DIRECT FILTRATION FOR THE WATER SUPPLY OF SUKABUMI, INDONESIA

J.W. de Lange

Supervision:
- Ir. W.F.J.M. Nooijen
  DHV Consultants
  Water Supply Engineering
- Prof. Ir. J.H. Kop
  Delft University of Technology
  Faculty of Civil Engineering
  Division of Sanitary Engineering
  and Water Management

Amersfoort, The Netherlands
July 1988

TU Delft
Technische Universiteit Delft

Faculteit der Civiele Techniek

DIRECT FILTRATION FOR THE WATER SUPPLY OF SUKABUMI, INDONESIA

J.W. de Lange

Supervision:
- Ir. W.F.J.M. Nooijen
  DHV Consultants
  Water Supply Engineering
- Prof. Ir. J.H. Kop
  Delft University of Technology
  Faculty of Civil Engineering
  Division of Sanitary Engineering
  and Water Management

Amersfoort, The Netherlands
July 1988

PREFACE

This report is the result of a survey which, accompanied by DHV consultants, is the final thesis for my masters degree of Civil Engineering at Delft University of Technology. The most important results are presented in tables and graphs and summarized in chapter 1 "Direct filtration in Sukabumi". The reader who is interested in the way of realization of these results may study the subsequent chapters and the annexes 1 to 6, where all measurements during the survey are presented.

I would like to thank the persons without whose contribution this survey would not have been possible:
the colleagues of DHV Consultants Sukabumi, especially Ing. R.v. Kerkvoorden for the pleasant cooperation, Ing. J. Kraaij for the preparations for the survey, Pak Asep and Pak Budi for the assistance by word and deed in the laboratory, Miss Rina Lans for the type-writing and Pak Suhanda for driving me safely to the laboratory almost every day;
Ir. Poedjastanto of Directorate Water Supply, Jakarta, for the cooperation between DHV/Deserco and the Indonesian Governement;
The Royal Dutch Institute of Engineers (KIvI), especially Mrs. W.E. Hollander for the financial contribution to the transport costs;
and last but not least Prof. Ir. J.H. Kop and Ir. W.F.J.M.Nooijen for their sublime and critical supervision.

J. W. de Lange

CONTENTS PAGE

1. DIRECT FILTRATION IN SUKABUMI

1.1. SUMMARY

A full-scale filtration plant with a capacity of 250 l/s is at present under construction in Sukabumi on the island of Java, Indonesia. The raw water will be taken from the Cigunung River which originates from an upland catchment. The water is low in total dissolved solids, pH, alkalinity and hardness. Furthermore it is moderately contaminated and most of the time low in turbidity and colour. Only during heavy rainfall the turbidity and the colour of the river water increase, as a result of soil erosion.

Pilot plant studies were initiated to investigate the feasibility of direct filtration. The present paper deals with the results of the study. It was found that:

- Dual media filtration with a top layer of anthracite (d_{eff} = 1.6 mm) and a bottom layer of sand (d_{eff} = 0.8 mm) results in an acceptable effluent quality (turbidity approx. 1 NTU) during periods with low raw water turbidity (below 30 NTU). The length of filter run is more than 12 hours and addition of coagulant is not required.

- In periods of high raw water turbidity (30 to more than 100 NTU) effluent turbidity increases above 5 NTU (WHO guideline) if no coagulant is added. A 20 mg/l alum dose is required. Effluent quality is then below 5 NTU and length of filter run is 4 hours at an average raw water turbidity of 100 NTU.

- Head loss is concentrated in the upper 0.10 m of the filter bed. Suspended solids hardly penetrate deeper into the filter bed, a coarser grain size than 0.8/1.6 might extend length of filter run and still give excellent effluent quality. It is suggested to continue the investigations with coarser filter material.

- The filters run in the declining rate mode. Introduction of extra head loss in the piping system to and from a newly backwashed filter is recommended during the first 20 minutes after backwashing, in order to avoid peak velocities and the risk of breakthrough of suspended solids for the filter that has just been backwashed. A ratio of 1.5 between maximum and average velocity in a battery of declining rate filters is acceptable.

1.2. INTRODUCTION

The present water supply system for the town of Sukabumi, West Java, consists of two spring tappings and two deepwells. The total capacity amounts to 90 l/s, which is quite insufficient to supply the entire population of about 200,000 people. Therefore shallow wells are widely used as an additional source of water. Water from these wells is generally not suitable for immediate consumption due to the presence of coliform bacteria. Epidemic diseases are widespread for this reason.

DGIS (Directorate General of International Cooperation) of the Dutch Ministry of Foreign Affairs, and DGHS (Directorate General of Human Settlements) of the Indonesian Ministry of Public Works started the Sukabumi Water Supply Augmentation and Improvement Project, to improve this situation. This development cooperation project results among others in the extension of the water supply for Sukabumi and vicinity by a river water treatment plant with a capacity of 250 l/s.

Raw water will be taken from the Cigunung River. The water from this river originates from an upland catchment that is part of a protected area "Hutan Taman Nasional Situgunung". Generally, the quality of Cigunung River water is excellent, with low turbidity and colour, and reasonable bacteriological quality. However, during heavy rainstorms, the water becomes brown and turbid within a few minutes, due to soil erosion in the catchment area.

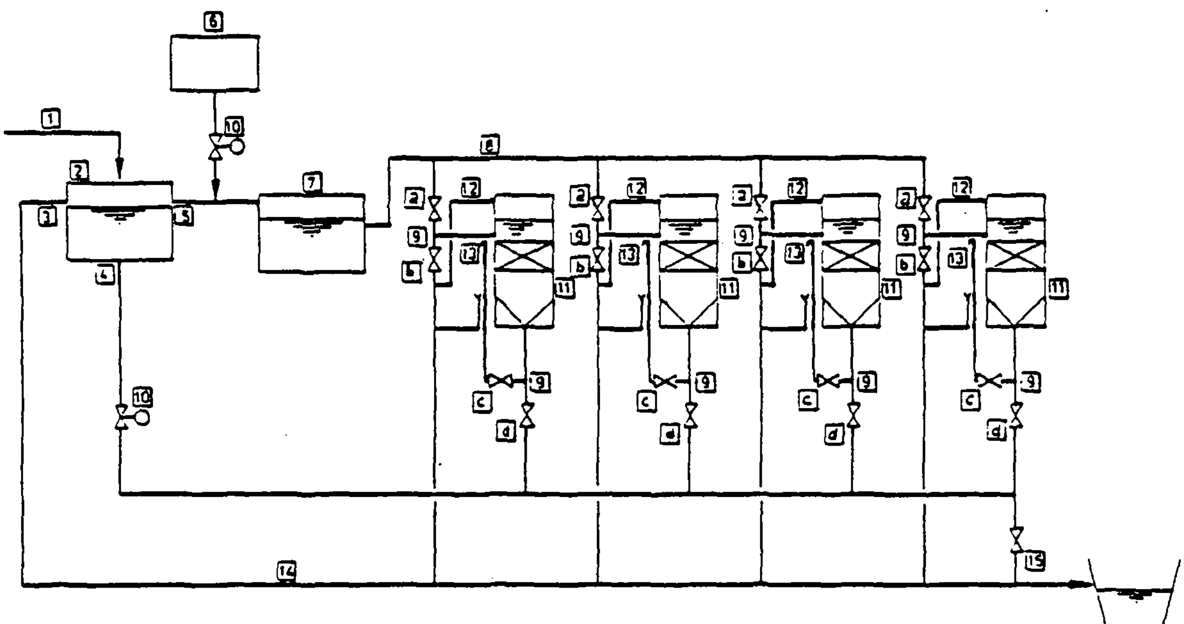
Direct filtration, if applicable, is the most economic form of treatment for this type of water. Savings in capital cost of 40% are possible if the flocculation and sedimentation stages can be eliminated. Investigation is required to demonstrate the feasibility of direct filtration. Raw water quality, filtered water quality and length of filter run have to be investigated. Furthermore, chemical dosing and filter grain size have to be optimized. As downflow declining rate filtration was selected to simplify both design and operation, special attention has to be paid to maximum velocities and the risk of breakthrough in a newly backwashed filter.

In 1987 a pilot study was initiated in cooperation with Ir. Poedjastanto of the Directorate of Water Supply (under the auspices of DGHS). The study was carried out by DHV Consulting Engineers in cooperation with PT Deserco, Jakarta and PT Indah Karya, Bandung. Further support was contributed by Prof. Ir. Kop of Delft University of Technology, The Netherlands and by Prof. Ir. Harjoko of the Institute of Technology Bandung, Indonesia.

The pilot plant was built on the bank of the Cigunung River, near the planned intake site, and the research took place during the rainy season from February to April 1988.

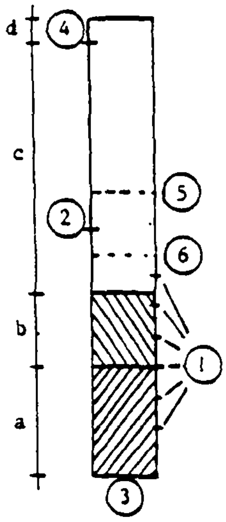
1.3. PILOT PLANT LAYOUT

Fig.1.1 shows the process flow scheme of the pilot plant. The raw water flows from the Cigunung River through a 200 m long HDPE gravity pipe (inner diameter 53 mm) into the raw water reservoir, which functions as a primitive sand trap. The total plant flow is regulated by an adjustable overflow weir. A part of the raw water passes a V-notch by which total plant flow is measured. Chemicals are dosed in the jet of the V-notch. The superfluous part of the water is discharged to the river through a waste conduit. After passing the V-notch and the chemical mixing tank, the water is diverted to four filter columns, which run in the downflow declining rate mode. The supernatant water level fluctuates and is practically equal to the level in the chemical mixing tank for all filters. The downstream level is constant for all filters and practically equal to the height of the overflow weir which is fixed at the filterbed surface level. The momentary output of each filter is measured manually with a stopwatch and calibrated cylinder.



1. Transmission main from intake
2. Raw water reservoir
3. Adjustable overflow weir
4. Backwash water main
5. V-notch (flow measurement)
6. Chemical tank
7. Chemical mixing tank
8. Raw water conduit
9. Stop valves:
   a. influent
   b. backwash effluent
   c. effluent
   d. backwash influent
10. Adjustable valve
11. Filter column
12. Overflow
13. Fixed weir
14. Waste conduit
15. Drain

Fig. 1.1. - <u>Process flow scheme of pilot plant</u>



part	above filterbed surface (m)	below filterbed surface (m)	dimensions
1. head measuring points	0.15	0.10; 0.35; 0.60; 0.85; 1.10	
2. influent gutter	0.50		
3. effluent nozzle		1.50	
4. overflow	2.00		
5. min. water level theoretical	0.80		
6. max. bed expansion theoretical (backwash velocity 35 m/h)	0.30		
column height consisting of:			
a. sand			0.90 m
b. anthracite			0.60 m
c. supernatant water			2.00 m
d. free board			0.20 m
diameter of filter column			0.30 m
average filtration rate			10.8 m/h
average discharge per filter			0.21 l/s

Fig. 1.2. - Filter column and dimensions

Table 1.1. - Filterbed characteristics

medium	material	depth m	eff.size mm	U.C.	clean bed m/m	resistance (V = 10.8 m/h) m
A	sand	0.9	0.8	1.3	0.60	0.54
	anthracite	0.6	1.6	1.35	0.15	0.09 (0.63 m total)
B	sand	0.9	0.6	1.4	0.80	0.72
	anthracite	0.6	1.6	1.35	0.15	0.09 (0.81 m total)

The four filter columns are identical (Fig.1.2). The filterbed consists of two materials, a coarse anthracite layer of 0.60 m overlaying a fine sand layer of 0.90 m. The effective sizes of the materials are 1.6 mm for anthracite and 0.8 mm for sand, this combination having often proved effective [lit. 1]. Filterbed composition and clean bed resistance at an average filtration rate of 10.8 m/h are presented in Table 1.1.

The clean bed resistance amounts to 0.63 m for medium A at a filtration velocity of 10.8 m/h. Including losses in the influent and effluent conduits, which are respectively 0.16 m and 0.24 m, the total minimum losses amount to 1.03 m at a velocity of 10.8 m/h.

When the supernatant water level is at a maximum of 1.80 m above the filterbed surface, the filter column with the lowest filtration rate at that moment (the dirtiest filter) has to be backwashed. The dirty washwater is discharged through the same opening where the raw water enters the column during operation. The backwash water is taken from the raw water reservoir, even during high raw water turbidity. The filterbed expansion during backwashing is almost negligible, 0 to 2%, at a backwash rate of 15 m/h. The water level in the raw water reservoir, from which the backwash water is drawn, is too low to achieve a backwash rate of more than 15 m/h. Therefore a backwash period of half an hour proved necessary for adequate filter cleaning, whereby the top layer had to be stirred manually to remove all impurities.

1.4. RAW WATER CHARACTERISTICS

Raw water quality

A typical analysis of the raw water of the Cigunung River during non-flood periods is given in Table1.2. The water is low in total dissolved solids, pH, alkalinity and hardness. Thus the water is characterized as agressive and soft. Furthermore, it is moderately contaminated and low in turbidity and colour, except for periods when heavy rainstorms occur.

Table 1.2. - Typical analysis of Cigunung River Water

parameter		value
colour	Pt-Co units	5-10 (200)*
turbidity	NTU	2-30 (100)*
pH		6- 7
specific conductance	mS/m	5-10
temperature	°C	19-22
Cations:		
sodium	mg/l	not measured
ammonium	mg/l	absent
calcium	mg/l	7-10
magnesium	mg/l	2- 4
iron	mg/l	0- 0.2
manganese	mg/l	absent
aluminium	mg/l	absent
Anions:		
chloride	mg/l	1-5
nitrate	mg/l	0-4
bicarbonate	mg/l	20-60
sulphate	mg/l	5-15
phosphate	mg/l	absent
Microbiological quality:		
coliform organisms	MPN/100 ml	130

* During heavy rainstorms

During 1986 and 1987 a survey programme was carried out on the turbidity of the Cigunung River, as well as on precipitation in the area. A frequency distribution of turbidity is presented in Fig.1.3. The probability of turbidity exceeding a value of 150 NTU is negligible, while the probability of exceeding a value of 30 NTU and 100 NTU is respectively 4% and 2.5%.

Table1.3 presents the duration of high raw water turbidity. In the period from February to end of April 1988 (end of rainy saeason) turbidity exceeded 30 NTU two times for short periods of 2 to 3 hours (turbidity approx. 50 NTU) and one time for an extended period of 20 hours (maximum turbidity was 100 NTU). The relation between turbidity and suspended solids was occasionally measured:

- turbidity 3.5 NTU = 5 mg/l SS
- turbidity 9.5 NTU = 49 mg/l SS
- turbidity 100 NTU = 92 mg/l SS

Impact of chemical dose on pH

Aluminium reacts with water:

$$Al^{3+} + 3H_2O \rightleftarrows Al(OH)_3 + 3H^+$$

The pH will drop after dosing alum ($Al_2(SO_4)_3$ * 18 H_2O).
The pH is adjusted with soda ash (Na_2CO_3):

$$CO_3^{2-} + H_2O \rightleftarrows HCO_3^- + OH^-$$

Table1.4 presents the $CaCO_3$-CO_2 equilibrium for two different raw water turbidities. The water is classified as agresive and has poor buffering capacity. Therefore addition of soda ash is required to correct pH values and to neutralize the water.

Fig.1.4 shows the impact on pH by alum and soda ash doses. From this figure it may be concluded that the pH change will not differ greatly in a range up to 20 NTU turbidity and a constant chemical dose.

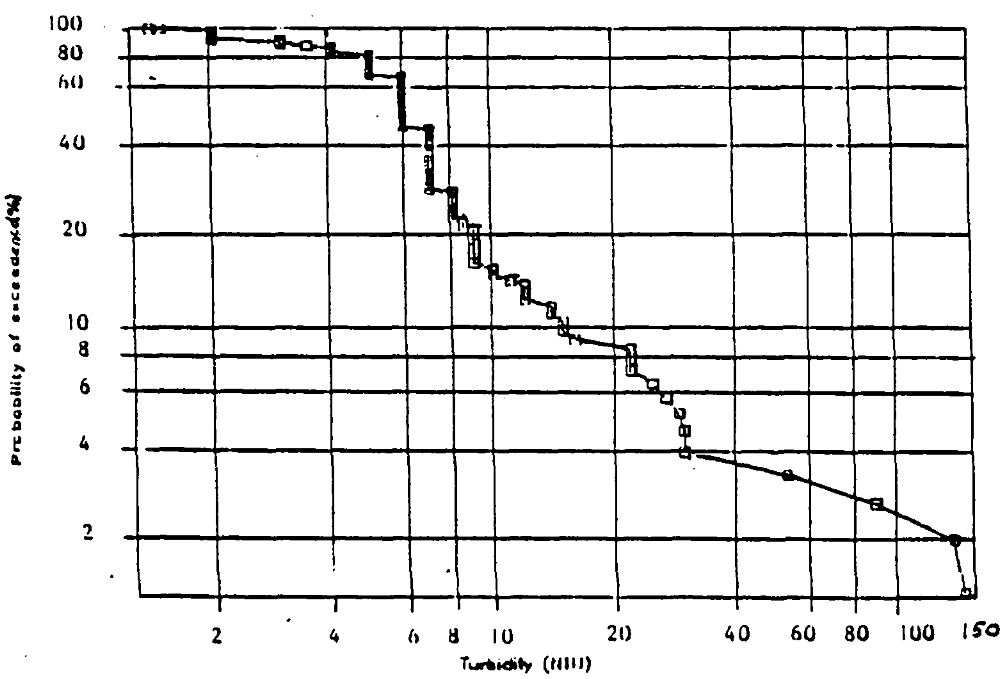


Fig. 1.3. - Frequency distribution of turbidity of the Cinunung River

Table 1.3. - Duration of high raw water turbidity; all periods wherein turbidity exceeded 10 NTU during period of measurements March to end of April '88

date:	March 8		March 10		March 15		April 1		April 2	
	time (h)	turb (NTU)	time (h)	turb (NTU)	time (h)	turb (NTU)	time (h)	turb (NTU)	time (h)	turb (NTU)
	10	6	9	4.5	10	8	10	7	8	75
	11	8	10	4.8	11	7.5	11	13	9	78
	12	16	11	4.8	12	6.8	12	8.5	10	55
	13	15	12	18	13	53	13	11	12	28
	14	12	13	43	14	60	14	13	13	23
	15	6.5	14	45	15	50	15	96		
	20	5	15	20	16	23	16	100		
			16	14	17	16	17	98		
			17	7			18	92		
>10 NTU (h)	3		5		5		continued		27	
>30 NTU (h)	0		2		3		on Apr. 2		20	

Table 1.4. - $CaCO_3$-CO_2 equilibrium of Cigunung River

Turbidity	(NTU)	4.0	20
Temperature	(Celc)	20.00	20.00
Ionstrength	(mMol/l)	1.16	1.32
Calcium	(mMol/l)	0.25	0.27
pH		6.00	6.00
m-value	(mMol/l)	0.68	0.68
p-value	(mMol/l)	-1.62	-1.62
CO_2	(mMol/l)	1.62	1.62
HCO_3	(mMol/l)	0.68	0.68
CO_3	(mMol/l)	0.00	0.00
Bufferindex	(mMol/l.pH)	1.15	1.15
Saturation index		-2.83	-2.81
Aggressive CO_2	(mMol/l)	1.34	1.33

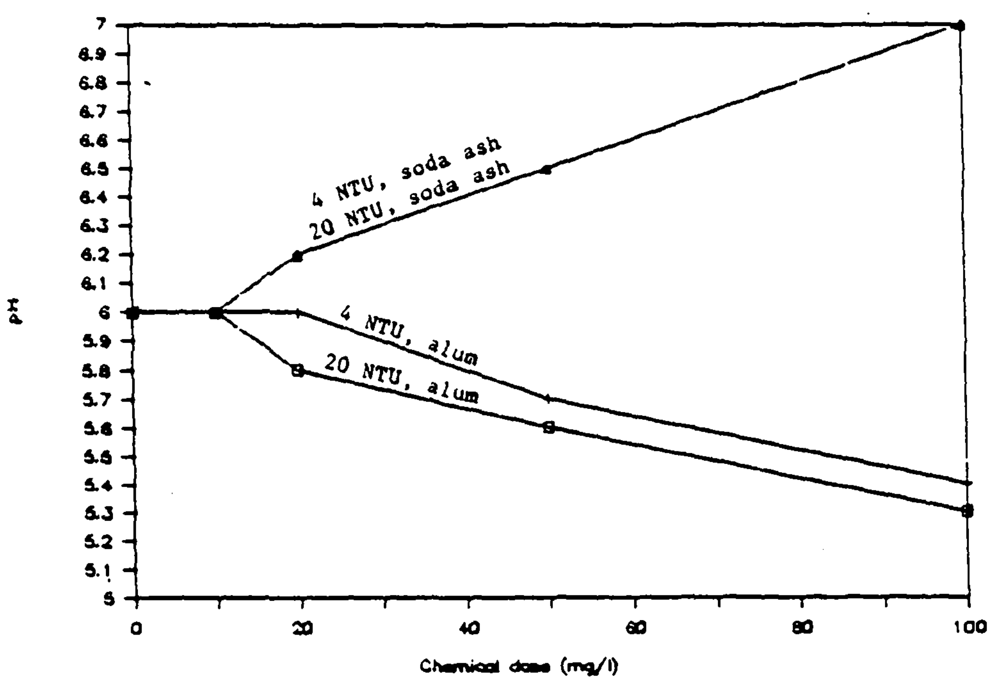


Fig. 1.4. - Impact by chemical dose on pH

1.5. FEASIBILITY OF DIRECT FILTRATION

The objective of filtration is to remove suspended and colloidal particles in such a way that the Indonesian drinking water standards of 10 NTU (turbidity) and 50 colour units (true colour) are met. By preference the WHO guideline values of 5 NTU (turbidity) and 15 true colour units should be met. The average filter run should preferably be more than 12 hours and the minimum filter run during high raw water turbidity should not drop below the time required to clean 8 filters. The assumed backwash period for one filter, including the operation of valves, is about half an hour. In the basic design of the full-scale treatment plant 8 filters are projected, thus the minimum acceptable filter run will be 4 hours.

The filtration rate is 10.8 m/h, based on common practice and refers to the average rate in a battery of declining rate filters. Raw water quality and optimal chemical dose will vary frequently. The raw water turbidity is roughly divided into two ranges: normally below 30 NTU and above 30 NTU after heavy rainfall (maximum values of 100 to 150 NTU).

Jar test

A sedimentation test (jar test) was carried out to establish the optimum coagulant dose. In direct filtration, optimum coagulant dose can generally be 60 to 80% of the dose derived from the sedimentation test. Table1.5 presents the jar test results. After dosing of chemicals the solution was mixed for 60 seconds at 100 revolutions per minute, followed by a coagulation/flocculation period of 15 minutes at 20 revolutions per minute. Sedimentation time was 2 hours. The optimum pH range for coagulation with aluminium salts is generally pH 6-7. As the pH of the raw water is in this range, only the acid produced by hydrolysis of alum has to be neutralized. This requires approximately the same doses for alum and soda ash.

Table1.5. - Jar test with raw water turbidity 6 and 60 NTU

Raw water NTU	Jar no.	Alum mg/l	Soda mg/l	Effluent NTU
6	A	0	0	6
6	B	20	0	6
6		20	20	5
6	C	50	0	7
6		50	50	5
6	D	100	0	6
6		100	100	6
60	A	0	0	14
60	B	20	0	14
60		20	20	14
60	C	50	0	10
60		50	50	9
60	D	100	0	10
60		100	100	10

The sedimentation tests shows that during low raw water turbidity dosing of chemicals hardly improves effluent quality. At times of high raw water turbidity, 50 mg/l alum gives the best result. Addition of soda ash for pH correction does not improve the results significantly.

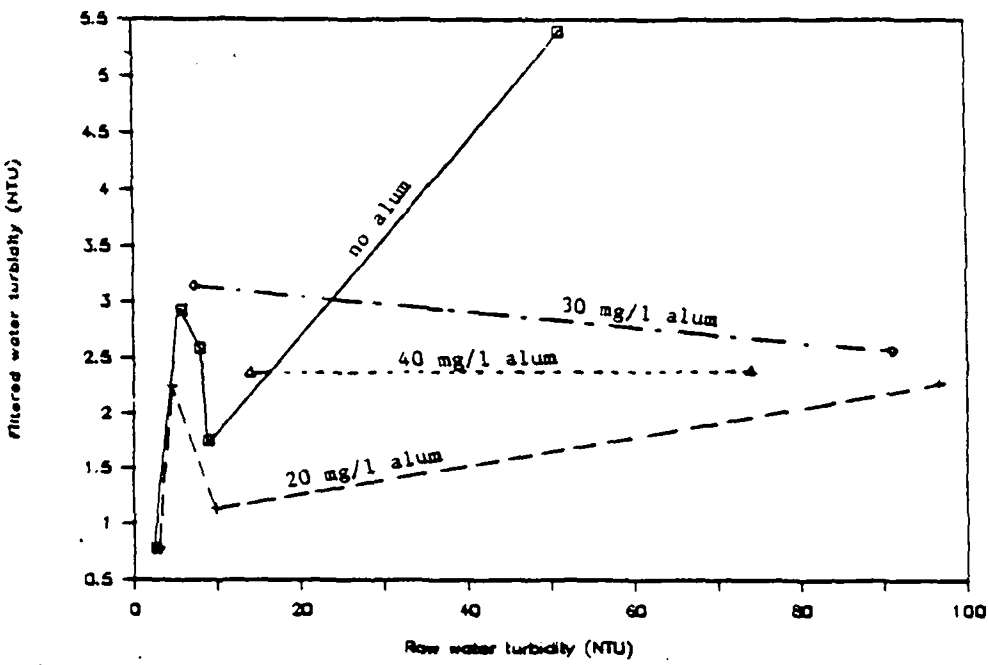


Fig. 1.5. - Filtered water turbidity

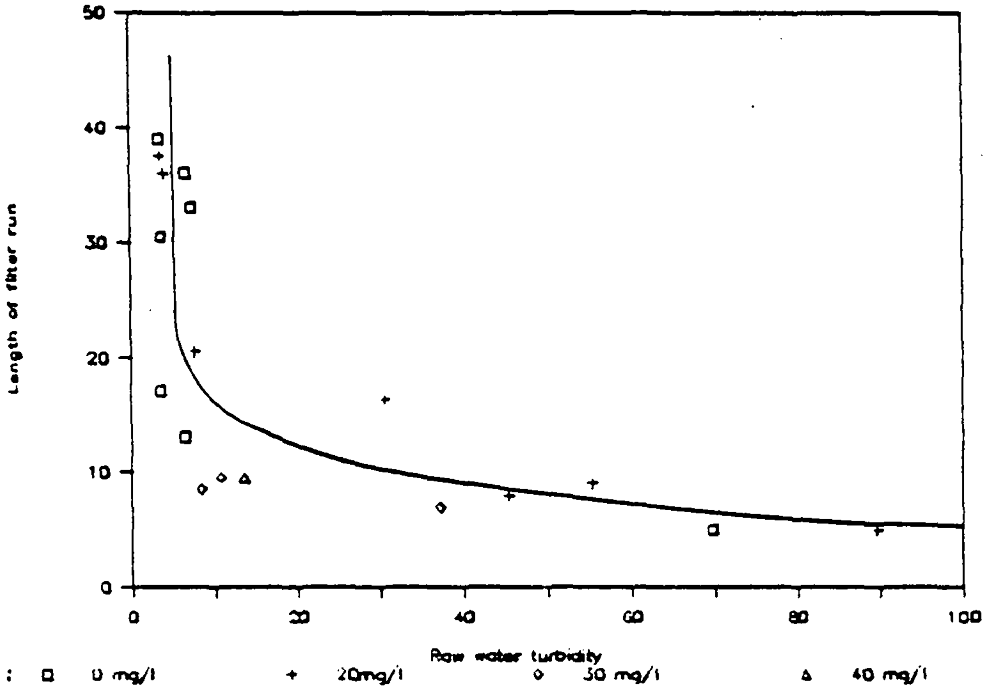


Fig. 1.6. - Length of filter run

Filtration results

Effluent turbidity and length of filter run are shown in Fig.1.5 and 1.6. During normal periods with low raw water turbidity (lower than 30 NTU) chemical dosing is not required to achieve an acceptable effluent quality. Even the raw water turbidity is below the WHO guideline of 5 NTU during extended periods.

In the 30 to 100 NTU range, a dose of 20 mg/l alum (40% of optimum jar test) is required. Doses of 30 and 40 mg/l alum do not improve effluent quality. At times of high raw water turbidity, above 30 NTU, filtration without alum dose results in an effluent turbidity that exceeds the 5 NTU guideline of the WHO. A minimum dose of 20 mg/l alum is required. Filter runs drop from 16 hours at 10 NTU raw water turbidity to 4 hours at 100 NTU raw water turbidity. Length of filter run decreases when more than 20 mg/l coagulant is added (see Fig.1.6), as a result of an increased filter load.

From Fig. 5 it may be concluded that no alum dose has to be applied during raw water turbidities lower than 30 NTU. The length of filter run then becomes 16 hours at an average turbidity of 10 NTU (Fig.1.6). In the high raw water turbidity range, the impact of alum dose on the length of filter run is negligible.

Head loss

The head loss over the filterbed during two typical filter runs (Fig.1.7 and 1.8) shows that clogging occurs in the upper 0.10 m anthracite layer, leaving the majority of the storage capacity unused. This poor floc penetration shortens filter runs considerably. The filter material A (Table 1.1) does not give satisfactory results with respect to head loss and a coarser grain size (top layer) should be applied to extend the length of filter run. Pilot plant experiments will be extended to verify the application of coarser filter material.

Colour removal

Normally (i.e. during raw water turbidity below 30 NTU) raw water colour is approximately 10 colour units and filterd water colour below 5 colour units. After (heavy) rainfall, raw water colour can rise to values of 200 colour units. After filtration, the colour drops to 10-15 colour units, within the WHO guideline of 15 colour units.

Comparison of finer filter material

Effluent turbidity of filter columns containing filter material A (see Table 1.1) meets WHO guidelines, as described before. A finer filter material (dual media B, see table 1.1) does not improve filtered water quality: the effluent turbidity is 1 NTU in periods of clear raw water (5 NTU), 2.5 NTU in periods of turbid raw water (40 NTU). Filter runs are smaller due to higher resistance in the fine sand layer; the difference in clean bed resistance is 0.18 m. Therefore, dual media B is not recommended for the treatment plant in Sukabumi.

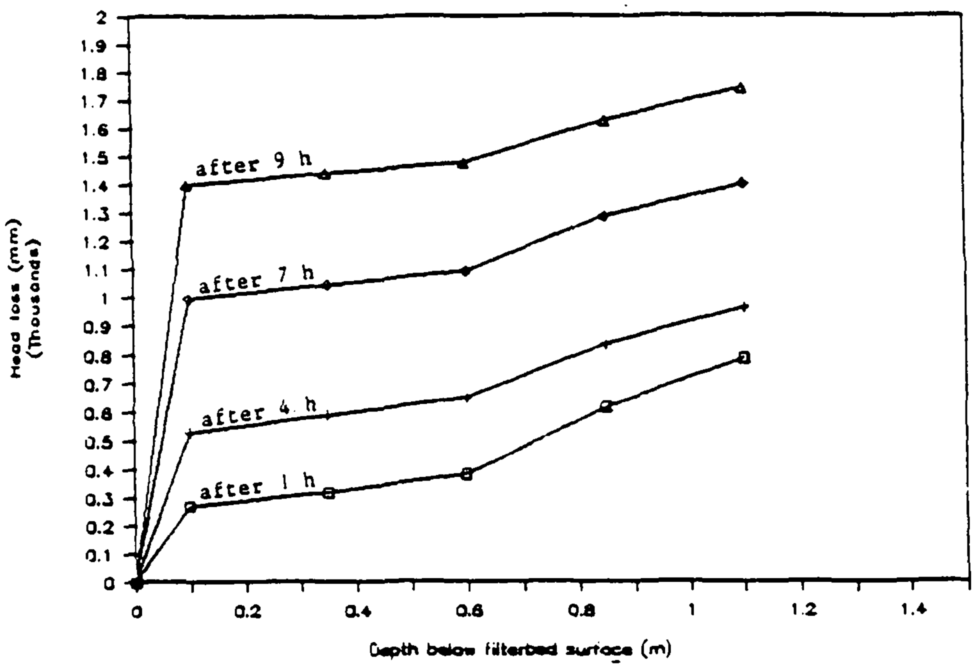


Fig. 1.7. - Head loss over filterbed with high raw water turbidity (max. 100 NTU); alum dose 20 mg/l

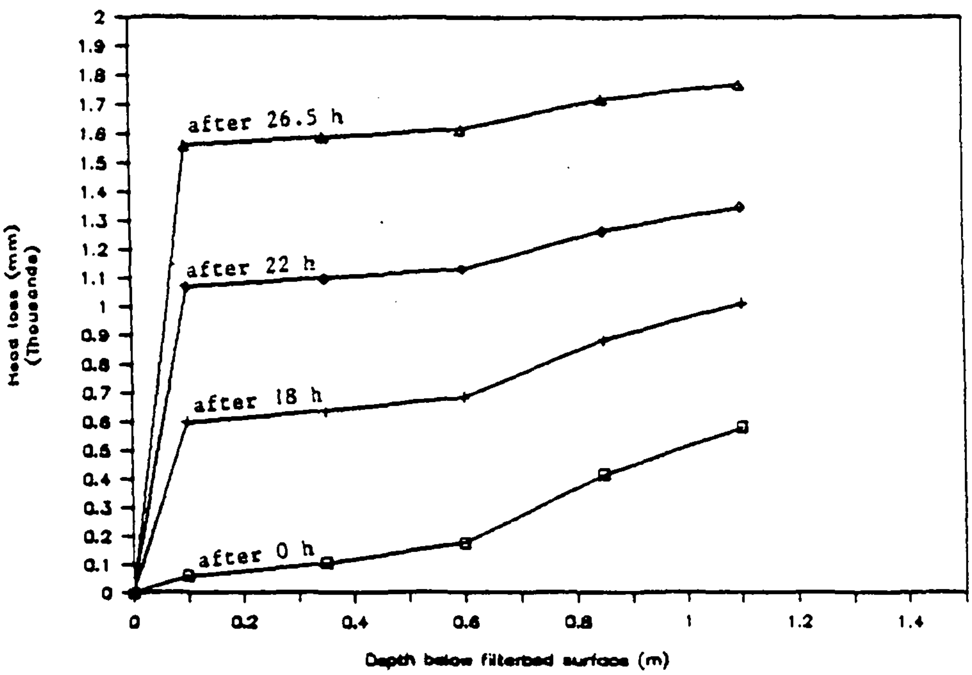


Fig. 1.8. - Head loss over filterbed with low raw water turbidity (max. 15 NTU); no chemical dosing

1.6 . STUDY OF DECLINING RATE FILTRATION

Principle of declining rate filtration

An extensive literature description of the principle of declining rate filtration has been published by Di Bernardo [lit. 2].
The advantage of filtration in the declining rate mode is that no flow adjusting valves are necessary, simplifying both design and operation. Fig.1.9 presents a typical filter run during a period of low turbidity and no dosing of chemicals. Filtration rate during one filter run is divided into a number of steps, equal to the number of filters (four in this case). A step is limited in time by backwashing of one of the filters. The filters are backwashed consecutively. Filtration rate during one step is more or less constant and the drop in filtration rate per step is more or less equal. The small peaks represent the rise in filtration rate when one of the other filters is backwashed.

Table 1.6 presents the filtration rate distribution over one filter run as a mean and standard deviation over the whole period, presupposing a distribution according to Gauss.
These experimental values are compared with the theoretical values according to the theory of Di Bernardo [lit. 2]. The theoretical filtration rate distribution matches the filtration rate distribution as measured within the range of standard deviation.
The theoretical and measured filtration rate distribution does not match during backwash of one filter. The difference is caused by a limited flow capacity of the remaining filters. During backwash the water level in the chemical mixing tank drowns the V-notch. As a result more water overflows and discharges to waste.

Maximum velocities

At high initial velocities just after backwashing there is a risk of breakthrough of suspended solids in a newly cleaned filter, in which the filtration rate is maximal. The maximum rate is influenced by the turbulent losses in the influent and effluent piping and can be limited to any desired value by introducing extra losses. The maximum acceptable filtration velocity is set at 1.5 times the average filtration velocity in accordance with [lit. 3]. Fig.1.10 presents the ratio of maximum and average filtration velocity as measured during the experiments. The ratio remains below the desired value of 1.5 at an average velocity 10.8 m/h.
The ratio rises at lower average velocities and falls at higher average velocities, due to decreasing and increasing resistance, respectively. The dashed line refers to the maximum ratio over the whole period, which is calculated from table 1.6 as maximum filtration rate divided by the average of all filters. The outcome of this is equivalent to a maximum ratio of (14.2 + 1.6)/10.8 = 1.46.

Fig.1.11 and 1.12 present the filtration velocity, supernatant water level and filtered water turbidity of one particular filter just after backwashing. The turbulent losses amount to 0.24 m (in effluent piping) and 0.40 m (0.16 m in influent piping, 0.24 m in effluent piping) respectively.

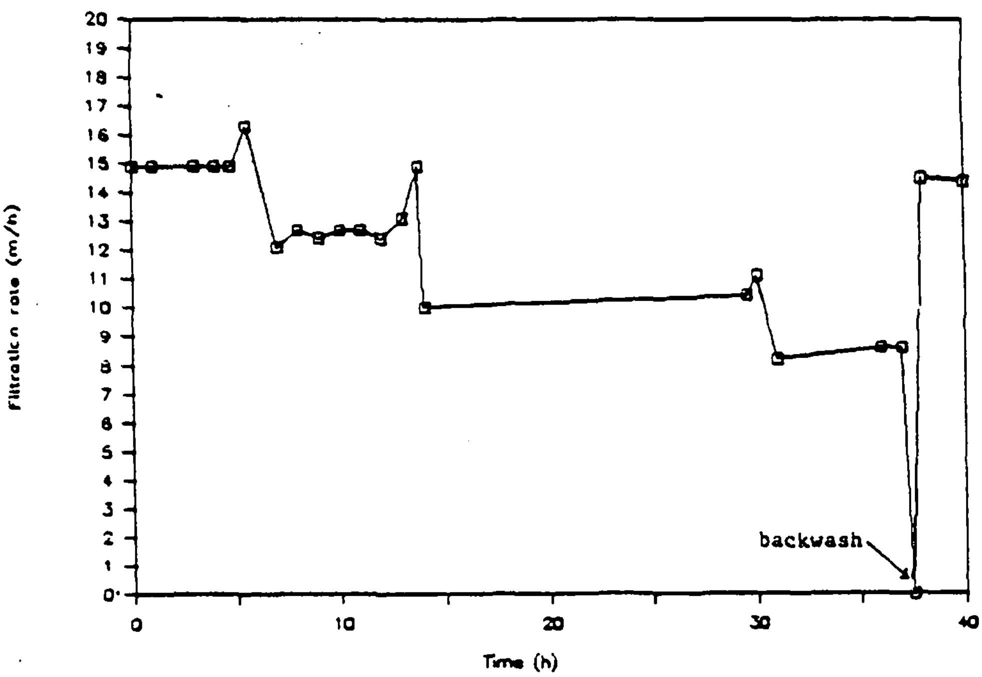


Fig. 1.9. - Typical filter run (raw water turbidity 3.7 NTU, no dosing of chemicals)

The supernatant water level in the filter is initially lower compared to the other 3 filters and equal the level of the backwash gutter overflow (which is 0.50 m above the filterbed in rest). This relatively low supernatant water level results in a limited maximum filtration velocity initially. The high initial turbidity results from backwashing with raw water: the bottom layer absorbs the suspended solids in the raw water during backwashing and releases them just after it. The filter gradually fills up and a maximum velocity is achieved in 10 to 20 minutes, at which time the water level is again the same for all filters.

A maximum velocity of 17.6 m/h (Fig.1.11) after 10 minutes results in a breakthrough of suspended solids. This is prevented by the introduction of extra head loss in the piping

Table 1.6. - Velocity distribution of declining rate filters

	as measured		as calculated**
	average* velocity m/h	standard deviation m/h	velocity m/h
1. During normal operation			
Step 1	14.2	1.6	13.7
Step 2	12.0	1.6	11.6
Step 3	9.8	1.5	9.7
Step 4	7.3	2.2	8.0
Average of all steps	10.8	0.8	10.8
2. During backwash of one filter			
Step 1	14.8	1.1	16.7
Step 2	12.1	2.1	14.4
Step 3	9.6	1.8	12.2
Step 4	0	0	0

* Average of all measurements during the whole period.
** According to theory of Di Bernardo [lit. 2]:
available head 1.8 m — laminar losses 0.63 m
filtration velocity 10.8 m/h — turbulent losses 0.40 m

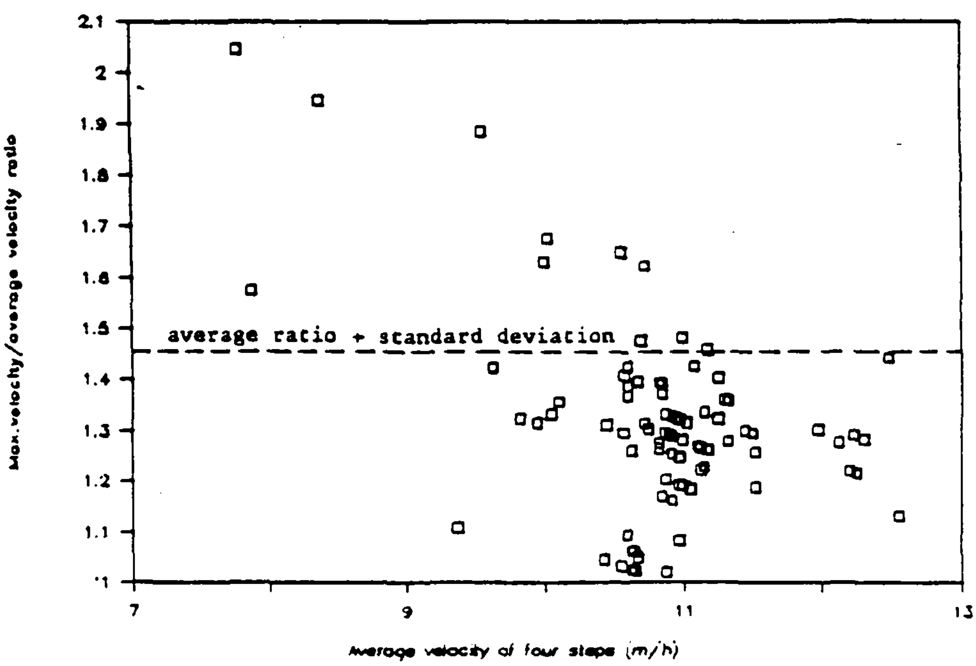


Fig. 1.10. - Ratio of maximum velocity and average velocity in declining rate filtration (as measured)

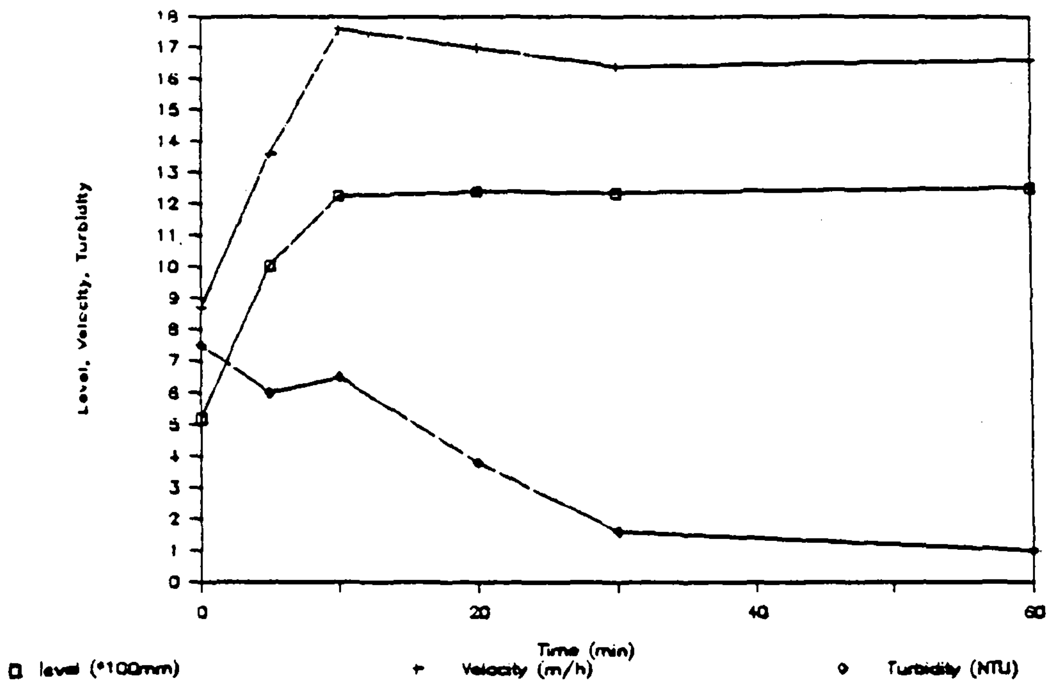


Fig. 1.11. - Filtration velocity, supernatant water level and effluent turbidity after backwashing (head loss in piping system 0.24 m at v = 10.8 m/h)

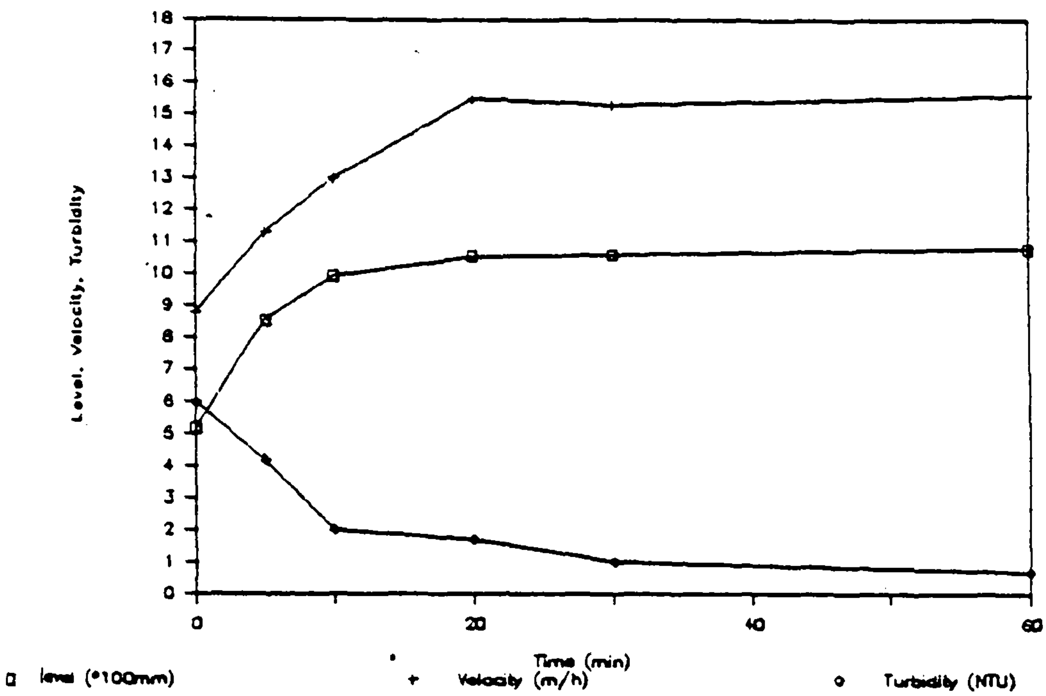


Fig. 1.12. - Filtration velocity, supernatant water level and effluent turbidity after backwashing (head loss in piping system 0.40 m at v = 10.8 m/h)

system to the newly backwashed filter during the first 20 minutes after backwashing (manipulation of valves). The result is shown in Fig.1.12. Extra head loss of 0.16 m limits the maximum filtration velocity to 15.5 m/h after 20 minutes and breakthrough does not occur (compare with Fig.1.11). The effluent turbidity is about 1 NTU after 20 minutes in both cases.
It may be concluded that a maximum velocity of 16 m/h (1.5 times the average) generally results in an acceptable effluent quality.
If the filtration rate in the other filters is assumed to be in accordance with step 2, 3 and 4 in table 6 and their effluent turbidity is maximal 3.5 NTU, the average effluent turbidity of all filters as a result of breakthrough (6 NTU) in the newly backwashed filter (v = 17.6 m/h) amounts to 4.8 NTU.
This turbidity still meets WHO guidelines.
However, peak velocities and breakthrough just after backwashing can be avoided easily.
Extra head loss during the first 20 minutes of a filter run is therefore recommended.

1.7. CONCLUSIONS AND RECOMMENDATIONS

Direct filtration of river water is a feasible form of treatment for the augmentation of the water supply in Sukabumi. Filtered water turbidity and length of filter run are acceptable, generally without coagulant dosage.
Only in periods of high raw water turbidity (> 30 NTU) an amount of 20 mg/l alum is required to meet the WHO guidelines with respect to effluent turbidity (5 NTU) and colour (15 true colour units).
Length of filter run falls in periods with extreme high turbidity (100 NTU) to a minimum acceptable value of 4 hours. The probability of exceeding high raw water turbidity is small (probability of exceeding a turbidity > 30 NTU is 4%) and such periods are short.
Clogging merely occurs in the upper 0.10 m anthracite layer. Therefore, further research with a coarser anthracite layer is recommended, to demonstrate that longer filter runs without concessions to filtered water turbidity are possible.
Declining Rate Filtration is a feasible filtration mode, provided that extra head loss is introduced in the piping system to a newly backwashed filter during the first 20 minutes, e.g. by manipulating the valves.

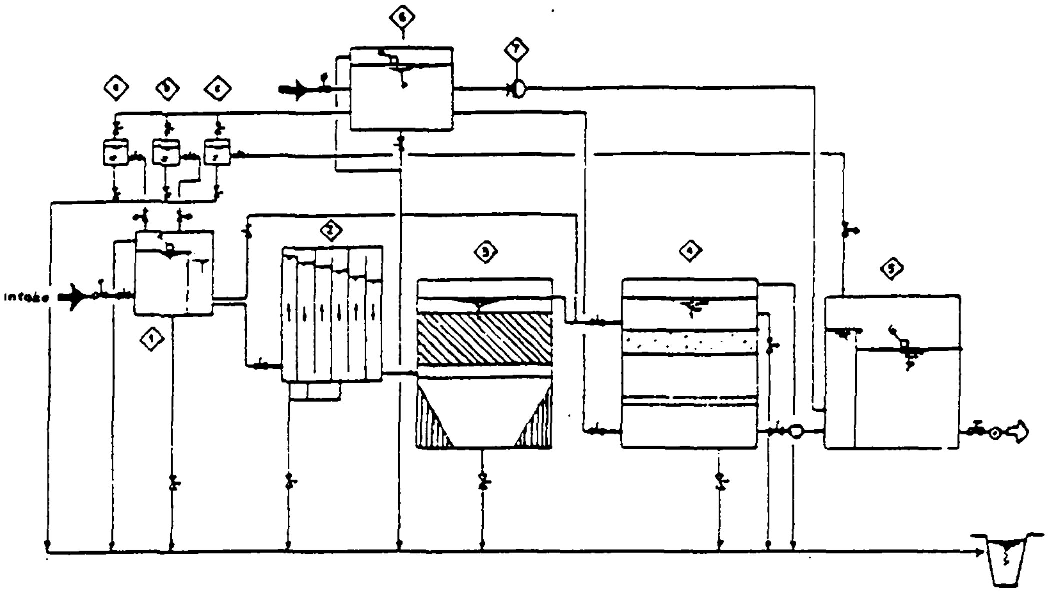
2. BASIC DESIGN CIGUNUNG TREATMENT PLANT

2.1. General

In former studies (lit. 4) the water quality of the Cigunung River is supposed to be suitable for direct filtration. In the basic design however a full treatment including flocculation and sedimentation has been worked out. This because the direct filtration plant can be extended to a full treatment, when water quality possibly deteriorates as a result of human activities in the catchment area. The treatment plant will be located at an elevation of approx. 820 m + MSL. This allows a raw water supply from the intake (920 m + MSL) by gravity and thus the use of raw water pumps is not required. Raw water flow and filtration velocity depend on the filtered water demand of the Cisaat and Sukabumi reservoirs downstream. A gradual increase and decrease of total water flow through the plant must be expected.
Figure 2.1. shows the process flow scheme of the treatment plant (full treatment) according to the basic design. The treatment plant consists of the following sections:

- Break pressure tank.
- Flocculation chambers with helicoidal flow.
- High rate sedimentation with inclined plate stettlers.
- Declining rate filtration.
- Clear water tank.
- Elevated clear water reservoir.
- Chemical dosing.

The flocculation/sedimentation sections can be omitted when direct filtration will be applied.
Pilot plant research was initiated to study the feasibility of direct filtration; filtered water turbidity and length of filter run are the most important parameters to be studied. Filtered water turbidity should meet the WHO guideline of 5 NTU. The length of filter run during high raw water turbidity should not drop below 4 hours and the average length of filter run should be more than 12 hours. If these conditions can not be met or if the high raw water turbidity frequently lasts longer than 24 hours, full treatment should be considered.



Process	Capacity (l/s)	Number of Units	Unit Cap. (l/s)	Unit Vol (m³)	Unit Surf. (m²)
1 Break Pressure Tank	250 (375)	1 (1)	-	27	10
2 Flocculation	250 (375)	4 (6)	62.5	54	10.8
3 Sedimentation	250 (375)	4 (6)	62.5	[illegible]	26
4 Filtration	250 (375)	8 (12)	31.25	45	10
5 Clear Water Tank	250 (375)	1 (1)	-	27	10
6 Elevated Reservoir	-	1 (1)	-	120	-
7 Clear Water Pump	10 (10)	1 (1)	-	-	-

250: Capacity First Stage (Th 1996) (375): Capacity Second Stage (Year 2000)

Chemicals	Dose mg/l	Consumption Pure Chemical kg/d
a Alum		
b Soda Ash		
c Kaporit		

Figure 2.1. - Process flow scheme Cigunung treatment plant

2.2. Filtration

Except for the filter materials, the basic design for the filtration section will not be changed by pilot test results. Filter bed height and composition, as well as filtration rate, are based on common practice. Direct filtration is considered as the river water turbidity is below 10 NTU normally.

However, after rainfall, especially after heavy rainstorms as occur in the rainy season, the turbidity increases and a large amount of suspended solids should be stored in the filter bed (lit. 5). For this reason, a double media filter bed will be applied. The pilot test purpose is the optimization of grain sizes and chemical dosing, as well as to demonstrate the feasibility of direct filtration in the declining rate filtration mode.
Principles of direct filtration are given in annex VIII. Variable declining rate filtration is selected as it requires no filter controls. The design shows much resemblance with the system based on flow splitting. The main difference is the location of the raw water inlet. The raw water inlet is situated below the level of the supernatant water. This level is essentially the same in all operating filters at all times and depends on the degree of clogging and the total plant flow. To achieve an equal level in all filters, a relatively large influent header, valve or gate must be provided to serve all filters. Thus head losses along the header or through the influent valve are small and do not restrict the flow to each filter.

<u>Basic design data filters</u>

		250 l/s (ist phase)	375 l/s (2nd phase)
Type of filtration	:	variable declining rate filtration	
Filtration velocity	:	11 m/h	
Surface area	:	80 m^2	120 m^2
Number of filters	:	8	12
Area per filter		10 m^2	
Dimensions per filter			
* length	:	4 m	
* Width	:	2.5 m	
* Height	:	4.5 m	
Consisting of false bottom	:	0.8 m	
filterbed	:	1.5 m	
Supernatant	:	2.0 m	
free board	:	0.2 m	

<u>Basic design data filterbed</u>

Dual media filterbed

* top layer	- material	:	anthracite
	- height	:	0.6 m
	- effective size d_{10}	:	1.6 mm
	- Uniformity coefficient	:	1.5 or less
* bottom layer	- material	:	sand
	- height	:	0.9 m
	- effective size d_{10}	:	0.8 mm
	- Uniformity coefficient	:	1.5 or less

2.3. Pilot plant set-up

The pilot plant design parameters should be in accordance with the basic design parameters of the treatment plant, apart from the surface area. A description of the pilot plant is presented in section 1.3, the pilot plant design parameters are presented below.

Design data pilot plant

Type of filtration	:	Variable declining rate filtration
Filtration velocity	:	11 m/h
Surface area	:	0.26 m^2
Number of filters	:	4
Area per filter	:	0.065 m^2
Dimensions per filter		
* Diameter	:	0.30 m
* Height	:	3.7 m
Consisting of filterbed	:	1.5 m
supernatant	:	2.0 m
free board	:	0.2 m

Design data filterbed

See section 2.2.

3. WORKING METHOD CIGUNUNG PILOT PLANT

3.1. Measurements during filtration

Filter column and pilot plant lay-out are presented in fig. 3.1 and fig. 3.2. The four filter columns, which are identical, were given a name to distinguish between the measurements. Filtration results are presented in a total view (Annex II) as well as per filter column (Annex III). In the total view the head loss over the filterbed is omitted.
In principle, a measurement interval of 1 hour was applied; at high raw water turbidity - when length of filter run drops to 4 hours - heads were read more frequently, at low raw water turbidity (below 5 NTU) an interval of 2 hours was applied. The actual intervals were also influenced by other conditions and activities that take some time, like preparation of chemicals, back-washing, and maintenance. Filtration was not always continued during the night; in the night time, the valves were closed and the water in the filters was stationary. Filtration was continued next morning.

Water level in filters, head loss

Each filter is equipped with 6 head measuring points, see figure 3.1. These are connected to transparent hoses, fixed on a board. The water level in each of the 6 hoses represents the head in the filter column at the level of the connection and can be read in mm water column above the filterbed surface level. With 4 filters in operation and 6 connections per filter, 24 heads have thus to be read each period. Annex II presents the supernatant water levels, annex III presents the head losses, compared to the head at the filterbed surface level.

Filtration velocity

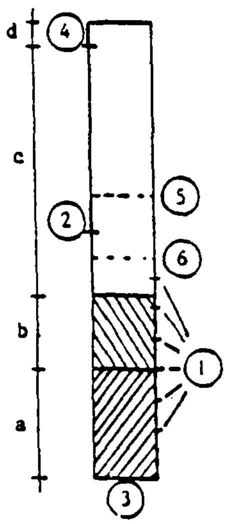
The filtered water is discharged in a 10 l bucket, one per filter column. With a column diameter D = 30 cm and t = time (in seconds) to fill a 10 l bucket, the filtration velocity follows from

$$V\ (m/h) = \frac{Q}{A} = \frac{0.01/t}{\Pi/4 * (0.30)^2} * 3600 = \frac{509}{t}$$

Annex II presents the filtration velocities.

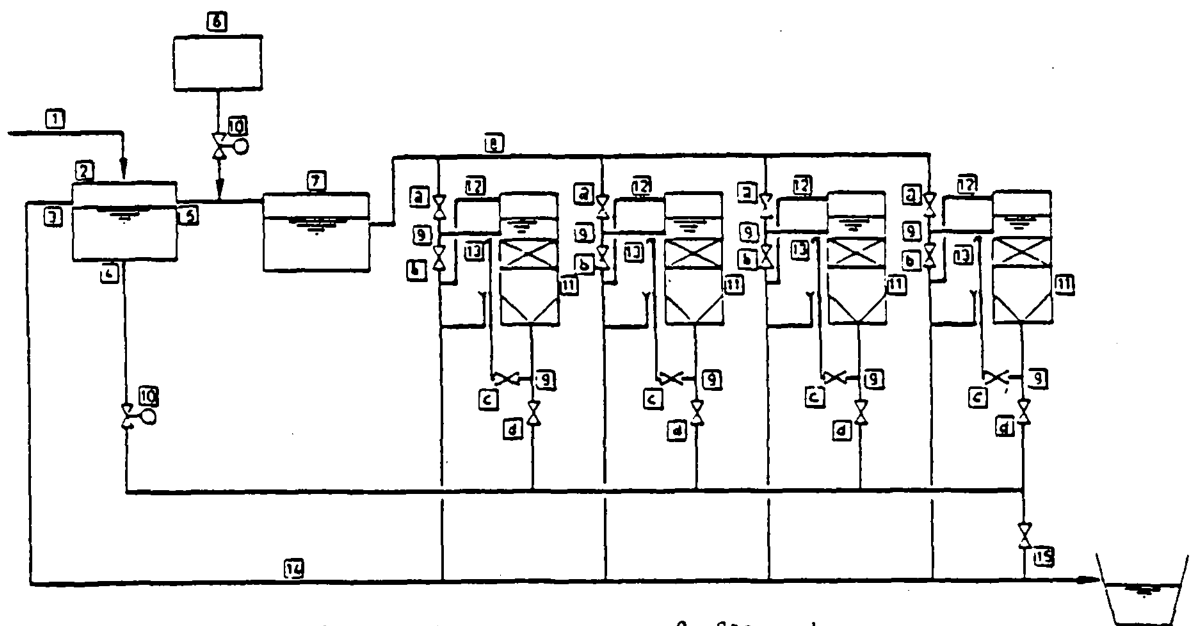
Turbidity

The raw water turbidity was measured at the drain (no. 15, see figure 3.2); by opening the backwash valve and the drain valve raw water flows from the raw water tank to the drain. Filtered water turbidity was measured below the fixed weir (no. 13, see figure 1.1). A Hach portable turbidity meter model 16800 was used. Annex II and III present the raw water turbidity as well as the filtered water turbidity.



part	above filterbed surface (m)	below filterbed surface (m)	dimensions
1. head measuring points	0.15	0.10; 0.35; 0.60; 0.85; 1.10	
2. influent gutter	0.50		
3. effluent nozzle		1.50	
4. overflow	2.00		
5. min. water level theoretical	0.80		
6. max. bed expansion theoretical (backwash velocity 35 m/h)	0.30		
column height consisting of:			
a. sand			0.90 m
b. anthracite			0.60 m
c. supernatant water			2.00 m
d. free board			0.20 m
diameter of filter column			0.30 m
average filtration rate			10.8 m/h
average discharge per filter			0.21 l/s

Fig. 3.1. - Filter column and dimensions



1. Transmission main from intake
2. Raw water reservoir
3. Adjustable overflow weir
4. Backwash water main
5. V-notch (flow measurement)
6. Chemical tank
7. Chemical mixing tank
8. Raw water conduit
9. Stop valves:
   a. influent
   b. backwash effluent
   c. effluent
   d. backwash influent
10. Adjustable valve
11. Filter column
12. Overflow
13. Fixed weir
14. Waste conduit
15. Drain

Fig. 3.2. - Process flow scheme of pilot plant

Colour

Colour was measured occasionally at the drain (raw water) and after the fixed weir (filtered water). A Hach colour test kit model CO-1 was used.

3.2. Other measurements

Impact on pH by chemicals

A series of 100 ml samples of raw water was taken, to which a volume of alum or soda ash solution (both 10 g/l) was added:
Thus concentrations of 0, 10, 20, 50 and 100 mg/l alum and soda ash were prepared. The test was done with low water turbidity (4 NTU) as well as with medium water turbidity (20 NTU). Annex VII and figure 1.4 (chapter 1) present the results. A Hatch digital pH meter model 16400 was used.

Sedimentation test (jar test)

Samples of 1.0 l raw water were taken, to which alum and/or soda ash (10 g/l) were added. Low raw water turbidity (6 NTU) as well as high raw water turbidity (60 NTU) were examined at concentrations of 0, 20, 50 and 100 mg/l alum. The tests were done with and without pH correction.
pH correction was done by adding soda ash in the same amount as for alum.
Chemical mixing period was 60 seconds at 100 revolutions per minute.
Flocculation period was 15 minutes at 20 revolutions per minute. Sedimentation time was 2 hours. After sedimentation samples were taken at approximately 1/3 below the water surface to measure the turbidity.
Table 1.5 (chapter 1) shows the sedimentation results.

Clean bed resistance

To measure clean bed resistance a newly backwashed filter was operated at a filtration velocity of 10.8 m/h. The head losses over 50 cm anthracite (ha), as well as over 50 cm sand (hs) were measured. Total bed resistance (H) equals to:

$$H\ (m) = \frac{0.60}{0.50}\ ha + \frac{0.90}{0.50}\ hs$$

Survey on river water turbidity

From September 1986 to August 1987 river water turbidity was measured every once or twice a week. Annex I presents the turbidity, sorted in ascending order.

4. SUMMARY OF RESULTS

4.1. Filtered water turbidity

The total view on measurements (Annex II) is divided into blocks of constant chemical dosing, head loss in piping and raw water turbidity range (< 30 NTU; > 30 NTU). Each block contains a begin and end code (date and time; for instance code 3211130 = March 21, 11:30 h), average raw water turbidity with standard deviation, and average filtered water turbidity with standard deviation. Table 4.1. presents these values. The standard deviation is calculated with the "N-method", a frequency distribution according to Gauss is presupposed. The momentary filtered water turbidity is calculated as the weighted average of the four filters, taking into account the filtration velocity of each filter. The intervals between the measurements are not taken into account.

Table 4.1. - Filtered water turbidity

Begin*	End*	Alum mg/l	Soda mg/l	loss m	Infl NTU	Std-dev NTU	Effl NTU	Std-dev NTU
3211130	3231400	0	0	0.40	5.8	1.6	2.9	0.4
3231500	3241600	20	0	0.40	4.6	0.2	2.3	0.3
3250830	3251430	0	0	0.40	8.0	4.8	2.6	0.2
3260930	3280900	30	0	0.40	7.4	4.3	3.2	0.8
3281100	3281530	40	40	0.40	14.0	3.0	2.4	0.2
4011000	4011100	0	0	0.40	9.0	3.0	1.8	0.1
4011200	4011430	20	0	0.40	9.8	1.8	1.1	0.3
4011500	4011615	20	0	0.40	97.8	2.3	2.8	0.2
4011700	4011800	30	0	0.40	91.7	5.3	2.6	0.0
4020745	4020745	40	0	0.40	74.0	0.0	2.4	0.0
4020900	4021200	0	0	0.40	51.3	17.9	5.4	0.3
4041230	4061700	20	0	0.40	2.9	0.5	0.8	0.3
4070830	4081030	0	0	0.40	2.7	0.3	0.7	0.2
4081200	4091240	0	0	0.24	2.9	0.1	0.8	0.6
4111100	4121200	0	0	0.40	2.4	0.3	0.8	0.1

* for instance 3211130 = March 21, 11:30 h

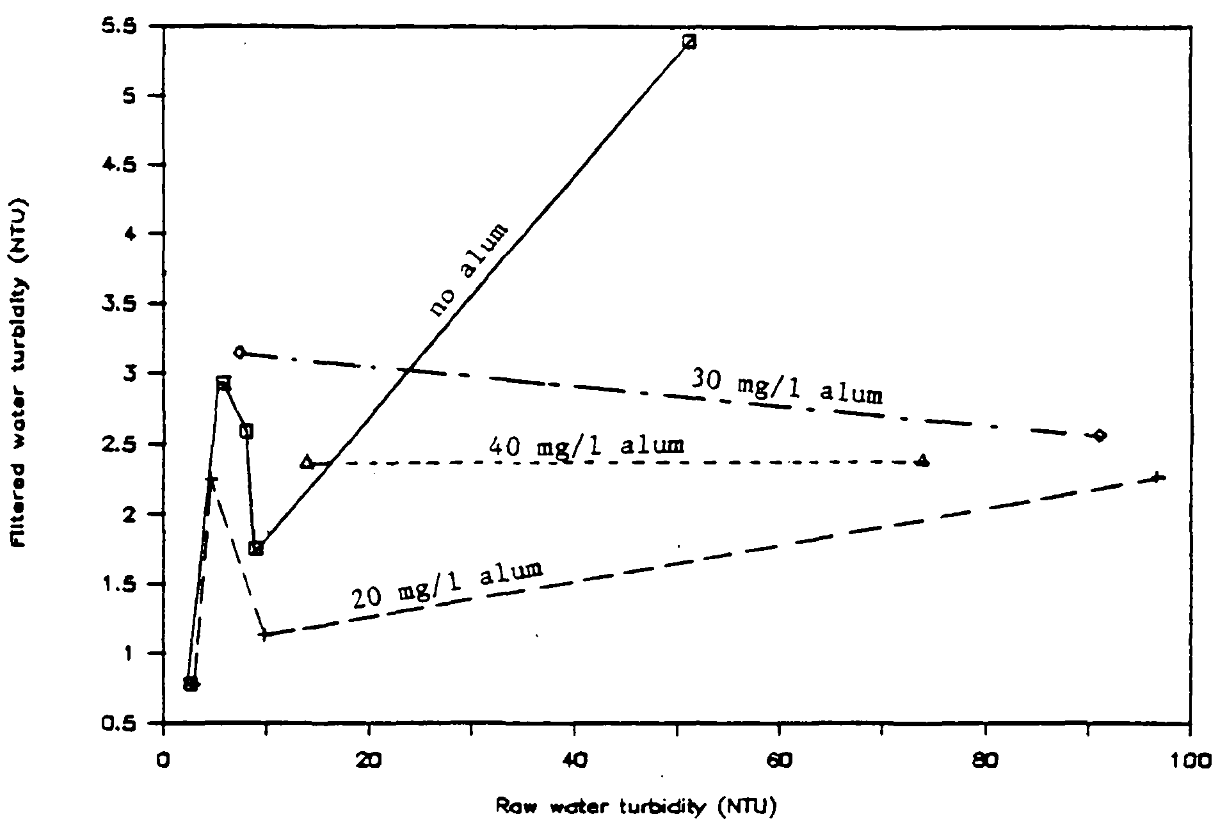


Fig. 4.1. - Filtered water turbidity

4.2. Length of filter run

Another calculation method is applied for the length of filter run, as presented in annex V. Each block in the annex represents one filter run, wherein the chemical dosing is more or less constant. The columns for the average raw water turbidity of one block present the weighted average (taking into account the velocity) and the non-weighted average turbidity of the raw water, respectively. The criterium for the end of a filter run is the maximum head loss (1.80 m supernatant water) or the maximum allowable effluent turbidity (5 NTU). In this pilot plant the maximum head loss was reached before breakthrough of suspended solids occured, generally. Table 4.2 presents the results of this calculation method.

Table 4.2.- Calculation of length of filter runs

Begin*	End*	Filter	Alum mg/l	Soda mg/l	loss m	W.Infl. NTU	Run h
3211130	3241300	Rina	0	0	0.40	5.5	13
3221030	3251400	Ninik	0	0	0.40	5.8	36
3231100	3261000	Yuke	0	0	0.40	6.4	33
3260930	3281100	Ninik	30	0	0.40	7.5	8.5
3261130	3281400	Yuke	30	0	0.40	9.8	9.5
3261330	3281530	Rina	40	40	0.40	12.7	9.5
3281200	4011600	Ninik	30	0	0.40	36.3	7
3281530	4011700	Yuke	20	0	0.40	44.6	8
4011000	4011800	Rina	20	0	0.40	54.4	9
4011515	4021000	Evie	20	0	0.40	88.8	5
4011615	4021015	Ninik	20	0	0.40	68.8	5
4011715	4011545	Yuke	20	0	0.40	29.7	16.25
4021015	4061600	Evie	20	0	0.40	6.7	20.5
4021200	4070830	Ninik	20	0	0.40	3.7	36
4051100	4071600	Rina	20	0	0.40	2.6	37.5
4061645	4080800	Evie	0	0	0.40	2.6	39
4071700	4080930	Rina	0	0	0.40	2.6	17
4081030	4120930	Rina	0	0	0.32	2.8	30.5

* for instance 3211130 = March 21, 11.30 h

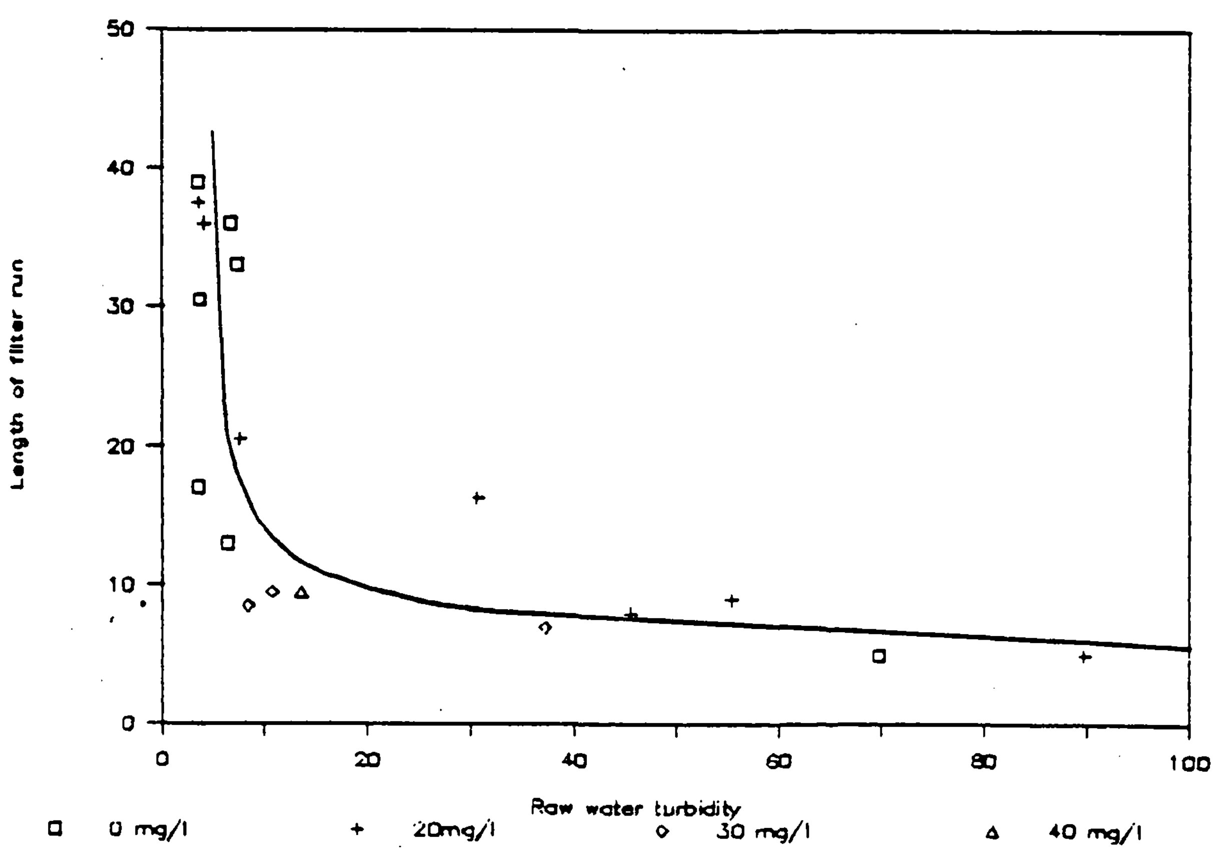


Fig. 4.2.- Length of filter runs

4.3. Source of figures

Table 4.3 shows the source of the figures as shown in chapter 1.

Table 4.3. - Source of figures

Fig. no.	description	source
1.3	frequency distribution on river water turbidity	annex I
1.4	impact on pH by chemical dosing	annex VII
1.5	filtered water turbidity	table 4.1, annex II, IV
1.6	length of filter run	table 4.2, annex V
1.7	head loss, high raw water turbidity	annex III-Rina, code 4011000-4011800
1.8	head loss, low raw water turbidity	annex III-Rina, code 3241500-3261130
1.9	typical filter run	annex III-Rina, code 4051100-4071700
1.10	ratio maximum-average velicities	annex VI
1.11	initial velocities, head loss in piping 0.24 m	annex II, code 4151400-4151500
1.12	initial velocities, head loss in piping 0.40 m	annex II, code 4141415-4141515

5. LITERATURE

(1) K. Craig
Direct Filtration: An Australian Study, Journal AWWA, December 1985, pp 56-61

(2) L. Di Bernardo
A Rational Method to the Design of Declining-Rate Filters, Proceedings 4th World Filtration Congress, April 1986, pp 1.43-1.52

(3) J. Arboleda-Valencia
A New Approach to Treatment Plant Design and Construction in Latin America, Journal AWWA, July 1986, pp 92-195

(4) DHV Consultants/P.T. Deserco/P.T. Indah Karya
Basic Design of the Cigunung Treatment Plant, May 1986

(5) L. Huisman
Rapid Filtration, Delft University of Technology, April 1984

ANNEX I

FREQUENCY DISTRIBUTION TURBIDITY

The following parameters are presented:

- Date : Date of measurements (yy/mm/dd)
- Time : Time of turbidity measurement (h)
- Turb : River water turbidity (NTU)
- Begin : Begin of rainfall (h)
- End : End of rainfall (h)
- Rain : Rainfall (mm)
- Intens : Rain intensity (mm/h)
- No : Number of ascending turbidity
- Probexc : Probability of exceedence (%)
- Logprob : 10 Log (probability of exceedence)
- Logturb : 10 Log (turbidity)

ANNEX I

FREQUENCY DISTRIBUTION TURBIDITY

The following parameters are presented:

- Date : Date of measurements (yy/mm/dd)
- Time : Time of turbidity measurement (h)
- Turb : River water turbidity (NTU)
- Begin : Begin of rainfall (h)
- End : End of rainfall (h)
- Rain : Rainfall (mm)
- Intens : Rain intensity (mm/h)
- No : Number of ascending turbidity
- Probexc : Probability of exceedence (%)
- Logprob : 10 Log (probability of exceedence)
- Logturb : 10 Log (turbidity)

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Analysis on turbidity and rainfall
Frequency distribution on turbidity Sept 1986 - Aug 1987

Date	Time h	Turb NTU	Begin h	End h	Rain mm	Intens mm/h	No.	Probexc %	Logprob	Logturb
870108			18	24	18	3				
870714						ERR				
860902										
870110						ERR				
860904										
870111						ERR				
860906						ERR				
870723						ERR				
870530						ERR				
861227			16	19	12	4				
861221			12	12.25	4	16				
870725			16	16.5	6	12				
860913						ERR				
870331						ERR				
861223						ERR				
870516			15.5	16	3	6				
870502						ERR				
870830						ERR				
861225						ERR				
860919						ERR				
860909			14	16	17	9				
860921			17	19	9	5				
860911						ERR				
860923			11	21	20	2				
861228			14	19	9	2				
860925					48	ERR				
870721						ERR				
860927						ERR				
861230						ERR				
870411						ERR				
870719						ERR				
870414			16	24	16	2				
870101						ERR				
870409						ERR				
870718						ERR				
861005						ERR				
870103						ERR				
861007			15	16	10	10				
870104						ERR				
861009			12	13	5	5				
870524						ERR				
861011			16	17	50	50				
870106			7	8	14	14				
870512			18	18.5	3	6				
870716						ERR				
870602			14	15	9	9				
870517						ERR				
870405			17.5	17.75	7	28				

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Analysis on turbidity and rainfall
Frequency distribution on turbidity Sept 1986 - Aug 1987

Date	Time h	Turb NTU	Begin h	End h	Rain mm	Intens mm/h	No.	Probexc %	Logprob	Logturb
860903										
861019						ERR				
870402			17	19	7	4				
861021						ERR				
860907						ERR				
861023			16	21	7	1				
870825						ERR				
870823						ERR				
861026			13	13.5	4	8				
870113						ERR				
861028			14	16	34	17				
870430			17	17.5	20	40				
861030			10	21	33	3				
870115						ERR				
861101			15	21	20	3				
870712						ERR				
870529			12.5	16	15	4				
870117						ERR				
870818						ERR				
870118						ERR				
870816						ERR				
870428						ERR				
861109						ERR				
870120						ERR				
861111			17	24	10	1				
870711						ERR				
861113						ERR				
870709						ERR				
861115						ERR				
870426						ERR				
870507			12.25	13	8	11				
870124						ERR				
870813						ERR				
870125						ERR				
870809			16	16.25	4	16				
870707						ERR				
861123			14	15	15	15				
870127						ERR				
861125			11	12	6	6				
870425						ERR				
861127			12	19	41	6				
870129						ERR				
861129						ERR				
870705						ERR				
870521						ERR				
870131						ERR				
870505			15	15.25	3	12				
870201						ERR				
870523						ERR				
870704						ERR				
861207			12	16	6	2				
870203			2	3	5	5				
861209			16	19	18	6				
870702						ERR				
861211			15	16	13	13				
870205						ERR				

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Analysis on turbidity and rainfall
Frequency distribution on turbidity Sept 1986 - Aug 1987

Date	Time h	Turb NTU	Begin h	End h	Rain mm	Intens mm/h	No.	Probexc %	Logprob	Logturb
870801						ERR				
870423						ERR				
870730						ERR				
870207			12	13	7	7				
870728						ERR				
870208			16	16.5	6	12				
870726						ERR				
870527			13	13.25	27	108				
870603						ERR				
870210						ERR				
860916			9	24	94	6				
870421			14.5	20	40	7				
860920						ERR				
870212			18	20	25	13				
870412						ERR				
870528			12	16	20	5				
860928						ERR				
870214						ERR				
861002						ERR				
870215			14	16	8	4				
870531			19	20	8	8				
870630						ERR				
870827						ERR				
870217			13	15	10	5				
861014			23	24	8	8				
870419			12	20	68	9				
861018						ERR				
870219			19	23	44	11				
870404			18	18.25	2	8				
870628						ERR				
870510			2	4	17	9				
870221						ERR				
870820						ERR				
870222						ERR				
861104			9	15	22	4				
870627			11.5	13	10	7				
861108			14	24	5	1				
870224						ERR				
861112			20	23	9	3				
870625			14	14.25	9	36				
861116						ERR				
870226			13	14	4	4				
870811						ERR				
870623						ERR				
870808						ERR				
870228			13	15	7	4				
870804						ERR				
870301			19	20	10	10				
861202						ERR				
860901										
861206						ERR				
870303			20	21	7	7				
870802						ERR				
870621						ERR				
861214						ERR				
870620			14.5	16	15	10				

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Analysis on turbidity and rainfall
Frequency distribution on turbidity Sept 1986 - Aug 1987

Date	Time h	Turb NTU	Begin h	End h	Rain mm	Intens mm/h	No.	Probexc %	Logprob	Logturb
861218						ERR				
870618						ERR				
860914						ERR				
870307			12	14	16	8				
870514			14	21	44	6				
870308			18	21	10	3				
860930			15	19	22	6				
870418			23.5	24	7	14				
870407			11.5	14	6	2				
870310			17.5	18	7	14				
861016						ERR				
870616						ERR				
870604			11.5	12	8	16				
870312						ERR				
861102						ERR				
870614						ERR				
870815						ERR				
870314						ERR				
861118			10	16	52	9				
870315						ERR				
870806						ERR				
870416			12	18	45	8				
861204						ERR				
870317			13	13.5	14	28				
861212						ERR				
870613						ERR				
861220						ERR				
870319			12.5	13	22	44				
870829						ERR				
870611						ERR				
861012						ERR				
870321						ERR				
870509			14	16	39	20				
870322			18	19	22	22				
861114						ERR				
870609						ERR				
861130						ERR				
870324						ERR				
861216						ERR				
870607						ERR				
861004						ERR				
870326			13	13.5	12	24				
861106						ERR				
870606			14.5	20	55	10				
870503			17	17.25	3	12				
870328			18	18.5	3	6				
870519						ERR				
860918						ERR				
861122						ERR				
870329						ERR				
860908	8	1.4	12	16	7	2	1	99.35483	1.997189	0.146128
860912	16	1.5	17	19	43	22	2	98.70967	1.994359	0.176091
860910	24	2				ERR	3	98.06451	1.991511	0.301029
861006	8	2				ERR	4	97.41935	1.988645	0.301029
860905	16	2	15	18	19	6	5	96.77419	1.985759	0.301029
861003	16	2				ERR	6	96.12903	1.982854	0.301029

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Analysis on turbidity and rainfall
Frequency distribution on turbidity Sept 1986 - Aug 1987

Date	Time h	Turb NTU	Begin h	End h	Rain mm	Intens mm/h	No.	Probexc %	Logprob	Logturb
861022	24	2				ERR	7	95.48387	1.979930	0.301029
861001	24	2				ERR	8	94.83870	1.976985	0.301029
861015	24	2				ERR	9	94.19354	1.974021	0.301029
860929	8	2				ERR	10	93.54838	1.971036	0.301029
861103	8	2				ERR	11	92.90322	1.968030	0.301029
861008	24	2				ERR	12	92.25806	1.965004	0.301029
861017	16	2				ERR	13	91.61290	1.961956	0.301029
860924	24	2	16.5	17	12	24	14	90.96774	1.958887	0.301029
870112	9	3	21	22	20	20	15	90.32258	1.955796	0.477121
861029	24	3	12	13	23	23	16	89.67741	1.952683	0.477121
861117	8	3				ERR	17	89.03225	1.949547	0.477121
861020	9	3				ERR	18	88.38709	1.946388	0.477121
861027	8	3				ERR	19	87.74193	1.943207	0.477121
860915	9	3.5				ERR	20	87.09677	1.940002	0.544068
860922	8	3.5	12	13	18	18	21	86.45161	1.936773	0.544068
861203	24	4				ERR	22	85.80645	1.933519	0.602059
861205	16	4				ERR	23	85.16129	1.930242	0.602059
870119	9	4				ERR	24	84.51612	1.926939	0.602059
861208	9	4				ERR	25	83.87096	1.923611	0.602059
861201	9	4				ERR	26	83.22580	1.920258	0.602059
870417	16	4				ERR	27	82.58064	1.916878	0.602059
861013	8	4				ERR	28	81.93548	1.913472	0.602059
870410	16	4				ERR	29	81.29032	1.910038	0.602059
870717	16	5				ERR	30	80.64516	1.906578	0.698970
870520	24	5				ERR	31	80	1.903089	0.698970
870211	24	5				ERR	32	79.35483	1.899573	0.698970
870114	24	5				ERR	33	78.70967	1.896029	0.698970
870213	16	5				ERR	34	78.06451	1.892453	0.698970
870724	16	5				ERR	35	77.41935	1.888849	0.698970
870629	9	5				ERR	36	76.77419	1.885215	0.698970
870128	24	5				ERR	37	76.12903	1.881550	0.698970
870617	24	5				ERR	38	75.48387	1.877854	0.698970
870701	24	5	18	18.5	4	8	39	74.83870	1.874126	0.698970
870518	9	5				ERR	40	74.19354	1.870366	0.698970
870429	24	5	18	18.25	6	24	41	73.54838	1.866573	0.698970
870316	9	5				ERR	42	72.90322	1.862746	0.698970
870708	24	5				ERR	43	72.25806	1.858886	0.698970
870515	16	5	16	17	6	6	44	71.61290	1.854991	0.698970
870209	9	5				ERR	45	70.96774	1.851060	0.698970
870526	14	5				ERR	46	70.32258	1.847094	0.698970
870525	9	5	15	15.5	7	14	47	69.67741	1.843092	0.698970
870403	16	5	15	15.33	3	9	48	69.03225	1.839052	0.698970
870302	9	6	20	24	21	5	49	68.38709	1.834974	0.778151
870513	23	6				ERR	50	67.74193	1.830857	0.778151
870622	8	6	17.25	18.5	20	16	51	67.09677	1.826701	0.778151
870123	16	6				ERR	52	66.45161	1.822505	0.778151
870831	9	6				ERR	53	65.80645	1.818268	0.778151
870130	16	6				ERR	54	65.16129	1.813989	0.778151
870727	9	6				ERR	55	64.51612	1.809668	0.778151
870609	9	6				ERR	56	63.87096	1.805303	0.778151
870501	16	6	9	9.25	3	12	57	63.22580	1.800894	0.778151
870202	9	6	1	2	4	4	58	62.58064	1.796440	0.778151
870424	15	6	14	16	5	3	59	61.93548	1.791939	0.778151
870204	24	6	13.5	15	32	21	60	61.29032	1.787391	0.778151
870420	9	6				ERR	61	60.64516	1.782796	0.778151
870826	24	6				ERR	62	60	1.778151	0.778151

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Analysis on turbidity and rainfall
Frequency distribution on turbidity Sept 1986 - Aug 1987

Date	Time h	Turb NTU	Begin h	End h	Rain mm	Intens mm/h	No.	Probexc %	Logprob	Logturb
870413	9	6				ERR	63	59.35483	1.773456	0.778151
870206	16	6	13	13.5	4	8	64	58.70967	1.768709	0.778151
870109	16	6				ERR	65	58.06451	1.763910	0.778151
870318	24	6	15.5	16	19	38	66	57.41935	1.759058	0.778151
870116	16	6				ERR	67	56.77419	1.754150	0.778151
870216	9	6				ERR	68	56.12903	1.749187	0.778151
870511	9	6	16	20	6	2	69	55.48387	1.744166	0.778151
870615	8	6	15.5	17	5	3	70	54.83870	1.739087	0.778151
861229	9	6	13	13.25	5	20	71	54.19354	1.733947	0.778151
870822	9	6				ERR	72	53.54838	1.728746	0.778151
870422	24	6	1	2.25	55	44	73	52.90322	1.723482	0.778151
870225	24	6	11.5	12	5	10	74	52.25806	1.718153	0.778151
870107	24	6				ERR	75	51.61290	1.712758	0.778151
870821	16	6				ERR	76	50.96774	1.707295	0.778151
870330	9	6				ERR	77	50.32258	1.701762	0.778151
870619	16	6				ERR	78	49.67741	1.696157	0.778151
870427	9	6	18	18.5	4	8	79	49.03225	1.690481	0.778151
870819	24	6				ERR	80	48.38709	1.684729	0.778151
870713	9	6				ERR	81	47.74193	1.678900	0.778151
870415	24	6				ERR	82	47.09677	1.672991	0.778151
870729	24	6				ERR	83	46.45161	1.667000	0.778151
870817	9	6				ERR	84	45.80645	1.660926	0.778151
870624	24	7	15	16.5	45	30	85	45.16129	1.654766	0.845098
870401	24	7				ERR	86	44.51612	1.648517	0.845098
870810	9	7				ERR	87	43.87096	1.642177	0.845098
870720	9	7	16	21	7	1	88	43.22580	1.635743	0.845098
860926	16	7	10	16	10	2	89	42.58064	1.629212	0.845098
870506	24	7				ERR	90	41.93548	1.622581	0.845098
870522	16	7				ERR	91	41.29032	1.615848	0.845098
870814	16	7				ERR	92	40.64516	1.609008	0.845098
870605	16	7	11	16	31	6	93	40	1.602059	0.845098
870824	9	7				ERR	94	39.35483	1.594998	0.845098
861219	16	7				ERR	95	38.70967	1.587819	0.845098
870610	24	7				ERR	96	38.06451	1.580520	0.845098
861222	9	7	13	14	8	8	97	37.41935	1.573096	0.845098
861010	16	7	11	17	36	6	98	36.77419	1.565543	0.845098
861224	24	7				ERR	99	36.12903	1.557856	0.845098
870706	9	7				ERR	100	35.48387	1.550030	0.845098
870601	9	7	12	13	5	5	101	34.83870	1.542062	0.845098
870223	9	7	16	18	4	2	102	34.19354	1.533944	0.845098
870715	24	7				ERR	103	33.54838	1.525671	0.845098
870612	16	7				ERR	104	32.90322	1.517238	0.845098
870805	24	7				ERR	105	32.25806	1.508638	0.845098
870803	9	7				ERR	106	31.61290	1.499864	0.845098
870722	24	7				ERR	107	30.96774	1.490909	0.845098
861119	24	7	12.5	14	30	20	108	30.32258	1.481766	0.845098
870309	9	7	13	14	30	30	109	29.67741	1.472426	0.845098
870812	23	7				ERR	110	29.03225	1.462880	0.845098
870504	9	7				ERR	111	28.38709	1.453120	0.845098
870227	16	8				ERR	112	27.74193	1.443136	0.903089
870731	16	8				ERR	113	27.09677	1.432917	0.903089
870121	24	8				ERR	114	26.45161	1.422452	0.903089
870102	16	8	16.5	18	11	7	115	25.80645	1.411728	0.903089
870122	15	8				ERR	116	25.16129	1.400732	0.903089
870105	9	8				ERR	117	24.51612	1.389451	0.903089
861126	24	8				ERR	118	23.87096	1.377870	0.903089

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Analysis on turbidity and rainfall
Frequency distribution on turbidity Sept 1986 - Aug 1987

Date	Time h	Turb NTU	Begin h	End h	Rain mm	Intens mm/h	No.	Probexc %	Logprob	Logturb
870325	24	8				ERR	119	23.22580	1.365970	0.903089
870406	9	8	2.75	3	17	68	120	22.58064	1.353736	0.903089
860917	9	8.5				ERR	121	21.93548	1.341147	0.929418
861110	8	8.5				ERR	122	21.29032	1.328182	0.929418
870710	16	9				ERR	123	20.64516	1.314818	0.954242
870218	24	9	2	3	6	6	124	20	1.301029	0.954242
870703	16	9	14	19	9	2	125	19.35483	1.286789	0.954242
861215	9	9				ERR	126	18.70967	1.272066	0.954242
861210	24	9	10	10.25	15	60	127	18.06451	1.256826	0.954242
870320	16	9	12	21	13	1	128	17.41935	1.241032	0.954242
861217	24	9	13	17	20	5	129	16.77419	1.224641	0.954242
861124	9	9	14	15	20	20	130	16.12903	1.207608	0.954242
870828	16	10				ERR	131	15.48387	1.189879	1
861031	16	10	13	15	9	5	132	14.83870	1.171396	1
870807	16	11				ERR	133	14.19354	1.152090	1.041392
870327	16	12	12	15	4	1	134	13.54838	1.131887	1.079181
870408	24	12	9.25	10.25	14	14	135	12.90322	1.110698	1.079181
861025	18	12	13	15	44	22	136	12.25806	1.088421	1.079181
870220	16	14	15	15.5	15	30	137	11.61290	1.064940	1.146128
870313	16	14				ERR	138	10.96774	1.040117	1.146128
870126	9	15				ERR	139	10.32258	1.013788	1.176091
870304	24	15	12	15	40	13	140	9.677419	0.985759	1.176091
870311	24	16				ERR	141	9.032258	0.955796	1.204119
861231	16	22				ERR	142	8.387096	0.923611	1.342422
861128	16	22	11	17	48	8	143	7.741935	0.888849	1.342422
870626	16	22	12.25	14	15	9	144	7.096774	0.851060	1.342422
861105	20	25	13.5	15	9	6	145	6.451612	0.809668	1.397940
870508	16	27	16	17	9	9	146	5.806451	0.763910	1.431363
861226	16	29	15	16	21	21	147	5.161290	0.712758	1.462397
861121	12	30				ERR	148	4.516129	0.654766	1.477121
870323	9	30				ERR	149	3.870967	0.587819	1.477121
861107	16	54	11	20	40	4	150	3.225806	0.508638	1.732393
870306	16	90	13	15	35	18	151	2.580645	0.411728	1.954242
870305	12	142	12.5	18	65	12	152	1.935483	0.286789	2.152288
861024	16	150	12	14	35	18	153	1.290322	0.110698	2.176091
861213	16	150	0	3	23	8	154	0.645161	-0.19033	2.176091
861120	16	190	14	20	6	1	155	0	ERR	2.278753

ANNEX II

TOTAL VIEW ON MEASUREMENTS DURING FILTRATION

The following parameters are presented:

- Code	:	Date/Time	
- Time	:	Time from start of filtration (h)	
- Infl	:	Turbidity of river water (NTU)	
- Alum	:	Alum dosing (mg/l)	
- Soda	:	Soda ash dosing (mg/l)	
- Loss	:	Head loss in piping at 10.8 m/h (m)	
- Lev	:	Supernatant water level (mm)	4 subsequent filter columns
- Vel	:	Filtration velocity (m/h)	
- Eff	:	Filtered water turbidity (NTU)	
- Run	:	Time from start of filter run (h)	

From code 4011000 filtration was started again after 3 days of standstill.

From code 4141040 to code 4151500 a special study on initial velocities was carried out with different head losses in the piping system.

Page No. 1
06/07/88

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Total view on measurements

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	LevR mm	VelR m/h	EffR NTU	RunR h	LevE mm	VelE m/h	EffE NTU	RunE h	LevN mm	VelN m/h	EffN NTU	RunN h	LevY mm	VelY m/h	EffY NTU	RunY h
3211130	0.00	5.0	0	0	0.40	1277	14.9	3.5	0.00	1378	12.4	3.0	6.00	1575	8.4	3.3	6.00	1308	13.1	2.6	6.00
3211230	1.00	6.0	0	0	0.40	1282	15.8	3.3	1.00	1488	12.1	2.8	7.00	1648	8.0	3.0	7.00	1360	13.3	3.0	7.00
3211330	2.00	6.5	0	0	0.40	1300	15.5	3.0	2.00	1850	12.0	3.0	8.00	1878	8.2	3.1	8.00	1808	12.8	2.8	8.00
3220930	2.00	5.0	0	0	0.40	1650	8.6	3.0	2.00	1386	15.9	2.5	0.00	1863	1.4	2.5	8.00	1806	5.2	2.8	8.00
3220945	2.25	5.0	0	0	0.40	1730	8.7	2.8	2.25	1430	15.4	2.7	0.25	1800	0.0	0.0	0.00	1820	5.5	3.0	8.25
3221030	2.50	5.0	0	0	0.40	1535	6.9	3.0	2.50	1261	14.1	2.8	1.00	1248	16.8	3.0	1.00	1610	2.3	3.1	9.00
3221130	4.00	5.0	0	0	0.40	1531	6.5	3.0	4.00	1254	13.7	2.6	2.00	1240	16.3	2.8	2.00	1615	3.5	2.8	10.00
3221300	5.50	5.0	0	0	0.40	1745	7.2	3.0	5.50	1430	14.3	2.5	3.50	1405	17.4	2.5	3.50	1828	4.0	2.8	11.50
3221330	6.00	5.0	0	0	0.40	1750	7.0	3.0	6.00	1435	14.1	2.5	4.00	1406	17.4	2.5	4.00	1828	3.7	2.8	12.00
3221400	6.50	5.0	0	0	0.40	1765	7.0	2.8	6.50	1447	16.3	2.3	4.50	1415	16.4	2.2	4.50	1800	0.0	0.0	0.00
3231100	7.00	11.0	0	0	0.40	1413	3.2	4.8	7.00	1132	13.1	4.0	5.00	1135	13.7	3.8	5.00	1155	13.7	3.8	0.00
3231200	8.00	6.0	0	0	0.40	1414	2.8	3.5	8.00	1126	12.7	3.2	6.00	1107	13.7	3.0	6.00	1108	14.5	3.4	1.00
3231400	10.00	5.8	0	0	0.40	1492	2.8	2.8	10.00	1196	12.6	2.8	8.00	1152	14.4	3.3	8.00	1138	15.4	3.6	3.00
3231500	11.00	4.5	20	0	0.40	1634	2.9	2.8	11.00	1338	12.7	2.6	9.00	1486	14.0	2.8	9.00	1486	14.5	3.0	4.00
3241200	11.50	5.0	20	0	0.40	1463	4.0	3.3	12.00	1240	12.1	2.6	10.00	1080	13.4	2.4	10.00	1023	13.8	2.2	5.00
3241300	13.00	4.5	20	0	0.40	1773	4.0	1.8	13.00	1517	12.4	2.2	11.00	1278	13.1	2.3	11.00	1205	14.1	2.4	6.00
3241400	14.00	4.5	20	0	0.40	1800	0.0	1.8	0.00	1580	12.8	2.1	12.00	1358	13.1	2.0	12.00	1258	14.1	2.1	7.00
3241500	15.00	4.5	20	0	0.40	1316	15.8	1.8	0.00	1570	10.4	1.9	13.00	1333	11.1	1.8	13.00	1200	11.6	2.0	8.00
3241600	16.00	4.5	20	0	0.40	1127	15.6	1.8	1.00	1360	10.5	1.9	14.00	1190	10.8	2.0	14.00	995	11.0	2.0	9.00
3250830	32.50	4.2	0	0	0.40	1510	13.7	2.5	17.50	1732	8.4	2.5	30.50	1457	10.0	2.8	30.50	1542	11.8	2.8	25.50
3250900	33.00	4.2	0	0	0.40	1516	13.4	2.5	18.00	1730	8.0	2.5	31.00	1446	9.5	2.8	31.00	1538	11.6	2.5	26.00
3250930	33.50	4.2	0	0	0.40	1538	13.7	2.4	18.50	1800	0.0	2.3	0.00	1535	10.0	2.4	31.50	1542	11.9	2.2	26.50
3251000	34.00	4.3	0	0	0.40	1535	11.4	2.4	19.00	1422	15.4	2.3	0.00	1521	8.2	2.6	32.00	1531	10.3	2.4	27.00
3251200	36.00	4.6	0	0	0.40	1343	11.6	2.2	21.00	1204	14.1	2.5	2.00	1425	8.0	2.6	34.00	1400	10.0	2.5	29.00
3251300	37.00	15.5	0	0	0.40	1590	11.1	2.5	22.00	1346	14.5	2.6	3.00	1603	8.7	2.6	35.00	1594	9.5	2.6	30.00
3251400	38.00	14.0	0	0	0.40	1620	10.6	2.8	23.00	1305	14.1	-2.8	4.00	1705	8.7	2.6	36.00	1715	9.5	2.6	31.00
3251430	38.50	13.0	0	0	0.40	1796	10.0	3.3	23.50	1323	14.5	3.1	4.50	1800	0.0	0.0	0.00	1818	10.0	3.0	31.50
3260930	39.50	5.5	30	0	0.40	1440	7.7	2.8	24.50	1334	11.3	2.4	5.50	1357	13.0	3.0	0.50	1523	7.3	3.0	32.50
3261000	40.00	5.5	30	0	0.40	1485	7.2	2.4	25.00	1380	11.3	2.2	6.00	1253	13.7	3.0	1.00	1458	6.3	3.0	33.00
3261130	41.50	5.5	30	0	0.40	1820	5.6	2.6	26.50	1675	9.5	2.4	7.50	1640	11.9	2.8	2.50	1470	15.8	3.0	0.50
3261200	42.00	5.5	30	0	0.40	1800	0.0	3.0	0.00	1680	9.5	2.5	8.00	1655	11.6	2.7	3.00	1490	15.0	2.9	1.00
3261330	43.50	5.5	30	0	0.40	1130	14.0	3.2	1.00	1365	6.7	2.2	9.50	1330	9.2	3.0	4.50	1198	13.1	3.0	2.50
3280900	45.50	17.0	30	0	0.40	1452	14.5	5.5	3.00	1713	6.9	4.8	11.50	1664	9.4	4.0	6.50	1547	13.1	5.2	4.50
3281100	47.50	12.0	40	40	0.40	1430	13.5	3.0	5.00	1412	13.7	2.7	0.50	1682	7.0	2.4	8.50	1526	11.9	3.0	6.50
3281200	48.50	9.0	40	40	0.40	1330	12.7	2.2	6.00	1220	13.1	2.2	1.50	1263	14.2	2.0	0.00	1323	10.2	2.0	7.50
3281400	50.50	17.0	40	40	0.40	1645	10.5	2.4	8.00	1387	10.4	2.2	3.50	1548	13.6	2.0	2.00	1646	10.0	2.5	9.50
3281500	51.50	16.0	40	40	0.40	1751	8.2	2.2	9.00	1596	10.8	2.6	4.50	1590	13.0	2.0	3.00	1800	0.0	0.0	0.00
3281530	52.00	16.0	40	40	0.40	1730	7.3	2.2	9.50	1588	9.0	2.4	5.00	1588	10.4	2.2	3.50	1515	13.1	2.6	0.00
4011000	1.00	6.0	0	0	0.40	1193	10.9	1.5	1.00	1275	9.5	1.8	1.00	1295	10.4	2.0	1.00	1257	11.6	2.0	1.00
4011100	2.00	12.0	0	0	0.40	1106	10.9	1.4	2.00	1180	9.5	1.8	2.00	1197	10.9	1.7	2.00	1165	11.3	1.8	2.00
4011200	3.00	7.5	20	0	0.40	1128	10.9	1.5	3.00	1233	10.0	1.6	3.00	1250	11.1	1.8	3.00	1240	11.9	1.6	3.00
4011300	4.00	10.0	20	0	0.40	1345	11.1	1.0	4.00	1440	10.4	1.0	4.00	1454	10.9	1.0	4.00	1430	11.1	0.5	4.00
4011430	5.50	12.0	20	0	0.40	1495	10.9	0.8	5.50	1617	10.4	0.8	5.50	1589	10.4	1.3	5.50	1595	10.9	0.7	5.50
4011500	6.00	95.0	20	0	0.40	1763	10.9	2.2	6.00	1810	10.0	2.0	6.00	1840	10.4	1.8	6.00	1793	10.9	2.4	6.00
4011515	6.25	100.0	20	0	0.40	1402	9.7	2.4	6.25	1350	13.7	1.9	0.00	1463	7.5	2.3	6.25	1462	9.5	1.8	6.25
4011600	7.00	100.0	20	0	0.40	1693	10.0	2.5	7.00	1731	13.4	2.7	0.50	1822	7.3	2.8	7.00	1808	9.5	2.0	7.00
4011615	7.25	95.0	20	0	0.40	1444	8.3	2.5	7.25	1308	11.3	2.2	0.75	1260	15.1	2.5	0.00	1538	7.7	2.2	7.25
4011700	8.00	98.0	30	0	0.40	1782	8.5	2.5	8.00	1658	11.3	2.8	1.50	1552	14.7	2.3	0.50	1842	7.9	3.0	8.00

Page No. 2
06/07/88

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Total view on measurements

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	LevR mm	VelR m/h	EffR NTU	RunR h	LevE mm	VelE m/h	EffE NTU	RunE h	LevN mm	VelN m/h	EffN NTU	RunN h	LevY mm	VelY m/h	EffY NTU	RunY h
4011715	8.25	85.0	30	0	0.40	1510	6.5	2.7	8.25	1324	9.7	2.3	1.75	1284	11.6	2.4	0.75	1240	14.9	2.8	0.00
4011800	9.00	92.0	30	0	0.40	1895	6.7	3.0	9.00	1683	9.5	2.5	2.50	1680	11.9	2.7	1.50	1668	13.7	2.2	0.50
4020745	9.25	74.0	40	40	0.40	1312	15.1	5.7	0.00	1470	6.9	5.2	2.75	1465	8.6	5.0	1.75	1435	12.7	5.5	0.75
4020900	10.50	77.0	0	0	0.40	1615	15.1	5.6	1.00	1652	7.3	4.8	4.00	1643	8.6	6.0	3.00	1612	12.4	5.3	2.00
4021000	11.50	54.0	0	0	0.40	1804	14.9	5.6	2.00	1840	6.5	5.2	5.00	1790	8.8	6.0	4.00	1782	12.1	4.8	3.00
4021015	11.75	47.0	0	0	0.40	1760	11.7	5.0	2.25	1413	13.7	6.0	0.00	1775	6.5	5.8	5.00	1767	10.4	4.6	3.25
4021200	13.50	27.0	0	0	0.40	1670	9.0	5.0	4.00	1642	10.9	5.2	1.00	1365	13.7	5.3	0.00	1673	9.7	4.0	5.00
4041230	14.50	3.5	20	0	0.40	1605	7.5	2.2	5.00	1515	10.4	2.0	2.00	1370	14.5	1.0	2.00	1550	10.0	1.0	6.00
4041330	15.50	3.5	20	0	0.40	1648	8.2	0.4	6.00	1540	11.3	1.0	3.00	1430	15.8	0.5	2.00	1610	9.7	0.4	7.00
4041430	16.50	3.0	20	0	0.40	1704	8.4	0.2	7.00	1595	11.3	0.3	4.00	1485	14.9	0.5	3.00	1656	10.0	0.5	8.00
4041600	18.00	4.0	20	0	0.40	1760	8.2	1.2	8.50	1660	11.3	0.7	5.50	1565	14.5	0.6	4.50	1730	9.5	0.3	9.50
4041630	18.50	3.5	20	0	0.40	1780	8.2	0.5	9.00	1700	11.3	0.6	6.00	1600	14.5	0.4	5.00	1765	9.5	0.3	10.00
4041700	19.00	3.5	20	0	0.40	1805	8.2	0.7	9.50	1733	11.3	0.6	6.50	1630	14.5	0.4	5.50	1798	9.5	0.3	10.50
4041710	19.00	3.5	20	0	0.40	1800	0.0	0.0	0.00	1885	11.6	0.6	6.50	1760	15.0	0.4	5.50	1950	10.7	0.3	10.50
4051000	19.00	3.0	20	0	0.40	1800	0.0	0.0	0.00	1874	12.4	0.7	6.50	1782	15.0	0.8	5.50	1973	10.4	0.7	10.50
4051100	20.00	2.7	20	0	0.40	1275	14.9	0.3	0.50	1508	10.0	0.7	7.50	1425	12.4	0.8	6.50	1554	8.7	0.7	11.50
4051200	21.00	3.0	20	0	0.40	1312	14.9	0.5	1.50	1560	9.8	0.3	8.50	1467	12.4	0.3	7.50	1605	8.7	0.2	12.50
4051400	23.00	3.0	20	0	0.40	1425	14.9	0.4	3.50	1687	9.6	0.3	10.50	1574	12.8	0.7	9.50	1708	8.7	0.7	14.50
4051500	24.00	2.7	20	0	0.40	1470	14.9	0.2	4.50	1754	9.5	0.2	11.50	1638	11.9	0.7	10.50	1789	8.7	0.3	15.50
4051545	24.75	2.8	20	0	0.40	1505	14.9	0.3	5.25	1783	9.5	0.5	12.25	1650	11.9	0.7	11.25	1810	8.7	0.5	16.25
4051630	25.50	2.8	20	0	0.40	1680	16.3	0.5	6.00	1956	10.4	1.0	13.00	1827	12.4	0.7	12.00	1800	0.0	0.0	0.00
4061000	27.00	2.5	20	0	0.40	1236	12.1	0.7	7.50	1400	8.6	1.2	14.50	1372	10.2	0.8	13.50	1252	13.7	1.2	0.00
4061100	28.00	2.6	20	0	0.40	1275	12.7	1.2	8.50	1446	8.2	1.0	15.50	1400	10.2	1.5	14.50	1285	13.1	1.4	1.00
4061200	29.00	2.5	20	0	0.40	1325	12.4	0.9	9.50	1513	8.0	0.9	16.50	1442	10.0	1.0	15.50	1315	13.1	1.2	2.00
4061300	30.00	2.5	20	0	0.40	1383	12.7	1.2	10.50	1570	8.0	0.8	17.50	1505	10.2	1.0	16.50	1347	13.1	1.0	3.00
4061400	31.00	2.5	20	0	0.40	1415	12.7	1.2	11.50	1604	8.0	1.4	18.50	1545	10.0	1.0	17.50	1383	12.7	1.4	4.00
4061500	32.00	2.3	20	0	0.40	1458	12.4	1.0	12.50	1650	8.2	1.0	19.50	1592	10.4	1.3	18.50	1428	12.7	1.2	5.00
4061600	33.00	2.4	20	0	0.40	1505	13.1	0.9	13.50	1703	8.2	0.9	20.50	1641	10.2	1.0	19.50	1473	12.4	1.0	6.00
4061645	33.75	2.4	20	0	0.40	1693	14.9	0.9	14.25	1800	0.0	0.0	0.00	1850	11.3	1.0	20.25	1558	15.8	1.0	6.75
4061700	34.00	2.4	20	0	0.40	1242	10.0	0.9	14.50	1123	14.1	1.4	0.00	1342	8.0	1.2	20.50	1118	12.4	1.2	7.00
4070830	49.50	3.0	0	0	0.40	1813	10.4	1.2	30.00	1736	13.1	1.2	15.50	1952	7.3	1.0	36.00	1664	14.5	1.2	22.50
4070900	50.00	2.8	0	0	0.40	1957	11.1	1.2	30.50	1826	13.1	1.0	16.00	1800	0.0	0.0	0.00	1758	15.9	0.8	23.00
4071000	51.00	2.8	0	0	0.40	1502	8.2	1.0	31.50	1466	9.3	0.8	17.00	1310	14.1	0.5	0.50	1370	12.4	0.7	24.00
4071500	56.00	2.5	0	0	0.40	1685	8.6	0.5	36.50	1700	8.6	0.5	22.00	1522	14.1	0.8	5.50	1543	13.1	1.2	29.00
4071600	57.00	2.4	0	0	0.40	1755	8.6	0.5	37.50	1772	8.6	0.5	23.00	1587	14.1	0.7	6.50	1607	13.4	1.0	30.00
4071630	57.50	2.4	0	0	0.40	1800	0.0	0.4	0.00	1788	9.8	0.5	23.50	1778	14.9	0.7	7.00	1778	14.5	1.0	30.50
4071700	58.00	2.4	0	0	0.40	1245	14.5	0.4	0.50	1527	7.3	0.7	24.00	1386	12.4	0.7	7.50	1380	11.9	0.8	31.00
4080800	73.00	2.4	0	0	0.40	1995	8.2	0.7	15.50	2020	2.2	0.8	39.00	2014	8.7	0.4	22.50	1892	12.4	1.0	46.00
4080900	74.00	2.8	0	0	0.40	2040	8.2	0.5	16.50	1800	0.0	0.0	0.00	2030	8.7	0.4	23.50	1895	12.4	0.8	47.00
4080930	74.50	3.0	0	0	0.40	1995	7.3	0.2	17.00	1585	16.3	0.7	0.50	1995	8.0	0.2	24.00	1849	12.4	0.3	47.50
4081030	75.50	3.0	0	0	0.40	1227	14.9	0.3	0.00	1276	14.1	0.8	1.50	1601	10.0	0.4	25.00	1484	10.0	1.0	48.50
4081200	77.00	3.0	0	0	0.24	1410	16.3	0.2	1.50	1410	15.4	0.7	3.00	1423	3.7	0.2	26.50	1437	9.3	0.3	50.00
4091000	78.50	3.0	0	0	0.24	1154	14.1	0.7	3.00	1154	14.1	0.7	4.50	1122	5.8	0.4	28.00	1123	9.5	0.6	51.50
4091100	79.50	2.8	0	0	0.24	1266	14.9	0.7	4.00	1250	14.5	0.7	5.50	1220	5.0	0.4	29.00	1207	9.0	0.6	52.50
4091200	80.50	2.8	0	0	0.24	1304	15.8	0.5	5.00	1282	14.5	0.7	6.50	1305	4.8	0.4	30.00	1300	9.2	0.6	53.50
4091240	81.00	3.0	0	0	0.24	1540	18.0	0.7	5.50	1532	16.8	1.0	7.00	1400	4.7	0.4	30.50	1495	10.4	0.8	54.00
4111100	83.50	2.8	0	0	0.40	932	11.3	1.0	8.00	962	10.9	1.0	9.50	900	10.7	1.0	33.00	807	9.6	1.2	57.00
4111200	84.50	2.5	0	0	0.40	929	10.4	0.8	9.00	889	10.6	0.8	10.50	892	10.9	0.9	34.00	894	9.8	0.9	58.00

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Total view on measurements

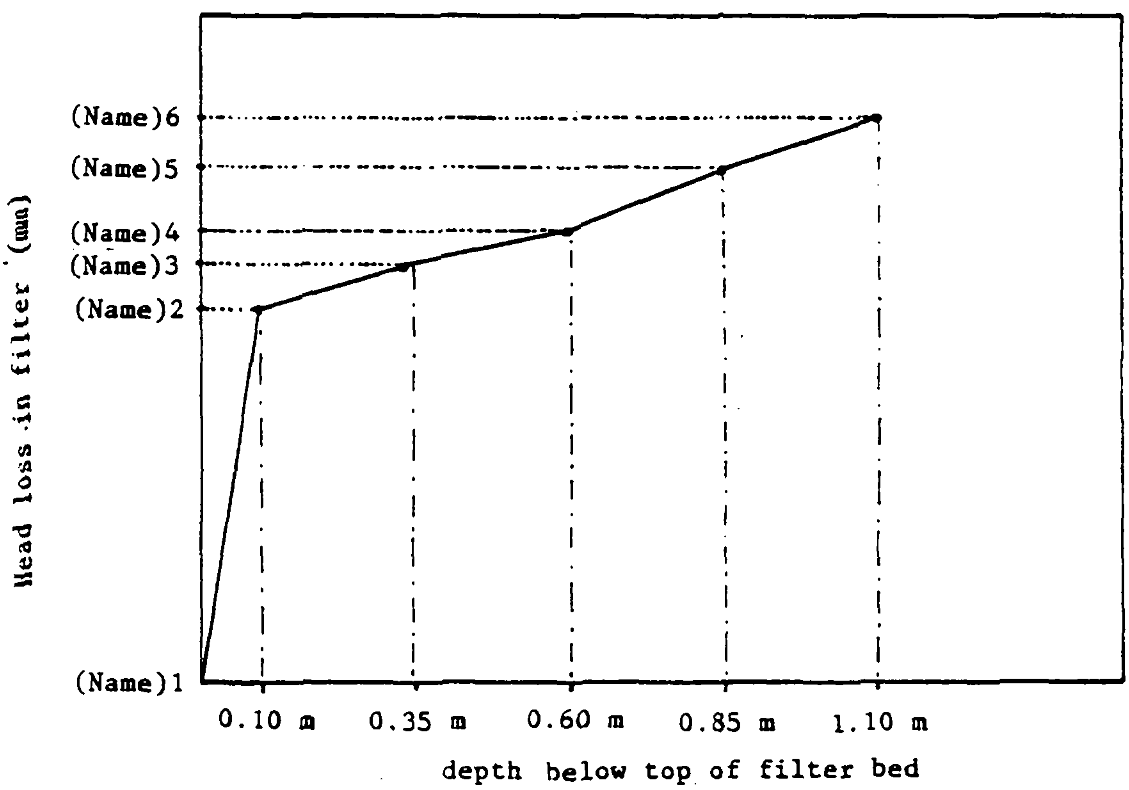
Code	Time	Infl	Alum	Soda	Loss	LevR	VelR	EffR	RunR	LevE	VelE	EffE	RunE	LevN	VelN	EffN	RunN	LevY	VelY	EffY	RunY
	h	NTU	mg/l	mg/l	m	mm	m/h	NTU	h	mm	m/h	NTU	h	mm	m/h	NTU	h	mm	m/h	NTU	h
4111400	86.50	2.5	0	0	0.40	1088	10.9	0.7	11.00	970	10.6	0.6	12.50	932	10.6	0.9	36.00	952	10.4	1.0	60.00
4111500	87.50	2.5	0	0	0.40	1164	10.9	0.7	12.00	1027	10.4	0.8	13.50	980	11.2	0.7	37.00	985	10.2	1.0	61.00
4120930	106.50	2.0	0	0	0.40	2003	7.7	0.8	30.50	2010	9.0	0.8	32.00	1966	10.4	0.9	55.50	1970	10.4	0.9	79.50
4121030	107.50	2.0	0	0	0.40	1570	18.0	0.7	0.50	1485	5.2	0.6	33.00	1477	7.5	0.8	56.50	1390	7.5	0.6	80.50
4121200	109.00	2.2	0	0	0.40	1597	16.3	0.6	2.00	1625	4.4	0.6	34.50	1542	6.8	0.8	58.00	1467	6.0	1.0	82.00
4141040	0.00	8.0	0	0	0.40	520	8.2	7.0	0.00	0	0.0	0.0	0.00	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141045	0.08	7.5	0	0	0.40	955	12.1	4.6	0.08	0	0.0	0.0	0.00	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141050	0.17	7.3	0	0	0.40	1178	13.9	2.5	0.17	0	0.0	0.0	0.00	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141100	0.33	7.0	0	0	0.40	1430	16.7	2.0	0.33	0	0.0	0.0	0.00	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141110	0.50	7.0	0	0	0.40	1445	15.6	0.6	0.50	0	0.0	0.0	0.00	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141140	1.00	7.2	0	0	0.40	1467	14.5	0.8	1.00	0	0.0	0.0	0.00	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141415	3.58	5.0	0	0	0.40	0	0.0	0.0	0.00	520	8.8	6.0	0.00	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141420	3.67	4.5	0	0	0.40	0	0.0	0.0	0.00	855	11.3	4.2	0.08	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141425	3.75	4.7	0	0	0.40	0	0.0	0.0	0.00	794	13.0	2.0	0.17	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141435	3.92	4.2	0	0	0.40	0	0.0	0.0	0.00	1054	15.5	1.7	0.33	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141445	4.08	4.8	0	0	0.40	0	0.0	0.0	0.00	1060	15.3	1.0	0.50	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4141515	4.58	5.0	0	0	0.40	0	0.0	0.0	0.00	1080	15.6	0.7	1.00	0	0.0	0.0	0.00	0	0.0	0.0	0.00
4151400	11.00	10.0	0	0	0.24	0	0.0	0.0	0.00	0	0.0	0.0	0.00	520	8.7	7.5	0.00	0	0.0	0.0	0.00
4151405	11.08	11.0	0	0	0.24	0	0.0	0.0	0.00	0	0.0	0.0	0.00	1004	13.6	6.0	0.08	0	0.0	0.0	0.00
4151410	11.17	11.0	0	0	0.24	0	0.0	0.0	0.00	0	0.0	0.0	0.00	1226	17.6	6.5	0.17	0	0.0	0.0	0.00
4151420	11.33	11.0	0	0	0.24	0	0.0	0.0	0.00	0	0.0	0.0	0.00	1240	17.0	3.8	0.33	0	0.0	0.0	0.00
4151430	11.50	14.0	0	0	0.24	0	0.0	0.0	0.00	0	0.0	0.0	0.00	1235	16.4	1.6	0.50	0	0.0	0.0	0.00
4151500	12.00	14.0	0	0	0.24	0	0.0	0.0	0.00	0	0.0	0.0	0.00	1253	16.6	1.0	1.00	0	0.0	0.0	0.00
0	0.00	-1.0	0	0	0.00	0	0.0	-1.0	0.00	0	0.0	-1.0	0.00	0	0.0	-1.0	0.00	0	0.0	-1.0	0.00

ANNEX III

FILTRATION RESULTS PER FILTER

The following parameters are presented:

- Code	:	Date/Time
- Time	:	Time from start of filtration (h)
- Infl	:	Turbidity of river water (NTU)
- Alum	:	Alum dosing (mg/l)
- Soda	:	Soda ash dosing (mg/l)
- Loss	:	Head loss in piping at 10.8 m/h (m)
- (Name)1	:	Head loss in filter at top of filter bed (0 mm)
- (Name)2	:	Head loss in filter 0.10 m below top of filter bed (mm)
- (Name)3	:	Head loss in filter 0.35 m below top of filter bed (mm)
- (Name)4	:	Head loss in filter 0.60 m below top of filter bed (mm)
- (Name)5	:	Head loss in filter 0.85 m below top of filter bed (mm)
- (Name)6	:	Head loss in filter 1.10 m below top of filter bed (mm)
- Rate	:	Filtration velocity (m/h)
- Effl	:	Filtered water turbidity (NTU)
- Run	:	Time from start of filter run (h)



Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Rina

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Rina1 mm	Rina2 mm	Rina3 mm	Rina4 mm	Rina5 mm	Rina6 mm	Rate m/h	Effl NTU	Run h
3211130	0.00	5.0	0	0	0.40	0	66	134	195	440	624	14.9	3.5	0.00
3211230	1.00	6.0	0	0	0.40	0	68	133	191	402	570	15.8	3.3	1.00
3211330	2.00	6.5	0	0	0.40	0	1192	1208	1222	1262	1300	15.5	3.0	2.00
3220930	2.00	5.0	0	0	0.40	0	1045	1064	1101	1308	1410	8.6	3.0	2.00
3220945	2.25	5.0	0	0	0.40	0	1115	1158	1196	1375	1488	8.7	2.8	2.25
3221030	2.50	5.0	0	0	0.40	0	1118	1149	1178	1301	1382	6.9	3.0	2.50
3221130	4.00	5.0	0	0	0.40	0	1167	1295	1221	1327	1398	6.5	3.0	4.00
3221300	5.50	5.0	0	0	0.40	0	1346	1378	1407	1509	1581	7.2	3.0	5.50
3221330	6.00	5.0	0	0	0.40	0	1400	1432	1457	1547	1612	7.0	3.0	6.00
3221400	6.50	5.0	0	0	0.40	0	1426	1457	1480	1568	1631	7.0	2.8	6.50
3231100	7.00	11.0	0	0	0.40	0	1208	1218	1233	1298	1348	3.2	4.8	7.00
3231200	8.00	6.0	0	0	0.40	0	1239	1255	1268	1303	1363	2.8	3.5	8.00
3231400	10.00	5.8	0	0	0.40	0	1341	1352	1362	1382	1444	2.8	2.8	10.00
3231500	11.00	4.5	20	0	0.40	0	1459	1477	1491	1524	1578	2.9	2.8	11.00
3241200	11.50	5.0	20	0	0.40	0	1201	1229	1248	1343	1403	4.0	3.3	12.00
3241300	13.00	4.5	20	0	0.40	0	1511	1548	1573	1663	1718	4.0	1.8	13.00
3241400	14.00	4.5	20	0	0.40	0	1800	1800	1800	1800	1800	0.0	1.8	0.00
3241500	15.00	4.5	20	0	0.40	0	59	106	175	416	581	15.8	1.8	0.00
3241600	16.00	4.5	20	0	0.40	0	95	151	217	430	567	15.6	1.8	1.00
3250830	32.50	4.2	0	0	0.40	0	580	620	666	870	1000	13.7	2.5	17.50
3250900	33.00	4.2	0	0	0.40	0	596	636	684	885	1014	13.4	2.5	18.00
3250930	33.50	4.2	0	0	0.40	0	624	668	716	915	1041	13.7	2.4	18.50
3251000	34.00	4.3	0	0	0.40	0	658	699	744	938	1063	11.4	2.4	19.00
3251200	36.00	4.6	0	0	0.40	0	703	735	773	923	1023	11.6	2.2	21.00
3251300	37.00	15.5	0	0	0.40	0	1070	1100	1132	1265	1348	11.1	2.5	22.00
3251400	38.00	14.0	0	0	0.40	0	1242	1262	1282	1390	1462	10.6	2.8	23.00
3251430	38.50	13.0	0	0	0.40	0	1536	1556	1571	1658	1714	10.0	3.3	23.50
3260930	39.50	5.5	30	0	0.40	0	940	970	1000	1140	1225	7.7	2.8	24.50
3261000	40.00	5.5	30	0	0.40	0	1173	1197	1211	1317	1378	7.2	2.4	25.00
3261130	41.50	5.5	30	0	0.40	0	1560	1590	1615	1720	1768	5.6	2.6	26.50
3261200	42.00	5.5	30	0	0.40	0	1800	1800	1800	1800	1800	0.0	3.0	0.00
3261330	43.50	5.5	30	0	0.40	0	148	215	270	497	635	14.0	3.2	1.00
3280900	45.50	17.0	30	0	0.40	0	295	352	417	707	872	14.5	5.5	3.00
3281100	47.50	12.0	40	40	0.40	0	370	422	483	730	880	13.5	3.0	5.00
3281200	48.50	9.0	40	40	0.40	0	547	605	655	877	1000	12.7	2.2	6.00
3281400	50.50	17.0	40	40	0.40	0	870	930	983	1241	1365	10.5	2.4	8.00
3281500	51.50	16.0	40	40	0.40	0	985	1048	1122	1383	1509	8.2	2.2	9.00
3281530	52.00	16.0	40	40	0.40	0	1155	1208	1253	1475	1570	7.3	2.2	9.50
4011000	1.00	6.0	0	0	0.40	0	268	318	382	616	785	10.9	1.5	1.00
4011100	2.00	12.0	0	0	0.40	0	291	336	393	573	715	10.9	1.4	2.00
4011200	3.00	7.5	20	0	0.40	0	373	416	467	628	753	10.9	1.5	3.00
4011300	4.00	10.0	20	0	0.40	0	527	589	648	835	962	11.1	1.0	4.00
4011430	5.50	12.0	20	0	0.40	0	653	722	780	995	1123	10.9	0.8	5.50
4011500	6.00	95.0	20	0	0.40	0	915	983	1043	1258	1388	10.9	2.2	6.00
4011515	6.25	100.0	20	0	0.40	0	707	762	810	1002	1117	9.7	2.4	6.25
4011600	7.00	100.0	20	0	0.40	0	993	1045	1092	1288	1401	10.0	2.5	7.00
4011615	7.25	95.0	20	0	0.40	0	880	918	952	1118	1241	8.3	2.5	7.25
4011700	8.00	98.0	30	0	0.40	0	1189	1234	1282	1441	1570	8.5	2.5	8.00

Page No. 2
06/22/88

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Rina

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Rina1 mm	Rina2 mm	Rina3 mm	Rina4 mm	Rina5 mm	Rina6 mm	Rate m/h	Effl NTU	Run h
4011715	8.25	85.0	30	0	0.40	0	1028	1062	1100	1250	1359	6.5	2.7	8.25
4011800	9.00	92.0	30	0	0.40	0	1397	1439	1475	1625	1741	6.7	3.0	9.00
4020745	9.25	74.0	40	0	0.40	0	172	231	288	519	682	15.1	5.7	0.00
4020900	10.50	77.0	0	0	0.40	0	433	497	549	820	989	15.1	5.6	1.00
4021000	11.50	54.0	0	0	0.40	0	594	670	712	1009	1184	14.9	5.6	6.60
4021015	11.75	47.0	0	0	0.40	0	792	860	904	1198	1365	11.7	5.0	2.00
4021200	13.50	27.0	0	0	0.40	0	970	1023	1073	1320	1450	9.0	5.0	4.00
4041230	14.50	3.5	20	0	0.40	0	867	933	991	1237	1372	7.5	2.2	5.00
4041330	15.50	3.5	20	0	0.40	0	952	1017	1072	1283	1413	8.2	0.4	6.00
4041430	16.50	3.0	20	0	0.40	0	1071	1129	1179	1354	1474	8.4	0.2	7.00
4041600	18.00	4.0	20	0	0.40	0	1200	1250	1295	1440	1545	8.2	1.2	8.50
4041630	18.50	3.5	20	0	0.40	0	1243	1290	1332	1470	1570	8.2	0.5	9.00
4041700	19.00	3.5	20	0	0.40	0	1285	1330	1370	1502	1600	8.2	0.7	9.50
4041710	19.00	3.5	20	0	0.40	0	1800	1800	1800	1800	1800	0.0	0.0	0.00
4051000	19.00	3.0	20	0	0.40	0	1800	1800	1800	1800	1800	0.0	0.0	0.00
4051100	20.00	2.7	20	0	0.40	0	140	198	257	488	651	14.9	0.3	0.50
4051200	21.00	3.0	20	0	0.40	0	182	239	296	526	685	14.9	0.5	1.50
4051400	23.00	3.0	20	0	0.40	0	293	348	403	635	793	14.9	0.4	3.50
4051500	24.00	2.7	20	0	0.40	0	342	395	450	683	842	14.9	0.2	4.50
4051545	24.75	2.8	20	0	0.40	0	371	425	481	714	875	14.9	0.3	5.25
4051630	25.50	2.8	20	0	0.40	0	417	475	535	788	964	16.3	0.5	6.00
4061000	27.00	2.5	20	0	0.40	0	339	384	430	632	772	12.1	0.7	7.50
4061100	28.00	2.6	20	0	0.40	0	381	427	471	673	810	12.7	1.2	8.50
4061200	29.00	2.5	20	0	0.40	0	431	477	521	721	858	12.4	0.9	9.50
4061300	30.00	2.5	20	0	0.40	0	463	513	558	763	900	12.7	1.2	10.50
4061400	31.00	2.5	20	0	0.40	0	502	550	595	796	933	12.7	1.2	11.50
4061500	32.00	2.3	20	0	0.40	0	538	586	632	835	970	12.4	1.0	12.50
4061600	33.00	2.4	20	0	0.40	0	580	627	674	877	1015	13.1	0.9	13.50
4061645	33.75	2.4	20	0	0.40	0	638	692	743	965	1119	14.9	0.9	14.25
4061700	34.00	2.4	20	0	0.40	0	545	587	622	787	902	10.0	0.9	14.50
4070830	49.50	3.0	0	0	0.40	0	1116	1158	1198	1368	1483	10.4	1.2	30.00
4070900	50.00	2.8	0	0	0.40	0	1199	1243	1284	1463	1587	11.1	1.2	30.50
4071000	51.00	2.8	0	0	0.40	0	1014	1044	1072	1202	1294	8.2	1.0	31.50
4071500	56.00	2.5	0	0	0.40	0	1185	1215	1245	1373	1463	8.6	0.5	36.50
4071600	57.00	2.4	0	0	0.40	0	1260	1292	1320	1450	1540	8.6	0.5	37.50
4071630	57.50	2.4	0	0	0.40	0	1800	1800	1800	1800	1800	0.0	0.4	0.00
4071700	58.00	2.4	0	0	0.40	0	162	215	265	497	655	14.5	0.4	0.50
4080800	73.00	2.4	0	0	0.40	0	1513	1546	1572	1707	1800	8.2	0.7	15.50
4080900	74.00	2.8	0	0	0.40	0	1558	1591	1619	1757	1850	8.2	0.5	16.50
4080930	74.50	3.0	0	0	0.40	0	1577	1607	1632	1752	1835	7.3	0.2	17.00
4081030	75.50	3.0	0	0	0.40	0	15	70	121	341	577	14.9	0.3	0.00
4081200	77.00	3.0	0	0	0.24	0	29	90	147	387	646	16.3	0.2	1.50
4091000	78.50	3.0	0	0	0.24	0	16	69	118	327	549	14.1	0.7	3.00
4091100	79.50	2.8	0	0	0.24	0	26	86	136	362	600	14.9	0.7	4.00
4091200	80.50	2.8	0	0	0.24	0	48	107	160	388	625	15.8	0.5	5.00
4091240	81.00	3.0	0	0	0.24	0	80	150	210	462	724	18.0	0.7	5.50
4111100	83.50	2.8	0	0	0.40	0	144	188	228	389	559	11.3	1.0	8.00
4111200	84.50	2.5	0	0	0.40	0	196	235	272	423	582	10.4	0.8	9.00

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Rina

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Rina1 mm	Rina2 mm	Rina3 mm	Rina4 mm	Rina5 mm	Rina6 mm	Rate m/h	Effl NTU	Run h
4111400	86.50	2.5	0	0	0.40	0	346	390	428	581	743	10.9	0.7	11.00
4111500	87.50	2.5	0	0	0.40	0	429	472	508	659	822	10.9	0.7	12.00
4120930	106.50	2.0	0	0	0.40	0	1569	1598	1623	1729	1843	7.7	0.8	30.50
4121030	107.50	2.0	0	0	0.40	0	42	110	177	440	712	18.0	0.7	0.50
4121200	109.00	2.2	0	0	0.40	0	159	223	257	536	795	16.3	0.6	2.00
4141040	0.00	8.0	0	0	0.40	0	520	520	520	520	520	8.2	7.0	0.00
4141045	0.08	7.5	0	0	0.40	0	955	955	955	955	955	12.1	4.6	0.08
4141050	0.17	7.3	0	0	0.40	0	1178	1178	1178	1178	1178	13.9	2.5	0.17
4141100	0.33	7.0	0	0	0.40	0	1430	1430	1430	1430	1430	16.7	2.0	0.33
4141110	0.50	7.0	0	0	0.40	0	1445	1445	1445	1445	1445	15.6	0.6	0.50
4141140	1.00	7.2	0	0	0.40	0	1467	1467	1467	1467	1467	14.5	0.8	1.00
4141415	3.58	5.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141420	3.67	4.5	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141425	3.75	4.7	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141435	3.92	4.2	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141445	4.08	4.8	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141515	4.58	5.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4151400	11.00	10.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151405	11.08	11.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151410	11.17	11.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151420	11.33	11.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151430	11.50	14.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151500	12.00	14.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
0	0.00	-1.0	0	0	0.00	0	0	0	0	0	0	0.0	-1.0	0.00

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Evie

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Evie1 mm	Evie2 mm	Evie3 mm	Evie4 mm	Evie5 mm	Evie6 mm	Rate m/h	Effl NTU	Run h
3211130	0.00	5.0	0	0	0.40	0	490	543	576	751	866	12.4	3.0	6.00
3211230	1.00	6.0	0	0	0.40	0	678	723	754	918	1028	12.1	2.8	7.00
3211330	2.00	6.5	0	0	0.40	0	1745	1750	1755	1775	1788	12.0	3.0	8.00
3220930	2.00	5.0	0	0	0.40	0	151	194	232	423	571	15.9	2.5	0.00
3220945	2.25	5.0	0	0	0.40	0	155	200	240	435	582	15.4	2.7	0.25
3221030	2.50	5.0	0	0	0.40	0	156	203	241	412	543	14.1	2.8	1.00
3221130	4.00	5.0	0	0	0.40	0	169	217	251	419	551	13.7	2.6	2.00
3221300	5.50	5.0	0	0	0.40	0	207	260	300	483	620	14.3	2.5	3.50
3221330	6.00	5.0	0	0	0.40	0	224	277	315	500	637	14.1	2.5	4.00
3221400	6.50	5.0	0	0	0.40	0	232	286	322	509	647	16.3	2.3	4.50
3231100	7.00	11.0	0	0	0.40	0	172	219	252	407	528	13.1	4.0	5.00
3231200	8.00	6.0	0	0	0.40	0	196	241	272	426	543	12.7	3.2	6.00
3231400	10.00	5.8	0	0	0.40	0	262	309	338	491	606	12.6	2.8	8.00
3231500	11.00	4.5	20	0	0.40	0	330	380	413	578	702	12.7	2.6	9.00
3241200	11.50	5.0	20	0	0.40	0	355	408	438	598	710	12.1	2.6	10.00
3241300	13.00	4.5	20	0	0.40	0	492	575	612	803	927	12.4	2.2	11.00
3241400	14.00	4.5	20	0	0.40	0	565	654	695	897	1020	12.8	2.1	12.00
3241500	15.00	4.5	20	0	0.40	0	612	705	735	950	1070	10.4	1.9	13.00
3241600	16.00	4.5	20	0	0.40	0	615	712	749	925	1020	10.5	1.9	14.00
3250830	32.50	4.2	0	0	0.40	0	1087	1162	1197	1364	1449	8.4	2.5	30.50
3250900	33.00	4.2	0	0	0.40	0	1087	1166	1198	1364	1450	8.0	2.5	31.00
3250930	33.50	4.2	0	0	0.40	0	1245	1185	1137	953	820	0.0	2.3	0.00
3251000	34.00	4.3	0	0	0.40	0	67	150	207	447	610	15.4	2.3	0.00
3251200	36.00	4.6	0	0	0.40	0	72	143	191	397	544	14.1	2.5	2.00
3251300	37.00	15.5	0	0	0.40	0	166	237	288	505	535	14.5	2.6	3.00
3251400	38.00	14.0	0	0	0.40	0	277	343	387	587	719	14.1	2.8	4.00
3251430	38.50	13.0	0	0	0.40	0	467	529	573	771	893	14.5	3.1	4.50
3260930	39.50	5.5	30	0	0.40	0	421	492	529	739	864	11.3	2.4	5.50
3261000	40.00	5.5	30	0	0.40	0	570	648	686	885	995	11.3	2.2	6.00
3261130	41.50	5.5	30	0	0.40	0	838	947	1001	1230	1337	9.5	2.4	7.50
3261200	42.00	5.5	30	0	0.40	0	857	970	1024	1255	1360	9.5	2.5	8.00
3261330	43.50	5.5	30	0	0.40	0	820	900	942	1115	1191	6.7	2.2	9.50
3280900	45.50	17.0	30	0	0.40	0	1072	1133	1160	1393	1488	6.9	4.8	11.50
3281100	47.50	12.0	40	40	0.40	0	130	212	262	522	682	13.7	2.7	0.50
3281200	48.50	9.0	40	40	0.40	0	190	277	320	580	717	13.1	2.2	1.50
3281400	50.50	17.0	40	40	0.40	0	359	457	505	805	944	10.4	2.2	3.50
3281500	51.50	16.0	40	40	0.40	0	570	675	730	1038	1184	10.8	2.6	4.50
3281530	52.00	16.0	40	40	0.40	0	563	678	730	1056	1190	9.0	2.4	5.00
4011000	1.00	6.0	0	0	0.40	0	127	307	352	630	799	9.5	1.8	1.00
4011100	2.00	12.0	0	0	0.40	0	163	307	348	568	710	9.5	1.8	2.00
4011200	3.00	7.5	20	0	0.40	0	253	390	428	633	760	10.0	1.6	3.00
4011300	4.00	10.0	20	0	0.40	0	408	570	612	855	977	10.4	1.0	4.00
4011430	5.50	12.0	20	0	0.40	0	547	710	753	1034	1161	10.4	0.8	5.50
4011500	6.00	95.0	20	0	0.40	0	738	890	935	1227	1355	10.0	2.0	6.00
4011515	6.25	100.0	20	0	0.40	0	20	100	141	376	528	13.7	1.9	0.00
4011600	7.00	100.0	20	0	0.40	0	407	484	520	749	903	13.4	2.7	0.50
4011615	7.25	95.0	20	0	0.40	0	320	370	400	628	782	11.3	2.2	0.75
4011700	8.00	98.0	30	0	0.40	0	676	732	766	986	1138	11.3	2.8	1.50

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Evie

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Evie1 mm	Evie2 mm	Evie3 mm	Evie4 mm	Evie5 mm	Evie6 mm	Rate m/h	Effl NTU	Run h
4011715	8.25	35.0	30	0	0.40	0	592	643	672	942	1044	9.7	2.3	1.75
4011800	9.00	92.0	30	0	0.40	0	927	993	1018	1297	1401	9.5	2.5	2.50
4020745	9.25	74.0	40	0	0.40	0	835	882	910	1175	1272	6.9	5.2	2.75
4020900	10.50	77.0	0	0	0.40	0	980	1032	1059	1360	1457	7.3	4.8	4.00
4021000	11.50	54.0	0	0	0.40	0	1158	1214	1240	1550	1652	6.5	5.2	5.00
4021015	11.75	47.0	0	0	0.40	0	135	143	229	463	599	13.7	6.0	0.00
4021200	13.50	27.0	0	0	0.40	0	465	560	660	870	1072	10.9	5.2	1.00
4041230	14.50	3.5	20	0	0.40	0	250	373	423	695	850	10.4	2.0	2.00
4041330	15.50	3.5	20	0	0.40	0	325	425	475	696	840	11.3	1.0	3.00
4041430	16.50	3.0	20	0	0.40	0	467	547	590	770	892	11.3	0.3	4.00
4041600	18.00	4.0	20	0	0.40	0	610	675	712	880	992	11.3	0.7	5.50
4041630	18.50	3.5	20	0	0.40	0	650	715	748	917	1028	11.3	0.6	6.00
4041700	19.00	3.5	20	0	0.40	0	691	750	785	953	1063	11.3	0.6	6.50
4041710	19.00	3.5	20	0	0.40	0	735	801	837	1019	1137	11.6	0.6	6.50
4051000	19.00	3.0	20	0	0.40	0	631	706	744	950	1082	12.4	0.7	6.50
4051100	20.00	2.7	20	0	0.40	0	675	730	756	906	1006	10.0	0.7	7.50
4051200	21.00	3.0	20	0	0.40	0	744	797	823	968	1065	9.8	0.3	8.50
4051400	23.00	3.0	20	0	0.40	0	880	931	957	1102	1197	9.6	0.3	10.50
4051500	24.00	2.7	20	0	0.40	0	940	993	1019	1164	1259	9.5	0.2	11.50
4051545	24.75	2.8	20	0	0.40	0	963	1015	1043	1190	1288	9.5	0.5	12.25
4051630	25.50	2.8	20	0	0.40	0	1013	1073	1104	1270	1376	10.4	1.0	13.00
4061000	27.00	2.5	20	0	0.40	0	678	732	756	883	982	8.6	1.2	14.50
4061100	28.00	2.6	20	0	0.40	0	760	811	833	964	1049	8.2	1.0	15.50
4061200	29.00	2.5	20	0	0.40	0	843	893	915	1043	1125	8.0	0.9	16.50
4061300	30.00	2.5	20	0	0.40	0	890	940	960	1090	1172	8.0	0.8	17.50
4061400	31.00	2.5	20	0	0.40	0	924	974	996	1126	1209	8.0	1.4	18.50
4061500	32.00	2.3	20	0	0.40	0	970	1020	1042	1168	1252	8.2	1.0	19.50
4061600	33.00	2.4	20	0	0.40	0	1013	1063	1088	1215	1298	8.2	0.9	20.50
4061645	33.75	2.4	20	0	0.40	0	1800	1800	1800	1800	1800	0.0	0.0	0.00
4061700	34.00	2.4	20	0	0.40	0	9	58	108	300	453	14.1	1.4	0.00
4070830	49.50	3.0	0	0	0.40	0	728	786	834	1024	1164	13.1	1.2	15.50
4070900	50.00	2.8	0	0	0.40	0	790	841	894	1086	1228	13.1	1.0	16.00
4071000	51.00	2.8	0	0	0.40	0	806	846	881	1016	1116	9.3	0.8	17.00
4071500	56.00	2.5	0	0	0.40	0	1107	1146	1178	1300	1390	8.6	0.5	22.00
4071600	57.00	2.4	0	0	0.40	0	1172	1211	1247	1364	1456	8.6	0.5	23.00
4071630	57.50	2.4	0	0	0.40	0	1103	1120	1158	1300	1403	9.8	0.5	23.50
4071700	58.00	2.4	0	0	0.40	0	1075	1103	1130	1231	1303	7.3	0.7	24.00
4080800	73.00	2.4	0	0	0.40	0	1860	1870	1880	1917	1944	2.2	0.8	39.00
4080900	74.00	2.8	0	0	0.40	0	1800	1800	1800	1800	1800	0.0	0.0	0.00
4080930	74.50	3.0	0	0	0.40	0	7	77	145	391	600	16.3	0.7	0.50
4081030	75.50	3.0	0	0	0.40	0	36	84	143	348	520	14.1	0.8	1.50
4081200	77.00	3.0	0	0	0.24	0	36	84	143	348	520	15.4	0.7	3.00
4091000	78.50	3.0	0	0	0.24	0	11	62	114	314	480	14.1	0.7	4.50
4091100	79.50	2.8	0	0	0.24	0	23	78	136	343	518	14.5	0.7	5.50
4091200	80.50	2.8	0	0	0.24	0	52	107	156	378	556	14.5	0.7	6.50
4091240	81.00	3.0	0	0	0.24	0	99	147	212	-355	640	16.8	1.0	7.00
4111100	83.50	2.8	0	0	0.40	0	109	187	229	385	512	10.9	1.0	9.50
4111200	84.50	2.5	0	0	0.40	0	81	158	197	344	466	10.6	0.8	10.50

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Evie

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Evie1 mm	Evie2 mm	Evie3 mm	Evie4 mm	Evie5 mm	Evie6 mm	Rate m/h	Effl NTU	Run h
4111400	86.50	2.5	0	0	0.40	0	183	260	298	443	562	10.6	0.6	12.50
4111500	87.50	2.5	0	0	0.40	0	240	312	352	497	617	10.4	0.8	13.50
4120930	106.50	2.0	0	0	0.40	0	1359	1444	1480	1603	1705	9.0	0.8	32.00
4121030	107.50	2.0	0	0	0.40	0	1192	1235	1252	1330	1375	5.2	0.6	33.00
4121200	109.00	2.2	0	0	0.40	0	1362	1405	1423	1483	1533	4.4	0.6	34.50
4141040	0.00	8.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141045	0.08	7.5	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141050	0.17	7.3	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141100	0.33	7.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141110	0.50	7.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141140	1.00	7.2	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141415	3.58	5.0	0	0	0.40	0	520	520	520	520	520	8.8	6.0	0.00
4141420	3.67	4.5	0	0	0.40	0	855	855	855	855	855	11.3	4.2	0.08
4141425	3.75	4.7	0	0	0.40	0	994	994	994	994	994	13.0	2.0	0.17
4141435	3.92	4.2	0	0	0.40	0	1054	1054	1054	1054	1054	15.5	1.7	0.33
4141445	4.08	4.8	0	0	0.40	0	1060	1060	1060	1060	1060	15.3	1.0	0.50
4141515	4.58	5.0	0	0	0.40	0	1080	1080	1080	1080	1080	15.6	0.7	1.00
4151400	11.00	10.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151405	11.08	11.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151410	11.17	11.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151420	11.33	11.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151430	11.50	14.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151500	12.00	14.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
0	0.00	-1.0	0	0	0.00	0	0	0	0	0	0	0.0	-1.0	0.00

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Ninik

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Ninik1 mm	Ninik2 mm	Ninik3 mm	Ninik4 mm	Ninik5 mm	Ninik6 mm	Rate m/h	Effl NTU	Run h
3211130	0.00	5.0	0	0	0.40	0	1023	1072	1095	1260	1335	8.4	3.3	6.00
3211230	1.00	6.0	0	0	0.40	0	1120	1176	1197	1357	1425	8.0	3.0	7.00
3211330	2.00	6.5	0	0	0.40	0	1772	1780	1784	1818	1822	8.2	3.1	8.00
3220930	2.00	5.0	0	0	0.40	0	1760	1768	1771	1803	1817	1.4	2.5	8.00
3220945	2.25	5.0	0	0	0.40	0	1800	1800	1800	1800	1800	0.0	0.0	0.00
3221030	2.50	5.0	0	0	0.40	0	53	108	150	400	538	16.8	3.0	1.00
3221130	4.00	5.0	0	0	0.40	0	63	114	155	400	535	16.3	2.9	2.00
3221300	5.50	5.0	0	0	0.40	0	85	139	185	448	593	17.4	2.5	3.50
3221330	6.00	5.0	0	0	0.40	0	95	148	191	456	601	17.4	2.5	4.00
3221400	6.50	5.0	0	0	0.40	0	99	151	199	462	606	16.4	2.2	4.50
3231100	7.00	11.0	0	0	0.40	0	95	155	198	425	548	13.7	3.8	5.00
3231200	8.00	6.0	0	0	0.40	0	94	146	185	387	509	13.7	3.0	6.00
3231400	10.00	5.8	0	0	0.40	0	117	160	197	399	525	14.4	3.3	8.00
3231500	11.00	4.3	20	0	0.40	0	1486	1486	1486	1486	1486	14.0	2.8	9.00
3241200	11.50	5.0	20	0	0.40	0	206	252	282	485	597	13.4	2.4	10.00
3241300	13.00	4.5	20	0	0.40	0	272	348	376	626	743	13.1	2.3	11.00
3241400	14.00	4.5	20	0	0.40	0	318	400	439	708	830	13.1	2.0	12.00
3241500	15.00	4.5	20	0	0.40	0	342	423	463	733	853	11.1	1.8	13.00
3241600	16.00	4.5	20	0	0.40	0	363	447	482	738	840	10.8	2.0	14.00
3250830	32.50	4.2	0	0	0.40	0	649	707	743	1007	1109	10.0	2.8	30.50
3250900	33.00	4.2	0	0	0.40	0	663	718	752	1010	1111	9.5	2.8	31.00
3250930	33.50	4.2	0	0	0.40	0	695	757	790	1061	1166	10.0	2.4	31.50
3251000	34.00	4.3	0	0	0.40	0	681	741	788	1047	1153	8.2	2.6	32.00
3251200	36.00	4.6	0	0	0.40	0	701	758	790	1029	1123	8.0	2.6	34.00
3251300	37.00	15.5	0	0	0.40	0	925	975	1008	1236	1326	8.7	2.6	35.00
3251400	38.00	14.0	0	0	0.40	0	1117	1162	1187	1400	1480	8.7	2.6	36.00
3251430	38.50	13.0	0	0	0.40	0	1800	1800	1800	1800	1800	0.0	0.0	0.00
3260930	39.50	5.5	30	0	0.40	0	167	217	259	440	564	13.0	3.0	0.50
3261000	40.00	5.5	30	0	0.40	0	220	273	310	478	593	13.7	3.0	1.00
3261130	41.50	5.5	30	0	0.40	0	405	505	560	790	920	11.9	2.8	2.50
3261200	42.00	5.5	30	0	0.40	0	438	540	600	835	960	11.6	2.7	3.00
3261330	43.50	5.5	30	0	0.40	0	480	562	605	792	885	9.2	3.0	4.50
3280900	45.50	17.0	30	0	0.40	0	506	607	664	908	1028	9.4	4.0	6.50
3281100	47.50	12.0	40	40	0.40	0	562	680	740	995	1097	7.0	2.4	8.50
3281200	48.50	9.0	40	40	0.40	0	108	181	239	488	633	14.2	2.0	0.00
3281400	50.50	17.0	40	40	0.40	0	298	406	476	788	943	13.6	2.0	2.00
3281500	51.50	16.0	40	40	0.40	0	430	545	612	922	1015	13.0	2.0	3.00
3281530	52.00	16.0	40	40	0.40	0	498	615	683	983	1118	10.4	2.2	3.50
4011000	1.00	6.0	0	0	0.40	0	190	267	332	610	778	10.4	2.0	1.00
4011100	2.00	12.0	0	0	0.40	0	217	279	335	545	684	10.9	1.7	2.00
4011200	3.00	7.5	20	0	0.40	0	330	385	435	628	747	11.1	1.8	3.00
4011300	4.00	10.0	20	0	0.40	0	489	564	620	844	962	10.9	1.0	4.00
4011430	5.50	12.0	20	0	0.40	0	628	703	758	1008	1128	10.4	1.3	5.50
4011500	6.00	95.0	20	0	0.40	0	884	952	1008	1262	1385	10.4	1.8	6.00
4011515	6.25	100.0	20	0	0.40	0	691	763	820	1081	1203	7.5	2.3	6.25
4011600	7.00	100.0	20	0	0.40	0	1052	1109	1165	1424	1540	7.3	2.8	7.00
4011615	7.25	95.0	20	0	0.40	0	0	48	115	354	528	15.1	2.5	0.00
4011700	8.00	98.0	30	0	0.40	0	269	332	401	644	816	14.7	2.3	0.50

III - 8

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Ninik

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Ninik1 mm	Ninik2 mm	Ninik3 mm	Ninik4 mm	Ninik5 mm	Ninik6 mm	Rate m/h	Effl NTU	Run h
4011715	8.25	85.0	30	0	0.40	0	44	88	142	389	560	11.6	2.4	0.75
4011800	9.00	92.0	30	0	0.40	0	410	472	522	764	952	11.9	2.7	1.50
4020745	9.25	74.0	40	0	0.40	0	383	432	475	693	860	8.6	5.0	1.75
4020900	10.50	77.0	0	0	0.40	0	545	591	635	970	1041	8.6	6.0	3.00
4021000	11.50	54.0	0	0	0.40	0	655	709	768	1008	1185	8.8	6.0	4.00
4021015	11.75	47.0	0	0	0.40	0	790	833	884	1090	1285	6.5	5.8	5.00
4021200	13.50	27.0	0	0	0.40	0	58	115	155	345	485	13.7	5.3	0.00
4041230	14.50	3.5	20	0	0.40	0	75	133	170	356	494	14.5	1.0	2.00
4041330	15.50	3.5	20	0	0.40	0	112	168	194	392	530	15.8	0.5	2.00
4041430	16.50	3.0	20	0	0.40	0	170	219	263	452	590	14.9	0.5	3.00
4041600	18.00	4.0	20	0	0.40	0	280	338	372	562	698	14.5	0.6	4.50
4041630	18.50	3.5	20	0	0.40	0	310	367	400	590	730	14.5	0.4	5.00
4041700	19.00	3.5	20	0	0.40	0	343	400	433	625	762	14.5	0.4	5.50
4041710	19.00	3.5	20	0	0.40	0	365	428	462	665	810	15.0	0.4	5.50
4051000	19.00	3.0	20	0	0.40	0	324	394	438	647	804	15.0	0.8	5.50
4051100	20.00	2.7	20	0	0.40	0	367	420	450	617	742	12.4	0.8	6.50
4051200	21.00	3.0	20	0	0.40	0	432	483	513	677	799	12.4	0.3	7.50
4051400	23.00	3.0	20	0	0.40	0	539	589	619	784	906	12.8	0.7	9.50
4051500	24.00	2.7	20	0	0.40	0	635	688	715	876	993	11.9	0.7	10.50
4051545	24.75	2.8	20	0	0.40	0	662	710	737	899	1015	11.9	0.7	11.25
4051630	25.50	2.8	20	0	0.40	0	724	782	813	985	1112	12.4	0.7	12.00
4061000	27.00	2.5	20	0	0.40	0	507	557	586	734	842	10.2	0.8	13.50
4061100	28.00	2.6	20	0	0.40	0	560	610	635	780	882	10.2	1.5	14.50
4061200	29.00	2.5	20	0	0.40	0	627	674	698	837	937	10.0	1.0	15.50
4061300	30.00	2.5	20	0	0.40	0	667	717	742	883	985	10.2	1.0	16.50
4061400	31.00	2.5	20	0	0.40	0	723	771	793	933	1032	10.0	1.0	17.50
4061500	32.00	2.3	20	0	0.40	0	760	808	835	977	1076	10.4	1.3	18.50
4061600	33.00	2.4	20	0	0.40	0	803	859	881	1021	1121	10.2	1.0	19.50
4061645	33.75	2.4	20	0	0.40	0	890	945	1025	1130	1240	11.3	1.0	20.25
4061700	34.00	2.4	20	0	0.40	0	746	784	804	912	992	8.0	1.2	20.50
4070830	49.50	3.0	0	0	0.40	0	1427	1456	1472	1576	1652	7.3	1.0	36.00
4070900	50.00	2.8	0	0	0.40	0	1800	1800	1800	1800	1800	0.0	0.0	0.00
4071000	51.00	2.8	0	0	0.40	0	95	144	200	402	602	14.1	0.5	0.50
4071500	56.00	2.5	0	0	0.40	0	321	371	424	618	810	14.1	0.8	5.50
4071600	57.00	2.4	0	0	0.40	0	386	435	489	684	876	14.1	0.7	6.50
4071630	57.50	2.4	0	0	0.40	0	443	498	558	768	970	14.9	0.7	7.00
4071700	58.00	2.4	0	0	0.40	0	436	478	524	689	851	12.4	0.7	7.50
4080800	73.00	2.4	0	0	0.40	0	1324	1361	1398	1533	1664	8.7	0.4	22.50
4080900	74.00	2.8	0	0	0.40	0	1372	1409	1442	1572	1697	8.7	0.4	23.50
4080930	74.50	3.0	0	0	0.40	0	1400	1433	1465	1585	1700	8.0	0.2	24.00
4081030	75.50	3.0	0	0	0.40	0	1236	1259	1281	1363	1443	10.0	0.4	25.00
4081200	77.00	3.0	0	0	0.24	0	1207	1220	1236	1291	1343	3.7	0.2	26.50
4091000	78.50	3.0	0	0	0.24	0	767	792	812	892	969	5.8	0.4	28.00
4091100	79.50	2.8	0	0	0.24	0	925	944	963	1033	1100	5.0	0.4	29.00
4091200	80.50	2.8	0	0	0.24	0	1023	1041	1059	1123	1190	4.8	0.4	30.00
4091240	81.00	3.0	0	0	0.24	0	1122	1138	1158	1213	1285	4.7	0.4	30.50
4111100	83.50	2.8	0	0	0.40	0	4	93	140	296	447	10.7	1.0	33.00
4111200	84.50	2.5	0	0	0.40	0	0	187	149	302	449	10.9	0.9	34.00

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Ninik

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Ninik1 mm	Ninik2 mm	Ninik3 mm	Ninik4 mm	Ninik5 mm	Ninik6 mm	Rate m/h	Effl NTU	Run h
4111400	86.50	2.5	0	0	0.40	0	104	142	185	338	485	10.6	0.9	36.00
4111500	87.50	2.5	0	0	0.40	0	5	162	206	366	516	11.2	0.7	37.00
4120930	106.50	2.0	0	0	0.40	0	1	1173	1216	1375	1524	10.4	0.9	55.50
4121030	107.50	2.0	0	0	0.40	0	2	1004	1034	1142	1246	7.5	0.8	56.50
4121200	109.00	2.2	0	0	0.40	0	1	1124	1149	1247	1340	6.8	0.8	58.00
4141040	0.00	8.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141045	0.08	7.5	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141050	0.17	7.3	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141100	0.33	7.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141110	0.50	7.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141140	1.00	7.2	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141415	3.58	5.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141420	3.67	4.5	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141425	3.75	4.7	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141435	3.92	4.2	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141445	4.08	4.8	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141515	4.58	5.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4151400	11.00	10.0	0	0	0.24	0	520	520	520	520	520	8.7	7.5	0.00
4151405	11.08	11.0	0	0	0.24	0	1004	1004	1004	1004	1004	13.6	6.0	0.08
4151410	11.17	11.0	0	0	0.24	0	1226	1226	1226	1226	1226	17.6	6.5	0.17
4151420	11.33	11.0	0	0	0.24	0	1240	1240	1240	1240	1240	17.0	3.8	0.33
4151430	11.50	14.0	0	0	0.24	0	1235	1235	1235	1235	1235	16.4	1.6	0.50
4151500	12.00	14.0	0	0	0.24	0	1253	1253	1253	1253	1253	16.6	1.0	1.00
0	0.00	-1.0	0	0	0.00	0	0	0	0	0	0	0.0	-1.0	0.00

Page No. 1
06/22/88

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Yuke

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Yuke1 mm	Yuke2 mm	Yuke3 mm	Yuke4 mm	Yuke5 mm	Yuke6 mm	Rate m/h	Effl NTU	Run h
3211130	0.00	5.0	0	0	0.40	0	115	193	235	444	589	13.1	2.6	6.00
3211230	1.00	6.0	0	0	0.40	0	129	195	236	410	543	13.3	3.0	7.00
3211330	2.00	6.5	0	0	0.40	0	1646	1648	1668	1718	1753	12.8	2.8	8.00
3220930	2.00	5.0	0	0	0.40	0	1400	1426	1438	1534	1596	5.2	2.8	8.00
3220945	2.25	5.0	0	0	0.40	0	1452	1472	1489	1572	1630	5.5	3.0	8.25
3221030	2.50	5.0	0	0	0.40	0	1353	1371	1382	1438	1478	2.3	3.1	9.00
3221130	4.00	5.0	0	0	0.40	0	1415	1428	1438	1482	1513	3.5	2.8	10.00
3221300	5.50	5.0	0	0	0.40	0	1597	1612	1623	1670	1705	4.0	2.8	11.50
3221330	6.00	5.0	0	0	0.40	0	1578	1594	1602	1648	1678	3.7	2.8	12.00
3221400	6.50	5.0	0	0	0.40	0	1800	1800	1800	1800	1800	0.0	0.0	0.00
3231100	7.00	11.0	0	0	0.40	0	57	157	197	397	535	13.7	3.8	0.00
3231200	8.00	6.0	0	0	0.40	0	69	148	188	348	470	14.5	3.4	1.00
3231400	10.00	5.8	0	0	0.40	0	102	168	203	356	463	15.4	3.6	3.00
3231500	11.00	4.5	20	0	0.40	0	1486	1486	1486	1486	1486	14.5	3.0	4.00
3241200	11.50	5.0	20	0	0.40	0	133	198	230	381	483	13.8	2.2	5.00
3241300	13.00	4.5	20	0	0.40	0	178	270	310	500	608	14.1	2.4	6.00
3241400	14.00	4.5	20	0	0.40	0	207	318	360	568	678	14.1	2.1	7.00
3241500	15.00	4.5	20	0	0.40	0	218	335	378	585	687	11.6	2.0	8.00
3241600	16.00	4.5	20	0	0.40	0	235	353	388	575	660	11.0	2.0	9.00
3250830	32.50	4.2	0	0	0.40	0	508	627	674	923	1033	11.8	2.8	25.50
3250900	33.00	4.2	0	0	0.40	0	508	636	685	930	1038	11.6	2.5	26.00
3250930	33.50	4.2	0	0	0.40	0	524	642	692	930	1037	11.9	2.2	26.50
3251000	34.00	4.3	0	0	0.40	0	551	666	711	946	1053	10.3	2.4	27.00
3251200	36.00	4.6	0	0	0.40	0	592	692	732	932	1022	10.0	2.5	29.00
3251300	37.00	15.5	0	0	0.40	0	853	938	972	1164	1252	9.5	2.6	30.00
3251400	38.00	14.0	0	0	0.40	0	1123	1197	1225	1390	1465	9.5	2.6	31.00
3251430	38.50	13.0	0	0	0.40	0	1371	1438	1462	1608	1664	10.0	3.0	31.50
3260930	39.50	5.5	30	0	0.40	0	898	989	1019	1203	1275	7.3	3.0	32.50
3261000	40.00	5.5	30	0	0.40	0	1033	1113	1133	1271	1323	6.3	3.0	33.00
3261130	41.50	5.5	30	0	0.40	0	120	220	278	490	635	15.8	3.0	0.50
3261200	42.00	5.5	30	0	0.40	0	145	260	320	540	685	15.0	2.9	1.00
3261330	43.50	5.5	30	0	0.40	0	191	293	345	532	644	13.1	3.0	2.50
3280900	45.50	17.0	30	0	0.40	0	229	419	432	674	839	13.1	5.2	4.50
3281100	47.50	12.0	40	40	0.40	0	296	419	478	681	816	11.9	3.0	6.50
3281200	48.50	9.0	40	40	0.40	0	398	508	559	738	843	10.2	2.0	7.50
3281400	50.50	17.0	40	40	0.40	0	683	796	849	1076	1188	10.0	2.5	9.50
3281500	51.50	16.0	40	40	0.40	0	1800	1800	1800	1800	1800	0.0	0.0	0.00
3281530	52.00	16.0	40	40	0.40	0	100	200	265	500	652	13.1	2.6	0.00
4011000	1.00	6.0	0	0	0.40	0	209	315	362	582	725	11.6	2.0	1.00
4011100	2.00	12.0	0	0	0.40	0	248	330	372	542	665	11.3	1.8	2.00
4011200	3.00	7.5	20	0	0.40	0	360	434	475	635	745	11.9	1.6	3.00
4011300	4.00	10.0	20	0	0.40	0	500	603	646	828	942	11.1	0.5	4.00
4011430	5.50	12.0	20	0	0.40	0	635	747	792	1003	1120	10.9	0.7	5.50
4011500	6.00	95.0	20	0	0.40	0	823	943	973	1195	1310	10.9	2.4	6.00
4011515	6.25	100.0	20	0	0.40	0	687	769	807	995	1097	9.5	1.8	6.25
4011600	7.00	100.0	20	0	0.40	0	1017	1100	1140	1328	1432	9.5	2.0	7.00
4011615	7.25	95.0	20	0	0.40	0	893	964	1022	1197	1290	7.7	2.2	7.25
4011700	8.00	98.0	30	0	0.40	0	1178	1252	1319	1497	1583	7.9	3.0	8.00

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Yuke

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Yuke1 mm	Yuke2 mm	Yuke3 mm	Yuke4 mm	Yuke5 mm	Yuke6 mm	Rate m/h	Effl NTU	Run h
4011715	8.25	85.0	30	0	0.40	0	-50	0	56	312	499	14.9	2.8	0.00
4011800	9.00	92.0	30	0	0.40	0	326	397	453	718	923	13.7	2.2	0.50
4020745	9.25	74.0	40	0	0.40	0	287	340	385	572	753	12.7	5.5	1.00
4020900	10.50	77.0	0	0	0.40	0	459	510	553	747	928	12.4	5.3	2.00
4021000	11.50	54.0	0	0	0.40	0	600	647	707	924	1106	12.1	4.8	3.00
4021015	11.75	47.0	0	0	0.40	0	785	825	873	1081	1235	10.4	4.6	4.00
4021200	13.50	27.0	0	0	0.40	0	858	967	1003	1195	1295	9.7	4.0	5.00
4041230	14.50	3.5	20	0	0.40	0	65	115	147	300	397	10.0	1.0	6.00
4041330	15.50	3.5	20	0	0.40	0	106	156	186	340	435	9.7	0.4	7.00
4041430	16.50	3.0	20	0	0.40	0	166	216	246	398	494	10.0	0.5	8.00
4041600	18.00	4.0	20	0	0.40	0	243	297	327	477	575	9.5	0.3	9.50
4041630	18.50	3.5	20	0	0.40	0	261	315	345	497	595	9.5	0.3	10.00
4041700	19.00	3.5	20	0	0.40	0	285	340	368	523	620	9.5	0.3	10.50
4041710	19.00	3.5	20	0	0.40	0	302	360	392	555	655	10.7	0.3	10.50
4051000	19.00	3.0	20	0	0.40	0	245	310	343	519	630	10.4	0.7	10.50
4051100	20.00	2.7	20	0	0.40	0	284	334	360	499	587	8.7	0.7	11.50
4051200	21.00	3.0	20	0	0.40	0	325	375	402	540	627	8.7	0.2	12.50
4051400	23.00	3.0	20	0	0.40	0	402	452	479	618	706	8.7	0.7	14.50
4051500	24.00	2.7	20	0	0.40	0	442	494	524	665	754	8.7	0.3	15.50
4051545	24.75	2.8	20	0	0.40	0	458	510	540	682	771	8.7	0.5	16.25
4051630	25.50	2.8	20	0	0.40	0	1800	1800	1800	1800	1800	0.0	0.0	0.00
4061000	27.00	2.5	20	0	0.40	0	38	82	137	332	479	13.7	1.2	0.00
4061100	28.00	2.6	20	0	0.40	0	55	102	156	350	493	13.1	1.4	1.00
4061200	29.00	2.5	20	0	0.40	0	99	142	195	385	527	13.1	1.2	2.00
4061300	30.00	2.5	20	0	0.40	0	149	192	243	430	570	13.1	1.0	3.00
4061400	31.00	2.5	20	0	0.40	0	190	235	286	471	610	12.7	1.4	4.00
4061500	32.00	2.3	20	0	0.40	0	263	305	356	538	673	12.7	1.2	5.00
4061600	33.00	2.4	20	0	0.40	0	329	370	421	599	730	12.4	1.0	6.00
4061645	33.75	2.4	20	0	0.40	0	18	68	133	358	525	15.8	1.0	6.75
4061700	34.00	2.4	20	0	0.40	0	18	52	103	280	412	12.4	1.2	7.00
4070830	49.50	3.0	0	0	0.40	0	144	194	262	491	657	14.5	1.2	22.50
4070900	50.00	2.8	0	0	0.40	0	151	204	274	510	686	15.9	0.8	23.00
4071000	51.00	2.8	0	0	0.40	0	152	197	252	443	585	12.4	0.7	24.00
4071500	56.00	2.5	0	0	0.40	0	241	290	348	543	685	13.1	1.2	29.00
4071600	57.00	2.4	0	0	0.40	0	271	319	379	579	722	13.4	1.0	30.00
4071630	57.50	2.4	0	0	0.40	0	284	335	401	620	778	14.5	1.0	30.50
4071700	58.00	2.4	0	0	0.40	0	266	312	363	538	668	11.9	0.8	31.00
4080800	73.00	2.4	0	0	0.40	0	645	702	760	956	1099	12.4	1.0	46.00
4080900	74.00	2.8	0	0	0.40	0	629	688	747	944	1087	12.4	0.8	47.00
4080930	74.50	3.0	0	0	0.40	0	659	712	768	958	1091	12.4	0.3	47.50
4081030	75.50	3.0	0	0	0.40	0	608	651	696	844	952	10.0	1.0	48.50
4081200	77.00	3.0	0	0	0.24	0	631	677	714	902	952	9.3	0.3	50.00
4091000	78.50	3.0	0	0	0.24	0	370	411	453	591	693	9.5	0.6	51.50
4091100	79.50	2.8	0	0	0.24	0	499	537	576	707	805	9.0	0.6	52.50
4091200	80.50	2.8	0	0	0.24	0	602	640	679	810	905	9.2	0.6	53.50
4091240	81.00	3.0	0	0	0.24	0	645	691	735	888	997	10.4	0.8	54.00
4111100	83.50	2.8	0	0	0.40	0	34	104	145	232	382	9.6	1.2	57.00
4111200	84.50	2.5	0	0	0.40	0	46	121	164	310	417	9.8	0.9	58.00

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Filtration results filter Yuke

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Yuke1 mm	Yuke2 mm	Yuke3 mm	Yuke4 mm	Yuke5 mm	Yuke6 mm	Rate m/h	Effl NTU	Run h
4111400	86.50	2.5	0	0	0.40	0	78	159	204	352	460	10.4	1.0	60.00
4111500	87.50	2.5	0	0	0.40	0	93	177	222	373	485	10.2	1.0	61.00
4120930	106.50	2.0	0	0	0.40	0	1015	1107	1153	1314	1428	10.4	0.9	79.50
4121030	107.50	2.0	0	0	0.40	0	882	938	968	1065	1135	7.5	0.6	80.50
4121200	109.00	2.2	0	0	0.40	0	1009	1064	1091	1181	1245	6.0	1.0	82.00
4141040	0.00	8.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141045	0.08	7.5	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141050	0.17	7.3	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141100	0.33	7.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141110	0.50	7.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141140	1.00	7.2	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141415	3.58	5.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141420	3.67	4.5	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141425	3.75	4.7	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141435	3.92	4.2	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141445	4.08	4.8	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4141515	4.58	5.0	0	0	0.40	0	0	0	0	0	0	0.0	0.0	0.00
4151400	11.00	10.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151405	11.08	11.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151410	11.17	11.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151420	11.33	11.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151430	11.50	14.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
4151500	12.00	14.0	0	0	0.24	0	0	0	0	0	0	0.0	0.0	0.00
0	0.00	-1.0	0	0	0.00	0	0	0	0	0	0	0.0	-1.0	0.00

ANNEX IV

FILTERED WATER TURBIDITY

The following parameters are presented:

- Code	:	Date/Time
- Time	:	Time from start of filtration (h)
- Infl	:	Turbidity of river water (NTU)
- Alum	:	Alum dosing (mg/l)
- Soda	:	Soda ash dosing (mg/l)
- Effl	:	Filtered water turbidity mean of 4 filters (NTU)
- Infl	:	Average turbidity of raw water during constant alum dosing (NTU)
- Filtered water quality	:	Average turbidity of filtered water during constant alum dosing (NTU)
- Std infl	:	Standard deviation turbidity of raw water during constant alum dosing (NTU)
- Std effl	:	Standard deviation turbidity of filtered water during constant alum dosing (NTU)

Sukabumi Water Supply Project
Ciqunung Pilot Plant Research
Study on filtered water turbidity

Code	Time h	Influent NTU	Alum mg/l	Soda mg/l	Effluent NTU	Infl NTU	Filtered water quality NTU 0 mg/l	20 mg/l	30 mg/l	40 mg/l	Std.infl NTU	Std.effl NTU
3211130	0	5	0	0	3.1							
3211230	1	6	0	0	3							
3211330	2	6.5	0	0	3							
3220930	2	5	0	0	2.7							
3220945	2.25	5	0	0	2.8							
3221030	2.5	5	0	0	2.9							
3221130	4	5	0	0	2.8							
3221300	5.5	5	0	0	2.6							
3221330	6	5	0	0	2.6							
3221400	6.5	5	0	0	2.3							
3231100	7	11	0	0	3.9							
3231200	8	6	0	0	3.2							
3231400	10	5.8	0	0	3.2	5.792307	2.930769				1.586705	0.374955
3231500	11	4.5	20	0	2.8							
3241200	11.5	5	20	0	2.5							
3241300	13	4.5	20	0	2.3							
3241400	14	4.5	20	0	2.1							
3241500	15	4.5	20	0	1.9							
3241600	16	4.5	20	0	1.9	4.583333		2.25			0.186338	0.325320
3250830	32.5	4.2	0	0	2.6							
3250900	33	4.2	0	0	2.6							
3250930	33.5	4.2	0	0	2.3							
3251000	34	4.3	0	0	2.4							
3251200	36	4.6	0	0	2.4							
3251300	37	15.5	0	0	2.6							
3251400	38	14	0	0	2.7							
3251430	38.5	13	0	0	3.1	8	2.5875				4.819491	0.231503
3260930	39.5	5.5	30	0	2.8							
3261000	40	5.5	30	0	2.7							
3261130	41.5	5.5	30	0	2.8							
3261200	42	5.5	30	0	2.7							
3261330	43.5	5.5	30	0	2.9							
3280900	45.5	17	30	0	5	7.416666			3.15		4.285796	0.830160
3281100	47.5	12	40	40	2.8							
3281200	48.5	9	40	40	2.1							
3281400	50.5	17	40	40	2.3							
3281500	51.5	16	40	40	2.3							
3281530	52	16	40	40	2.4	14				2.38	3.033150	0.231516
4011000	1	6	0	0	1.8							
4011100	2	12	0	0	1.7	9	1.75				3	0.05
4011200	3	7.5	20	0	1.6							
4011300	4	10	20	0	0.9							
4011430	5.5	12	20	0	0.9	9.833333		1.133333			1.840893	0.329983
4011500	6	96	20	0	2.1							
4011515	6.25	100	20	0	2.1							
4011600	7	100	20	0	2.5							
4011615	7.25	95	20	0	2.4	97.75		2.275			2.277608	0.178535
4011700	8	98	30	0	2.6							
4011715	8.25	85	30	0	2.6							
4011800	9	92	30	0	2.5	91.66666			2.566666		5.312457	0.047140

Sukabumi Water Supply
Cigunung Pilot Plant Research
Study on filtered water turbidity

Code	Time h	Influent NTU	Alum mg/l	Soda mg/l	Effluent NTU	Infl NTU	Filtered water quality NTU 0 mg/l	20 mg/l	30 mg/l	40 mg/l	Std.infl NTU	Std.effl NTU
4020745	9.25	74	40	0	2.4	74				2.4	0	0.000000
4020900	10.5	77	9	0	5.7							
4021000	11.5	54	0	0	5.7							
4021015	11.75	47	0	0	5.3							
4021200	13.5	27	0	0	4.9	51.25	5.4				17.86381	0.331662
4041230	14.5	3.5	20	0	1.5							
4041330	15.5	3.5	20	0	0.6							
4041430	16.5	3	20	0	0.4							
4041600	18	4	20	0	0.7							
4041630	18.5	3.5	20	0	0.4							
4041700	19	3.5	20	0	0.5							
4041710	19	3.5	20	0	0.4							
4051000	19	3	20	0	0.7							
4051100	20	2.7	20	0	0.6							
4051200	21	3	20	0	0.3							
4051400	23	3	20	0	0.5							
4051500	24	2.7	20	0	0.4							
4051545	24.75	2.8	20	0	0.5							
4051630	25.5	2.8	20	0	0.7							
4061000	27	2.5	20	0	1							
4061100	28	2.6	20	0	1.3							
4061200	29	2.5	20	0	1							
4061300	30	2.5	20	0	1							
4061400	31	2.5	20	0	1.2							
4061500	32	2.3	20	0	1.1							
4061600	33	2.4	20	0	1							
4061645	33.75	2.4	20	0	1							
4061700	34	2.4	20	0	1.2	2.895652		0.782608			0.465765	0.337061
4070830	49.5	3	0	0	1.2							
4070900	50	2.8	0	0	1							
4071000	51	2.8	0	0	0.7							
4071500	56	2.5	0	0	0.8							
4071600	57	2.4	0	0	0.7							
4071630	57.5	2.4	0	0	0.8							
4071700	58	2.4	0	0	0.6							
4080800	73	2.4	0	0	0.7							
4080900	74	2.8	0	0	0.6							
4080930	74.5	3	0	0	0.4							
4081030	75.5	3	0	0	0.6							
4081200	77	3	0	0	0.4							
4091000	78.5	3	0	0	0.6							
4091100	79.5	2.8	0	0	0.6							
4091200	80.5	2.8	0	0	0.6							
4091240	81	3	0	0	2							
4111100	83.5	2.8	0	0	1							
4111200	84.5	2.5	0	0	0.8							
4111400	86.5	2.5	0	0	0.8							
4111500	87.5	2.5	0	0	0.8							
4120930	106.5	2	0	0	0.9							
4121030	107.5	2	0	0	0.7							
4121200	109	2.2	0	0	0.7	2.634782	0.782608				0.312922	0.315749

ANNEX V

LENGTH OF FILTER RUN

The following parameters are presented:

- Code	:	Date/time
- Time	:	Time from start of filtration (h)
- Infl	:	Turbidity of river water (NTU)
- Alum	:	Alum dosing (mg/l)
- Soda	:	Soda ash dosing (mg/l)
- Loss	:	Head loss in piping at 10.8 m/h (m)
- (Name)	:	Filtration velocity filter (Name) (m/h)
- Run	:	Time from start of filter run (h)
- Mean	:	Mean filtration velocity of 4 filters (m/h)
- Avg infl	:	Weighted average* of raw water turbidity during one filter run (NTU)
- Infl	:	Non-weighted average of raw water turbidity during one filter run (NTU)
- Length of filter run	:	Length of filter run during more or less constant alum dosing (h)

$$* \quad Avg = \frac{\sum_{1}^{n} ((Name) * infl)}{n}$$

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Study on length of filter run

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Rina m/h	Run h	Evie m/h	Run h	Ninik m/h	Run h	Yuke m/h	Run h	Mean m/h	Avg infl NTU	Infl NTU	Length of filter run: Alum 0 h	Alum 20 h	Alum 30 h	Alum 40 h
3211130	0	5	0	0	0.4	14.9	0	12.4	6	8.4	6	13.1	6	12.2						
3211230	1	6	0	0	0.4	15.8	1	12.1	7	8	7	13.3	7	12.3						
3211330	2	6.5	0	0	0.4	15.5	2	12	8	8.2	8	12.8	8	12.1						
3220930	2	5	0	0	0.4	8.6	2	15.9	0	1.4	8	5.2	8	7.8						
3220945	2.25	5	0	0	0.4	8.7	2.25	15.4	0.25	0	0	5.5	8.25	7.4						
3221030	2.5	5	0	0	0.4	6.9	2.5	14.1	1	16.8	1	2.3	9	10						
3221130	4	5	0	0	0.4	6.5	4	13.7	2	16.3	2	3.5	10	10						
3221300	5.5	5	0	0	0.4	7.2	5.5	14.3	3.5	17.4	3.5	4	11.5	10.7						
3221330	6	5	0	0	0.4	7	6	14.1	4	17.4	4	3.7	12	10.6						
3221400	6.5	5	0	0	0.4	7	6.5	16.3	4.5	16.4	4.5	0	0	9.9						
3231100	7	11	0	0	0.4	3.2	7	13.1	5	13.7	5	13.7	0	10.9						
3231200	8	6	0	0	0.4	2.8	8	12.7	6	13.7	6	14.5	1	10.9						
3231400	10	5.8	0	0	0.4	2.8	10	12.6	8	14.4	8	15.4	3	11.3						
3231500	11	4.5	20	0	0.4	2.9	11	12.7	9	14	9	14.5	4	11						
3241200	11.5	5	20	0	0.4	4	12	12.1	10	13.4	10	13.8	5	10.8						
3241300	13	4.5	20	0	0.4	4	13	12.4	11	13.1	11	14.1	6	10.9	5.5	5.58125	13			
3241400	14	4.5	20	0	0.4	0	0	12.8	12	13.1	12	14.1	7	10						
3241500	15	4.5	20	0	0.4	15.8	0	10.4	13	11.1	13	11.6	8	12.2						
3241600	16	4.5	20	0	0.4	15.6	1	10.5	14	10.8	14	11	9	12						
3250830	32.5	4.2	0	0	0.4	13.7	17.5	8.4	30.5	10	30.5	11.8	25.5	11						
3250900	33	4.2	0	0	0.4	13.4	18	8	31	9.5	31	11.6	26	10.6						
3250930	33.5	4.2	0	0	0.4	13.7	18.5	0	0	10	31.5	11.9	26.5	8.9						
3251000	34	4.3	0	0	0.4	11.4	19	15.4	0	8.2	32	10.3	27	11.3						
3251200	36	4.6	0	0	0.4	11.6	21	14.1	2	8	34	10	29	10.9						
3251300	37	15.5	0	0	0.4	11.1	22	14.5	3	8.7	35	9.5	30	10.9						
3251400	38	14	0	0	0.4	10.6	23	14.1	4	8.7	36	9.5	31	10.7	5.8	6.014285	36			
3251430	38.5	13	0	0	0.4	10	23.5	14.5	4.5	0	0	10	31.5	8.6						
3260930	39.5	5.5	30	0	0.4	7.7	24.5	11.3	5.5	13	0.5	7.3	32.5	9.8						
3261000	40	5.5	30	0	0.4	7.2	25	11.3	6	13.7	1	6.3	33	9.6	6.4	6.594736	33			
3261130	41.5	5.5	30	0	0.4	5.6	26.5	9.5	7.5	11.9	2.5	15.8	0.5	10.7						
3261200	42	5.5	30	0	0.4	0	0	9.5	8	11.6	3	15	1	9						
3261330	43.5	5.5	30	0	0.4	14	1	6.7	9.5	9.2	4.5	13.1	2.5	10.8						
3280900	45.5	17	30	0	0.4	14.5	3	6.9	11.5	9.4	6.5	13.1	4.5	11						
3281100	47.5	12	40	40	0.4	13.5	5	13.7	0.5	7	8.5	11.9	6.5	11.5	7.5	8.071428			8.5	
3281200	48.5	9	40	40	0.4	12.7	6	13.1	1.5	14.2	0	10.2	7.5	12.6						
3281400	50.5	17	40	40	0.4	10.5	8	10.4	3.5	13.6	2	10	9.5	11.1	9.8	10.21428			9.5	
3281500	51.5	16	40	40	0.4	8.2	9	10.8	4.5	13	3	0	0	8						
3281530	52	16	40	40	0.4	7.3	9.5	9	5	10.4	3.5	13.1	0	10	12.7	13.21428				9.5
4011000	1	6	0	0	0.4	10.9	1	9.5	1	10.4	1	11.6	1	10.6						
4011100	2	12	0	0	0.4	10.9	2	9.5	2	10.9	2	11.3	2	10.6						
4011200	3	7.5	20	0	0.4	10.9	3	10	3	11.1	3	11.9	3	11						
4011300	4	10	20	0	0.4	11.1	4	10.4	4	10.9	4	11.1	4	10.9						
4011430	5.5	12	20	0	0.4	10.9	5.5	10.4	5.5	10.4	5.5	10.9	5.5	10.7						
4011500	6	96	20	0	0.4	10.9	6	10	6	10.4	6	10.9	6	10.5						
4011515	6.25	100	20	0	0.4	9.7	6.25	13.7	0	7.5	6.25	9.5	6.25	10.1						
4011600	7	100	20	0	0.4	10	7	13.4	0.5	7.3	7	9.5	7	10.1	36.3	33.45833			7	
4011615	7.25	95	20	0	0.4	8.3	7.25	11.3	0.75	15.1	0	7.7	7.25	10.6						
4011700	8	98	20	0	0.4	8.5	8	11.3	1.5	14.7	0.5	7.9	8	10.6	44.6	50.22727		8		
4011715	8.25	85	20	0	0.4	6.5	8.25	9.7	1.75	11.6	0.75	14.9	0	10.7						
4011800	9	91	20	0	0.4	6.7	9	9.5	2.5	11.9	1.5	13.7	0.5	10.4	54.4	59.375		9		
4020745	9.25	74	0	0	0.4	15.1	0	6.9	2.75	8.6	1.75	12.7	1	10.8						
4020900	10.5	77	0	0	0.4	15.1	1	7.3	4	8.6	3	12.4	2	10.8						
4021000	11.5	54	0	0	0.4	14.9	6.6	6.5	5	8.8	4	12.1	3	10.6	88.8	86		5		
4021015	11.75	47	0	0	0.4	11.7	2	13.7	0	6.5	5	10.4	4	10.6	68.8	77.625	5			
4021200	13.5	27	0	0	0.4	9	4	10.9	1	13.7	0	9.7	5	10.8						

Code	Time h	Infl NTU	Alum mg/l	Soda mg/l	Loss m	Rina m/h	Run h	Evie m/h	Run h	Minik m/h	Run h	Yuke m/h	Run h	Mean m/h	Avg infl NTU	Infl NTU	Length of filter run — Alum 0 h	Alum 20 h	Alum 30 h	Alum 40 h
4041230	14.5	3.5	20	0	0.4	7.5	5	10.4	2	14.3	2	10	6	10.6						
4041330	15.5	3.5	20	0	0.4	8.2	6	11.3	3	15.8	2	9.7	7	11.2						
4041430	16.5	3	20	0	0.4	8.4	7	11.3	4	14.9	3	10	8	11.2						
4041600	18	4	20	0	0.4	8.2	8.5	11.3	5.5	14.5	4.5	9.5	9.5	10.9						
4041630	18.5	3.5	20	0	0.4	8.2	9	11.3	6	14.5	5	9.5	10	10.9						
4041700	19	3.5	20	0	0.4	8.2	9.5	11.3	6.5	14.5	5.5	9.5	10.5	10.9						
4041710	19	3.5	20	0	0.4	0	0	11.6	6.5	15	5.5	10.7	10.5	9.3						
4051000	19	3	20	0	0.4	0	0	12.4	6.5	15	5.5	10.4	10.5	9.4						
4051100	20	2.7	20	0	0.4	14.9	0.5	10	7.5	12.4	6.5	8.7	11.5	11.5						
4051200	21	3	20	0	0.4	14.9	1.5	9.8	8.5	12.4	7.5	8.7	12.5	11.4						
4051400	23	3	20	0	0.4	14.9	3.5	9.6	10.5	12.8	9.5	8.7	14.5	11.5						
4051500	24	2.7	20	0	0.4	14.9	4.5	9.5	11.5	11.9	10.5	8.7	15.5	11.2						
4051545	24.75	2.8	20	0	0.4	14.9	5.25	9.5	12.25	11.9	11.25	8.7	16.25	11.2	29.7	24.835		16.25		
4051630	25.5	2.8	20	0	0.4	16.3	6	10.4	13	12.4	12	0	0	9.8						
4061000	27	2.5	20	0	0.4	12.1	7.5	8.6	14.5	10.2	13.5	13.7	0	11.1						
4061100	28	2.6	20	0	0.4	12.7	8.5	8.2	15.5	10.2	14.5	13.1	1	11						
4061200	29	2.5	20	0	0.4	12.4	9.5	8	16.5	10	15.5	13.1	2	10.9						
4061300	30	2.5	20	0	0.4	12.7	10.5	8	17.5	10.2	16.5	13.1	3	11						
4061400	31	2.5	20	0	0.4	12.7	11.5	8	18.5	10	17.5	12.7	4	10.8						
4061500	32	2.3	20	0	0.4	12.4	12.5	8.2	19.5	10.4	18.5	12.7	5	10.9						
4061600	33	2.4	20	0	0.4	13.1	13.5	9.2	20.5	10.2	19.5	12.4	6	11	6.7	5.904347		20.5		
4061645	33.75	2.4	20	0	0.4	14.9	14.25	0	0	11.3	20.25	15.8	6.75	10.5						
4061700	34	2.4	20	0	0.4	10	14.5	14.1	0	8	20.5	12.4	7	11.1						
4070830	49.5	3	0	0	0.4	10.4	30	13.1	15.5	7.3	36	14.5	22.5	11.3	3.7	3.864		36		
4070900	50	2.8	0	0	0.4	11.1	30.5	13.1	16	0	0	15.9	23	10						
4071000	51	2.8	0	0	0.4	8.2	31.5	9.3	17	14.1	0.5	12.4	24	11						
4071500	56	2.5	0	0	0.4	8.6	36.5	8.6	22	14.1	5.5	13.1	29	11.1						
4071600	57	2.4	0	0	0.4	8.6	37.5	8.6	23	14.1	6.5	13.4	30	11.2	2.6	2.63		37.5		
4071630	57.5	2.4	0	0	0.4	0	0	9.8	23.5	14.9	7	14.5	30.5	9.8						
4071700	58	2.4	0	0	0.4	14.5	0.5	7.3	24	12.4	7.5	11.9	31	11.5						
4080800	73	2.4	0	0	0.4	8.2	15.5	2.2	39	8.7	22.5	12.4	46	7.9	2.6	2.566666	39			
4080900	74	2.8	0	0	0.4	8.2	16.5	0	0	8.7	23.5	12.4	47	7.3						
4080930	74.5	3	0	0	0.4	7.3	17	16.3	0.5	8	24	12.4	47.5	11	2.6	2.65	17			
4081030	75.5	3	0	0	0.4	14.9	0	14.[illegible]	1.5	10	25	10	48.5	12.2						
4091200	77	3	0	0	0.24	16.3	1.5	15.4	3	3.7	26.5	9.3	50	11.2						
4091000	78.5	3	0	0	0.24	14.1	3	14.1	4.5	5.8	28	9.5	51.5	10.9						
4091100	79.5	2.8	0	0	0.24	14.9	4	14.5	5.5	5	29	9	52.5	10.8						
4091200	80.5	2.8	0	0	0.24	15.8	5	14.5	6.5	4.8	30	9.2	53.5	11.1						
4091240	81	3	0	0	0.24	18	5.5	16.8	7	4.7	30.5	10.4	54	12.5						
4111100	83.5	2.8	0	0	0.4	11.3	8	10.9	9.5	10.7	33	9.6	57	10.6						
4111200	84.5	2.5	0	0	0.4	10.4	9	10.6	10.5	10.9	34	9.8	58	10.4						
4111400	86.5	2.5	0	0	0.4	10.9	11	10.6	12.5	10.6	36	10.4	60	10.6						
4111500	87.5	2.5	0	0	0.4	10.9	12	10.4	13.5	11.2	37	10.2	61	10.7						
4120930	106.5	2	0	0	0.4	7.7	30.5	9	32	10.4	55.5	10.4	79.5	9.4	~~2.8~~	2.710181	30.5			
4121030	107.5	2	0	0	0.4	18	0.5	5.2	33	7.5	56.5	7.5	80.5	9.6						
4121200	109	2.2	0	0	0.4	16.3	2	4.4	34.5	6.8	58	6	82	8.4						

ANNEX VI

MAXIMUM VELOCITIES

The following parameters are presented:

- Code : Date/time
- Time : Time from start of filtration (h)
- (Name) : Filtration velocity filter (Name) (m/h)
- Run( ) : Time from start of filter run (h)
- Mean : Mean filtration velocity of 4 filters (m/h)
- Max : Maximum filtration velocity (m/h)
- Mean : Mean filtration velocity (m/h)
- Backwash: Filtration velocity during backwashing (m/h)
- Max : Maximum filtration velocity during backwashing (m/h)
- Mean : Mean filtration velocity during backwashing (m/h)
- Ratio : Ratio between maximum and mean filtration velocity (-)

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Study on declining rate filtration
Maximum velocities

Code	3211130	3211230	3211330	3220930	3220945	3221030	3221130	3221300	3221330	3221400	3231100	3231200	3231400
Time	0	1	2	2	2.25	2.5	4	5.5	6	6.5	7	8	10
Rina	14.9	15.8	15.5	8.6	8.7	6.9	6.5	7.2	7	7	3.2	2.8	2.8
RunR	0	1	2	2	2.25	2.5	4	5.5	6	6.5	7	8	10
Evie	12.4	12.1	12	15.9	15.4	14.1	13.7	14.3	14.1	16.3	13.1	12.7	12.6
RunE	6	7	8	0	0.25	1	2	3.5	4	4.5	5	6	8
Ninik	8.4	8	8.2	1.4	0	16.8	16.3	17.4	17.4	16.4	13.7	13.7	14.4
RunN	6	7	8	8	0	1	2	3.5	4	4.5	5	6	8
Yuke	13.1	13.3	12.8	5.2	5.5	2.3	3.5	4	3.7	0	13.7	14.5	15.4
RunY	6	7	8	8	8.25	9	10	11.5	12	0	0	1	3
Mean	12.2	12.3	12.1	7.8	7.4	10	10	10.7	10.6	9.9	10.9	10.9	11.3
Min	8.4	8	8.2	1.4		2.3	3.5	4	3.7		3.2	2.8	2.8
	12.4	12.1	12	5.2		6.9	6.5	7.2	7		13.1	12.7	12.6
	13.1	13.3	12.8	8.6		14.1	13.7	14.3	14.1		13.7	13.7	14.4
Max	14.9	15.8	15.5	15.9		16.8	16.3	17.4	17.4		13.7	14.5	15.4
Mean	12.2	12.3	12.125	7.775		10.025	10	10.725	10.55		10.925	10.925	11.3
Backwash					0					0			
					5.5					7			
					8.7					16.3			
Max					15.4					16.4			
Mean					9.866666					13.23333			
Ratio	1.221311	1.284552	1.278350	2.045016	ERR	1.675810	1.63	1.622377	1.649289	ERR	1.254004	1.327231	1.362831

Code	3231500	3241200	3241300	3241400	3241500	3241600	3250830	3250900	3250930	3251000	3251200	3251300	3251400
Time	11	11.5	13	14	15	16	32.5	33	33.5	34	36	37	38
Rina	2.9	4	4	0	15.8	15.6	13.7	13.4	13.7	11.4	11.6	11.1	10.6
RunR	11	12	13	0	0	1	17.5	18	18.5	19	21	22	23
Evie	12.7	12.1	12.4	12.8	10.4	10.5	8.4	8	0	15.4	14.1	14.5	14.1
RunE	9	10	11	12	13	14	30.5	31	0	0	2	3	4
Ninik	14	13.4	13.1	13.1	11.1	10.8	10	9.5	10	8.2	8	8.7	8.7
RunN	9	10	11	12	13	14	30.5	31	31.5	32	34	35	36
Yuke	14.5	13.8	14.1	14.1	11.6	11	11.8	11.6	11.9	10.3	10	9.5	9.5
RunY	4	5	6	7	8	9	25.5	26	26.5	27	29	30	31
Mean	11	10.8	10.9	10	12.2	12	11	10.6	8.9	11.3	10.9	10.9	10.7
Min	2.9	4	4		10.4	10.5	8.4	8		8.2	8	8.7	8.7
	12.7	12.1	12.4		11.1	10.8	10	9.5		10.3	10	9.5	9.5
	14	13.4	13.1		11.6	11	11.8	11.6		11.4	11.6	11.1	10.6
Max	14.5	13.8	14.1		15.8	15.6	13.7	13.4		15.4	14.1	14.5	14.1
Mean	11.025	10.825	10.9		12.225	11.975	10.975	10.625		11.325	10.925	10.95	10.725
Backwash				0					0				
				12.8					10				
				13.1					11.9				
Max				14.1					13.7				
Mean				13.33333					11.86666				
Ratio	1.315192	1.274826	1.293577	ERR	1.292433	1.302713	1.248291	1.261176	ERR	1.359823	1.290617	1.324200	1.314685

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Study on declining rate filtration
Maximum velocities

Code	3251430	3260930	3261000	3261130	3261200	3261330	3280900	3281100	3281200	3281400	3281500	3281530	4011000
Time	38.5	39.5	40	41.5	42	43.5	45.5	47.5	48.5	50.5	51.5	52	1
Rina	10	7.7	7.2	5.6	0	14	14.5	13.5	12.7	10.5	8.2	7.3	10.9
RunR	23.5	24.5	25	26.5	0	1	3	5	6	8	9	9.5	1
Evie	14.5	11.3	11.3	9.5	9.5	6.7	6.9	13.7	13.1	10.4	10.8	9	9.5
RunE	4.5	5.5	6	7.5	8	9.5	11.5	0.5	1.5	3.5	4.5	5	1
Ninik	0	13	13.7	11.9	11.6	9.2	9.4	7	14.2	13.6	13	10.4	10.4
RunN	0	0.5	1	2.5	3	4.5	6.5	8.5	0	2	3	3.5	1
Yuke	10	7.3	6.3	15.8	15	13.1	13.1	11.9	10.2	10	0	13.1	11.6
RunY	31.5	32.5	33	0.5	1	2.5	4.5	6.5	7.5	9.5	0	0	1
Mean	8.6	9.8	9.6	10.7	9	10.8	11	11.5	12.6	11.1	8	10	10.6
Min		7.3	6.3	5.6		6.7	6.9	7	10.2	10		7.3	9.5
		7.7	7.2	9.5		9.2	9.4	11.9	12.7	10.4		9	10.4
		11.3	11.3	11.9		13.1	13.1	13.5	13.1	10.5		10.4	10.9
Max		13	13.7	15.8		14	14.5	13.7	14.2	13.6		13.1	11.6
Mean		9.825	9.625	10.7		10.75	10.975	11.525	12.55	11.125		9.95	10.6
Backwash	0				0						0		
	10				9.5						8.2		
	10				11.6						10.8		
Max	14.5				15						13		
Mean	11.5				12.03333						10.66666		
Ratio	ERR	1.323155	1.423376	1.476635	ERR	1.302325	1.321184	1.188720	1.131474	1.222471	ERR	1.316582	1.094339

Code	4011100	4011200	4011300	4011430	4011500	4011515	4011600	4011615	4011700	4011715	4011800	4020745	4020900
Time	2	3	4	5.5	6	6.25	7	7.25	8	8.25	9	9.25	10.5
Rina	10.9	10.9	11.1	10.9	10.9	9.7	10	8.3	8.5	6.5	6.7	15.1	15.1
RunR	2	3	4	5.5	6	6.25	7	7.25	8	8.25	9	0	1
Evie	9.5	10	10.4	10.4	10	13.7	13.4	11.3	11.3	9.7	9.5	6.9	7.3
RunE	2	3	4	5.5	6	0	0.5	0.75	1.5	1.75	2.5	2.75	4
Ninik	10.9	11.1	10.9	10.4	10.4	7.5	7.3	15.1	14.7	11.6	11.9	8.6	8.6
RunN	2	3	4	5.5	6	6.25	7	0	0.5	0.75	1.5	1.75	3
Yuke	11.3	11.9	11.1	10.9	10.9	9.5	9.5	7.7	7.9	14.9	13.7	12.7	12.4
RunY	2	3	4	5.5	6	6.25	7	7.25	8	0	0.5	1	2
Mean	10.6	11	10.9	10.7	10.5	10.1	10.1	10.6	10.6	10.7	10.4	10.8	10.8
Min	9.5	10	10.4	10.4	10	7.5	7.3	7.7	7.9	6.5	6.7	6.9	7.3
	10.9	10.9	10.9	10.4	10.4	9.5	9.5	8.3	8.5	9.7	9.5	8.6	8.6
	10.9	11.1	11.1	10.9	10.9	9.7	10	11.3	11.3	11.6	11.9	12.7	12.4
Max	11.3	11.9	11.1	10.9	10.9	13.7	13.4	15.1	14.7	14.9	13.7	15.1	15.1
Mean	10.65	10.975	10.875	10.65	10.55	10.1	10.05	10.6	10.6	10.675	10.45	10.825	10.85
Backwash													
Max													
Mean													
Ratio	1.061032	1.084282	1.020689	1.023474	1.033175	1.356435	1.333333	1.424528	1.386792	1.395784	1.311004	1.394919	1.391705

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Study on declining rate filtration
Maximum velocities

Code	4021000	4021015	4021200	4041230	4041330	4041430	4041600	4041630	4041700	4041710	4051000	4051100	4051200
Time	11.5	11.75	13.5	14.5	15.5	16.5	18	18.5	19	19	19	20	21
Rina	14.9	11.7	9	7.5	8.2	8.4	8.2	8.2	8.2	0	0	14.9	14.9
RunR	2	3	4	5	6	7	8.5	9	9.5	0	0	0.5	1.5
Evie	6.5	13.7	10.9	10.4	11.3	11.3	11.3	11.3	11.3	11.6	12.4	10	9.8
RunE	5	0	1	2	3	4	5.5	6	6.5	6.5	6.5	7.5	8.5
Ninik	8.8	6.5	13.7	14.5	15.8	14.9	14.5	14.5	14.5	15	15	12.4	12.4
RunN	4	5	0	2	2	3	4.5	5	5.5	5.5	5.5	6.5	7.5
Yuke	12.1	10.4	9.7	10	9.7	10	9.5	9.5	9.5	10.7	10.4	8.7	8.7
RunY	3	4	5	6	7	8	9.5	10	10.5	10.5	10.5	11.5	12.5
Mean	10.6	10.6	10.8	10.6	11.2	11.2	10.9	10.9	10.9	9.3	9.4	11.5	11.4
Min	6.5	6.5	9	7.5	8.2	8.4	8.2	8.2	8.2			8.7	8.7
	8.8	10.4	9.7	10	9.7	10	9.5	9.5	9.5			10	9.8
	12.1	11.7	10.9	10.4	11.3	11.3	11.3	11.3	11.3			12.4	12.4
Max	14.9	13.7	13.7	14.5	15.8	14.9	14.5	14.5	14.5			14.9	14.9
Mean	10.575	10.575	10.825	10.6	11.25	11.15	10.875	10.875	10.875			11.5	11.45
Backwash										0	0		
										10.7	10.4		
										11.6	12.4		
Max										15	15		
Mean										12.43333	12.6		
Ratio	1.408983	1.295508	1.265588	1.367924	1.404444	1.336322	1.333333	1.333333	1.333333	ERR	ERR	1.295652	1.301310

Code	4051400	4051500	4051545	4051630	4061000	4061100	4061200	4061300	4061400	4061500	4061600	4061645	4061700
Time	23	24	24.75	25.5	27	28	29	30	31	32	33	33.75	34
Rina	14.9	14.9	14.9	16.3	12.1	12.7	12.4	12.7	12.7	12.4	13.1	14.9	10
RunR	3.5	4.5	5.25	6	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.25	14.5
Evie	9.6	9.5	9.5	10.4	8.6	8.2	8	8	8	8.2	8.2	0	14.1
RunE	10.5	11.5	12.25	13	14.5	15.5	16.5	17.5	18.5	19.5	20.5	0	0
Ninik	12.8	11.9	11.9	12.4	10.2	10.2	10	10.2	10	10.4	10.2	11.3	8
RunN	9.5	10.5	11.25	12	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.25	20.5
Yuke	8.7	8.7	8.7	0	13.7	13.1	13.1	13.1	12.7	12.7	12.4	15.8	12.4
RunY	14.5	15.5	16.25	0	0	1	2	3	4	5	6	6.75	7
Mean	11.5	11.2	11.2	9.8	11.1	11	10.9	11	10.8	10.9	11	10.5	11.1
Min	8.7	8.7	8.7		8.6	8.2	8	8	8	8.2	8.2		8
	9.6	9.5	9.5		10.2	10.2	10	10.2	10	10.4	10.2		10
	12.8	11.9	11.9		12.1	12.7	12.4	12.7	12.7	12.4	12.4		12.4
Max	14.9	14.9	14.9		13.7	13.1	13.1	13.1	12.7	12.7	13.1		14.1
Mean	11.5	11.25	11.25		11.15	11.05	10.875	11	10.85	10.925	10.975		11.125
Backwash				0								0	
				10.4								11.3	
				12.4								14.9	
Max				16.3								15.8	
Mean				13.03333								14	
Ratio	1.295652	1.324444	1.324444	ERR	1.228699	1.185520	1.204597	1.190909	1.170506	1.162471	1.193621	ERR	1.267415

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Study on declining rate filtration
— Maximum velocities

Code	4070830	4070900	4071000	4071500	4071600	4071630	4071700	4080800	4080900	4080930	4081030	4081200	4091000
Time	49.5	50	51	56	57	57.5	58	73	74	74.5	75.5	77	78.5
Rina	10.4	11.1	8.2	8.6	8.6	0	14.5	8.2	8.2	7.3	14.9	16.3	14.1
RunR	30	30.5	31.5	36.5	37.5	0	0.5	15.5	16.5	17	0	1.5	3
Evie	13.1	13.1	9.3	8.6	8.6	9.8	7.3	2.2	0	16.3	14.1	15.4	14.1
RunE	15.5	16	17	22	23	23.5	24	39	0	0.5	1.5	3	4.5
Ninik	7.3	0	14.1	14.1	14.1	14.9	12.4	8.7	8.7	8	10	3.7	5.8
RunN	36	0	0.5	5.5	6.5	7	7.5	22.5	23.5	24	25	26.5	28
Yuke	14.5	15.9	12.4	13.1	13.4	14.5	11.9	12.4	12.4	12.4	10	9.3	9.5
RunY	22.5	23	24	29	30	30.5	31	46	47	47.5	48.5	50	51.5
Mean	11.3	10	11	11.1	11.2	9.8	11.5	7.9	7.3	11	12.2	11.2	10.9
Min	7.3		8.2	8.6	8.6		7.3	2.2		7.3	10	3.7	5.8
	10.4		9.3	8.6	8.6		11.9	8.2		8	10	9.3	9.5
	13.1		12.4	13.1	13.4		12.4	8.7		12.4	14.1	15.4	14.1
Max	14.5		14.1	14.1	14.1		14.5	12.4		16.3	14.9	16.3	14.1
Mean	11.325		11	11.1	11.175		11.525	7.875		11	12.25	11.175	10.875
Backwash		0				0			0				
		11.1				9.8			8.2				
		13.1				14.5			8.7				
Max		15.9				14.9			12.4				
Mean		13.36666				13.06666			9.766666				
Ratio	1.280353	ERR	1.281818	1.270270	1.261744	ERR	1.258134	1.574603	ERR	1.481818	1.216326	1.458612	1.296551

Code	4091100	4091200	4091240	4111100	4111200	4111400	4111500	4120930	4121030	4121200	Average	Stddev	Maximum
Time	79.5	80.5	81	83.5	84.5	86.5	87.5	106.5	107.5	109			
Rina	14.9	15.8	18	11.3	10.4	10.9	10.9	7.7	18	16.3			
RunR	4	5	5.5	8	9	11	12	30.5	0.5	2			
Evie	14.5	14.5	16.8	10.9	10.6	10.6	10.4	9	5.2	4.4			
RunE	5.5	6.5	7	9.5	10.5	12.5	13.5	32	33	34.5			
Ninik	5	4.8	4.7	10.7	10.9	10.6	11.2	10.4	7.5	6.8			
RunN	29	30	30.5	33	34	36	37	55.5	56.5	58			
Yuke	9	9.2	10.4	9.6	9.8	10.4	10.2	10.4	7.5	6			
RunY	52.5	53.5	54	57	58	60	61	79.5	80.5	82			
Mean	10.8	11.1	12.5	10.6	10.4	10.6	10.7	9.4	9.6	8.4			
Min	5	4.8	4.7	9.6	9.8	10.4	10.2	7.7	5.2	4.4	7.3	2.2	
	9	9.2	10.4	10.7	10.4	10.6	10.4	9	7.5	6	9.8	1.5	
	14.5	14.5	16.8	10.9	10.6	10.6	10.9	10.4	7.5	6.8	12	1.6	
Max	14.9	15.8	18	11.3	10.9	10.9	11.2	10.4	18	16.3	14.2	1.6	18
Mean	10.85	11.075	12.475	10.625	10.425	10.625	10.675	9.375	9.55	8.375	10.825	0.8	
Backwash											0	0	
											9.6	1.8	
											12.1	2.1	
Max											14.8	1.1	
Mean											12.19761	1.3	
Ratio	1.373271	1.426636	1.442885	1.063529	1.045563	1.025882	1.049180	1.109333	1.884816	1.946268			

ANNEX VII

IMPACT ON PH BY CHEMICALS

The following parameters are presented:

- Alum	:	Alum dosing
- Soda	:	Soda ash dosing
- 4 NTU pH units	:	pH at turbidity 4 NTU
- 20 NTU pH units	:	pH at turbidity 20 NTU

Sukabumi Water Supply Project
Cigunung Pilot Plant Research
Impact on pH by chemical dosing

- Raw water turbidity 4 NTU resp 20 NTU

Alum mg/l	4 NTU pH units	20 NTU pH units
0	6	6
10	6	6
20	5.8	6
50	5.6	5.7
100	5.3	5.4
Soda mg/l		
0	6	6
10	6	6
20	6.2	6.2
50	6.5	6.5
100	7	7

ANNEX VIII

DIRECT FILTRATION

1. Introduction

Direct filtration is an attractive alternative for conventional treatment in case a suitable raw water quality is present. The chief advantage of direct filtration is the potential for capital cost savings up to 30 per cent under favorable conditions. This results from the elimination of sludge-collecting equipment, settling basin structures, flocculation equipment, and flocculation-basin structures. This cost reduction may make possible the provision of needed filtration for some communities that could not otherwise afford it.
With direct filtration there may also be a savings of 10-30 per cent in chemical costs, because generally less alum is required to produce a filtrable floc than to produce a settleable floc. The costs for polymer may be greater than in conventional plants, but these higher costs are more than offset by the lower costs for coagulant.
Operation and maintenance costs are reduced because there is less equipment to operate and maintain.
Direct filtration produces less sludge than conventional treatment, and the sludge is more dense. The collection of waste solids is simplified. Waste solids are all contained in a single stream, the waste filter-backwash water.

Filter runs are generally shorter in direct filtration than in filtration preceded by settling. The cost consequences of this are not significant, but the ability to handle suspended solids in direct filtration is limited. There is a point where operating difficulties are such that it would be better to reduce the load to the filters by introducing settling into the process chain.

2. Raw water quality

In general, raw water considered suitable for direct filtration is of the following quality (1, 2):

- suspended solids loads below 20-40 mg/l, average turbidity and color each should be < 25 units, the maximum turbidity should be < 250 NTU, the maximum color should be < 100 Hazen units
- iron and manganese should be < 0.3 and < 0.05 mg/l respectively
- algae counts (especially diatoms) should be < 1000 asu/ml

Before recommending direct filtration as a viable alternative, it is necessary to evaluate water quality records and climatological data.

Some general considerations are:
- are turbidity producing storms seasonal and do they coincide with maximum water demands
- what effect, if any, does seasonal turnover of the raw water source have on raw water quality
- what is the duration of periods with high turbidity
- what is the likelyhood of algae growths

3. PROCESS DESIGN AND OPERATIONS

The rapid mixing process for direct filtration usually does not differ from that for conventional plants. A hydraulic jump (for instance in a Parshall flume or a waterfall) may be used, and field experience in direct filtration plants has been good with this type of mixing device. Some engineers extend the time for mechanical rapid mixing in direct filtration plants up to as much as 5 min., which is longer than that used in most conventional plants.

If settling is omitted from the plant-flow sheet, as in a direct filtration plant, and if a properly designed rapid mix is provided, then there is no reason to include flocculation in the direct filtration process. Rather than spending money on flocculation, improvement of the rapid mixing, provision of finer filter media, or increase of the depth of fine filter media may be better.

3.1. Filter media and filtration rate

Filtration rates in direct filtration vary from 6 m/h to 22 m/h. For economic design and optimum length of filterrun velocities of 10-12.5 m/h are normally selected.
Generally two media types have proven to be succesfull:

- Coarse monomedium deep-bed filters (2, 3)
  layer = 1.2-2.4 m sand; deff = 1.6-2 mm; velocity = 10-22 m/h.
  Storage of impurities is provided by the deeper sand-layer applied. Breakthrough will not occur when the raw water is low in turbidity (less than 10 NTU). The large diameter requires great backwash velocities.

- Dual media filters.
  anthracite layer = 800 mm; deff = 1.1 mm à 1.75 mm;
  sand layer = 400 mm; deff = 0.5 mm à 0.8 mm
  velocity = 10-16 m/h.
  Anthracite layers with an effective size of deff = 0.8 mm or less will result in short filterruns and are more subject to algae blinding (1). The combination of anthracite (deff = 1.1 mm) and sand (deff = 0.5 mm) has in many cases proven to be effective. Coarser material and deeper layers may be selected depending on raw water quality and type of coagulant applied.

ANNEX VIII

DIRECT FILTRATION

1. Introduction

Direct filtration is an attractive alternative for conventional treatment in case a suitable raw water quality is present. The chief advantage of direct filtration is the potential for capital cost savings up to 30 per cent under favorable conditions. This results from the elimination of sludge-collecting equipment, settling basin structures, flocculation equipment, and flocculation-basin structures. This cost reduction may make possible the provision of needed filtration for some communities that could not otherwise afford it.
With direct filtration there may also be a savings of 10-30 per cent in chemical costs, because generally less alum is required to produce a filtrable floc than to produce a settleable floc. The costs for polymer may be greater than in conventional plants, but these higher costs are more than offset by the lower costs for coagulant.
Operation and maintenance costs are reduced because there is less equipment to operate and maintain.
Direct filtration produces less sludge than conventional treatment, and the sludge is more dense. The collection of waste solids is simplified. Waste solids are all contained in a single stream, the waste filter-backwash water.

Filter runs are generally shorter in direct filtration than in filtration preceded by settling. The cost consequences of this are not significant, but the ability to handle suspended solids in direct filtration is limited. There is a point where operating difficulties are such that it would be better to reduce the load to the filters by introducing settling into the process chain.

2. Raw water quality

In general, raw water considered suitable for direct filtration is of the following quality (1, 2):
- suspended solids loads below 20-40 mg/l, average turbidity and color each should be < 25 units, the maximum turbidity should be < 250 NTU, the maximum color should be < 100 Hazen units
- iron and manganese should be < 0.3 and < 0.05 mg/l respectively
- algae counts (especially diatoms) should be < 1000 asu/ml

Before recommending direct filtration as a viable alternative, it is necessary to evaluate water quality records and climatological data.

Some general considerations are:
- are turbidity producing storms seasonal and do they coincide with maximum water demands
- what effect, if any, does seasonal turnover of the raw water source have on raw water quality
- what is the duration of periods with high turbidity
- what is the likelyhood of algae growths

3. PROCESS DESIGN AND OPERATIONS

The rapid mixing process for direct filtration usually does not differ from that for conventional plants. A hydraulic jump (for instance in a Parshall flume or a waterfall) may be used, and field experience in direct filtration plants has been good with this type of mixing device. Some engineers extend the time for mechanical rapid mixing in direct filtration plants up to as much as 5 min., which is longer than that used in most conventional plants.

If settling is omitted from the plant-flow sheet, as in a direct filtration plant, and if a properly designed rapid mix is provided, then there is no reason to include flocculation in the direct filtration process. Rather than spending money on flocculation, improvement of the rapid mixing, provision of finer filter media, or increase of the depth of fine filter media may be better.

3.1. Filter media and filtration rate

Filtration rates in direct filtration vary from 6 m/h to 22 m/h. For economic design and optimum length of filterrun velocities of 10-12.5 m/h are normally selected.
Generally two media types have proven to be succesfull:

- Coarse monomedium deep-bed filters (2, 3)
  layer = 1.2-2.4 m sand; deff = 1.6-2 mm; velocity = 10-22 m/h.
  Storage of impurities is provided by the deeper sand-layer applied. Breakthrough will not occur when the raw water is low in turbidity (less than 10 NTU). The large diameter requires great backwash velocities.

- Dual media filters.
  anthracite layer = 800 mm; deff = 1.1 mm à 1.75 mm;
  sand layer = 400 mm; deff = 0.5 mm à 0.8 mm
  velocity = 10-16 m/h.
  Anthracite layers with an effective size of deff = 0.8 mm or less will result in short filterruns and are more subject to algae blinding (1). The combination of anthracite (deff = 1.1 mm) and sand (deff = 0.5 mm) has in many cases proven to be effective. Coarser material and deeper layers may be selected depending on raw water quality and type of coagulant applied.

Despite the generalizations given above, the different characteristics of various raw waters make it advisable if not essential, to conduct pilot plant work on each water to establish the most effective process.
The basic requirement in pilot testing of the direct filtration process is to determine:

- the design of the filter media that will remove the largest amount of solids during a filter run and obtain the longest filter run
- the design of the filter media that will permit operation to a maximum head loss before breakthrough occurs.

Of course, chemical conditioning is an important feature of these tests, since it can control the operation of the filter media.

3.2. Coagulants

alum

In direct filtration the alum dose has a significant influence on the length of run and filtrate quality. A conventional jar test dose produces short filter runs. The optimum alum dose for direct filtration is found to be 40 to 75 percent of jar test dose. This will result in a at least doubled filter run length.
Alum doses reported are:

- 5-10 mg/l alum for turbidities in 2-20 NTU range
- 10-35 mg/l alum for turbidities in 20-100 NTU range

Efficient filtration with alum is achieved with dual media filtration at a velocity of approximately 10 m/h and a sand layer up to 0.6 mm grain size.
The delay time between dosing of coagulant and contact filtration has no influence in filter performance in a range of 0-40 min. (2, 3). A flocculation stage can thus be omitted.

iron

Ferric chloride is reported to give better results than alum (2, 4). The optimal dose of $FeCl_3$ is less than the dose required for alum and filter runs are extended with 30% or more. In both cases an equal filtrate turbidity is obtained.

coagulant aid

Direct filtration with alum alone is not sufficient at high rates and coarse media. To prevent early break-through nonionic powder polymers are usually best as coagulant aid.
Dosages may range from 0.05 to 0.5 mg/l for turbidities from 2-200 NTU.

The lag time between dosing of coagulant and coagulant aid is reported to be critical. Craig (3) found an optimum of 6.5 sec. When the lag time was reduced to 4 sec. a finer floc was formed which resulted in a 40% decrease of through put because of break-through. Increasing the lag time to 10 sec. resulted in larger floc and subsequently shorter filter runs (35% decrease of throughput). For flexible operation several dosing points of coagulant aid have to be installed.

polyelectrolytes

Cationic polyelectrolytes as primary coagulant are efficient at high hydraulic loads (20 m/h) or high turbidity. In the first case they will prevent break-through whereas in the latter they produce less sludge compared to alum. Above an optimal dose of 15 mg/l alum the use of polyelectrolytes instead of alum is advantageous and extend filter runs significantly. Typical dosages are in the range of 0.1-5 mg/l.

For direct filtration. low to medium weight cationic polymers (molar weight 10.000-200.000) seem to perform best.
Optimal G-values are found to be (9, 10):

- G = 300 - 600 sec^{-1} (3 to 8 min.) for polymers 10.000-100.000
- G = 600 - 1000 sec^{-1} for polymers > 100.000 molar weight

The use of polyelectrolytes as a sole coagulant requires adequate backwashing (including air-scour) to prevent stickiness and formation of mud balls.
Polyelectrolytes are reported to give excellent results in color removal.

3.3. Others

filtration mode

Direct can be operated either as constant rate filtration or as declining rate filtration. With regard to the construction of filterboxes and appurtenances no modifications compared to conventional treatment filters have to be made.

Declining rate filters have higher initial filtration rates which may cause elevated initial turbidities. An initial rate of 150 percent of the mean rate is reported not to increase filtrate turbidity. Throughputs of the two modes are reported to be consistently similar over a range of 2-100 NTU raw water quality.

influence of temperature and pH

The optimum pH for direct filtration ranges from pH = 5 to pH = 7. Other pH values might result in elevated aluminium levels in the filtered water. Aluminium residuals will cause after-floc formation in reservoir or distribution network.
Lower temperatures may cause early break-through. Although Cleasby reported that performance was not impaired by water temperature as low as 2°C.

Direct filtration pilot studies

- Literature	Craig (3)	Bratby (2)	Cleasby (4)	Parmasivam (5)	Spink (6)	Foley (15)
- Filterdata						
coagulant	alum	$FeCl_3$	Alum	Alum	Alum	Alum
dose (mg/l)	10-35	5.5	5-10		3-15	20
polyelectrolyte			cat. poly			NP 10
dose (mg/l)			0.1-1.5			0.1
first layer	anthr.	sand	anthr.	sand	anthr.	filter coal
deff (mm)	1.75	2.4	1.54	0.55	0.6-0.7	1.55
unif. coeff (-)	1.2	1.1	1.18	1.6	1.75	
depth (mm)	780	900	400	700	500	
second layer	silica sand		sand		sand	
deff (mm)	0.77		0.43		0.45-0.5	
unif. coeff (-)	1.4		1.53		1.50	
depth (mm)	370		300		250	
run length (h)	26-30	11	30		80	18-24
velocity (m/h)	10	10	11		12	7
headloss (m)		2.0	1.86			2.4
- Quality data						
influent						
turbidity (NTU)						
. average	10-20	< 5	8		1-3	40-50
. range	0-110	0-20		13-54		
colour	25-30 cu	25 units				
effluent						
turbidity (NTU)	0.5	0.32	0.28	< 1	< 0.1	< 0.3
colour	< 5 cu					
- Backwash procedure						
air	1.5 min. 45 m/h	3 min. 60/90 m/h				
air/water	1.5 min.					
. air	20 m/h					
. water	25 m/h					
water	5 min. 60 m/h	4 min. 150 m/h		3-4 min.		

Literature

1. AWWA filtration committee
The status of direct filtration
JAWWA, july 1980, pp 405-411

2. J.R. Bratby
Optimizing direct filtration in Brasilia
JAWWA, july 1986, pp 106-115

3. K. Craig
Direct filtration: An Australian study
JAWWA, december 1985, pp 56-61

4. J.L. Cleasby et al.
Slow sand and direct in-line filtration of a surface water
JAWWA, december 1984, pp 44-54

5. R. Paramasivam et al.
Comparative studies on constant rate versus declining rate control system for direct filtration of turbid waters
Journal of the IWWA, july-sept. 1985, pp 235-242

6. C.M. Spink, J.T. Monscvitz
Design and operation of a 200 MGD Direct filtration facility
JAWWA, february 1974, pp 127-133

7. R.G. Tredgett
Direct-filtration studies for metropolitan Toronto
JAWWA, february 1974, pp 103-108

8. A. Adin, M. Rebhun
High-rate contact flocculation-filtration with cationic polyelectrolytes
JAWWA, february 1974, pp 109-117

9. H. Yeh, M.M. Ghosh
Selecting polymers for direct filtration
JAWWA, april 1981, pp 211-217

10. V.L. Stump, J.T. Novak
Polyelectrolyte selection for direct filtration
JAWWA, june 1979, pp 338-343

11. R.D. Letterman, R.R. Sama, E.J. Didomenico
Direct filtration using polyelectrolyte coagulants
JAWWA, june 1979, pp 332-337

12. K.E. Carns, J.D. Parker
Using polymers with direct filtration
JAWWA, march 1985, pp 44-49

13. D.L. Peterson
Direct filtration of lake Superior water
AWWA 1979, Annual conference

14. C.H. Tate, R.R. Trussell
Recent developments in direct filtration
AWWA 1979, Annual conference

15. P.D. Foley
Direct filtration in Ontario
AWWA 1979, Annual conference

16. G.P. Westerhoff et al.
Plant scale comparison of direct filtration vs standard treatment of lake Erie water
AWWA 1979, Annual conference

WN/GvH/C-3590/86