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EVALUATION OF THE ENVIRONMENTAL IMPACT AT THE KAMOJANG GEOTHERMAL FIELD IN INDONESIA APPLYING THE EMS OF ISO 14001

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ABSTRACT

Power generation is an industry which is likely to have an adverse impact on the environment. It is, therefore, necessary to exercise careful environmental management in order to reduce any negative impact. Although geothermal energy is considered a "green energy source", its exploration and exploitation will cause land disturbances, noise, thermal pollution and the release of geothermal gases. By careful environmental management during design, construction and the operation of geothermal power facilities, negative impacts can be minimized. At the Kamojang geothermal field in Indonesia a power plant has been in operation since 1982 producing 140 MWe. The operator of the steam supply system, PT Pertamina, has drilled 76 deep wells to provide 1,100 tons/hour of steam for power production. In 2002 the management of Pertamina adopted a new environmental management system for all its operations at Kamojang geothermal field, which has been certified in accordance with the international ISO 14001 environmental standards. The ISO 14001 certificate has been renewed annually after the management system was audited by an external examiner. ISO 14001 requires that all potential environmental hazards which may arise from the operation be identified and documented. A thorough monitoring program has to be implemented and documented, including production of geothermal steam and fluids as well as waste condensed water and gases from the power plant. The application of the ISO 14001 environmental management system has proven to be a useful tool for improving management of the geothermal resource at Kamojang.

1. INTRODUCTION

The Kamojang geothermal field is located in West Java (Indonesia), in the Ibun sub-province of Bandung Province. It is about 40 km southeast of the province capital Bandung. Geothermal exploration in the Kamojang geothermal field was initiated by Pertamina in 1976. The exploration led to the exploitation of the Kamojang geothermal system, the first geothermal power plant in Indonesia. Unit I with 30 MWe started producing in 1982, and was followed by units II and III in 1987, each with a capacity of 55 MWe, bringing the total capacity of the Kamojang Power Plant to 140 MWe.

The national oil company, Pertamina, operates the field and produces about 1,100 tons/hour of dry steam for the production of 140 MWe at the Kamojang Power Plant, which is operated by PT Indonesia Power. The condensed steam is re-injected into the geothermal system by Pertamina. The third company at Kamojang is PT. PLN, which distributes and markets the electricity.

In its effort to minimize the environmental impact of the geothermal utilization, Pertamina is following the Environmental Management System of ISO 14001, which is a tool for managing the environmental impact of a geothermal operation, in the planning, design and operation of the geothermal field. On 10th December, 2002 Pertamina's geothermal operation Kamojang received an international certificate for ISO 14001 environmental management.

In this report a brief description of the environmental impact of a geothermal operation is given, the environmental management at Kamojang is discussed and data concerning the environmental monitoring is presented.

2. GEOLOGY AND PRODUCTION FACILITIES IN KAMOJANG GEOTHERMAL FIELD

2.1 Field geology

The Kamojang geothermal field (Figure 1) is located in the western part of the Java Island, Indonesia, about 42 km south-southeast of the west Java province capital city Bandung. The field is geographically situated between 07°11'02"-07°06'08" South latitude and 107°44'36"-107°49'30" East longitude. Topographic elevation ranges from 1,400 to 1,800 m above sea level.

The main production zone in the geothermal reservoir is from fractured andesites ranging in depth from 700 to 1,200 m. In 1926, five wells were drilled ranging between 18.5 and 130 m in depth. Well 3 is still discharging with a temperature of 130°C and 12.4 tons/hr of steam. Pertamina has drilled 76 wells with bottom hole temperatures ranging from 115 to 245°C. The pressure and temperature logs indicate a typical convecting vapour-dominated geothermal system. The pressure and temperature increase linearly down to the top of the steam zone. At greater depths they increase slowly

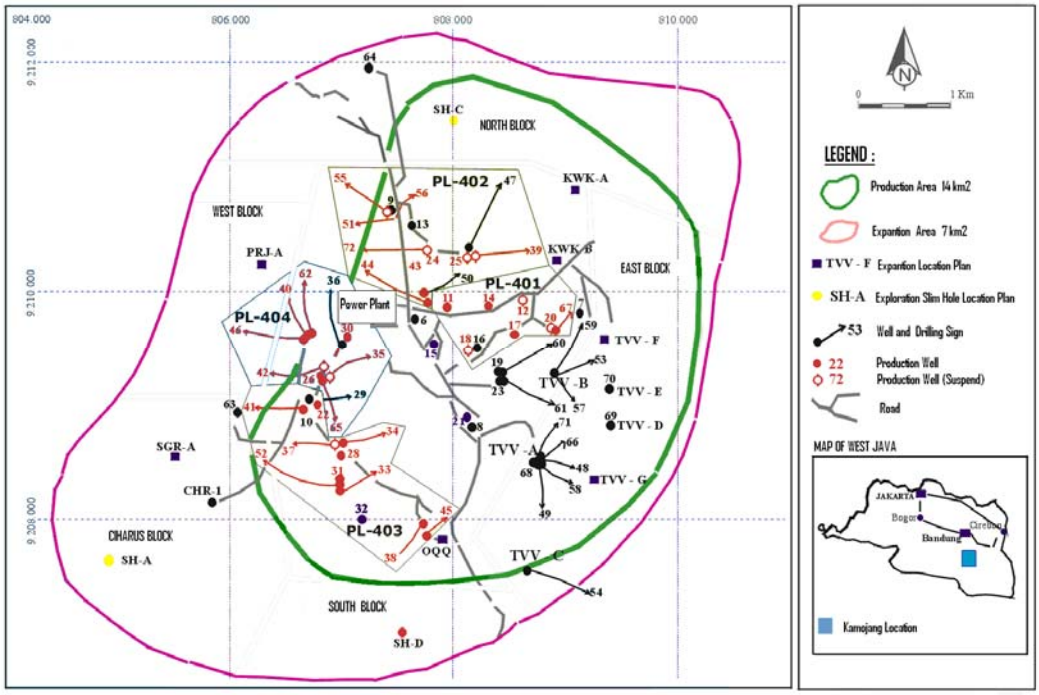

FIGURE 1: The Kamojang geothermal field with location of boreholes and pipelines

(Sumintadireja et al., 2000). Figure 1 shows the Kamojang geothermal field, with boreholes, major pipelines and the location of the power plant.

The geometry of Kamojang reservoir is the result of complex interactions of active volcano-tectonic processes, older stratigraphy, and structure. Generally the caprock is 500-600 m thick but seems to be only 200-300 m thick towards the northern and eastern parts (Figure 2). This caprock consists of prophylitic altered volcanic rock. The productive geothermal reservoir, which usually has high porosity, high permeability, high temperature, and adequate size with sufficient fluid, is located between 600 and 2,000 m in depth. The reservoir consists of strongly altered andesitic rocks and some volcanic pyroclastics. Permeability is produced by structural events such as faults, joints and fractures or by stratigraphic characteristics such as intergranular porosity in lapili (Sumintadireja et al., 2000; Utami, 2000).

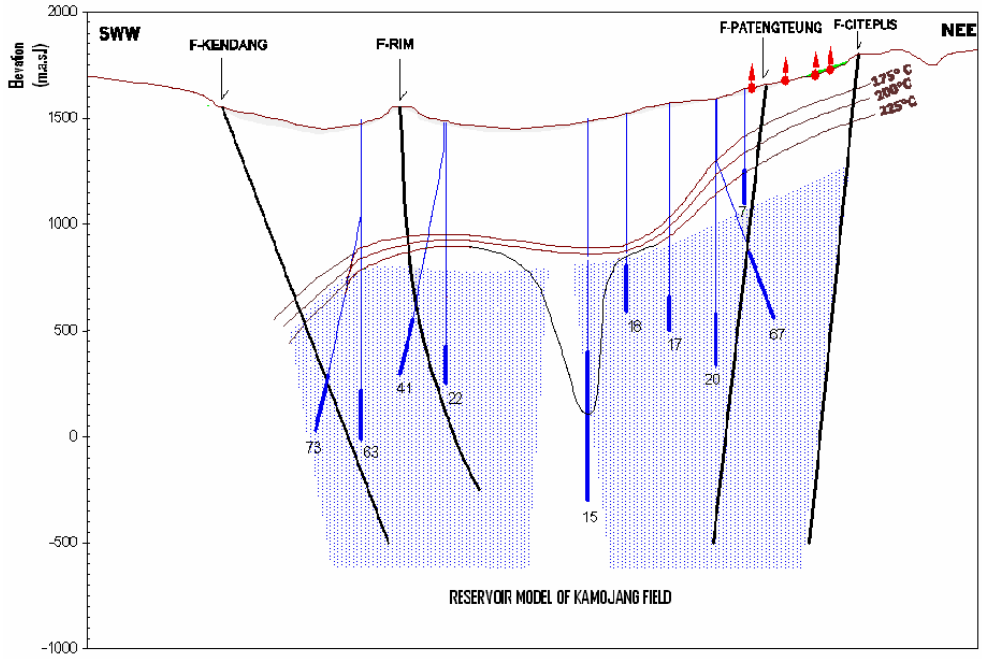

FIGURE 2: Reservoir model

2.2 Production facilities

The exploited part of the Kamojang geothermal field can be divided into four sub-fields, depending on which of the four main pipelines from the field to the power plant each borehole is connected to, i.e. PL-401, PL-402, PL-403 and PL-404 (Figure 1). Pertamina is responsible for the production of steam, and delivers it to PT Indonesia Power, the operator of the power plant, at a header before the steam is distributed to each of the power plants. Pressure fluctuations are controlled by a venting system. Each of the main pipelines is operated without the possibility of compensating production decline in one sub-area with another. This has limited the ability to keep the flow rate constant with declining production. A schematic drawing and description of the Kamojang power plant is in Appendix I.

2.3 Production history

Production in the Kamojang field started in early 1983 with an installed capacity of 30 MWe. About 240 tons/hr of steam is produced for unit I through 6 production wells. In September 1987, 2 additional turbines, each 55 MWe (unit II and III) were put into operation to utilize steam from 20

additional wells. The total electric generating capacity of the Kamojang field is now about 140 MWe. About 1,100 tons/hour of steam is produced to feed the power plant. The mass output of steam has declined with time but constant power output has been maintained by lowering operational wellhead pressure. Wellhead pressure in shut-in wells is about 33 bar-g and the pipeline operational pressure is about 7-8 bar-g. From 1976 to the present, some 76 wells have been drilled in the Kamojang field (Sasradipoera et al., 2000). Production of additional 60 MWe is planned in 2006, increasing the total capacity to about 200 MWe.

2.4 Reinjection wells

Three deep unproductive wells, situated in the centre of the field, have been used as injection wells. At first, injection wells KMJ-15, 21 and 32 were used for condensed steam from the power plant (Figure 3). To increase the efficiency of cooling in the condenser and to increase the reinjection rate, water from Cikaro lake at the centre of the field is pumped to the cooling tower, and injected with the condensed steam.

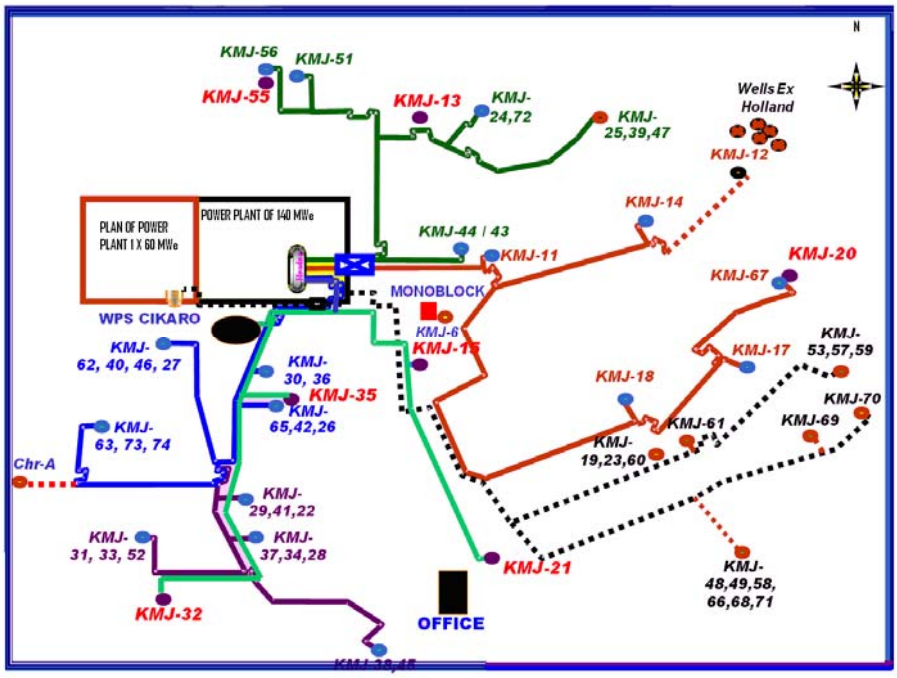

FIGURE 3: Production and reinjection pipelines

3. ENVIRONMENTAL IMPACT OF GEOTHERMAL UTILIZATION

During the initial geothermal exploration stages, the impact on the environment is slight, mainly caused by the construction of access tracks for geochemical and geophysical measurements. If wells are drilled, access roads and drill pads need to be constructed influencing the landscape, noise is emitted from the drilling operation and cooling water has to be piped to the drilling site. With the exploitation phase, a number of new impacts on the physical environment become important. Natural geothermal features may decrease or increase in activity, the local climate may be affected, large volumes of cooling water may contribute to thermal pollution of local waterways and some areas of land may be subject to subsidence (Ármannsson, 2004).

3.1 The landscape

In general, the area required for geothermal development is a function of the power output of development, the types of countryside and the properties of the reservoir. Land is required for drill pads, access roads, steam lines, power plant and transmission line (Brown, 1995).

3.2 Noise

Noise is one of the most ubiquitous disturbances to the environment from geothermal development – particularly during the construction and operation phases. Noise intensity is usually measured in decibels (dB(A)). The human ear is a remarkably sensitive device which can detect sound intensities as low as 10^{-12} W/m^2 with the threshold of pain occurring at 10 W/m^2. This gives 13 orders of magnitude (or Bels) as the human response range, or 130 dB(A). This approximates equal subjective "loudness" for a particular noise intensity at different frequencies (Brown, 1995). Table 1 shows typical noise level for familiar sounds.

TABLE 1: Typical noise level descriptions

dB (A)	Familiar sounds	Average subjective description
130	Jet takeoff at 60 m	Intolerable
125	Geothermal well discharge	
120	Threshold of pain at 1000 Hz	
110	Drilling with air 8 m	Very noisy
100	Unmuffled diesel truck at 15 m	
95	Loud motorcycle at 15 m	
90	Well vented to rock muffler	
85	Bleed line not muffled	Noisy
80	Mud drilling	
75	Street corner in large city	
70	Outside generator building 8 m	
65	Normal speech at 3 m	Quiet
40	Residential area at night	
25	Broadcasting studio	Very quiet
0	Threshold of hearing	

3.3 Airborne contaminants

Geothermal power plants have sulphur-emission rates that range from zero to a very small fraction of the emissions. Hydrogen sulphide (H_2S) is the source of sulphur emission that is commonly found in geothermal steam. Geothermal plants emit no NOx, the small amount of ammonia that may be found in geothermal resources is oxidized to nitrogen and water and the pressures of combustion are avoided. Emission of CO_2 is extremely low, the geothermal power plant emission of CO_2 ranges from zero for a binary plant to 0.48 kg per megawatt-hour of electricity produced from new flash-technology plants (Brown, 1995). Although the emission is relatively low, all emissions must be accounted for under the ISO 14001.

3.4 Subsidence

During production from a geothermal system, a large pressure drop can occur in the reservoir. Withdrawal of fluid from any type of underground reservoir will normally result in the reduction of pressure in the formation pores which can lead to subsidence. Subsidence has been observed in groundwater reservoirs as well as in geothermal reservoirs. The subsidence has a number of implications for geothermal power production and also for its effect on the surrounding countryside. The area of subsidence corresponds to the area of fluid withdrawal and lowered reservoir pressure, for example at The Geysers and Broadlands geothermal fields. At Wairakei and at Cerro Prieto, however, the area of maximum subsidence is offset from the production area (Brown, 1995).

3.5 Vegetation and wildlife

The impact on vegetation and wildlife is mainly due to land use during geothermal development. During drilling and power plant operation the land is disturbed or changed to accommodate other use; natural habitats for wildlife and plants may be destroyed or altered. This kind of impact cannot be prevented, but with careful project planning, direct-heat facilities may be sited to avoid unusual or unique habitats and critical habitats for endangered species.

3.6 Fluid composition

The mass flowrate from geothermal wells is usually in the range of 5-100 kg/s. The mass produced can either be single-phase liquid water, dry steam or a mixture of both. The discharge also contains some dissolved solids (100-50,000 ppm) and non-condensable gasses (NCG), usually less than 2 % of the mass produced.

The main potential pollutants in the liquid effluent are: hydrogen sulphide (H_2S), carbon dioxide (CO_2), arsenic (As), boron (B), mercury (Hg), and trace metals (e.g. lead (Pb) and cadmium (Cd)) (Ármannsson and Kristmannsdóttir, 1992).

One of the main effects of geothermal exploitation on the environment is the emission of gases with geothermal steam. In vapour-dominated fields in which all waste fluids are reinjected, non-condensable gases in steam will be the most important discharge from an environmental perspective. The emission is mainly from the gas ejectors of the power station, often discharged through a cooling tower. Gas and particulate discharges during well drilling, bleeding, clean-outs and testing and from line valves and waste bore water degassing, are usually insignificant. The concentration of NCG varies not only between fields but also from well to well within a field, thus changes in the proportion of steam from different wells may cause changes in the amounts of NCG discharged (Gíslason, 2000).

Carbon dioxide. Carbon dioxide frequently occurs in geothermal fluids, especially in high-temperature systems. Carbon dioxide is often the most abundant NCG. A 5% concentration in the air can result in shortness of breath, dizziness, and mental confusion. At 10% a person will normally lose consciousness and quickly be asphyxiated.

Hydrogen sulphide. H_2S is characterised by a rotten egg odour, detectable by humans at a very low concentration of about 0.3 ppm. At such concentration it is primarily a nuisance, but as the concentration increases, it may irritate and injure the eye (10 ppm), the membranes of the upper respiratory tracts (50-100 ppm), and lead to loss of smell (150 ppm). At a concentration of about 700 ppm, it is fatal. The impacts of H_2S discharge will depend on local topography, wind pattern and land use. The gas can be highly toxic, causing eye irritation and respiratory damage in human and animals, and has an unpleasant odour (Huang, 2001).

4. ENVIRONMENTAL POLICY OF PERTAMINA

4.1 Introduction

The environmental policy is the driver for implementing and improving the organization's environmental management system so that it can maintain and potentially improve its performance. The policy should therefore reflect the commitment of top management to comply with applicable laws and continual improvement. The policy forms the basis upon which the organization sets its objectives and targets. The policy should be sufficiently clear to be understood by internal and external interested parties and should be periodically reviewed and revised to reflect changing

conditions and information. Its area application should be clearly identifiable. The organization's top management should define and document its environmental policy within the context of the environmental policy of any broader corporate body, if there is one.

In order to meet the above requirements, the Pertamina Kamojang company adopted a new environmental policy in the year 2002, and decided to take up an environmental management system certified by the ISO 14001 international standard. In December 2002 the first certificate was issued. This policy applies for all sector of activity of company business and its activity partners.

4.2 Environmental Management System of ISO 14001

4.2.1 General

Since 2002 Pertamina adopted the ISO 14001 Environmental Management System (EMS) in order to manage and to minimize the environmental impact of its geothermal steam supply operation at the Kamojang geothermal field. The environmental management is integrated with other management operations at Kamojang, with the aim to (Pertamina, 2003a):

- Assure that the facilities of Pertamina at the Kamojang geothermal project have been designed, operated and maintained in accordance with environmental requirements and to fulfil laws and regulations.
- Prevent and lessen possibilities of contamination from the steam supply operation, including influence on human population, facilities and equipment, and the work environment.
- Ensure that the steam supply is efficient at the same time as it is in harmony with the environment.

The aim of the EMS is to give guidelines and instruction for all functions of the geothermal operation of Pertamina in order to ensure that the negative impact on the environment is minimal. In 2002 the first certificate was issued to confirm that Pertamina has established and applied an environmental management system in accordance with ISO 14001. In Appendix II is a copy of the latest certificate, valid till December 2005.

4.2.2 Environmental Management System of ISO 14001 requirements

ISO 14001 EMS involves all aspects of Pertamina's operation at Kamojang as is set forward in the company environmental policy (Figure 4):

1. **Planning**
   - Environmental aspects
   - Legal and other requirements
   - Objective and targets
   - Environmental management programmes
2. **Implementation and operation**
   - Structure and responsibility
   - Training, awareness and competence
   - Communication
   - Environmental management system documentation

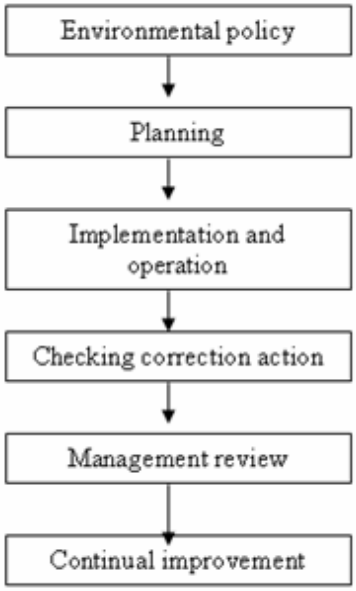

FIGURE 4 : EMS of ISO 14001

3. **Checking and corrective action**
   - Monitoring and measurement
   - Non-conformance and corrective and preventive action
   - Records
   - Environmental management system audit
4. **Management review**

Planning:

Environmental aspect. The organization shall establish and maintain procedures to identify the environmental aspects of its activities, products, or services that it controls and over which it can be expected to have influence, in order to determine those which have or can have significant impacts on the environmental.

Legal and other requirements. The organization shall establish and maintain a procedure to identify and have access to legal and other requirements to which the organization subscribes.

Objective and targets. The organization shall establish and maintain documented environmental objectives and targets, at each relevant function and level within the organization.

Environmental management programmes. The objectives shall establish and maintain a programme for achieving its objectives and target.

Implementation and operation:

Structure and responsibility. Roles, responsibilities and authorities shall be defined, documented and communicated in order to facilitate effective environmental management.

Training, awareness and competence. The organization shall identify training needs. It shall require that all personnel, whose work may create a significant impact upon the environment, have received appropriate training.

Communication. The management system shall establish and maintain procedures for receiving, documenting and responding to relevant communication, internal or external.

Environmental management system documentation. The organization shall establish and maintain information to describe the core elements of the management system and their interaction and provide direction to related documentation.

Document control. The organization shall establish procedures controlling all documents. Documentation shall be legible, dated and readily identifiable, maintained in an orderly manner and retained for a specified period.

Operational control. The organization shall identify those operations and activities that are associated with the identified significant environmental aspects in line with its policy, objectives and targets.

Emergency preparedness and response. The organization shall review and revise, where necessary, its emergency preparedness and response procedure, after the occurrence of accidents or emergency situations.

Checking and corrective action:

Monitoring and measurement. The organization shall establish and maintain documented procedures to monitor and measure, on a regular basis, the key characteristic of its operations and activities that can have a significant impact on the environment.

Non-conformance and corrective and preventive action. The organization shall establish and maintain procedures for defining responsibility and authority for handling and investigating non-conformance, taking action to mitigate any impacts caused, and for initiating and completing corrective and preventive action.

Records. The organization shall establish and maintain procedures for the identification, maintenance and disposition of environmental records.

Environmental management system audit. The organization shall establish and maintain a programme and procedures for periodic environmental management system audits to be carried out.

Management review:
The organization's top management shall, at intervals that it determines, review the environmental management system, to ensure its continuing suitability, adequacy and effectiveness. The management review shall address the possible need for changes to policy, objectives and other elements of the environmental management system, in light of the environmental management system audit results, changing circumstances and the commitment to continual improvement.

4.2.3 Identification aspect

In applying EMS ISO 14001 all departments have identified the potential environmental hazards in its operation, and possible mitigating actions recommended. The result of this work forms the bases of the environmental management at Kamojang, and is presented in Table 2. A detailed description of the Environmental Programme Management is given in Appendix III.

TABLE 2: Identification of environmental aspects

IDENTIFY ENVIRONMENTAL ASPECT
KAMOJANG GEOTHERMAL FIELD

AMOUNT ASPECT	ASPECT CODE	ACTIVITY AND PRODUCT ASPECT (A)		ENVIRONMENTAL ASPECT (B)		(C)	ASPECT CRITERIA (D)					AMOUNT (E)	STATUS (P)
		DESCRIPTION	CAPACITY	DESCRIPTION	AMOUNT	ENVIRONMENTAL IMPACT	POSSIBILITY HAPPENED	IMPACT CONSEQUENCE	SWAMPY FOREST IMPACT.	OBEDIENTNESS of TO REGULATION.	CONVALESCE DEGREE of IMPACT.		P=for important aspect, if amount >= Total/N or there is regulation , TP = for not important aspect if amount < Total/n
N	(1)	(1)	(2)	(1)	(2)		(1)	(2)	(3)	(4)	(5)	(D1..D5)	
1. OPERATION													
1	OPS-1.A	Horizontal production test	± 50 t/j/well	- Gas discharge in vapour	< 0,1%	- Contamination of air	10	1	1	10	1	23	P
2	OPS-1.B			- Arise noise.	70 - 80 dB (sb	- Lessening comfort.	10	1	1	10	1	23	P
3	OPS-2.A	Vertical production test	± 50 t/j/well	- Arise noise.	80 dB (sumbe	- Lessening comfort.	10	1	5	10	1	27	P
4	OPS-2.B			- Gas discharge in vapour	< 0,1%	- Contamination of air	10	1	1	10	1	23	P
5	OPS-3	Bleeding awal sumur	± 50 t/j/well	- Gas discharge in vapour	CO2 (1000 ppm)	- Contamination of air	10	1	5	10	1	27	P
6	OPS-4.A	Supply steam to power plant	± 1100 ton/h	- Vapour kondensat discharge.	-	- Hot radiasi	10	1	1	1	1	14	TP
7	OPS-4.B			- Noise	-	- Bothering comfort.	10	1	1	1	1	14	TP
8	OPS-5.A	Measurement of underground	3 times /m	- swampy forest of oli and oil fuel	± 0,1 ltr/m	- contamination of landground & water.	5	5	1	10	1	22	P
9	OPS-5.B			- Strand of metal scrap.	± 0,5 kg/m	- Contam. of landground &	10	1	1	1	1	14	TP
2. PRODUCTION FACILITY													
10	FP-1	Installation of test pipe medium.	3 unit/y	- Iron scrap	± 10 kg/y	- Contam. of landground &	5	1	1	1	1	9	TP
11	FP-2.A	Painting of well head and its	76 unit/y	- swampy forest of paint and thinner	± 5 ltr/y	- Contam. of landground &	5	1	1	1	1	9	TP
12	FP-2.B			- Paint can	± 250 Pcs/y	- Contam. of landground &	5	1	1	1	1	9	TP
13	FP-3	Replacement of Rupture Disc.	15 unit/y	- Arise disc rapture of ex	15 unit/y	- Contam. of landground &	5	1	1	1	1	9	TP
14	FP-4	Replacement of Steam Trap &	50 unit/y	- Scrap of iron	25 unit/y	- Contam. of landground &	5	1	1	1	1	9	TP
15	FP-5	Replacement of instrument (PT Recorder)	20 unit/m	- Arise discard of kondensat gas.	-	- Contam. of landground & water	10	1	1	1	1	14	TP
16	FP-6.A	Valve recondition	15 unit/m	- Arise materials of scrap	-	- Contam. of landground &	5	1	1	1	1	9	TP
17	FP-6.B			Fuel oil swampy forest, greese and	± 5 ltr/m	- Contam. of landground &	10	1	1	10	1	23	P
18	FP-7	Calibrate temperature measuring instrument.	25 times/m	- Oil swampy forest and oil media vapour.	-	- Contamination of dangerous and poisonous materialses	10	10	1	10	5	36	P
19	FP-8	Calibrate pressure measuring instrument.	25 times/m	- Oil swampy forest	-	- Contamination of dangerous and poisonous materialses	10	10	1	10	5	36	P
3. LABORATORY													
20	LAB-1.A	Chemical analysis	200 sample /m	- Ex-chemicals	± 3 ltr/m	- contamination of land;ground and water.	10	5	1	10	1	27	P
21	LAB-1.B			- statute bared chemicals	-	- contamination of land;ground and water.	10	5	1	10	1	27	P
22	LAB-1.C			- Tidiness	-	- contamination of landground	10	1	1	1	1	14	TP
23	LAB-2.A	depository for chemicals	-	- statute bared chemicals	-	- contamination of land;ground and water.	10	5	1	10	1	27	P
24	LAB-2.B			- Tidiness		- contamination of landground	10	1	1	1	1	14	TP
25	LAB-3	Intake of steam and condensate sample	200 sample /m	- Chemicals swampy forest	-	- Cont. of danger. and poison. M	5	1	1	10	1	18	P
4. DRILLING													
26	PBR-1.A	Usage of mud (bentonite,CMC-HV,SAPP,Lig)	821 bag	swampy forest is not dangerous and poisonous materialses	± 10 bag	contamination of landground	5	1	1	1	1	9	TP
27	PBR-1.B	Usage of mud (Caustic soda)	41 bag	swampy forest is dangerous and poisonous materialses	± 1 bag	Cont. of danger. and poison. M	5	10	1	10	1	27	P
28	PBR-1.C	Usage of mud (bentonite,CMC-HV,SAPP,Lig)	821 bag	Tidiness forest is not dangerous and poisonous materialses	± 821 bag	contamination of landground	5	1	1	1	1	9	TP
29	PBR-1.D	Usage of mud (Caustic soda)	41 bag	Tidiness forest is dangerous and poisonous materialses	± 41 bag		5	10	1	10	1	27	P
30	PBR-	Usage of fuel	72.600 ltr	Oil swampy forest	± 200 ltr	Contamination of water	5	5	1	10	1	22	P
31	PBR-					contamination of landground	5	5	1	10	1	22	P
32	PBR-	Usage of olie and greese	5.000 ltr	Lubricant swampy forest	± 50 ltr	Contamination of water	5	5	1	10	1	22	P
33	PBR-					contamination of landground	5	5	1	10	1	22	P
34	PBR-	Casing cementing	3000 bag	Cement swampy forest	10 bag	Contam. of landground & water	10	5	1	10	1	27	P
35	PBR-			Dirt swampy forest	-	Contamination of air	10	5	1	1	1	18	TP
36	PBR-			Arise tidiness	3000 bag	contamination of landground	10	5	1	1	1	18	TP
37	PBR-	Rig operation	1000 hp	Arise noise	-	Influencing comfort	10	5	1	10	1	27	P
38	PBR-			Arise vibration	-	Influencing comfort	5	5	1	1	1	13	TP
39	PBR-	Management of drilling cutting	± 175 m3	Arise hoard of cutting	± 175 m3	Contam. of landground & water	10	5	1	10	1	27	P

TABLE 2: Continued

5. SURVEY													
40	S-1.A	Survey geofisika	1 paket	Arise of tidiness of accu	5 pcs	Cont. of danger. and poison. Mat.	10	5	1	10	1	27	P
6. TOPO - CIVIL													
41	TS-1.A	Land Clearing	-	Cut & Fill	-	Contamination of water	10	5	1	1	5	22	P
42	TS-1.B			Hewing of tree		Reduction of natural resources	10	5	1	10	5	31	P
43	TS-2.A	Print to ttrace (Blue Print)	+ 120 sheet	Ammonia discard	± 20 ltr/y	Gas emission of NH3 (aroma)	10	5	1	10	1	27	P
44	TS-2.B			Paper	+10 sheet/y	Reduction of natural resources	10	1	1	1	1	14	TP
45	TS-2.C			Ink	+ 10 pcs/y	contamination of landground	10	1	1	10	1	23	P
46	TS-3	Survey and mapping	-	Making of road	-	Reduction of vegetation	3	1	1	1	1	7	TP
47	TS-4.A	Treatment of building	+ 10 paket/y	Heaping of ex-material	± 5 m3/y	contamination of landground	5	1	1	1	1	9	TP
48	TS-4.B			Swampy forest paint and thinner	± 5 ltr/y	Contam. of landground & water	10	1	1	10	1	23	P
49	TS-4.C			Ex-can	± 500 can/y	contamination of landground	5	1	1	1	1	9	TP
50	TS-4.D			Dirt swampy forest	-	Contamination of air and	5	1	1	10	1	18	P
51	TS-5.A	road;street asphalt process.	+ 20 km/y	Smoke emission	-	Contamination of air	10	5	1	10	1	27	P
52	TS-5.B			Asphalt drum	± 200 pcs/y	contamination of landground	10	1	1	1	1	14	TP
53	TS-5.C			Dirt swampy forest	-	Contamination of air	10	1	1	1	1	14	TP
54	TS-6	Sweeping of location and vapour pipe path way in.	± 10 ha/y	Fuel oil swampy forest and olie.	± 2 ltr/y	contamination of landground	10	1	1	10	1	23	P
7. TECHNIC MAINTENANCE													
55	TP-1.A	repair and conservancies of heavy equipment.	+ 20 unit/y	Fuel oil swampy forest, greese and olie.	± 0,1 m3/y	Contam. of landground & water	10	5	1	10	1	27	P
56	TP-1.B			Ex material	± 1 m3/y	contamination of landground	10	1	1	1	1	14	TP
57	TP-1.C			Ex-accu	± 20 Pcs/y	contamination of landground	10	1	1	10	1	23	P
58	TP-2.A	Workshop activity of grind and	± 3 unit/y	Swampy forest of greese, olie, diesel	± 0,1 m3/y	Contam. of landground & water	10	5	1	10	1	27	P
59	TP-2.B			Scrap and cutting metal	-	contamination of landground	10	1	1	10	1	23	P
60	TP-2.C			Noise	-	Influencing comfort	10	5	1	10	1	27	P
61	TP-3.A	Operation of station pump	4.000 lpm	Swampy forest of olie and diesel fuel	± 0,5 m3/y	Contam. of landground & water	10	5	1	10	5	31	P
62	TP-3.B			Waste gas emission	-	Contamination of air	10	1	1	10	1	23	P
63	TP-3.C			Noise	-	Influencing comfort	10	5	1	10	5	31	P
64	TP-4	Depository for oli of workshop.	± 400 ltr/m	swampy forest of olie.	± 2 ltr/m	Contam. of landground & water	5	5	1	10	5	26	P
65	TP-5	Depository of furl in Cikaro	± 12 m3/y	Fuel oil swampy forest	± 60 ltr/y	Contam. of landground & water	5	5	1	10	5	26	P
66	TP-6	Relocation of ex oli.	± 1.000 ltr/y	swampy forest of olie.	± 10 ltr/y	Contam. of landground & water	5	5	1	10	5	26	P
8. ELECTRICITY													
67	LIST-1	Conservancy of electrics		Heaping of electrics material		Influencing of storage area	5	1	1	1	1	9	TP
68	LIST-2	Replacement of bulb.	± 1 m3/y	Heaping of bulb and danger. & poison	± 1 m3/y	Cont. of danger. and poison. Mat.	10	10	1	10	10	41	P
69	LIST-3.A	Operation of GENSET.	175 KVA	swampy forest of olie and fuel diesel	± 10 ltr/y	Contam. of landground & water	10	5	1	10	1	27	P
70	LIST-3.B			Waste gas emission	-	Contamination of air	5	1	1	10	1	18	P
71	LIST-3.C			Noise	-	Influencing comfort	5	1	1	10	1	18	P
9. INFORMATION TECHNOLOGY													
72	IFK-1	Conservancy of telephone	± 6 km	Heaping of ex material	+ 2 km	contamination of landground	5	1	1	1	1	9	TP
10. FIRE AND SAFETY													
73	KL-1.A	Practice Fire Extinguishing	1 times/m	Waste gas emission	-	Potency of contamination of air	1	1	1	10	1	14	P
74	KL-1.B			Fuel oil swampy forest	1 ltr/y	Pot. of contm. of landground &	10	1	1	10	1	23	P
75	KL-2.A	Making of health fringes and working safety.	20 pcs/y	Swampy forest paint and thinner	0,5 ltr/y	Pot. of contm. of landground & water	5	1	1	1	1	9	TP
76	KL-2.B			Ex-can	20 pcs/y	Potency contamination of	5	1	1	1	1	9	TP
77	KL-3	Refilling save extinguisher.	40 unit/y	Dry powder	± 300 kg/y	Potency contamination of	5	1	1	1	1	9	TP
78	KL-4	Fire Extinguishing.	-	Waste gas emission	-	Potency of contamination of air	5	1	1	1	1	9	TP
11. QUALITY AND INPECTION													
79	MDI-1	Radiography inspection	± 3 paket/y	Isotope radiasi	-	Waste radio-activity emission	5	5	1	10	1	22	P
80	MDI-2	Inspection Dye Penetran	± 10 paket/y	Ex-can discard	+ 10 can/y	Waste tidiness heap	5	1	1	1	1	9	TP
12. LOGISTIC													
81	PGD-1	Depository for drilling chemical	± 245 m3/y	swampy forest of solid and dirt	+ 1,5 m3/y	Contamination of land and air	5	5	1	10	1	22	P
82	PGD-2	Depository of fuel	± 1.900 m3/y	Potency fuel oil swampy forest	± 3 m3/y	Contam. of landground & water	5	5	1	10	5	26	P
83	PGD-3	Depository of lubricant.	± 17 m3/y	Potency lubricant swampy forest	± 0,2 m3/y	Contam. of landground & water	5	5	1	10	5	26	P
84	PGD-	Operation of Vehicle.	± 30 unit/y	Waste gas emission	-	Contamination of air	10	5	1	10	1	27	P
85	PGD-		± 0,9 m3/y	Axle journal swampy forest of olie.	± 0,09 m3/y	Contam. of landground & water	10	1	1	10	1	23	P
86	PGD-		± 180 pcs/y	Ex-tire	± 180 pcs/y	contamination of landground	5	1	1	1	1	9	TP
87	PGD-5	chemical Distribution Material.	± 22 m3/y	swampy forest of material chemical	± 1 m3/y	Contam. of landground & water	5	1	1	10	1	18	P
88	PGD-6	The settlement of disposal of material.	± 100 m3/y	Heaping of scrap waste	± 100 m3/y	Influencing waste place of scrap	5	1	1	1	1	9	TP
13. HRD													
89	SDM-1	Service of patient of which medicinizing.	20 people/m	Paper discard, drug paper.	1 m3/m	contamination of landground	5	5	1	1	1	13	TP
90	SDM-2	Management Of Office & Mess	± 8.000 m2	Domestic garbage discard and paper	+ 2 m3/m	contamination of landground	10	5	1	1	1	18	P
91	SDM-3	Sweeping of Floor	± 4.000 m2	Usage of detergen	± 3 ltr/m	Contamination of water	10	1	1	10	1	23	P
92	SDM-4	Activity of general	± 300 rim/y	Usage of paper	± 300 rim/y	Reduction of natural resources	10	1	1	1	1	14	TP
93	SDM-5	Ready of ribbon / cartridge, toner, floppy disk	± 500 pcs/y	Waste potency of cartridge, tonner, ribbon	± 500 pcs/y	Contamination of dangerous and poisonous materialses	10	1	1	10	1	23	P
94	SDM-6	Ready of clean water for office	± 4.000 m3/y	Intake of ground water	± 4.000 m3/y	Reduction of water resources	10	1	5	1	1	18	TP

5. MONITORING PROGRAMME OF KAMOJANG

In Section 4 the importance of documenting and recording the key characteristics of the operation and activities at geothermal utilities is discussed. In a geothermal operation as in Kamojang this includes monitoring the production of steam and fluids from the geothermal reservoir, to measure its chemical composition, and to record how the steam and fluid are utilized. Monitoring of the discharge of the various components of the geothermal steam and fluids is of major importance, as these may cause negative impact on the environment. In accordance with the ISO 14001 all methods and procedures have to be documented.

In the following sections monitoring data from Kamojang will be used to demonstrate how the presentation can be reported (Pertamina, 1983-1999).

5.1 Production

Based on the fluid type conditions at the wellhead we distinguish between two main types of wells, each divided into two subgroups:

1. Single-phase wells :
   - Hot water wells
   - Steam wells

2. Two-phase wells
   - Liquid water inflow into the well at all feed zones. Liquid inflow in the lower section of the well and two-phase boiling flow in the upper section. The boundaries between these two zones are the boiling level in the well. It is defined by the pressure and temperature conditions in the well during discharge.
   - Mixed liquid water and steam inflow at feed zone i.e. the fluid starts to boil in the reservoir before it enters the well. The well, therefore, contains a flowing mixture of steam and liquid from the wellhead down to the deepest feed zone.

The equipment used to measure the discharge will depend on what type of well is being tested and the maximum expected flowrate from the well. The main parameters to be determined besides the mass flow rate are, the wellhead pressure and the enthalpy of the produced fluid (wellhead temperature for single phase wells) (Steingrímsson, 2004).

5.1.1 Discharge measurement technique

The Kamojang field has a dry steam reservoir (single phase) and differential pressure over an orifice is used to measure the steam flow.

Measuring differential pressure over an orifice:
The most common flow restrictions in use for measuring steam flow rates in pipes are orifices, thin metal plates with a circular hole through the centre. The formula that relates the flowrate, Q, and the pressure drop over the orifice depends on the exact design of the orifice. The relation is of the form:

$$Q = K\sqrt{\rho\,\Delta P} \qquad (1)$$

where ρ = Density of steam;
ΔP = Pressure drop over the orifice;
K = Constant.

5.1.2 Production of steam

Each producing well is measured every day and the readings are calculated to tons per hour. The daily reading is used to calculate the monthly discharge of steam, and thus to calculate the annual discharge from each well. These calculations (Ívarsson et al., 2003) are shown in Table 1 in Appendix IV and summarized in Table 3 (Pertmanina, 1998; 1999). Also shown in Table 3 is the total discharge from each of the sub-areas of the Kamojang field as well as the total

TABLE 3: Amount of steam in 1998 and 1999

PL-401	1998-1997	1998-1999
KMJ-11	621,208	557,753
KMJ-14	445,326	613,860
KMJ-17	533,054	455,939
KMJ-18	933,208	766,979
TOTAL PL-401	**2,532,796**	**2,394,531**
PL-402		
KMJ-24	366,969	170,224
KMJ-25	180,856	82,987
KMJ-43	182,233	149,920
KMJ-44	167,174	147,652
KMJ-51	811,862	674,765
KMJ-72		359.746
TOTAL PL-402	**1,709,094**	**1,585,294**
PL-403		
KMJ-22	669,819	612,005
KMJ-28	236,465	238,424
KMJ-31	266,925	239,253
KMJ-33	160,404	139,926
KMJ-34	216,555	169,676
KMJ-37	555,038	375,117
KMJ-38	162,395	165,488
KMJ-41	508,729	539,897
KMJ-45	171,930	179,249
KMJ-52	341,836	290,450
TOTAL PL-403	**3,290,097**	**2,949,484**
PL-404		
KMJ-26	415,173	370,812
KMJ-27	486,892	461,139
KMJ-30	103,637	91,647
KMJ-35	85,442	85,118
KMJ-36	721,080	680,495
KMJ-40	91,234	111,636
KMJ-42	107,960	157,110
KMJ-46	238,403	173,835
KMJ-62	624,198	569,199
KMJ-65	555,553	526,108
TOTAL PL-404	**3,429,571**	**3,227,100**
TOTAL	**10,961,558**	**10,156,409**

steam production. The data available in this report covers the period 1998-1999. In Figures 5-8 the production from each well for the two-year period is shown graphically. Figure 9 presents the total discharge from the sub-areas.

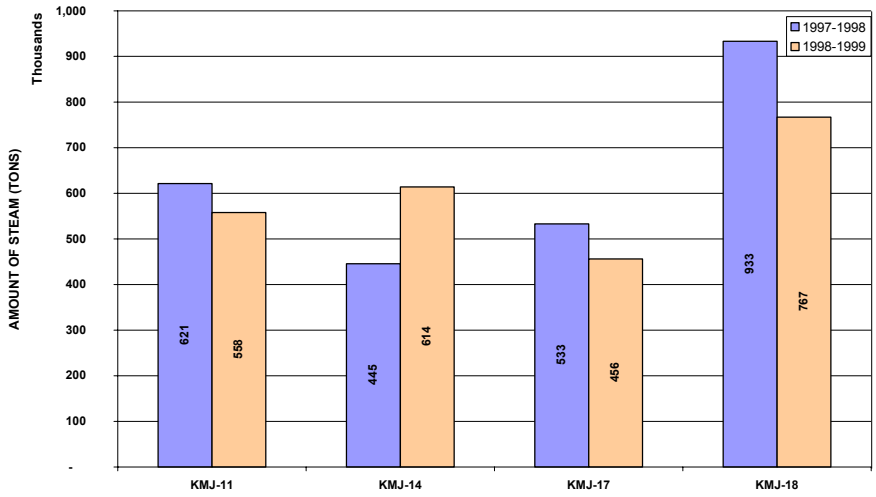

FIGURE 5: Amount of steam from wells in PL-401

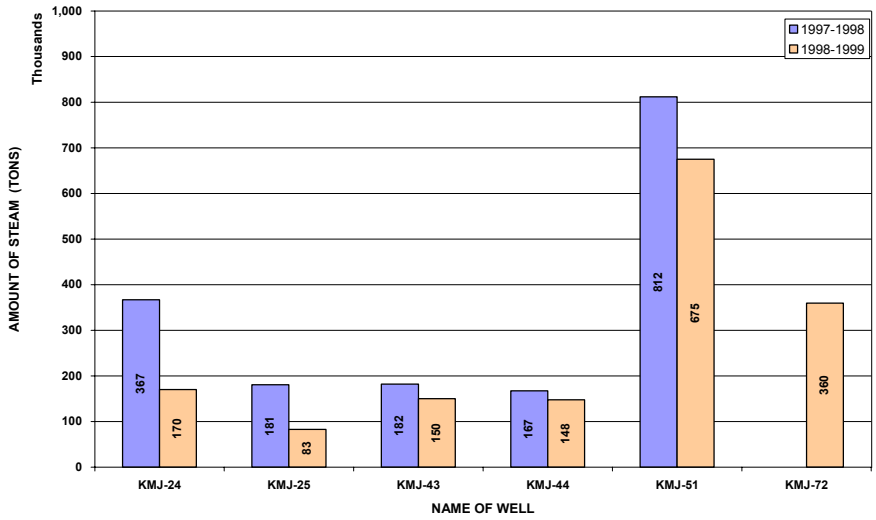

FIGURE 6: Amount of steam from wells in PL-402

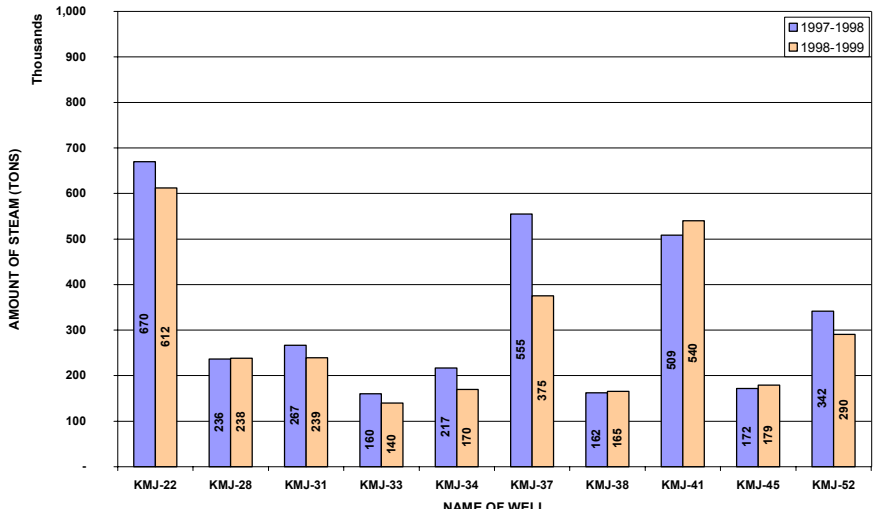

FIGURE 7: Amount of steam from wells in PL-403

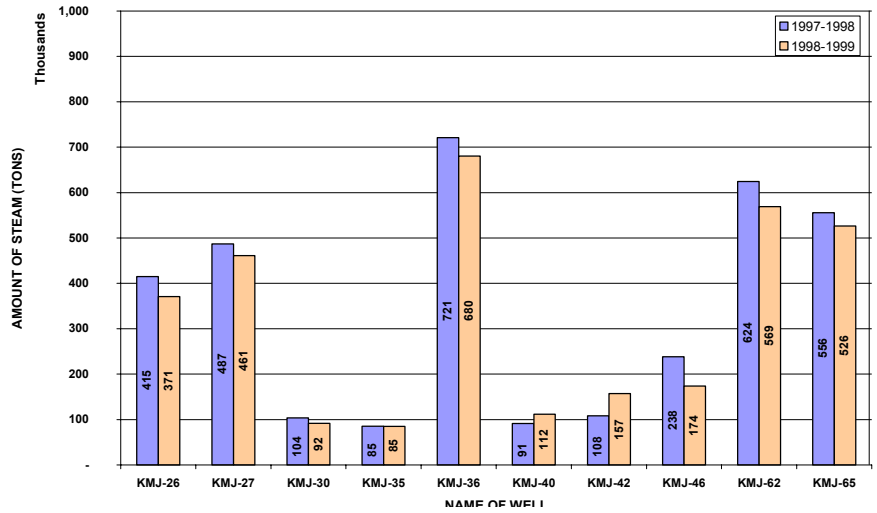

FIGURE 8: Amount of steam from wells in PL-404

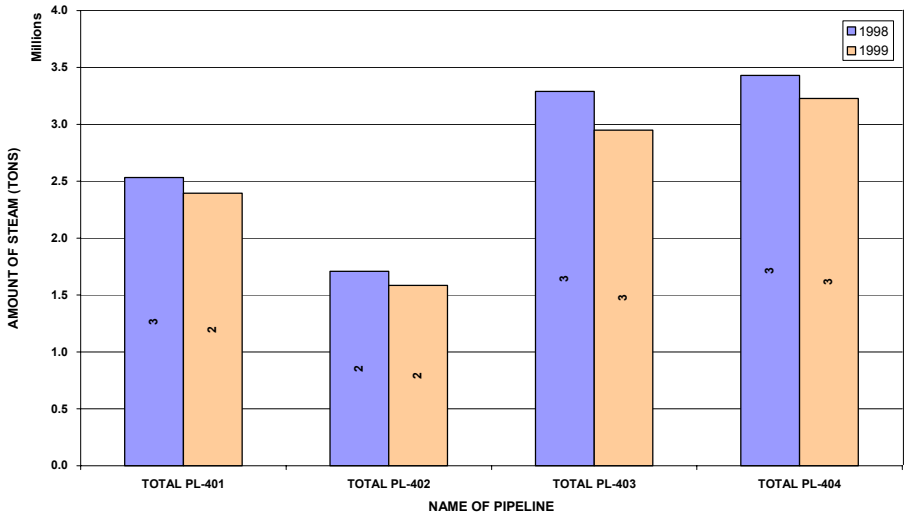

FIGURE 9: Amount of steam from PL-401, PL-402, PL-403 and PL-404

The data show that, in general, production decreased from 1998 to 1999. This trend has been a persistent problem at Kamojang. To maintain the required steam flow, a new well (KMJ-72) was connected to PL-402 in 1999 (Table 3, Figure 6). The best producers have annual steam production of 0.7-0.9 million tons, with KMJ-18 in sub-field PL-401 being the best overall producer.

5.2 Reinjection

Reinjection of the used fluids back into the geothermal resource has two objectives. By reinjecting the available fluid, the influence of fluid withdrawal from the reservoir and thus decreasing pressure drawdown and related influences, is reduced. Secondly by reinjecting the fluid, its negative impact on vegetation and the atmosphere is reduced. The operator has to account for the difference between the production and reinjection, i.e. the components which remain in the surface environment.

5.2.1 Reinjection measurement technique

As the Kamojang reservoir produces only steam, the reinjected water is mainly condensed steam from the cooling tower. Kamojang field has 3 reinjection wells, KMJ-15, KMJ-21 and KMJ-32, which are located in the centre of the drill field (Figure 3). The flowrate of the condensed water is measured by flow meters, available on the market, to determine fluid flow inside pipes. One of these devices is the turbine meter (spinner). It is inserted into the flowing pipe and the flowrate found from the rotational speed of the spinner.

5.2.2 Reinjection monitoring

The reinjection rate is recorded every day with a spinner flow meter. Table 4 shows the annual amount of condensed water reinjected into each of the 3 wells during the period 1983-1998 (Pertamina, 1983-1998). The production and reinjection can be compared for the year 1998; then the production was 10,156,409 tons (Table 3) but the reinjected water only 687 tons (Table 4). The difference evaporates in the cooling towers. The reinjection is an insignificant part of the total steam production. The total reinjected water during the period 1983-1998 into the three wells is shown in a graph in Figure 10.

TABLE 4: Amount of reinjected water in Kamojang

Year	KMJ-15 (tons)	KMJ-21 (tons)	KMJ-32 (tons)	TOTAL (tons)
1983	230			230
1984	269			269
1985				0
1986				0
1987				0
1988	484	611	466	1,561
1989	472	722	801	1,995
1990	546	717	714	1,977
1991	484	676	841	2,001
1992	532	576	758	1,865
1993	420	397	764	1,581
1994	236	616	590	1,442
1995		595	586	1,181
1996		607	483	1,090
1997		488	687	1,175
1998		47	640	687
TOTAL	**3,673**	**6,052**	**7,330**	**17,055**

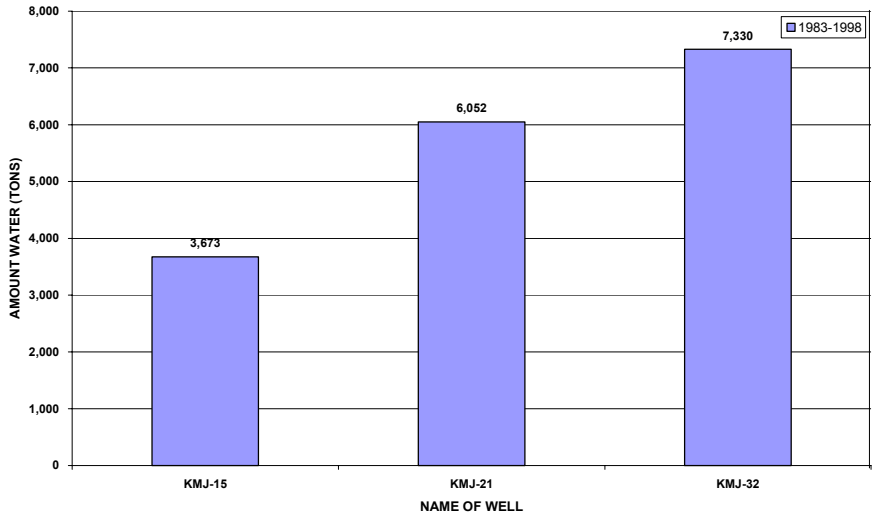

FIGURE 10: Amount of water reinjected

5.3 Gas emission

The main components carried with the steam which cause environmental concern are H_2S and CO_2. When the steam condenses in the condenser, these gases remain in a gas-phase, so called non-condensable gases, and are released to the atmosphere. The actual release of the gas is not a part of the Pertamina operation at Kamojang, but rather of the operator of the power plant. No direct measurement is available, but the amount of gas can be calculated indirectly by measuring the gas content in the steam at well-head and in the reinjected water. The total gas released is calculated from the mass flow and the concentration.

5.3.1 Gas measurement technique

The main non-condensable gases in the steam are CO_2 and H_2S, and these components are monitored by regular sampling and analyses. Samples are collected every day from a 10" pipe by the wellhead. The samples are collected and analysed by a laboratory employee of Pertamina Kamojang. The gas concentrations are presented as mol gas per 100 mol H_2O. The records are kept by the laboratory. The sampling and analysis are complex and are described in the following section, which is rewritten from the procedure manual (Pertamina, 1998).

Sampling from high-temperature wells (dry steam)
The collection of representative samples from high-temperature drillholes is a complex procedure (Arnórsson, 2000; D'Amore et al., 1998). The sample is collected at a sampling valve, near the wellhead. The hole through which the fluid sample flows should be large enough so as not to become regularly blocked by deposition, yet small enough for a faulty valve to be replaced without turning off the flow in the pipeline. A sampling separator is connected to the steam line and kept open for 15 minutes to rinse it out and warm it up. In order to obtain a representative sample, the pressure on the separator gauge should be comparable to a pressure reading on the steam line itself. After opening the separator, care must be taken that the pressure does not fall significantly, because a pressure drop will cause boiling at lower temperatures in the separator and upset the separation of the two phases.

The cooling coil is connected to one of the steam outlet valves on the separator. The valves are kept closed. The other steam outlet is opened, and the water and steam taps closed. The water tap is then partly opened, and the gas tap slightly opened so that a mixture of steam and water will discharge through the water tap and dry steam through the steam tap. The dry steam is barely visible close to the steam outlet and is conical in shape. Then the steam outlet, connected with the cooling coil, is opened but the other one closed. Keep it open for a while to rinse the cooling coil. During sampling the steam will condense, but not gases such as CO_2, H_2S and H_2. The two phases, i.e. condensate and gas, are then collected.

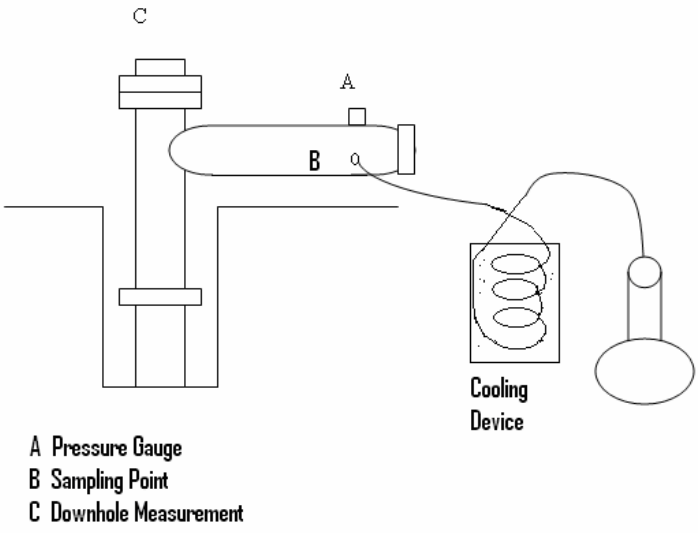

FIGURE 11: Sampling gas CO_2 and H_2S

Gas and condensate are collected into two gas sampling flasks, and the condensate into a 100 ml polyethylene bottle as well. All containers are first thoroughly cleaned with the cooled steam (Figure 11). The two gas flasks are connected by rubber tubing. A short piece of rubber tubing is used to connect the second glass flask with a measuring cylinder. When sampling, one gas flask is first filled with condensate, then it is turned upside down and the gas flask expels the condensate into the second gas flask and finally into the measuring cylinder. During the sampling procedure the fluid temperature is kept as constant as possible and recorded. Having sampled the gas, the volume of the condensate sampled with gas is calculated by adding the volumes of condensate in flask and in cylinder, and subtracting from it the volume of the gas flask. Finally, steam is collected into a concentrated (40%) NaOH solution in a vacuumed flask. By determining the mass of the vacuumed flask with 40% NaOH solution (Mo), the mass of the flask after collection of steam (Ms) and the total volume of the sample and NaoH solution (Vs), we can calculate the ratio according to Equation 2.

$$R = \frac{(Ms - Mo)}{Vs} \tag{2}$$

where R = Ratio;
Ms = Weight of steam, NaOH and flask;
Mo = Weight of NaOH and flask.

If the amount of other gases is insignificant, we can calculate the mass-percentage of gas based on the CO_2 and H_2S analyses in the following way:

$$\%\, GAS = \frac{CO_2(\text{ppm}) + H_2S(\text{ppm})}{10{,}000} \tag{3}$$

Procedure of analysing CO_2 and H_2S

Measurement procedure (steam condensate) for CO_2 :

1. Extract 1 ml aliquot of the alkaline solution from the gas sampling bulb and pour into a 150 ml beaker. Add 2-5 drops of hydrogen peroxide, mix well and leave for 1 min.
2. Adjust the pH to 8.30, and add some 1 M HCl solution. When the pH is 9.0-9.5, add 0.1 M HCl standard solution from a microburette to adjust the pH accurately to 8.3 .
3. Titrate with the 0.1 M HCl standard solution to pH 3.8 (titre A).
4. $CO_2 = \frac{(\text{titre A})\ x\ 4{,}400}{\text{ml sample}} - 6.97$; CO_2 is the total carbonate in ppm.

Measurement procedure for H_2S:

1. Pipette 5 ml of a 5 M NaOH solution and 5 ml of acetone into an Erlenmeyer flask.
2. Add 1-50 ml of sample. If the sample aliquot is < 10 ml, add deionised water to make the total sample volume about 10 ml.
3. With a glass rod, add a tiny crystal of dithizone. The solution should be very pale yellow and only one phase.
4. Titrate with the standard $Hg(CH_3COO)_2$ solution to a pink end-point. Record titre.
5. $H_2S\,(\text{ppm}) = \frac{\text{ml } 0.001\text{ M Hg } (CH_3COO)_2 \text{ solution} \times 34}{\text{ml sample}}$

If H_2S is < 0.3 ppm, it is best to take a 50 ml sample aliquot. If H_2S concentration is in the range 0.3-5.0 ppm, take 10 ml aliquot. If H_2S > 5 ppm, it is best to take a sample aliquot of < 10 ml and as little as 0.05 ml of condensate rich in H_2S.

Calculating CO_2 and H_2S

In Pertamina's records the concentration of CO_2 and H_2S is presented as mol per 100 mol of water, and to calculate the weight of gases per kg of steam (gr/kg) in the discharge, the following calculations are performed:

$$\text{Gas of } CO_2 = \frac{\text{mol of } CO_2 \times \text{WM of } CO_2}{\text{mol of } H_2O \times \text{WM of } H_2O} \tag{4}$$

$$\text{Gas of } H_2S = \frac{\text{mol of } H_2S \times \text{WM of } H_2S}{\text{mol of } H_2O \times \text{WM of } H_2O} \tag{5}$$

where 1 mol = 1,000 mmol;
1 ppm = 1 mg / kg;

WM = Molecular weight
WM of CO_2 = 44;
WM of H_2S = 34;
WM of H_2O = 18;

Gas monitoring

The amount of CO_2 and H_2S in the steam from each borehole (Appendix IV, Table 2) has been calculated in this report for the year 1998 and is presented in Table 5 (Pertamina, 1998). The sum from each sub-area is shown on a graph in Figure 12. The ratio between CO_2 and H_2S has been calculated for each sub-area (Table 5, column 5) and is similar for all the areas. The last column shows the percentage of NCG from each of the sub-areas. In general, the NCG-content is low (range 0.27-0.57%), with sub-area PL-403 significantly higher than the other areas.

No analyses of the gas concentrations in the reinjected water are available and it is therefore not known how much of the gas is reinjected into the reservoir. From experience it can be concluded that well over 95% of the gas goes into the gas phase when the steam is condensed, and is released into the atmosphere. The results indicate that the total gas release in 1998 was close to 37,000 tons of CO_2 and 3,500 tons of H_2S.

TABLE 5: Content of CO_2 and H_2S gas in wells in Kamojang

	NAME OF WELL	MASS FLOW (TONS)	CO2 (TONS)	H2S (TONS)	RATIO C02/H2S	GAS IN STEAM (%)
PL-401	KMJ-11	621.208	1,168	158		
	KMJ-14	445.326	1,410	114		
	KMJ-17	533.054	1,334	117		
	KMJ-18	933.208	2,226	233		
		2,532,796	**6,138**	**622**	**10**	**0.27**
PL-402	KMJ-24	366.969	592	89		
	KMJ-25	180.856	-	-		
	KMJ-43	182.233	900	60		
	KMJ-44	167.174	625	55		
	KMJ-51	811.862	2,935	250		
	KMJ-72		-	-		
		1,709,094	**5,052**	**454**	**11**	**0.322**
PL-403	KMJ-22	669.819	4,943	883		
	KMJ-28	236.465	639	74		
	KMJ-31	266.925	804	70		
	KMJ-33	160.404	843	53		
	KMJ-34	216.555	381	54		
	KMJ-37	555.038	1,313	165		
	KMJ-38	162.395	4,636	76		
	KMJ-41	508.729	980	102		
	KMJ-45	171,930	1,558	48		
	KMJ-52	341.836	962	101		
		3,290,096	**17,059**	**1,626**	**11**	**0.57**
PL-404	KMJ-26	415.173	620	100		
	KMJ-27	486.892	1,441	110		
	KMJ-30	103.637	216	26		
	KMJ-35	85.442	80	16		
	KMJ-36	721,080	1,621	164		
	KMJ-40	91.234	667	26		
	KMJ-42	107,960	673	30		
	KMJ-46	238.403	1,039	61		
	KMJ-62	624.198	1,697	154		
	KMJ-65	555.553	673	113		
		3,429,572	**8,727**	**800**	**11**	**0.28**
TOTAL		**10,961,558**	**36.976**	**3.502**		

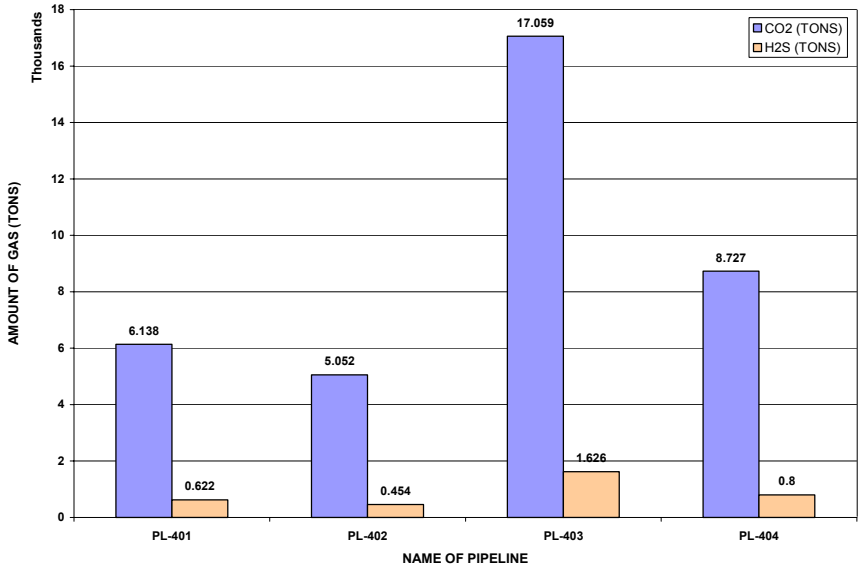

FIGURE 12: Total content of CO_2 and H_2S gas in the Kamojang field in 1998

5.4 Airborne contaminants

An airborne contaminant refers to a geothermal component which can be measured in the atmosphere at the location and may be a product of geothermal exploitation. The main contaminants considered in this report are hydrogen sulphide (H_2S) and carbon monoxide (CO). The origin of these components in Kamojang are thought to be from leakage at wellhead. Another source may be the discharge point from the condensers at the power plant or from natural discharge, i.e. a geothermal surface manifestation. These components are measured monthly at a number of locations at the Kamojang geothermal area. The points of measurements are by each wellhead (Figure 3). During the first week of each month wells in the PL-401 group are measured, PL-402 during the second week and so on.

The concentration of H_2S and CO in the atmosphere is measured by Drager tubes, where a sample of air is passed through a chemical component which changes colour depending on the concentration of the gas to be measured. At Kamojang, Drager PAC III B tubes are used, having detection limits in the range 0-100 ppm. The data available in this report covers the period September 2003 to April 2004 (Pertamina, 2003b; 2003c).

5.4.1 H_2S in atmosphere at Kamojang field

Table 6 shows the results from the H_2S monitoring in atmosphere at Kamojang during the period September 2003 to April 2004, and Figure 13 shows a histogram of the distribution of measured values. 81% of the measurements are below the detection limits of the methods used for analysing. The highest value is 5 ppm which is well below safety limits, but gives a very strong (and annoying) smell (see Section 3.6).

TABLE 6: H_2S in the atmosphere at Kamojang

	2003 Septem	2003 October	2003 Novemb	2003 Decemb	2004 January	2004 Februar	2004 March	2004 April
PL-401								
KMJ-11	0	0	0	2	1	0	0	0
KMJ-14	4	3	3	1	3	0	0	0
KMJ-17	4	2	2	0	1	2	0	1
KMJ-18	0	1	1	0	0	2	0	1
PL-402								
KMJ-24	2	0	0	1	1	0	0	0
KMJ-25	1	1	1	0	1	0	0	0
KMJ-43	3	2	2	0	0	0	4	4
KMJ-44	1	1	1	0	0	0	0	0
KMJ-51	1	0	0	0	0	0	0	0
KMJ-72	5	3	3	3	3	0	0	0
PL-403								
KMJ-22	0	0	0	0	0	0	0	0
KMJ-28	0	0	1	0	0	0	0	1
KMJ-31	2	3	0	3	3	0	0	2
KMJ-33	1	0	0	0	0	0	0	2
KMJ-34	0	0	0	0	0	0	1	1
KMJ-37	0	0	0	0	0	0	0	0
KMJ-38	3	3	3	3	2	0	1	1
KMJ-41	0	1	0	0	0	0	2	0
KMJ-45	3	2	2	2	1	1	0	2
KMJ-52	0	1	0	0	0	1	0	0
PL404								
KMJ-26	0	0	0	1	0	0	0	0
KMJ-27	0	3	3	3	3	3	0	0
KMJ-30	0	1	0	0	0	0	0	0
KMJ-35	0	0	0	0	0	0	0	0
KMJ-36	0	0	0	2	2	0	0	0
KMJ-40	0	0	0	1	0	0	0	0
KMJ-42	0	0	0	0	0	0	2	0
KMJ-46	0	0	0	0	0	0	0	0
KMJ-62	0	0	0	0	0	0	0	0
KMJ-65	0	0	0	0	0	0	0	0

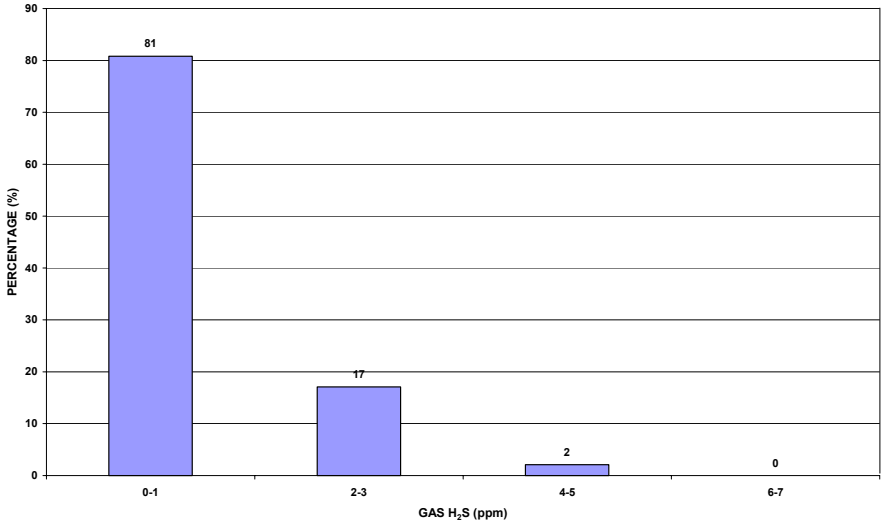

FIGURE 13: H_2S concentration in the atmosphere at Kamojang

5.4.2 CO in atmosphere at Kamojang

The carbon monoxide is measured in the same locations as the hydrogen sulphide, and is presented in the same way in Table 7 and a histogram in Figure 14. The range is up to 8 ppm, with 78% of the readings below the detection limits of 1 ppm.

5.5 Noise in the Kamojang field

Activity in the Kamojang geothermal field creates noise, mainly because of discharging wells. The wellhead shut-in pressure is about 33 bar-g, but the operational pressure in the pipelines is about 7-8 bar-g. Noise in the production area is measured every month at each wellhead or at a cluster of wellheads. In this report data from September 2003 - April 2004 are analysed, and the results are presented in Table 8. The range of measured noise level is between 40 and 82 dB(A), with 90% of the

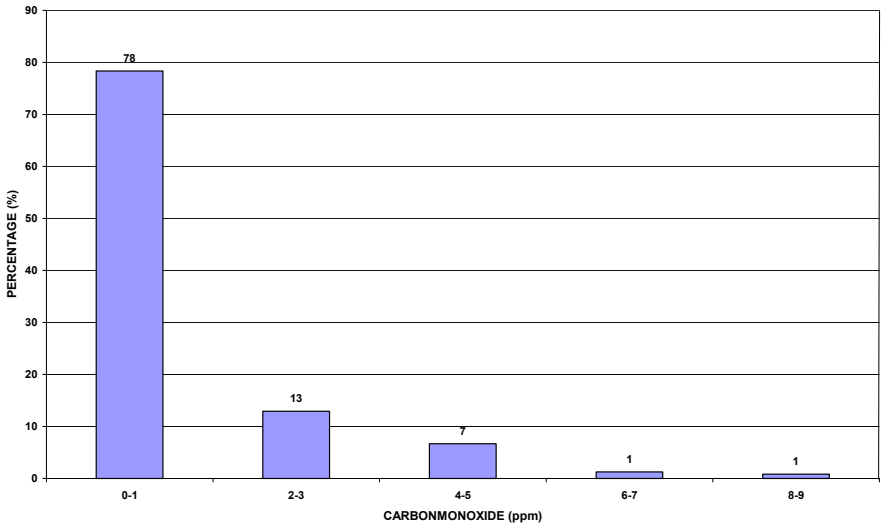

FIGURE 14: Amount of CO in the atmosphere at Kamojang

TABLE 7: CO in the atmosphere at Kamojang

	2003 Septem	2003 October	2003 Novemb	2003 Decemb	2004 January	2004 Februar	2004 March	2004 April
PL-401								
KMJ-11	4	4	4	4	2	0	0	0
KMJ-14	2	0	0	1	0	0	3	3
KMJ-17	2	0	0	0	0	0	0	2
KMJ-18	3	3	3	4	0	0	0	0
PL-402								
KMJ-24	6	0	0	0	0	0	0	0
KMJ-25	2	2	2	0	0	0	0	0
KMJ-43	7	4	4	0	0	0	0	0
KMJ-44	4	3	3	0	0	0	2	2
KMJ-51	3	0	0	0	0	6	0	0
KMJ-72	3	1	1	0	0	0	0	0
PL-403								
KMJ-22	0	0	0	0	0	0	0	0
KMJ-28	0	0	0	0	0	0	3	0
KMJ-31	3	0	4	3	2	0	0	3
KMJ-33	0	0	0	0	0	0	0	2
KMJ-34	0	2	0	0	0	0	2	0
KMJ-37	0	0	0	0	0	0	0	1
KMJ-38	8	9	5	0	4	0	0	0
KMJ-41	0	2	0	0	0	0	0	0
KMJ-45	4	0	0	0	0	0	0	2
KMJ-52	0	2	0	0	0	0	0	0
PL-404								
KMJ-26	0	5	0	0	0	0	0	0
KMJ-27	0	0	0	4	4	2	0	0
KMJ-30	0	3	0	0	0	0	0	0
KMJ-35	0	0	0	0	0	0	0	0
KMJ-36	0	0	0	0	0	0	0	0
KMJ-40	0	0	0	1	0	0	0	0
KMJ-42	0	0	0	0	0	0	4	0
KMJ-46	0	0	0	0	0	0	0	0
KMJ-62	0	0	0	0	0	0	0	0
KMJ-65	0	0	0	0	0	0	0	0

TABLE 8: Noise in the surroundings at Kamojang in dB(A)

	2003 Septem	2003 October	2003 Novemb	2003 Decemb	2004 January	2004 Februar	2004 March	2004 April
PL-401								
KMJ-11	76	74	74	73	70	69	73	73
KMJ-14	73	70	70	69	68	67	67	67
KMJ-17	73	74	77	70	64	60.3	63	68
KMJ-18	72	67	72	66	68	50	67	64
PL-402								
KMJ-24	74	72	72	68	65	68	67	67
KMJ-25	73	68	68	68	63	67	69	69
KMJ-43	72	76	76	76	78	70	70	70
KMJ-44	72	76	76	76	78	70	70	70
KMJ-51	72	70	70	71	69	68	65	65
KMJ-72	74	65	65	68	65	68	67	67
PL-403								
KMJ-22	71	79	70	80	78	67	60	71
KMJ-28	73	70	76	71	69	62	73	75
KMJ-31	73	65	73	73	68	67	73	69
KMJ-33	73	65	73	73	68	67	73	69
KMJ-34	73	70	76	71	69	62	73	75
KMJ-37	73	70	76	71	69	62	73	75
KMJ-38	71	64	74	69	70	62	74	67
KMJ-41	71	79	70	80	78	67	60	71
KMJ-45	71	64	74	69	70	62	74	67
KMJ-52	73	65	73	69	68	68	73	69
PL-404								
KMJ-26	82	77	71	78	75	68	68	71
KMJ-27	75	77	70	76	73	65	67	68
KMJ-30	82	76	70	76	77	67	58	70
KMJ-35	82	77	71	78	75	68	68	71
KMJ-36	82	76	70	76	77	67	58	70
KMJ-40	75	77	70	76	73	65	67	68
KMJ-42	82	77	71	78	75	68	68	71
KMJ-46	75	77	70	76	73	65	67	68
KMJ-62	75	77	70	76	73	65	67	68
KMJ-65	82	76	70	76	77	67	58	70

measurements in the range 65-79 dB(A) and 37% in the range of 70-74 dB(A) (Figure 15). In September 2003, the average produced noise of the pipeline was about 74.8 dB(A) and produced noise was higher for this month than in other months. In February 2004, the average produced noise of the pipeline was about 65.6 dB(A), which was lower than in other months.

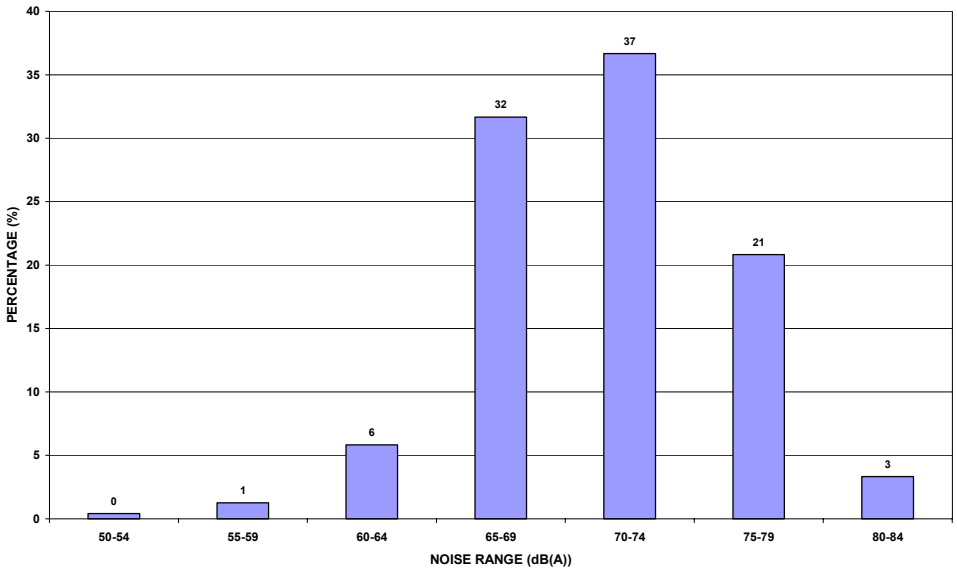

FIGURE 15: Noise in surrounding pipeline in the Kamojang field

5.6 Vegetation

The Kamojang geothermal field is a wooded area, and Pertamina has an active reforestation programme to reduce the negative influence of the geothermal development. Since 1994-2003 about 43,000 pieces of various trees have been planted in the Kamojang area. The trees are pine, natural wood, eucalyptus and special trees for wood production (Table 9).

TABLE 9: Reforestation in Kamojang 1994-2003

NO.	LOCATION	AREA (ha.)	AMOUNT OF TREES (pcs.)	TREE TYPE	YEAR PLANT
1	KMJ-51		500	Pine	1994
2	KMJ-43		1,000	Natural wood	1997
3	KMJ-15		1,000	Pine	1999
4	KMJ-12		500	Pine	1995
5	KMJ-20		500	Pine	1997
6	KMJ-48		1,000	Eucalyptus	1998
7	KMJ-64		1,500	Natural wood	1996
8	KMJ-70		1,000	Natural wood	1998
9	Malvinas		5,000	Natural wood	2001
10	PL-401, PL-402	7	8,000	Natural wood	2001
11	PL-403, PL-404	7.8	7,000	Natural wood	2001
12	Ciharus		3,000	Natural wood	2002
13	Cihejo lake		2,000	Wood production	2002
14	Warrior mausoleum		1,000	Natural wood	2003
15	Road side KMJ-41		8,000	Natural wood	2003
16	Around KMJ-41		1,000	Natural wood	2003
17	KMJ-63		1,000	Natural wood	2003
	Total		**43,000**		

5.7 Socio-economic impact

The steam production has been ongoing since 1984 without any major socio-economic conflicts. The companies working at Kamojang geothermal field are concerned about the well being of the local population and the company supports the society in the form of finance or the so-called programme of community development. The supported areas are the sub-province of Garut and Bandung. Table 10 lists the funding to the various socio-economic projects which Pertamina has supported in the Kamojang area, and they are also shown in Figure 16.

TABLE 10: Community development programme

NO.	PROGRAMME NAME	AMOUNT (Rp) x 1,000	LOCATION CITY
1	PUKK (324 partners)	2,951,615	BD,GRT,TSK, SMD & CMS
2	Repair of public facility	162,655	BD & GRT
3	Bursary and education	42,550	BD & GRT
4	Medium sport	128,523	BD & GRT
5	Sanitation for clean water	35,072	BD & GRT
6	Medium sport	113,304	BD & GRT
7	Religious activity	17,925	BD & GRT
8	Activity of young men	1,993	BD & GRT
9	Aid to other institutions	42,970	BD & GRT
10	Victims of natural distasters	3,000	BD & GRT
11	Aid heavy equipment	547,596	BD & GRT
	TOTAL	**4,047,202**	

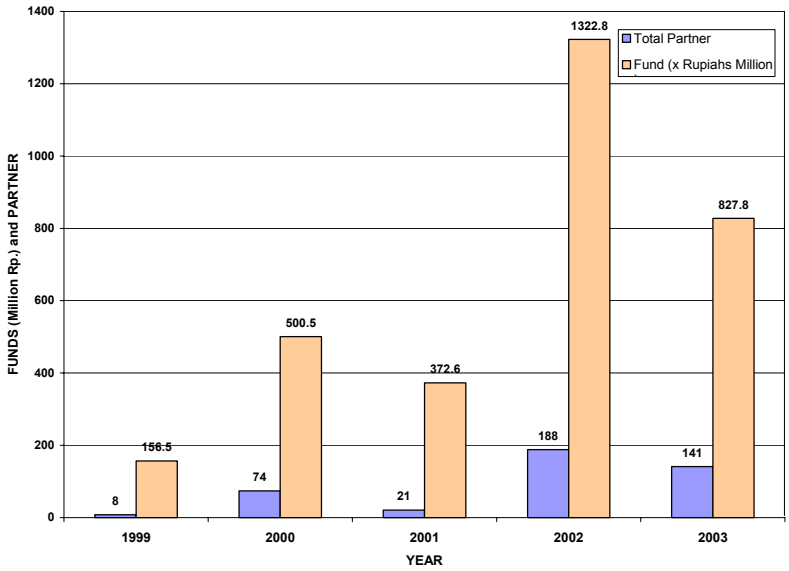

FIGURE 16: Channelling of aid funds for community development

6. DISCUSSION

Adopting the ISO 14001 EMS for managing the exploitation of the Kamojang geothermal system in 2002 has proven to be very important. It is a large operation with 76 production wells, three reinjection wells and a production of 1,100 tons of steam per hour. Analyses under ISO 14001 have helped to identify possible environmental hazards and made counteractive planning more accurate.

The exploited area within the Kamojang geothermal field is about 100 ha. It is mostly a forested area but includes also some residential or governmental land. In order to accommodate geothermal development land has been bought or leased. The department of forestry has received compensation for land required for power generation. An extensive reforestation program has been set up by Pertamina. To ensure that the socio-economic influence of the harnessing of geothermal energy at Kamojang is a positive one, Pertamina has supported a variety of projects in the vicinity of the power production.

The EMS requires an intensive monitoring of the production of steam from the reservoir. Production is in the range of 10 million tons per annum, and, in the reports, it is divided into four sub-areas within the production field. The main non-condensable gases in the discharge are CO_2 and H_2S, released to the atmosphere when the steam condenses. The annual discharge of CO_2 is about 37,000 tons and 3,500 tons of H_2S. Only a small ratio of the steam is reinjected into the reservoir as condensed water, or about 3,000 tons. The difference evaporates in the cooling towers.

A programme has been set up to monitor the concentration of possible geothermal gases in the atmosphere, to ensure that these components are within acceptable levels. The main concern are gases H_2S and CO, but regular measurement shows that these components are within acceptable levels, and in a majority of cases, within detectable levels. Noise is also monitored regularly within the field, and is within the required 80 dB(A) level in 95% of the cases.

7. CONCLUSIONS

- EMS ISO 14001 has proven to be very useful at Kamojang to depress and minimize negative environmental impact.

- Environmental impact in the Kamojang geothermal field is small, including land use, vegetation and wildlife, air quality, noise and socio-economic impact.

- Pertamina has been planting trees to compensate for lost forest land due to power generation. The tree types are: pine, natural wood, eucalyptus, and wood for production.

- The Kamojang geothermal field has airborne contaminants in the atmosphere including hydrogen sulphide (H_2S), carbon monoxide (CO) and also noise. The average CO in the atmosphere is about 0.76 ppm, H_2S is about 0.67 ppm and noise is about 70.77 dB(A). These values of CO, H_2S and noise are under the maximum level.

- The total NCG gas released to the atmosphere is about 37,000 tons of CO_2, and about 3,500 tons of H_2S.

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APPENDIX I: The Kamojang power plant

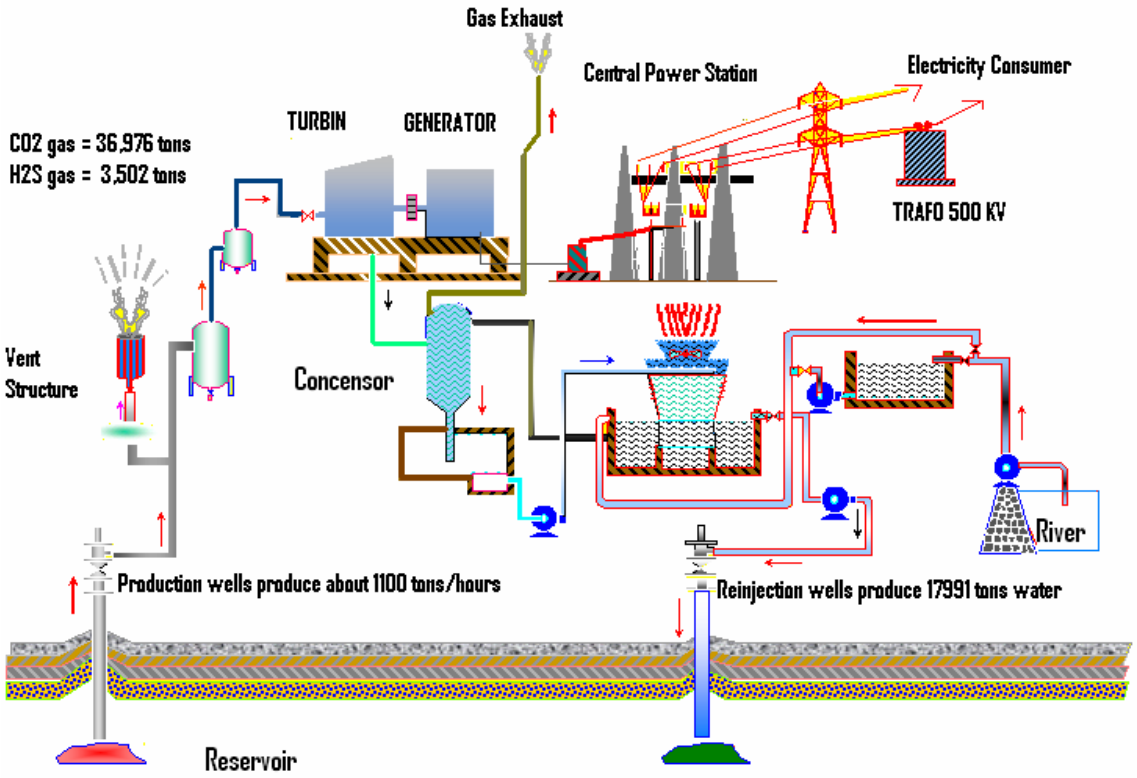

FIGURE 1: Schematic showing the Kamojang power plant

APPENDIX II: ISO 14001 certificate

TÜV CERT

CERTIFICATE

The TÜV CERT Certification Body
of TÜV Anlagentechnik GmbH
Unternehmensgruppe TÜV Rheinland Berlin Brandenburg

hereby certifies in accordance with
TÜV CERT procedures that

PERTAMINA Area Geothermal Kamojang
Jalan Raya Kamojang, PO. BOX 120 Garut 44101,
Jawa Barat - Indonesia

has established and applies an environmental management system for

Geothermal Steam Supply for Electric Power Plant

An audit was performed, Report No. 021161
Proof has been furnished that the requirements according to

DIN EN ISO 14001:1996

are fulfilled.
The certificate is valid until 2005 December
Certificate Registration No. 01 104 021161

Cologne, 2002-12-05

TÜV

TÜV Rheinland
Berlin Brandenburg

APPENDIX III: Environmental programme management in Kamojang geothermal field

FUNCTION : ALIANCE.
CONDITION : NORMAL

NO.	ASPECT CODE	POLICY OF ENVIRONMENT	TARGET	SPECIFIK TARGET	ACTION	ENVIRONMENTAL PROGRAM			CONTROLLING OPERATIONAL	UNDERWRITER OF ANSWER
						COMAND OF JOB	GOALS HAVE	RELATED FUNCTION		
1	OPS-1.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Protecting environmental gases presentation.	Protecting gases presentation of to maximum environment.	- Presentation gases monitoring.	-	-	-	B-015/DCK10/02-S0	Ka. Ops
					- Equiping worker of with gas masker	-	-	-	B-011/DCK10/02-S0	Ka. Ops
					- Repair of silencer.	WO.022/DC120	Des '02	Teknik	-	Ka. Ops
2	OPS-1.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Protecting noise of to environment.	Protecting or lessening noise of maximum environment.	- Noise monitoring.	-	-	-	B-013/SML/D00457/S0-02	Ka. Ops
					- Repair of silencer	WO.022/DC120	Des '02	Teknik	-	Ka. Ops
					- Equiping worker of with ear plug	-	-	-	B-011/DCK10/02-S0	Ka. Ops
3	OPS-2.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Protecting noise of to environment.	Protecting or lessening noise of maximum environment.	- Noise monitoring.	-	-	-	B-013/SML/D00457/S0-02	Ka. Ops
					- Equiping worker of with ear plug	-	-	-	B-011/DCK10/02-S0	Ka. Ops
4	OPS-2.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Protecting environmental gases presentation.	Protecting gases presentation of to maximum environment.	- Presentation gases monitoring.	-	-	-	B-015/DCK10/02-S0	Ka. Ops
					- Equiping worker of with gas masker	-	-	-	B-011/DCK10/02-S0	Ka. Ops
5	OPS-3	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Protecting environmental gases presentation.	Protecting gases presentation of to maximum environment.	- Presentation gases monitoring.	-	-	-	B-015/DCK10/02-S0	Ka. Ops
					- Equiping worker of with gas masker	-	-	-	B-011/DCK10/02-S0	Ka. Ops
6	OPS-5.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing swampy forest of oli measurement well location and oil fuel.	Do not swampy forest.	- Accomodating swampy forest of oil fuel and use pail.	-	-	-	B-007/DCK10/02-S0	Ka. Ops
					- Throwing away majun to determined place.	-	-	-	B-020/DCI32/02-S0	Ka. Ops
7	FP-6.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing swampy forest of grease, oli and oil fuel of recondition valve rekondisi work shop.	Do not swampy forest.	- Scattering wood sawdust of hit by location is swampy forest, accomodated in place which determined	-	-	-	C-003/SML/D00457/02-S)	Ka. Ops
					- Cleaning oil channel move to oil catcher	-	-	-	C-003/SML/D00457/02-S)	Ka. Ops
8	FP-6.C	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing waste of majun which it is contamination by oil.	Avoiding from dangerous and poisonous Materialses danger.	- Arrangement of dismissal of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. Ops
9	FP-7A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil swampy forest and oil vapour.	Avoiding swampy forest to and oil vapour do not regarding worker.	- oil swampy forest is immediately cleaned	-	-	-	C-003/SML/D00457/02-S)	Ka. Ops
					- Equiping worker of with masker	-	-	-	B-011/DCK10/02-S0	Ka. Ops
					- Giving skill calibrated equipments	-	-	-	-	Ka. Ops
10	FP-7B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing waste of majun which it is contamination by oil.	Avoiding from dangerous and poisonous Materialses danger.	- Arrangement of dismissal of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. Ops
11	FP-8	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil swampy forest.	swampy forest / oil drop as small as possible.	- oil swampy forest is immediately cleaned	-	-	-	C-003/SML/D00467/02-S)	Ka. Ops
					- Giving skill calibrated equipments	-	-	-	-	Ka. Ops
12	LAB-1.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Lessening ex- chemicals discard.	Discard Consentration < standard of quality.	- Make installation of processing water waste	WO.019/DC130	Sept '02	Teknik	-	Ka. Ops
					- Standard monitoring of quality irrigate laboratory discard.	-	-	-	B-018/SML/D00457/02-S0	Ka. Ops
					- Training of the settlement of disposal	-	-	-	B-003/SML/D00457/02-S0	Ka. Ops
13	LAD-1.D	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Chemicals minimization of kadaluarsa.	Optimalisasi of usage of chemicals.	- Order of material of according to material	-	-	-	A-002/SML/D00457/02-S0	Ka. Ops
					- Training of chemicals handling	-	-	-	B-003/SML/D00457/02-S0	Ka. Ops
14	LAB-2.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Chemicals minimization of kadaluarsa.	Optimalisasi of usage of chemicals.	- Labeling	-	-	-	C-001/SML/D00457/02-S0	Ka. Ops
					- Depository according to order	-	-	-	C-001/SML/D00457/02-S0	Ka. Ops
15	LAB-3	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing chemicals swampy forest	Do not swampy forest	- Training of chemicals handling	-	-	-	B-003/SML/D00457/02-S0	Ka. Ops
					- Execution of according to procedure.	-	-	-	C-003/SML/D00457/02-S)	Ka. Ops
									C-002/SML/D00452/02-S0	Ka. Ops
16	PDR-1.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing dangerous and poisonous Materialses mud swampy forest in drilling location	Do not swampy forest.	- Handling of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. Eng
					- Conservancy of field, ditch, dam and disposal water in drilling location	WO.010/DC200	Des '02	Teknik	-	Ka. Eng
					- Giving training at operator	-	-	-	B-003/SML/D00457/02-S0	Ka. Eng

17	PBR-1.D	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing waste of tidiness of dangerous and poisonous Materialses in drilling location.	Avoiding from dangerous and poisonous Materialses danger.	- Arrangement of tidinessl of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. Eng
					- Obliging usage of working safety	-	-	-	B-014/SML/D00457/02-S0	Ka. Eng
					- Training of chemicals handling	-	-	-	B-003/SML/D00457/02-S0	Ka. Eng
					- Handling of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. Eng
18	PBR-2.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil fuel swampy forest of in drilling location.	Do not swampy forest.	- Improvement of observation usage of appliance	-	-	-	Kontrak dengan pihak ke III	Ka. Eng
					Conservancy of field, ditch, dam and disposal water in drilling location.	WO.010/DC200	Des '02	Teknik	-	Ka. Eng
					- Handling of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. Eng
19	PBR-2.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil fuel swampy forest in drilling location.	Do not swampy forest.	- Improvement of observation usage of appliance	-	-	-	-	Ka. Eng
20	PBR-3.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing swampy forest of oli & grease in drilling location.	Do not swampy forest.	- Handling of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. Eng
					- Conservancy of field, ditch, dam and disposal water in drilling location.	WO.010/DC200	Des '02	Teknik	-	Ka. Eng
					- Improvement of observation usage of appliance	-	-	-	-	Ka. Eng
21	PBR-3.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing swampy forest of oli grease and in drilling location.	Do not swampy forest.	- Improvement of observation usage of appliance	-	-	-	Kontrak dengan pihak ke III	Ka. Eng
					- Handling of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. Eng
22	PBR-4.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing swampy forest cement in drilling location.	Do not swampy forest.	- Improvement of observation usage of appliance				Kontrak dengan pihak ke III	Ka. Eng
					- Handling of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. Eng
23	PBR-5.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing noise in drilling location.	Balmy and peaceful Atmosphere activity creation.	- Improvement of observation usage of appliance	-	-	-	Kontrak dengan pihak ke III	Ka. Eng
24	PBR-5.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Lessening gas emission throw away.	Gas emission throw away < standard for quality.	- Emission gas monitoring throw away	-	-	-	B-015/SML/D00457/02-S0	Ka. Eng
25	PBR-6.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing waste of cutting in drilling location.	Taking care of spreading of waste of cutting.	- Conservancy of field, ditch, dam and disposal water in drilling location.	WO.010/DC200	Des '02	Teknik	-	Ka. Eng
					- Location of cutting waste	WO.017/DC200	Des '02	Teknik	-	Ka. Eng
26	S-1.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing solid waste of dangerous and Poisonous materialses (tidiness of accu).	Localize dismissal / heaping of tidiness of accu.	- The settlement of disposal of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. Eng
27	TS-1.A	Doing prevention of contamination potency and control arising out impact.	Preventing swampy forest of land clearing of outside requirement.	Optimalisasi of usage of farm.	- Reboisasi and cultivation of grass	-	-	-	B-019/SML/D00457/02-S0	Ka. LU
28	TS-1.B	Doing prevention of contamination potency and control arising out impact.	Controling hewing of tree.	Optimalisasi of usage of farm.	- Reboisasi	-	-	-	B-019/SML/D00457/02-S0	Ka. LU
29	TS-2.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Management of dangerous and poisonous Materialses waste (NH3).	Lessening gas emission of NH3.	- Installation of flue ventilation	-	-	-	-	Ka. LU
					- Usage of masker	-	-	-	B-014/SML/D00457/02-S0	Ka. LU
					- Training of skill executor of handling ammonia	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
30	TS-4.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing paint swampy forest & thinner.	Do not swampy forest.	- Improvement of observation usage of appliance and material	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
31	TS-4.D	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Lessening dirt swampy forest of around building location.	Avoiding the happening of acute exhalation channel infection trouble.	- Sprinkler unload building	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
					- Usage of masker	-	-	-	B-014/SML/D00457/02-S0	Ka. LU
32	TS-5.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Lessening smoke swampy forest of combustion of asphalt.	Avoiding the happening of acute exhalation channel infection trouble.	- Usage of masker	-	-	-	B-014/SML/D00457/02-S0	Ka. LU
					- arrangement of combustion time of asphalt adapted for weather	-	-	-	C-004/SML/D00457/02-S0	Ka. LU
33	TS-6	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil fuel swampy forest and oli.	Do not swampy forest.	- Operation of equipment according to procedure	-	-	-	D-001/SML/D00457/02-S0	Ka. LU
					- Training of skill executor	-	-	-	-	Ka. LU
34	TP-1.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil fuel swampy forest and oli.	Do not swampy forest.	- Conservancy of field, ditch, dam and disposal water in workshop	WO.026/DC320	Nop '02	Teknik	-	Ka. LU
35	TP-1.C	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing solid waste of dangerous and Poisonous materialses (tidiness of accu).	Localize dismissal / heaping of tidiness of accu.	- The settlement of disposal of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
36	TP-1.D	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing solid waste of dangerous and Poisonous materialses (majun oil contamination).	Localize dismissal / heaping of majun oil contamination.	- The settlement of disposal of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
37	TP-2.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil fuel swampy forest and oli to the ground and water.	Do not swampy forest.	- Conservancy of field, ditch, dam and disposal water in workshop	WO.026/DC320	Nop '02	Teknik	-	Ka. LU
		Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.			- Scattering wood sawdust of hit by location is swampy forest, accomodated is later then burned.	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
38	TP-2.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing scrap and metal cutting	Managing scrap and metal cutting	- The settlement of disposal of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
39	TP-2.C	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing noise in work shop.	Balmy and peaceful Atmosphere activity creation.	- Improvement of observation usage of safety equipment appliance	-	-	-	Kontrak dengan pihak ke III	Ka. LU
40	TP-3.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil fuel swampy forest and oli to the ground and water.	Do not swampy forest.	- Conservancy of field, ditch, dam and disposal water in cikaro pump station	WO.026/DC320	Nop '02	Teknik	-	Ka. LU

41	TP-3.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Lessening gas emission swampy forest throw away.	Avoiding the happening of acute exhalation channel infection trouble.	-	Conservancy of equipment according to procedure	-	-	-	B-014/SML/D00457/02-S0	Ka. LU
42	TP-3.C	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing noise in work shop.	Balmy and peaceful Atmosphere activity creation.	-	Improvement of observation usage of working safety appliance	-	-	-	Kontrak dengan pihak ke III	Ka. LU
43	TP-4.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing swampy forest of oli to the ground and irrigate in work shop.	Do not swampy forest.	-	Conservancy of field, ditch, dam and disposal water in workshop	WO.026/DC320	Nop '02	Teknik	-	Ka. LU
44	TP-4.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing tidiness of grease.	Localize dismissal / heaping of tidiness of grease.	-	The settlement of disposal of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
45	TP-5	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil fuel swampy forest and oli to the ground and water di cikaro.	swampy forest < 60 litre / year.	-	Conservancy of field, ditch, dam and disposal water in cikaro pump station	WO.026/DC320	Nop '02	Teknik	-	Ka. LU
46	TP-6	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	anaging dangerous and poisonous Materialses liquid waste (of ex-oli).	Localizing dismissal / heaping of of ex-oli.	-	The settlement of disposal of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
47	LIST-2	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing dangerous and poisonous Materialses waste (mercuri).	Localize dismissal / heaping of bulb waste	-	The settlement of disposal of according to procedure	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
48	LIST-3.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing swampy forest of oli to the ground and irrigate in cikaro.	Do not swampy forest.	-	Conservancy of field, ditch, dam and disposal water in cikaro pump station	WO.026/DC320	Nop '02	Teknik	-	Ka. LU
49	LIST-3.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Lessening gas emission swampy forest throw away.	Avoiding the happening of acute exhalation channel infection trouble.	-	Conservancy of equipment according to procedure	-	-	-	Kontrak dengan pihak ke III	Ka. LU
50	LIST-3.C	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Managing noise of in cikaro.	Balmy and peaceful Atmosphere activity creation.	-	Improvement of observation usage of working safety appliance	-	-	-	Kontrak dengan pihak ke III	Ka. LU
51	KL-1.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Lessening gas emission throw away.	Emisi gas buang < baku mutu	-	Emission gas monitoring throw away	-	-	-	B-015/SML/D00457/02-S0	Ka. LU
52	KL-1.B	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil fuel swampy forest	Do not swampy forest	-	Giving training of skill executor	-	-	-	-	Ka. LU
53	MDI-1	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Avoiding the happening of direct isotope radiasi to environment.	Mengisolir daerah radiasi isotop	-	Installing the finges	-	-	-	Kontrak dengan pihak ke III	Ka. LU
54	PGD-1	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing chemicals swampy forest.	Do not swampy forest.	-	Making cool water installation for the safety of shower in bond chemicals to rinse body and material swampy forest	WO.022/DCJ10	Des '02	Teknik	-	Ka. LU
					-	Making ditch of around warehouse of chemicals	WO.027/DCJ10	Des '02	Teknik	-	Ka. LU
					-	Giving training of depository prosedure chemicals for officer warehouse	Memo No. 143	Sep '02	SDM	B-003/SML/D00457/02-S0	Ka. LU
					-	Setting right chemicals bag over and fitter of lable	-	Mar '03	Ada	C-001/SML/D00457/02-S0	Ka. LU
					-	Searching material safety data sheet for chemicals which there is no	Fac. No. 253,254,255,256	MSDS diterima	-	-	Ka. LU
55	PGD-2	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing oil fuel swampy forest to the ground and water	Do not swampy forest.	-	Making ditch in front of yards and fuel oil supply move to oil catcher	WO.037/DCJ10	Des '02	Teknik	-	Ka. LU
					-	equiping appliance-hygienen appliance, funnel, mop of majun, can of relocation fo fuel oil	-	Okt '02	-	-	Ka. LU
56	PGD-3	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing swampy forest of oli to the ground and water	Do not swampy forest.	-	Membuat parit / tanggul di depan yard supply bahan bakar minyak di tembuskan ke yard oli / oil catcher.	WO.037/DCJ10	Des '02	Teknik	-	Ka. LU
					-	Making ditch in front of yards and fuel oil supply move to oil catcher	WO.037/DCJ10	Des '02	Teknik	-	Ka. LU
57	PGD-4.A	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Lessening gas emission swampy forest throw away.	Avoiding the happening of acute exhalation channel infection trouble.	-	Conservancy of equipment according to procedure	-	-	-	B-020/SML/D00457/02-S0	Ka. LU
58	PGD-5	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing chemicals swampy forest.	Do not swampy forest.	-	Equiping each every vehicle of heavy equipment with appliance hygieni appliance	MR (Petty Cash)	Okt '02	-	-	Ka. LU
					-	Giving training of procedure load to unload for driver and kondektur	-	-	-	C-003/SML/D00457/02-S0	Ka. LU
59	SDM-2	Doing prevention of contamination potency and control arising out impact.	Handling white colars and domestic garbage discard.	Localize swampy forest / garbage discard in white colars area .	-	Ready ash can	MR	Des '02	Ada	-	Ka. LU
					-	making of landfill	WO.069/DBI10	Des '02	Teknik	-	Ka. LU
					-	Dismissal of garbage to final place of exide local government of Garut	-	-	-	B-017/SML/D00457/02-S0	Ka. LU
60	SDM-3	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing its impure of ditch water of materials of detergent.	Below/Under standard quality of discard water.	-	Monitoring irrigate discard	-	-	-	B-010/SML/D00457/02-S0	Ka. LU
					-	Thinning	-	-	-	-	Ka. LU
61	SDM-5	Doing prevention of contamination potency and control arising out impact and obedient to regulation of invitation.	Preventing its impure of land;ground of materials of catridge printer toner and.	Localize heaping of waste of catridge & toner.	-	Delivering waste to logistic	-	-	-	C-003/SML/D00457/02-S0 B-017/SML/D00457/02-S0	Ka. LU

APPENDIX IV: Results of discharge and NCG gas monitoring in Kamojang

TABLE 1: Cumulative production of steam in Kamojang until 1999

TABLE CUMULATIVE PRODUCTION UNTIL 1999 IN KAMOJANG GEOTHERMAL FIELD

Page 1

	1997	1998	Januarg	Februarg	March	April	Mag	June	July	August	September	October	November	December	1999
KMJ-11 (Ton/hours)			68.81	73.47	65.83	66.82	69.63	68.83	67.78	68.09	75.14	75.14	75.14	75.14	
Kg/s			19.11	20.41	18.29	19.12	19.34	19.14	18.83	18.91	20.87	20.87	20.87	20.87	
Ton/month			46,240.32	52,838.40	47,337.60	49,550.40	50,133.60	49,600.80	48,801.60	49,024.80	54,100.80	54,100.80	54,100.80	1,803.36	
kg/month			46,240,320.00	52,838,400.00	47,337,600.00	49,550,400.00	50,133,600.00	49,600,800.00	48,801,600.00	49,024,800.00	54,100,800.00	54,100,800.00	54,100,800.00	1,803,360.00	
Ton/month Cum.(84-98)	8,896,668.17	9,517,876.49	9,564,116.81	9,617,015.21	9,664,412.81	9,713,963.21	9,764,096.81	9,813,697.61	9,862,499.21	9,911,524.01	9,965,624.81	10,019,725.61	10,073,826.41	10,075,629.77	10,075,629.77
KMJ-17 (Ton/hours)			59.38	58.07	58.93	58.07	57.54	57.74	57.41	57.41	56.92	56.92	56.92	56.92	
Kg/s			16.49	16.13	16.37	16.13	15.98	16.04	15.95	15.95	15.81	15.81	15.81	15.81	
Ton/month			39,903.36	41,810.40	42,429.60	41,810.40	41,428.80	41,572.80	41,335.20	41,335.20	40,982.40	40,982.40	40,982.40	1,366.08	
kg/month			39,903,360.00	41,810,400.00	42,429,600.00	41,810,400.00	41,428,800.00	41,572,800.00	41,335,200.00	41,335,200.00	40,982,400.00	40,982,400.00	40,982,400.00	1,366,080.00	
Ton/month Cum.(84-98)	6,875,810.30	7,408,864.22	7,448,767.58	7,490,577.98	7,533,007.58	7,574,817.98	7,616,246.78	7,657,819.58	7,699,154.78	7,740,489.98	7,781,472.38	7,822,454.78	7,863,437.18	7,864,803.26	7,864,803.26
KMJ-18 (Ton/hours)			97.83	94.52	95.97	93.57	94.07	92.13	93.11	103.13	101.86	102.79	102.79	102.79	
Kg/s			27.17	26.26	26.66	25.99	26.13	25.59	25.86	28.65	28.29	28.55	28.55	28.55	
Ton/month			65,741.76	68,054.40	63,038.40	67,370.40	67,730.40	66,333.60	67,033.20	74,253.60	73,339.20	74,008.80	74,008.80	74,008.80	
kg/month			65,741,760.00	68,054,400.00	63,038,400.00	67,370,400.00	67,730,400.00	66,333,600.00	67,033,200.00	74,253,600.00	73,339,200.00	74,008,800.00	74,008,800.00	74,008,800.00	
Ton/month Cum.(84-98)	11,934,237.12	12,927,444.96	12,993,186.72	13,061,241.12	13,130,333.52	13,197,709.92	13,265,440.32	13,331,773.92	13,398,813.12	13,473,066.72	13,546,405.92	13,620,414.72	13,694,423.52	13,768,432.32	13,768,432.32
KMJ-30 (Ton/hours)			12.86	12.06	12.21	12.21	11.98	11.9	10.87	10.87	10.94	10.94	10.94	10.94	
Kg/s			3.57	3.35	3.39	3.39	3.33	3.31	3.02	3.02	3.04	3.04	3.04	3.04	
Ton/month			8,641.92	8,683.20	8,791.20	8,791.20	8,625.60	8,568.00	7,826.40	7,826.40	7,876.80	7,876.80	7,876.80	262.56	
kg/month			8,641,920.00	8,683,200.00	8,791,200.00	8,791,200.00	8,625,600.00	8,568,000.00	7,826,400.00	7,826,400.00	7,876,800.00	7,876,800.00	7,876,800.00	262,560.00	
Ton/month Cum.(84-98)	2,327,111.04	2,430,748.32	2,439,390.24	2,448,073.44	2,456,864.64	2,465,655.84	2,474,281.44	2,482,849.44	2,490,675.84	2,498,502.24	2,506,379.04	2,514,255.84	2,522,132.64	2,522,395.20	2,522,395.20
KMJ-31 (Ton/hours)			26.32	26.75	28.68	34.04	34.04	30.49	30.49	30.49	30.28	30.28	30.61	30.61	
Kg/s			7.48	7.43	7.97	9.46	9.46	8.47	8.47	8.47	8.41	8.41	8.50	8.50	
Ton/month			18,030.24	19,260.00	20,649.60	24,508.80	24,508.80	21,952.80	21,952.80	21,952.80	21,801.60	21,801.60	22,039.20	734.64	
kg/month			18,030,240.00	19,260,000.00	20,649,600.00	24,508,800.00	24,508,800.00	21,952,800.00	21,952,800.00	21,952,800.00	21,801,600.00	21,801,600.00	22,039,200.00	734,640.00	
Ton/month Cum.(84-98)	13,945,630.30	14,212,555.18	14,230,645.42	14,249,305.42	14,270,555.02	14,295,063.82	14,319,572.62	14,341,525.42	14,363,478.22	14,385,431.02	14,407,232.62	14,429,034.22	14,451,073.42	14,451,808.06	14,451,808.06
KMJ-34 (Ton/hours)			22.51	22.15	21.44	19.05	19.05	21.79	21.17	21.14	21.02	21.02	20.15	20.15	
Kg/s			6.25	6.15	5.96	5.29	5.29	7.72	5.88	5.87	5.84	5.84	5.60	5.60	
Ton/month			15,126.72	15,348.00	15,436.80	13,716.00	13,716.00	20,008.80	15,242.40	15,220.80	15,134.40	15,134.40	14,508.00	483.60	
kg/month			15,126,720.00	15,348,000.00	15,436,800.00	13,716,000.00	13,716,000.00	20,008,800.00	15,242,400.00	15,220,800.00	15,134,400.00	15,134,400.00	14,508,000.00	483,600.00	
Ton/month Cum.(84-98)	3,166,585.68	3,383,141.04	3,398,267.76	3,414,215.76	3,429,652.56	3,443,368.56	3,457,084.56	3,477,093.36	3,492,335.76	3,507,556.56	3,522,690.96	3,537,825.36	3,552,333.36	3,552,816.96	3,552,816.96
KMJ-35 (Ton/hours)			3.85	3.85	3.85	3.85	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	
Kg/s			2.74	2.74	2.74	2.74	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	
Ton/month			6,619.20	7,092.00	7,092.00	7,092.00	8,136.00	8,136.00	8,136.00	8,136.00	8,136.00	8,136.00	8,136.00	271.20	
kg/month			6,619,200.00	7,092,000.00	7,092,000.00	7,092,000.00	8,136,000.00	8,136,000.00	8,136,000.00	8,136,000.00	8,136,000.00	8,136,000.00	8,136,000.00	271,200.00	
Ton/month Cum.(84-98)	4,508,346.96	4,593,788.88	4,600,408.08	4,607,500.08	4,614,592.08	4,621,684.08	4,629,820.08	4,637,956.08	4,646,092.08	4,654,228.08	4,662,364.08	4,670,500.08	4,678,636.08	4,678,907.28	4,678,907.28
KMJ-36 (Ton/hours)			86.83	84.21	87.36	87.36	84.19	88.85	92.02	85.26	85.83	83.12	83.12	83.12	
Kg/s			24.12	23.39	24.27	24.27	23.39	24.68	25.56	23.68	23.84	23.09	23.09	23.09	
Ton/month			58,349.76	60,631.20	62,899.20	62,899.20	60,616.80	63,912.00	66,254.40	61,387.20	61,797.60	59,846.40	59,846.40	1,994.88	
kg/month			58,349,760.00	60,631,200.00	62,899,200.00	62,899,200.00	60,616,800.00	63,912,000.00	66,254,400.00	61,387,200.00	61,797,600.00	59,846,400.00	59,846,400.00	1,994,880.00	
Ton/month Cum.(84-98)	9,403,066.96	10,130,148.48	10,188,496.24	10,249,129.44	10,312,028.64	10,374,927.84	10,435,544.64	10,499,456.64	10,565,711.04	10,627,159.24	10,688,957.84	10,748,804.24	10,808,648.64	10,810,643.52	10,810,643.52
KMJ-38 (Ton/hours)			18.89	19.16	19.16	20.71	20.71	20.71	20.71	20.71	20.71	20.71	21.90	21.90	
Kg/s			5.27	5.32	5.32	5.75	5.75	5.75	5.75	5.75	5.75	5.75	7.75	7.75	
Ton/month			12,761.28	13,795.20	13,795.20	14,911.20	14,911.20	14,911.20	14,911.20	14,911.20	14,911.20	14,911.20	20,088.00	663.60	
kg/month			12,761,280.00	13,795,200.00	13,795,200.00	14,911,200.00	14,911,200.00	14,911,200.00	14,911,200.00	14,911,200.00	14,911,200.00	14,911,200.00	20,088,000.00	663,600.00	
Ton/month Cum.(85-98)	2,853,106.61	3,015,501.60	3,028,262.88	3,042,058.08	3,055,853.28	3,070,764.48	3,085,675.68	3,100,586.88	3,115,498.08	3,130,409.28	3,145,320.48	3,160,231.68	3,180,319.68	3,180,983.28	3,180,983.28
KMJ-41 (Ton/hours)			63.68	72.19	73.01	73.01	73.01	73.01	64.77	64.48	63.08	63.08	63.08	63.08	
Kg/s			19.36	20.05	20.28	20.28	20.28	20.28	17.99	17.91	17.52	17.52	17.52	17.52	
Ton/month			46,824.96	51,976.80	52,567.20	52,567.20	52,567.20	52,567.20	46,634.40	46,425.60	45,417.60	45,417.60	45,417.60	1,513.92	
kg/month			46,824,960.00	51,976,800.00	52,567,200.00	52,567,200.00	52,567,200.00	52,567,200.00	46,634,400.00	46,425,600.00	45,417,600.00	45,417,600.00	45,417,600.00	1,513,920.00	
Ton/month Cum.(85-98)	8,430,135.96	8,938,865.40	8,965,630.36	9,037,667.16	9,090,234.36	9,142,801.56	9,195,368.76	9,247,935.96	9,294,570.36	9,340,995.36	9,386,413.56	9,431,831.16	9,477,248.76	9,478,762.68	9,478,762.68

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KMJ-42 (Ton/hours)			23.20	21.71	20.10	20.10	20.10	14.03	13.97	13.97	13.97	13.97	13.97	13.97	
Kg/s			6.44	6.03	5.58	5.58	5.58	3.90	3.88	5.55	5.55	5.55	5.55	5.55	
Ton/month			15,590.40	15,631.20	14,472.00	14,472.00	14,472.00	10,101.60	14,378.40	14,378.40	14,378.40	14,378.40	14,378.40	479.28	
kg/month			15,590,400.00	15,631,200.00	14,472,000.00	14,472,000.00	14,472,000.00	10,101,600.00	14,378,400.00	14,378,400.00	14,378,400.00	14,378,400.00	14,378,400.00	479,280.00	
Ton/month Cum.(85-98)	4,645,329.36	4,753,289.28	4,768,879.68	4,784,510.88	4,798,982.88	4,813,454.88	4,827,926.88	4,838,028.48	4,852,406.88	4,866,785.28	4,881,163.68	4,895,542.08	4,909,920.48	4,910,399.76	4,910,399.76
KMJ-43 (Ton/hours)			20.68	20.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	
Kg/s			5.74	5.73	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	
Ton/month			13,896.96	14,853.60	13,413.60	13,413.60	13,413.60	13,413.60	13,413.60	13,413.60	13,413.60	13,413.60	13,413.60	447.12	
kg/month			13,896,960.00	14,853,600.00	13,413,600.00	13,413,600.00	13,413,600.00	13,413,600.00	13,413,600.00	13,413,600.00	13,413,600.00	13,413,600.00	13,413,600.00	447,120.00	
Ton/month Cum.(86-98)	2,230,110.22	2,472,343.66	2,486,240.62	2,501,094.22	2,514,507.82	2,527,921.42	2,541,335.02	2,554,748.62	2,568,162.22	2,581,575.82	2,594,989.42	2,608,403.02	2,621,816.62	2,622,263.74	2,622,263.74
KMJ-44 (Ton/hours)			18.05	18.88	18.64	18.76	18.76	18.76	18.76	18.76	18.76	18.76	18.76	18.76	
Kg/s			5.01	5.24	5.18	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21	
Ton/month			12,129.60	13,593.60	13,420.80	13,507.20	13,507.20	13,507.20	13,507.20	13,507.20	13,507.20	13,507.20	13,507.20	450.24	
kg/month			12,129,600.00	13,593,600.00	13,420,800.00	13,507,200.00	13,507,200.00	13,507,200.00	13,507,200.00	13,507,200.00	13,507,200.00	13,507,200.00	13,507,200.00	450,240.00	
Ton/month Cum.(86-98)	2,930,841.58	3,158,015.26	3,170,144.86	3,183,738.46	3,197,159.26	3,210,666.46	3,224,173.66	3,237,680.86	3,251,188.06	3,264,695.26	3,278,202.46	3,291,709.66	3,305,216.86	3,305,667.10	3,305,667.10
KMJ-22 (Ton/hours)			76.12	76.12	76.12	76.12	76.12	67.59	77.52	95.36	76.45	76.94	77.44	77.44	
Kg/s			21.14	21.14	21.14	21.14	21.14	18.77	21.53	26.66	21.24	21.37	21.51	21.51	
Ton/month			51,152.64	54,806.40	54,806.40	54,806.40	54,806.40	48,664.80	55,814.40	69,091.20	55,044.00	55,396.80	55,756.80	1,858.56	
kg/month			51,152,640.00	54,806,400.00	54,806,400.00	54,806,400.00	54,806,400.00	48,664,800.00	55,814,400.00	69,091,200.00	55,044,000.00	55,396,800.00	55,756,800.00	1,858,560.00	
Ton/month Cum.(87-98)	6,311,880.48	7,581,699.84	7,632,852.48	7,687,658.88	7,742,465.28	7,797,271.68	7,852,078.08	7,900,742.88	7,956,557.28	8,025,648.48	8,080,692.48	8,136,089.28	8,191,846.08	8,193,704.64	8,193,704.64
KMJ-24 (Ton/hours)			39.71	39.71	39.71	39.71	39.71	40.52	Test Prod.	Test Prod.	Test Prod.	Test Prod.	Test Prod.	Test Prod.	
Kg/s			11.03	11.03	11.03	11.03	11.03	11.26	-	-	-	-	-	-	
Ton/month			26,685.12	28,591.20	28,591.20	28,591.20	28,591.20	29,174.40	-	-	-	-	-	-	
kg/month			26,685,120.00	28,591,200.00	28,591,200.00	28,591,200.00	28,591,200.00	29,174,400.00	-	-	-	-	-	-	
Ton/month Cum.(87-98)	3,780,351.12	4,147,320.48	4,174,005.60	4,202,596.80	4,231,188.00	4,259,779.20	4,288,370.40	4,317,544.80	-	-	-	-	-	-	4,288,370.40
KMJ-25 (Ton/hours)			10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	
Kg/s			2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	
Ton/month			7,062.72	7,567.20	7,567.20	7,567.20	7,567.20	7,567.20	7,567.20	7,567.20	7,567.20	7,567.20	7,567.20	252.24	
kg/month			7,062,720.00	7,567,200.00	7,567,200.00	7,567,200.00	7,567,200.00	7,567,200.00	7,567,200.00	7,567,200.00	7,567,200.00	7,567,200.00	7,567,200.00	252,240.00	
Ton/month Cum.(87-98)	1,595,342.40	1,776,198.48	1,783,261.20	1,790,828.40	1,798,395.60	1,805,962.80	1,813,530.00	1,821,097.20	1,828,664.40	1,836,231.60	1,843,798.80	1,851,366.00	1,858,933.20	1,859,185.44	1,859,185.44
KMJ-26 (Ton/hours)			44.72	50.73	46.49	44.72	44.72	44.72	44.72	44.72	46.19	52.65	51.86	43.75	
Kg/s			12.42	14.09	12.91	12.42	12.42	12.42	12.42	12.42	12.83	14.62	14.40	13.82	
Ton/month			30,051.84	36,525.60	33,472.80	32,198.40	32,198.40	32,198.40	32,198.40	32,198.40	33,256.80	37,908.00	37,411.20	1,194.00	
kg/month			30,051,840.00	36,525,600.00	33,472,800.00	32,198,400.00	32,198,400.00	32,198,400.00	32,198,400.00	32,198,400.00	33,256,800.00	37,908,000.00	37,411,200.00	1,194,000.00	
Ton/month Cum.(87-98)	4,977,991.92	5,393,165.28	5,423,217.12	5,459,742.72	5,493,215.52	5,525,413.92	5,557,612.32	5,589,810.72	5,622,009.12	5,654,207.52	5,687,464.32	5,725,372.32	5,762,783.52	5,763,977.52	5,763,977.52
KMJ-27 (Ton/hours)			52.52	52.82	56.48	57.10	55.58	54.26	54.26	58.23	65.23	67.56	67.56	67.56	
Kg/s			14.59	14.67	15.69	15.86	15.44	15.07	15.07	16.19	18.14	18.77	18.77	18.77	
Ton/month			35,293.44	38,030.40	40,665.60	41,112.00	40,017.60	39,067.20	39,067.20	41,968.80	47,008.80	48,643.20	48,643.20	1,621.44	
kg/month			35,293,440.00	38,030,400.00	40,665,600.00	41,112,000.00	40,017,600.00	39,067,200.00	39,067,200.00	41,968,800.00	47,008,800.00	48,643,200.00	48,643,200.00	1,621,440.00	
Ton/month Cum.(87-98)	6,034,401.60	6,581,293.68	6,616,587.12	6,654,617.52	6,695,283.12	6,736,395.12	6,776,412.72	6,815,479.92	6,854,547.12	6,896,515.92	6,943,524.72	6,992,167.92	7,040,811.12	7,042,432.56	7,042,432.56
KMJ-37 (Ton/hours)			53.36	53.36	53.36	57.17	57.17	57.17	49.53	21.14	21.14	50.15	49.30	49.30	
Kg/s			14.82	14.82	14.82	15.88	15.88	15.88	13.77	5.87	5.87	13.93	13.69	13.69	
Ton/month			35,857.92	38,419.20	38,419.20	41,162.40	41,162.40	41,162.40	35,704.80	15,220.80	15,220.80	36,108.00	35,496.00	1,183.20	
kg/month			35,857,920.00	38,419,200.00	38,419,200.00	41,162,400.00	41,162,400.00	41,162,400.00	35,704,800.00	15,220,800.00	15,220,800.00	36,108,000.00	35,496,000.00	1,183,200.00	
Ton/month Cum.(87-98)	5,228,044.80	5,783,082.48	5,818,940.40	5,857,359.60	5,895,778.80	5,936,941.20	5,978,103.60	6,019,266.00	6,054,970.80	6,070,191.60	6,085,412.40	6,121,520.40	6,157,016.40	6,158,199.60	6,158,199.60
KMJ-46 (Ton/hours)			23.16	23.10	23.05	23.05	21.38	21.38	21.38	21.38	21.38	21.38	21.38	28.83	
Kg/s			6.43	6.42	6.40	6.40	5.94	5.94	5.94	5.94	5.94	5.94	5.94	8.01	
Ton/month			15,563.52	16,632.00	16,596.00	16,596.00	15,393.60	15,393.60	15,393.60	15,393.60	15,393.60	15,393.60	15,393.60	691.92	
kg/month			15,563,520.00	16,632,000.00	16,596,000.00	16,596,000.00	15,393,600.00	15,393,600.00	15,393,600.00	15,393,600.00	15,393,600.00	15,393,600.00	15,393,600.00	691,920.00	
Ton/month Cum.(87-98)	3,163,230.10	3,407,632.66	3,423,196.18	3,439,828.18	3,456,424.18	3,473,020.18	3,488,413.78	3,503,807.38	3,519,200.98	3,534,594.58	3,549,988.18	3,565,381.78	3,580,775.38	3,581,467.30	3,581,467.30

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KMJ-14 (Ton/hours)			43.97	43.99	43.93	43.99	453.71	32.51	19.82	43.04	43.04	43.04	43.04	43.04	
Kg/s			12.21	12.22	12.20	12.22	126.03	9.03	5.51	11.96	11.96	11.96	11.96	11.96	
Ton/month			29,547.84	31,672.80	31,629.60	31,672.80	326,671.20	23,407.20	14,270.40	30,988.80	30,988.80	30,988.80	30,988.80	1,032.96	
kg/month			29,547,840.00	31,672,800.00	31,629,600.00	31,672,800.00	326,671,200.00	23,407,200.00	14,270,400.00	30,988,800.00	30,988,800.00	30,988,800.00	30,988,800.00	1,032,960.00	
Ton/month Cum.(88-98)	4,025,713.44	4,471,038.36	4,500,586.80	4,532,259.60	4,563,889.20	4,595,562.00	4,922,233.20	4,945,640.40	4,959,910.80	4,990,899.60	5,021,888.40	5,052,877.20	5,083,866.00	5,084,898.96	5,084,898.96
KMJ-28 (Ton/hours)			32.41	30.91	30.71	25.86	25.86	33.04	30.08	29.84	30.03	31.86	31.65	31.65	
Kg/s			9.00	8.59	8.53	7.18	7.18	9.18	8.36	8.29	8.34	8.85	8.79	8.79	
Ton/month			21,773.52	22,255.20	22,111.20	18,619.20	18,619.20	23,788.80	21,657.60	21,484.80	21,621.60	22,939.20	22,788.00	759.60	
kg/month			21,773,520.00	22,255,200.00	22,111,200.00	18,619,200.00	18,619,200.00	23,788,800.00	21,657,600.00	21,484,800.00	21,621,600.00	22,939,200.00	22,788,000.00	759,600.00	
Ton/month Cum.(88-98)	2,868,233.04	3,104,636.10	3,126,477.62	3,148,732.82	3,170,844.02	3,189,463.22	3,208,082.42	3,231,871.22	3,253,528.82	3,275,013.62	3,296,635.22	3,319,574.42	3,342,362.42	3,343,122.02	3,343,122.02
KMJ-45 (Ton/hours)			23.18	22.36	21.27	19.53	19.53	19.53	19.53	28.04	23.79	27.02	25.26	25.26	
Kg/s			6.44	6.38	5.91	5.42	5.42	5.42	5.42	7.79	6.61	7.51	7.02	7.02	
Ton/month			15,576.96	16,545.60	15,314.40	14,061.60	14,061.60	14,061.60	14,061.60	20,188.80	17,128.80	19,454.40	18,187.20	606.24	
kg/month			15,576,960.00	16,545,600.00	15,314,400.00	14,061,600.00	14,061,600.00	14,061,600.00	14,061,600.00	20,188,800.00	17,128,800.00	19,454,400.00	18,187,200.00	606,240.00	
Ton/month Cum.(88-98)	2,567,373.84	2,733,903.84	2,755,480.80	2,772,026.40	2,787,340.80	2,801,402.40	2,815,464.00	2,829,525.60	2,843,587.20	2,863,776.00	2,880,904.80	2,900,359.20	2,918,546.40	2,919,152.64	2,919,152.64
KMJ-20 (Ton/hours)			-	-	-	-	-	-	-	-	-	-	-	-	-
Kg/s			-	-	-	-	-	-	-	-	-	-	-	-	-
Ton/month			-	-	-	-	-	-	-	-	-	-	-	-	-
kg/month			-	-	-	-	-	-	-	-	-	-	-	-	-
Ton/month Cum.(83-98)	366,513.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KMJ-33 (Ton/hours)			16.75	16.37	16.75	17.32	17.32	17.32	17.32	17.32	19.45	19.45	19.44	19.44	
Kg/s			4.65	4.55	4.65	4.81	4.81	4.81	4.81	4.81	5.40	5.40	5.40	5.40	
Ton/month			11,256.00	11,786.40	12,060.00	12,470.40	12,470.40	12,470.40	12,470.40	12,470.40	14,004.00	14,004.00	13,996.80	466.56	
kg/month			11,256,000.00	11,786,400.00	12,060,000.00	12,470,400.00	12,470,400.00	12,470,400.00	12,470,400.00	12,470,400.00	14,004,000.00	14,004,000.00	13,996,800.00	466,560.00	
Ton/month Cum.(92-98)	316,374.48	1,077,378.48	1,088,634.48	1,100,420.88	1,112,480.88	1,124,951.28	1,137,421.68	1,149,892.08	1,162,362.48	1,174,832.88	1,188,836.88	1,202,840.88	1,216,837.68	1,217,304.24	1,217,304.24
KMJ-40 (Ton/hours)			11.24	10.72	11.24	11.24	15.62	15.62	15.62	15.62	15.62	15.62	17.07	17.07	
Kg/s			3.12	2.98	3.12	3.12	4.34	4.34	4.34	4.34	4.34	4.34	4.74	4.74	
Ton/month			7,553.28	7,718.40	8,092.80	8,092.80	11,246.40	11,246.40	11,246.40	11,246.40	11,246.40	11,246.40	12,290.40	403.68	
kg/month			7,553,280.00	7,718,400.00	8,092,800.00	8,092,800.00	11,246,400.00	11,246,400.00	11,246,400.00	11,246,400.00	11,246,400.00	11,246,400.00	12,290,400.00	403,680.00	
Ton/month Cum.(92-98)	711,700.08	802,933.32	810,487.20	818,205.60	826,298.40	834,391.20	845,637.60	856,884.00	868,130.40	879,376.80	890,623.20	901,869.60	914,160.00	914,563.68	914,563.68
KMJ-51 (Ton/hours)			85.23	86.15	85.14	84.69	84.69	85.39	85.39	83.62	86.63	82.98	82.98	82.98	
Kg/s			23.67	23.93	23.65	23.52	23.52	23.89	23.89	24.89	24.06	23.05	23.05	23.05	
Ton/month			57,274.56	62,028.00	61,300.80	60,976.80	60,976.80	61,912.80	61,912.80	64,526.40	62,373.60	59,745.60	59,745.60	1,991.52	
kg/month			57,274,560.00	62,028,000.00	61,300,800.00	60,976,800.00	60,976,800.00	61,912,800.00	61,912,800.00	64,526,400.00	62,373,600.00	59,745,600.00	59,745,600.00	1,991,520.00	
Ton/month Cum.(92-98)	3,408,271.62	4,220,133.74	4,277,408.30	4,339,436.30	4,400,737.10	4,461,713.90	4,522,690.70	4,584,603.50	4,646,516.30	4,711,042.70	4,773,416.30	4,833,161.90	4,892,907.50	4,894,899.02	4,894,899.02
KMJ-52 (Ton/hours)			40.18	39.68	40.34	29.20	29.20	38.89	38.10	37.30	38.16	36.87	36.35	36.35	
Kg/s			11.16	11.02	11.21	8.11	8.11	10.80	10.58	10.53	10.60	10.24	10.10	10.10	
Ton/month			27,000.96	28,563.60	29,044.80	21,024.00	21,024.00	28,000.80	27,432.00	27,288.00	27,475.20	26,546.40	26,172.00	872.40	
kg/month			27,000,960.00	28,563,600.00	29,044,800.00	21,024,000.00	21,024,000.00	28,000,800.00	27,432,000.00	27,288,000.00	27,475,200.00	26,546,400.00	26,172,000.00	872,400.00	
Ton/month Cum.(93-98)	1,752,126	2,093,962.32	2,120,963.28	2,149,532.88	2,178,577.68	2,199,601.68	2,220,625.68	2,248,626.48	2,276,058.48	2,303,346.48	2,330,821.68	2,357,368.08	2,383,540.08	2,384,412.48	2,384,412.48
KMJ-62 (Ton/hours)			73.14	70.74	70.72	70.72	71.93	73.46	71.91	71.91	72.83	72.83	72.83	72.32	
Kg/s			20.32	19.65	19.64	19.64	19.98	20.41	19.97	19.97	20.23	20.23	20.23	20.09	
Ton/month			49,150.08	50,332.80	50,318.40	50,318.40	51,783.60	52,891.20	51,775.20	51,775.20	52,437.60	52,437.60	52,437.60	1,735.68	
kg/month			49,150,080.00	50,332,800.00	50,318,400.00	50,318,400.00	51,783,600.00	52,891,200.00	51,775,200.00	51,775,200.00	52,437,600.00	52,437,600.00	52,437,600.00	1,735,680.00	
Ton/month Cum.(97-98)	437,190.24	1,121,387.76	1,170,537.84	1,221,470.64	1,272,389.04	1,323,307.44	1,375,091.04	1,427,888.24	1,479,763.44	1,531,538.64	1,583,976.24	1,636,413.84	1,688,851.44	1,690,587.12	1,690,587.12
KMJ-65 (Ton/hours)			61.13	62.53	62.53	62.53	65.57	63.02	63.39	68.14	70.53	70.53	70.53	70.53	
Kg/s			16.98	17.37	17.37	17.37	18.21	17.51	17.61	18.93	19.59	19.59	19.59	19.59	
Ton/month			41,073.36	45,021.60	45,021.60	45,021.60	47,210.40	43,634.40	43,960.80	43,060.80	50,781.60	50,781.60	50,781.60	1,692.72	
kg/month			41,073,360.00	45,021,600.00	45,021,600.00	45,021,600.00	47,210,400.00	43,634,400.00	43,960,800.00	43,060,800.00	50,781,600.00	50,781,600.00	50,781,600.00	1,692,720.00	
Ton/month Cum.(97-98)	310,032.48	865,585.44	906,664.80	951,686.40	996,708.00	1,041,729.60	1,088,940.00	1,138,634.40	1,186,595.20	1,237,656.00	1,288,437.60	1,339,219.20	1,390,000.80	1,391,693.52	1,391,693.52
KMJ-72 (Ton/hours)							75.85	70.91	70.91	70.93	70.93	68.91	68.91	68.91	
Kg/s		-	-	-	-	-	21.07	19.70	19.70	19.70	19.70	19.14	19.14	19.14	
Ton/month		-	-	-	-	-	54,612.00	51,055.20	51,055.20	51,063.60	51,063.60	49,615.20	49,615.20	1,653.84	
kg/month		-	-	-	-	-	54,612,000.00	51,055,200.00	51,055,200.00	51,063,600.00	51,063,600.00	49,615,200.00	49,615,200.00	1,653,840.00	
Ton/month Cum.(1993)		-	-	-	-	-	54,612.00	105,667.20	156,722.40	207,792.00	258,861.60	308,476.80	358,092.00	359,745.84	359,745.84
Total Cumultaive (T	**132,114,953.70**	**142,109,998.23**													**152,311,241.91**

TABLE 2: Cumulative release of non-condensable gas in Kamojang until 1999

TABLE : CUMULATIVE GAS CO_2 AND H_2S UNTIL 1999 IN KAMOJANG GEOTHERMAL FIELD

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	1998	January	February	March	April	May	June	July	August	September	October	November	December	1999
KMJ-11 (Ton/hours)		68.81	73.47	65.83	68.82	69.63	68.89	67.78	68.09	75.14	75.14	75.14	75.14	
CO_2 (gr/Kg)	1.61	1.62	1.40	1.66	1.56	1.49	1.38	1.55	1.44	1.86	1.86	1.86	1.86	0.00
CO_2 Cumulative (T	82.16	156.90	230.96	309.81	387.10	461.78	530.18	606.06	676.67	777.41	878.15	978.89	982.25	982.25
H_2S (gr/Kg)	0.22	0.22	0.24	0.21	0.23	0.24	0.25	0.21	0.20	0.20	0.20	0.20	0.20	0.00
H_2S Cumulative (T	11.14	21.53	34.05	44.18	55.79	67.57	80.03	90.19	99.92	110.74	121.55	132.36	132.72	132.72
KMJ-17 (Ton/hours)		59.38	58.07	58.93	58.07	57.54	57.74	57.41	57.41	56.92	56.92	56.92	56.92	
CO_2 (gr/Kg)	3.90	3.68	3.74	4.02	3.68	3.77	3.70	3.67	3.67	4.69	4.56	4.56	4.56	0.00
CO_2 Cumulative (T	167.34	314.02	470.56	641.04	795.04	951.17	1104.89	1256.43	1407.96	1600.27	1786.97	1973.67	1979.90	1979.90
H_2S (gr/Kg)	0.25	0.26	0.24	0.24	0.26	0.25	0.23	0.22	0.22	0.24	0.22	0.22	0.22	0.00
H_2S Cumulative (T	10.58	20.94	31.01	41.21	52.12	62.43	72.05	80.95	89.85	99.59	108.70	117.81	118.11	118.11
KMJ-18 (Ton/hours)		97.83	94.52	95.97	93.57	94.07	92.13	93.11	103.13	101.86	102.79	102.79	102.79	
CO_2 (gr/Kg)	1.48	1.27	1.67	1.66	1.27	1.34	1.39	1.36	1.74	1.52	2.40	2.40	2.40	0.00
CO_2 Cumulative (T	103.48	192.61	313.76	428.16	513.98	604.57	697.03	787.88	917.25	1028.83	1206.38	1383.93	1383.93	1383.93
H_2S (gr/Kg)	0.22	0.24	0.23	0.25	0.25	0.24	0.20	0.18	0.20	0.21	0.21	0.21	0.21	0.00
H_2S Cumulative (T	15.61	32.28	49.10	66.14	82.79	98.84	112.38	124.24	139.23	154.36	169.98	185.59	185.59	185.59
KMJ-30 (Ton/hours)		12.86	12.06	12.21	12.21	11.98	11.9	10.87	10.87	10.94	10.94	10.94	10.94	
CO_2 (gr/Kg)	2.15	2.15	1.96	2.07	2.07	2.16	2.34	2.22	2.49	2.67	2.11	2.11	2.11	0.00
CO_2 Cumulative (T	19.93	38.53	55.57	73.77	91.97	110.59	130.63	147.99	167.48	188.52	205.14	222.31	222.86	222.86
H_2S (gr/Kg)	0.26	0.26	0.23	0.22	0.22	0.24	0.23	0.22	0.23	0.24	0.22	0.22	0.22	0.00
H_2S Cumulative (T	2.37	4.57	6.55	8.50	10.45	12.54	14.53	16.25	18.05	19.93	21.65	23.44	23.49	23.49
KMJ-31 (Ton/hours)		26.92	26.75	28.68	34.04	34.04	30.49	30.49	30.49	30.28	30.28	30.61	30.61	
CO_2 (gr/Kg)	2.99	2.87	2.78	2.83	3.36	3.36	3.06	3.06	3.06	2.97	2.97	2.74	2.74	0.00
CO_2 Cumulative (T	56.15	108.01	161.62	220.01	302.44	384.86	451.92	518.99	586.06	650.74	715.43	775.81	777.82	777.82
H_2S (gr/Kg)	0.24	0.28	0.24	0.28	0.29	0.29	0.23	0.23	0.23	0.22	0.22	0.21	0.21	0.00
H_2S Cumulative (T	4.58	9.57	14.17	19.98	27.03	34.08	39.13	44.18	49.23	54.02	58.81	63.54	63.70	63.70
KMJ-34 (Ton/hours)		22.51	22.15	21.44	19.05	19.05	27.79	21.17	21.14	21.02	21.02	20.15	20.15	
CO_2 (gr/Kg)	1.42	0.64	1.47	1.47	1.54	1.54	1.46	1.42	1.95	1.70	1.70	1.41	1.41	0.00
CO_2 Cumulative (T	24.80	34.50	57.97	80.73	101.84	122.95	152.25	173.93	203.67	229.47	255.27	275.68	276.36	276.36
H_2S (gr/Kg)	0.27	0.27	0.26	0.24	0.24	0.24	0.19	0.23	0.27	0.22	0.22	0.20	0.20	0.00
H_2S Cumulative (T	4.68	8.77	12.97	16.67	20.02	23.37	27.15	30.67	34.73	38.02	41.32	44.15	44.24	44.24
KMJ-35 (Ton/hours)		9.85	9.85	9.85	9.85	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	
CO_2 (gr/Kg)	0.95	0.95	0.95	0.95	0.95	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.00
CO_2 Cumulative (T	6.71	12.97	19.68	26.38	33.09	39.30	45.52	51.73	57.94	64.15	70.36	76.58	76.78	76.78
H_2S (gr/Kg)	0.19	0.19	0.19	0.19	0.19	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.00
H_2S Cumulative (T	1.34	2.60	3.94	5.28	6.63	8.33	10.03	11.74	13.44	15.15	16.85	18.56	18.61	18.61
KMJ-36 (Ton/hours)		86.83	84.21	87.36	87.36	84.19	88.85	92.02	85.26	85.83	83.12	83.12	83.12	
CO_2 (gr/Kg)	1.84	1.84	1.74	2.01	2.01	1.78	1.77	1.68	1.78	2.29	1.86	1.86	1.86	0.00
CO_2 Cumulative (T	114.85	222.05	327.45	453.68	579.90	687.80	801.26	912.32	1021.56	1163.23	1274.58	1385.93	1389.65	1389.65
H_2S (gr/Kg)	0.26	0.26	0.23	0.19	0.19	0.21	0.22	0.19	0.19	0.22	0.19	0.19	0.19	0.00
H_2S Cumulative (T	16.11	31.14	44.86	57.11	69.37	81.81	95.60	108.47	120.31	134.04	145.28	156.51	156.88	156.88
KMJ-38 (Ton/hours)		18.99	19.16	19.16	20.71	20.71	20.71	20.71	20.71	20.71	20.71	27.90	27.90	
CO_2 (gr/Kg)	31.86	28.14	27.41	30.16	29.90	29.90	29.90	29.90	29.90	29.90	29.90	25.21	25.21	0.00
CO_2 Cumulative (T	438.21	797.25	1175.37	1591.38	2037.15	2482.92	2928.69	3374.46	3820.23	4266.01	4711.78	5218.24	5235.12	5235.12
H_2S (gr/Kg)	0.51	0.52	0.41	0.48	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.36	0.36	0.00
H_2S Cumulative (T	6.99	13.66	19.30	25.92	33.00	40.07	47.14	54.22	61.29	68.37	75.44	82.59	82.82	82.82
KMJ-41 (Ton/hours)		69.68	72.19	73.01	73.01	73.01	73.01	64.77	64.48	63.08	63.08	63.08	63.08	
CO_2 (gr/Kg)	2.58	2.13	2.13	2.13	2.13	2.13	2.13	1.99	2.16	2.15	2.15	2.15	2.15	0.00
CO_2 Cumulative (T	127.43	227.36	337.87	449.66	561.44	673.23	785.02	877.97	978.18	1075.98	1173.77	1271.56	1274.82	1274.82
H_2S (gr/Kg)	0.23	0.22	0.24	0.22	0.22	0.22	0.22	0.21	0.24	0.20	0.20	0.20	0.20	0.00
H_2S Cumulative (T	11.46	21.96	34.67	46.49	58.30	70.12	81.93	91.52	102.78	111.87	120.97	130.06	130.37	130.37

KMJ-42 (Ton/hours)		23.20	21.71	20.10	20.10	20.10	14.03	19.97	19.97	19.97	19.97	19.97	19.97	
CO_2 (gr/Kg)	6.15	6.15	6.87	7.79	7.79	7.29	5.75	7.97	7.97	7.97	7.97	7.97	7.97	0.00
CO_2 Cumulative (T	102.71	198.58	305.97	418.69	531.41	636.96	695.07	809.67	924.26	1038.86	1153.45	1268.04	1271.86	1271.86
H_2S (gr/Kg)	0.25	0.25	0.27	0.27	0.27	0.24	0.22	0.26	0.26	0.26	0.26	0.26	0.26	0.00
H_2S Cumulative (T	4.21	8.15	12.35	16.20	20.06	23.55	25.75	29.44	33.12	36.81	40.50	44.18	44.31	44.31
KMJ-43 (Ton/hours)		20.68	20.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	
CO_2 (gr/Kg)	4.47	4.30	3.90	4.27	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	0.00
CO_2 Cumulative (T	67.01	126.72	184.66	242.00	304.61	367.23	429.84	492.46	555.07	617.69	680.30	742.92	745.01	745.01
H_2S (gr/Kg)	0.26	0.25	0.27	0.27	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.00
H_2S Cumulative (T	3.92	7.46	11.49	15.08	19.05	23.02	26.99	30.97	34.94	38.91	42.88	46.85	46.98	46.98
KMJ-44 (Ton/hours)		18.05	18.88	18.64	18.76	18.76	18.76	18.76	18.76	18.76	18.76	18.76	18.76	
CO_2 (gr/Kg)	2.92	2.64	2.92	3.02	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	0.00
CO_2 Cumulative (T	41.22	73.21	112.84	153.39	196.37	239.35	282.33	325.31	368.29	411.27	454.25	497.23	498.67	498.67
H_2S (gr/Kg)	0.26	0.23	0.26	0.25	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.00
H_2S Cumulative (T	3.66	6.41	9.89	13.25	16.90	20.56	24.22	27.88	31.54	35.20	38.86	42.51	42.64	42.64
KMJ-22 (Ton/hours)		76.12	76.12	76.12	76.12	76.12	67.59	77.52	95.96	76.45	76.94	77.44	77.44	
CO_2 (gr/Kg)	17.06	17.06	17.06	17.06	17.06	17.06	1.31	0.97	0.97	1.04	1.30	1.01	1.01	0.00
CO_2 Cumulative (T	934.81	1807.31	2742.12	3676.94	4611.75	5546.57	5610.27	5664.17	5731.09	5788.29	5860.57	5917.14	5919.02	5919.02
H_2S (gr/Kg)	3.14	3.14	3.14	3.14	3.14	3.14	0.20	0.19	0.26	0.19	0.19	0.17	0.17	0.00
H_2S Cumulative (T	171.98	332.50	504.48	676.46	848.44	1020.42	1030.29	1040.92	1058.76	1069.45	1080.02	1089.68	1090.01	1090.01
KMJ-24 (Ton/hours)		39.71	39.71	39.71	39.71	39.71	40.52	Test Prod.	Test Prod.	Test Prod.	Test Prod.	Test Prod.	Test Prod.	
CO_2 (gr/Kg)	1.47	1.37	1.37	1.37	1.37	1.37	1.31	1.45	1.45	1.45	1.45	1.45	1.45	0.00
CO_2 Cumulative (T	43.13	79.66	118.81	157.95	197.10	236.24	274.36	274.36	274.36	274.36	274.36	274.36	274.36	274.36
H_2S (gr/Kg)	0.23	0.21	0.21	0.21	0.21	0.21	0.20	0.19	0.19	0.19	0.19	0.19	0.19	0.00
H_2S Cumulative (T	6.76	12.41	18.46	24.51	30.56	36.61	42.50	42.50	42.50	42.50	42.50	42.50	42.50	42.50
KMJ-25 (Ton/hours)		10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	
CO_2 (gr/Kg)	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	0.00
CO_2 Cumulative (T	45.03	87.06	132.10	177.13	222.17	267.20	312.23	357.27	402.30	447.33	492.37	537.40	538.90	538.90
H_2S (gr/Kg)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.00
H_2S Cumulative (T	1.43	2.77	4.21	5.64	7.08	8.51	9.95	11.38	12.82	14.25	15.68	17.12	17.17	17.17
KMJ-26 (Ton/hours)		44.72	50.73	46.49	44.72	44.72	44.72	44.72	44.72	46.19	52.65	51.96	49.75	
CO_2 (gr/Kg)	1.30	1.30	1.02	0.99	1.15	1.15	1.15	1.15	1.15	0.98	1.05	1.24	1.21	0.00
CO_2 Cumulative (T	41.82	80.85	118.18	151.34	188.40	225.46	262.51	299.57	336.63	369.15	409.06	455.30	456.75	456.75
H_2S (gr/Kg)	0.23	0.23	0.21	0.21	0.19	0.19	0.19	0.19	0.19	0.21	0.20	0.20	0.09	0.00
H_2S Cumulative (T	7.28	14.07	21.61	28.79	34.88	40.96	47.05	53.13	59.21	66.23	73.80	81.24	81.35	81.35
KMJ-27 (Ton/hours)		52.52	52.82	56.48	57.10	55.58	54.26	54.26	58.29	65.29	67.56	67.56	67.56	
CO_2 (gr/Kg)	2.68	2.56	2.50	2.78	2.56	2.60	2.28	2.15	2.33	2.49	2.33	2.33	2.33	0.00
CO_2 Cumulative (T	104.65	194.87	289.86	402.96	508.37	612.43	701.64	785.65	883.37	1000.21	1113.39	1226.57	1230.34	1230.34
H_2S (gr/Kg)	0.22	0.26	0.21	0.25	0.21	0.22	0.20	0.22	0.19	0.20	0.18	0.18	0.18	0.00
H_2S Cumulative (T	8.70	18.05	25.89	35.98	44.81	53.60	61.45	70.11	78.09	87.26	96.15	105.04	105.33	105.33
KMJ-37 (Ton/hours)		53.36	53.36	53.36	57.17	57.17	57.17	49.59	21.14	21.14	50.15	49.30	49.30	
CO_2 (gr/Kg)	3.05	3.05	3.05	3.05	1.61	1.61	1.61	1.40	1.95	1.95	1.78	1.67	1.67	0.00
CO_2 Cumulative (T	117.09	226.37	343.46	460.55	526.66	592.78	658.89	708.82	738.56	768.30	832.53	891.67	893.64	893.64
H_2S (gr/Kg)	0.39	0.39	0.39	0.39	0.21	0.21	0.21	0.28	0.27	0.27	0.19	0.19	0.19	0.00
H_2S Cumulative (T	14.89	28.78	43.67	58.56	67.18	75.79	84.40	94.33	98.39	102.45	109.18	115.86	116.09	116.09
KMJ-46 (Ton/hours)		23.16	23.10	23.05	23.05	21.38	21.38	21.38	21.38	21.38	21.38	21.38	28.83	
CO_2 (gr/Kg)	3.29	3.29	3.34	3.37	3.37	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.19	0.00
CO_2 Cumulative (T	54.86	106.05	161.66	217.59	273.53	323.23	372.92	422.62	472.32	522.02	571.72	621.42	623.62	623.62
H_2S (gr/Kg)	0.24	0.24	0.24	0.22	0.22	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.20	0.00
H_2S Cumulative (T	3.99	7.72	11.74	15.47	19.19	22.67	26.15	29.63	33.11	36.59	40.07	43.55	43.68	43.68
KMJ-14 (Ton/hours)		43.97	43.99	43.93	43.99	453.71	32.51	19.82	43.04	43.04	43.04	43.04	43.04	
CO_2 (gr/Kg)	3.41	3.13	3.55	3.54	3.03	2.92	2.87	2.99	2.67	2.67	2.67	2.67	2.67	0.00
CO_2 Cumulative (T	109.24	201.75	314.30	426.16	522.14	1474.62	1541.72	1584.44	1667.30	1750.16	1833.01	1915.87	1918.63	1918.63
H_2S (gr/Kg)	0.23	0.26	0.24	2.56	0.25	0.25	0.21	0.23	0.22	0.22	0.22	0.22	0.22	0.00
H_2S Cumulative (T	7.34	14.95	22.66	103.55	111.45	193.91	198.91	202.13	208.96	215.80	222.63	229.47	229.70	229.70

KMJ-28 (Ton/hours)		32.41	30.91	30.71	25.86	25.86	33.04	30.08	29.84	30.03	31.86	31.65	31.65	
CO_2 (gr/Kg)	2.89	2.36	2.26	2.37	2.52	2.52	2.16	1.99	2.49	2.50	2.39	2.15	2.15	0.00
CO_2 Cumulative (T	68.78	120.11	170.39	222.69	269.61	316.52	367.89	411.06	464.57	518.63	573.46	622.47	624.11	624.11
H_2S (gr/Kg)	0.29	0.27	0.28	0.28	0.28	0.28	0.23	0.23	0.27	0.23	0.23	0.22	0.22	0.00
H_2S Cumulative (T	6.82	12.60	18.93	25.20	30.41	35.61	40.98	45.88	51.77	56.67	61.93	66.85	67.02	67.02
KMJ-45 (Ton/hours)		23.18	22.98	21.27	19.53	19.53	19.53	19.53	28.04	23.79	27.02	25.26	25.26	
CO_2 (gr/Kg)	7.27	10.62	11.38	11.38	11.59	11.59	11.59	11.59	11.57	13.33	6.36	13.24	#VALUE!	0.00
CO_2 Cumulative (T	118.40	283.86	472.13	646.48	809.48	972.48	1135.48	1298.48	1532.16	1760.48	1884.29	2125.03	#VALUE!	2133.00
H_2S (gr/Kg)	0.21	0.29	0.30	0.28	0.32	0.32	0.32	0.32	0.32	0.28	0.26	0.27	619.13	0.00
H_2S Cumulative (T	3.41	7.94	12.92	17.28	21.73	26.17	30.61	35.05	41.49	46.24	51.31	56.19	431.53	56.35
KMJ-20 (Ton/hours)		11.11	11.09	10.99	11.05	11.05	10.99	14.10	13.79	12.92	12.92	12.92	12.92	
CO_2 (gr/Kg)	5.20	5.78	5.46	6.18	6.08	5.82	5.30	5.14	5.24	5.56	5.56	5.56	5.56	0.00
CO_2 Cumulative (T	41.36	84.53	128.09	176.96	225.31	271.65	313.58	365.76	417.81	469.55	521.30	573.04	574.77	574.77
H_2S (gr/Kg)	0.23	0.23	0.23	0.25	0.25	0.24	0.25	0.20	0.21	0.24	0.24	0.24	0.24	0.00
H_2S Cumulative (T	1.80	3.53	5.36	7.34	9.32	11.22	13.20	15.22	17.27	19.47	21.67	23.87	23.95	23.95
KMJ-33 (Ton/hours)		16.75	16.37	16.75	17.32	17.32	17.32	17.32	17.32	19.45	19.45	19.44	19.44	
CO_2 (gr/Kg)	5.19	4.68	4.50	5.01	4.89	4.89	4.89	4.89	4.89	4.97	4.97	4.92	4.92	0.00
CO_2 Cumulative (T	62.57	115.26	168.29	228.68	289.67	350.65	411.64	472.62	533.61	603.19	672.77	741.60	743.89	743.89
H_2S (gr/Kg)	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.23	0.23	0.24	0.24	0.00
H_2S Cumulative (T	3.55	6.85	10.24	13.75	17.33	20.91	24.48	28.06	31.64	34.87	38.11	41.53	41.64	41.64
KMJ-40 (Ton/hours)		11.24	10.72	11.24	11.24	15.62	15.62	15.62	15.62	15.62	15.62	17.07	17.07	
CO_2 (gr/Kg)	6.82	6.82	7.45	7.80	7.80	7.21	7.21	7.21	7.21	7.21	7.08	6.41	6.41	0.00
CO_2 Cumulative (T	55.20	106.73	164.20	227.30	290.39	371.45	452.51	533.56	614.62	695.68	775.33	854.15	856.78	856.78
H_2S (gr/Kg)	0.25	0.25	0.29	0.28	0.28	0.27	0.27	0.27	0.27	0.27	0.19	0.18	0.18	0.00
H_2S Cumulative (T	2.02	3.90	6.11	8.39	10.66	13.72	16.79	19.85	22.91	25.97	28.13	30.37	30.45	30.45
KMJ-51 (Ton/hours)		85.23	86.15	85.14	84.69	84.69	85.99	85.99	89.62	86.63	82.98	82.98	82.98	
CO_2 (gr/Kg)	3.16	3.06	3.56	3.12	3.10	3.10	3.03	3.03	2.90	3.24	2.94	2.76	2.76	0.00
CO_2 Cumulative (T	190.13	365.25	586.12	777.44	966.56	1155.67	1343.00	1530.33	1717.68	1919.82	2095.18	2259.89	2265.38	2265.38
H_2S (gr/Kg)	0.20	0.24	0.25	0.24	0.25	0.25	0.23	0.23	0.25	0.24	0.22	0.21	0.21	0.00
H_2S Cumulative (T	12.12	25.58	41.31	55.79	70.85	85.91	99.92	113.92	130.21	145.24	158.23	170.94	171.37	171.37
KMJ-52 (Ton/hours)		40.18	39.68	40.34	29.20	29.20	38.89	38.10	37.90	38.16	36.87	36.35	36.35	
CO_2 (gr/Kg)	2.85	2.34	2.35	2.64	2.46	2.46	2.36	2.17	2.25	2.29	2.33	2.17	2.17	0.00
CO_2 Cumulative (T	82.29	145.55	212.77	289.51	341.30	393.10	459.27	518.77	580.20	643.23	705.11	761.88	763.77	763.77
H_2S (gr/Kg)	0.27	0.27	0.25	0.29	0.28	0.28	0.22	0.27	0.25	0.22	0.21	0.20	0.20	0.00
H_2S Cumulative (T	7.83	15.11	22.25	30.53	36.34	42.14	48.32	55.76	62.64	68.78	74.48	79.80	79.98	79.98
KMJ-62 (Ton/hours)		73.14	70.74	70.72	70.72	71.93	73.46	71.91	71.91	72.83	72.83	72.83	72.32	
CO_2 (gr/Kg)	2.55	2.55	2.47	2.56	2.56	2.49	4.10	3.00	3.04	3.38	3.38	3.38	3.25	0.00
CO_2 Cumulative (T	134.37	259.77	385.37	515.79	646.21	774.94	991.71	1147.23	1304.52	1481.76	1659.00	1836.24	1841.88	1841.88
H_2S (gr/Kg)	0.25	0.25	0.21	0.23	0.23	0.23	0.20	0.20	0.22	0.19	0.19	0.19	0.19	0.00
H_2S Cumulative (T	13.04	25.21	36.14	47.77	59.40	71.33	81.86	92.18	103.63	113.71	123.78	133.85	134.18	134.18
KMJ-65 (Ton/hours)		61.13	62.53	62.53	62.53	65.57	69.02	69.39	68.14	70.53	70.53	70.53	70.53	
CO_2 (gr/Kg)	1.32	1.32	1.10	1.04	1.04	1.03	1.18	1.23	1.38	0.96	0.96	0.97	0.97	0.00
CO_2 Cumulative (T	58.23	112.57	162.16	208.94	255.71	304.50	363.35	424.91	492.84	541.51	590.17	639.62	641.27	641.27
H_2S (gr/Kg)	0.26	0.26	0.26	0.25	0.25	0.23	0.24	0.25	0.23	0.18	0.18	0.20	0.20	0.00
H_2S Cumulative (T	11.62	22.46	34.17	45.30	56.43	67.14	78.88	91.35	102.68	112.03	121.38	131.32	131.65	131.65
KMJ-72 (Ton/hours)						75.85	70.91	70.91	70.93	70.93	68.91	68.91	68.91	
CO_2 (gr/Kg)						2.18	2.09	2.09	2.54	2.54	2.14	2.14	2.14	0.00
CO_2 Cumulative (Ton)						429.13	812.89	1196.64	1663.95	2131.25	2513.44	2895.62	2908.36	2908.36
H_2S (gr/Kg)						1.87	1.79	1.79	2.18	2.18	1.83	1.83	1.83	0.00
H_2S Cumulative (Ton)						367.81	696.74	1025.66	1426.19	1826.72	2154.30	2481.87	2492.79	2492.79
Total Cumultaive (Ton)														