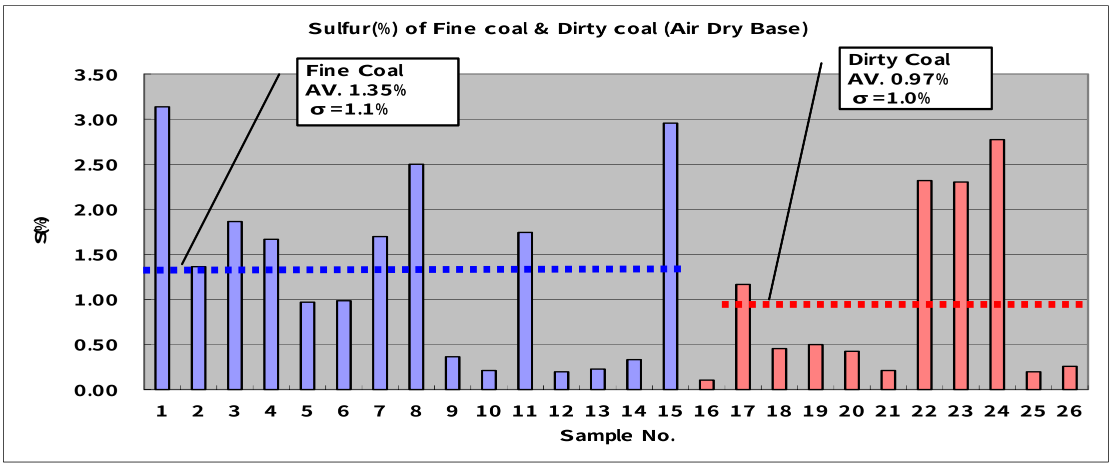


Figure 4-3-7 Changes of sulfur contents of Non-marketable Fine Coal and Dirty Coal

4. Content of Analyses by Local Consultant

We placed an order with a local consultant for the service of analyzing characteristic values resulting from wastewater monitoring and coal preparation process.

Analysis results are described in Reference document 4, "Local consultant contract / analysis results".

4.1 Wastewater monitoring

Table 4-4-1 lists analysis items of wastewater monitoring, including particle size analysis, proximate analysis (moisture, ash content, volatile matter, and fixed carbon), calorific value, total sulfur, and ash composition. We analyzed wastewater TSS with a measurement instrument we brought in the site. We also analyzed wastewater pH with a measurement instrument we brought in the site because on-site measurement is fundamental for measurement of wastewater pH. Furthermore, we analyzed Fe and Mn with a simple measurement instrument that we brought in the site because keeping sample water (such as acid treatment) was difficult. Since the measurement instruments that we brought in the site are left in the analysis room of the East Kalimantan Province Mineral Resource and Energy Bureau (Dinas Pertambangan dan Energi), our counterparts can use them for analysis anytime. Refer to Chapter 6, "Technical Transfer", for details of these measurement instruments.

Table 4-4-1 Analysis items / wastewater monitoring

<table>
<tr><td rowspan="5">Particle Size Analysis</td><td colspan="2">Sizing (6 fractions)</td></tr>
<tr><td colspan="2">+1000(μm)、～600、～150、～75、～45、-45</td></tr>
<tr><td rowspan="3">Sample after Sizing</td><td>IM
of every above Size Fraction</td></tr>
<tr><td>Ash
of every above Size Fraction</td></tr>
<tr><td>Total Sulfur of
every above Size Fraction</td></tr>
<tr><td rowspan="7">Coal Analysis</td><td colspan="2">Heat Value</td></tr>
<tr><td rowspan="4">Proximate Analysis</td><td>IM</td></tr>
<tr><td>Ash</td></tr>
<tr><td>VM</td></tr>
<tr><td>FC</td></tr>
<tr><td colspan="2">Ash Analysis</td></tr>
<tr><td colspan="2">Total Sulfur</td></tr>
</table>

4.2 Coal preparation process

Table 4-4-2 lists analysis items of coal preparation process, including proximate analysis (moisture, ash content, volatile matter, fixed carbon), calorific value, total sulfur, grindability, ash fusibility, ash composition, particle size analysis, and float and sink test (F/S test). An F/S test is a test in which coals are divided by specific gravity into different sections whose weight, ash content, and sulfur content are measured. The test reveals the separation conditions of the gravity separator, such as jigs. In addition, such a test can forecast, with a high degree of accuracy, the results of products in case that a jig is introduced.

Table 4-4-2 Analysis items / coal preparation process

<table>
<tr><td rowspan="8">Coal Analysis</td><td rowspan="3">Prox. Analysis</td><td>IM</td></tr>
<tr><td>Ash</td></tr>
<tr><td>VM</td></tr>
<tr><td>Heat Value</td><td></td></tr>
<tr><td>Total Sulfur</td><td></td></tr>
<tr><td colspan="2">Hardgrove Index</td></tr>
<tr><td colspan="2">Ash Fusion Temp.</td></tr>
<tr><td colspan="2">Ash Analysis</td></tr>
<tr><td rowspan="7">Particle Size Analysis</td><td colspan="2">Sizing (6 fractions)</td></tr>
<tr><td colspan="2">+1000(μm)、～600、～150、～75、～45、-45</td></tr>
<tr><td colspan="2">Sizing (8 fractions)</td></tr>
<tr><td colspan="2">+100(mm)、～50、～25、～10、～5、～2、～0.5、-0.5</td></tr>
<tr><td rowspan="3">Sample after Sizing</td><td>Ash of every above Size Fraction</td></tr>
<tr><td>Heat Value of every above Size Fraction</td></tr>
<tr><td>Total Sulfur of every above Size Fraction</td></tr>
<tr><td rowspan="5">F/S Test
of every abobe
Size Fraction</td><td colspan="2">F/S test (8 fractions)</td></tr>
<tr><td colspan="2">-1.2、～1.3、～1.4、～1.5、～1.6、～1.8、～2.0、+2.0</td></tr>
<tr><td rowspan="3">Sample after F/S Test</td><td>Ash of every above F/S test Fraction</td></tr>
<tr><td>Heat Value of every above F/S test Fraction</td></tr>
<tr><td>Total Sulfur of every above F/S test Fraction</td></tr>
</table>