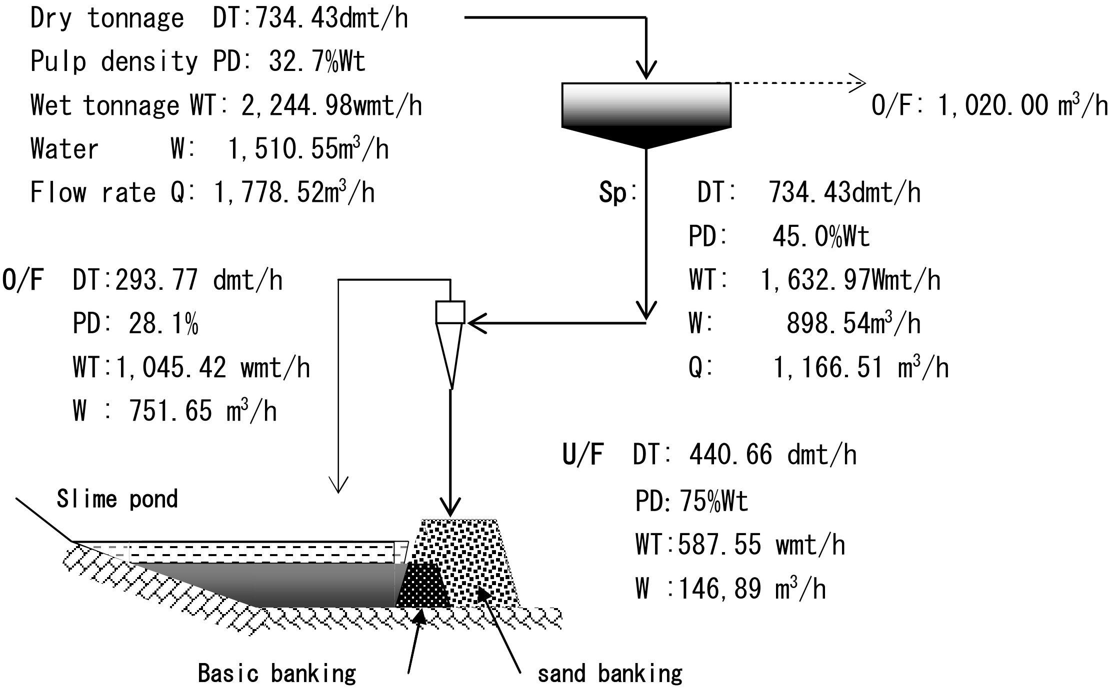
13. Tailing disposal

13-1. Tailing thickener

13-1-1. Design concept

1] Material balance

Dry tonnage DT: 734.43dmt/h
Pulp density PD: 32.7%Wt
Wet tonnage WT: 2,244.98wmt/h
Water W: 1,510.55m^3/h
Flow rate Q: 1,778.52m^3/h



2] Design concept

[1] **Number**: It might be better to be one set if possible, because it is rather difficult to obtain proper installation area and feed distribution may be unequal for plural units. We consulted with SANKI Engineering Co. Ltd which was in close association with Dorr at that time and received good answer that thickener larger than the biggest 333 ft≒100mϕ could be available.

[2] **Structure**: The tailing thickener should be center post type with double slope rake arms having light structure and less required power. Bottom of the thickener should be made by tamped clay which had experienced in coal mines already at that time. So concrete should be not applied except near center post and around wall.

13-1-2. Calculation of required dimensions

1] **Required water area A**:

The required area A is given by the following equation.

$$A = \frac{Q}{V\alpha} \qquad [m^2]$$

where Q: Flow rate of up flow in the thickener [m^3/h]
V: settling velocity [m/h]

α : Factor

The settling velocity V was determined as 0.25m/h in the laboratory tests, since V, however, may be variable by reasons of variations in ore characteristics, pulp densities, temperatures etc., the factor should be 0.6 for safety against serpentinized ore.

Then　$A = Q/v = 1,304.75 m^3/h \div (0.25 m/h \times 0.6) = 8,698.33 m^2$

So, thickener diameter can be given

$$D = \sqrt{\frac{4A}{\pi}}$$

Hence　$D = \sqrt{\frac{4 \times 8,698.33}{3.14}} = 105.26\ m\phi \rightarrow 106.0 m$

On thickener depth, slope of rake arms, rake revolutionary speed and installed motor power, we accepted values recommended by the manufacturer.

13-2. Tailing transportation piping

13-2-1. Calculation of required pipe diameter

Since design and construction were exerted by mechanical division of construction department, only calculations for confirmation will be described here.

1] Averaging velocity

$$V = Q/\pi r^2$$

where　Q: pulp flow rate　$1,166.51\ m^3/h \div 3,600\ sec/h = 0.324\ m^3/sec$

r: Pipe inner radius　$0.478/2 = 0.239\ m$

π: the circular constant

Then　$v = 0.324\ m^3/sec \div (3.14 \times 0.239^2) = 1.806\ m/sec$

This value is bigger than critical flow velocity 0.83 m/sec, so there will be no clogging problem due to particle sedimentation. Besides that, this value is smaller than 3.0 m/sec practically, which is boundary velocity of severe wearing so that this velocity is appropriate.

2] Friction loss

Calculation of friction loss after Darcy's formula

$$hs = f \cdot \frac{L \cdot V^2}{D \cdot 2g}$$

Where

hs	: friction head loss	[m]
L	: pipe length	[m]
D	: inside pipe diameter	[m]
V	: averaging velocity	[m/sec]
g	: gravitational acceleration	[m/sec^2]

f : friction loss coefficient

Then

$$hs = 0.02 \times \frac{100 \times 1.806^2}{0.478 \times 2 \times 9.8} = 0.69\ m$$

Since slope of steel piping is 5/100, head difference between 100 m equals 5m＞0.69m.

So clogging due to head loss will be not realized. Hence tailing slurry should be transported by natural gravity flow.

13-2-2. Piping for sharp slope

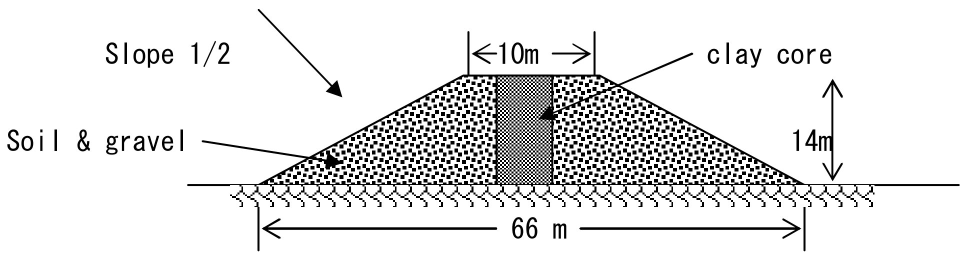
Since 910 m of level difference between mine site and tailing dam can not be covered by pipe slope of 5/100, a few types of method trough, fish ladder etc. have been discussed except drop tank systems which were successfully experienced at the initial period of designing. From view point of costs, trough system was adopted consequently. The troughs were designed with slope of 1/6. The tailing slurry, however, flowed with much higher speed than that of plan, so that many problems such as spill out of trough, slurry leakage from breathing pipes and extraordinary quick wearing of trough liners had issued. So the system was changed to the drop tank system finally. The liner material was anti-corrosion and anti abrasive special steel developed by Nippon Steel Corporation for dredge of marine bottom. So we expected excellent performance of newly developed material. But wearing progressed with speed higher than ten times of planed life and no anti-wearing effect was found.

13-3. Banking facilities

13-3-1. Basic banking

1] Design concept

Since it is difficult to dispose cyclone over flow by cyclone under flow sand only at the start-up stage of operation, basic banking with 1,500m length should be constructed by soil and gravel dug by bull dozers in the dam site area.



Conceptual figure of basic banking on down stream side

Clay core should be inserted in the center of the banking to enhance water tightness.

2] Tailing disposal area

By original proposed disposal area of 3,700,000 m^2, the total tailing tonnage of whole life of the mine will be disposed.

Soil volume for banking : 850,000 m^3

Area for sand pile : 1,700,000 m^2

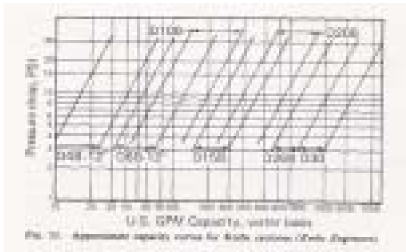
Area for slime pond : 2,000,000 m^2

Spill way (culvert) should be constructed on dam bottom to discharge top clear layer of the slime and flow in rain water.

13-3-2. Banking cyclones

1] Cyclone selection

After graph of Krebs Engineers, the capacity of D15B at pressure drop of 14 psi is 500 GPM =1,900 ℓ/min.



Based on this capacity and material balance described in section 13-1-1. Design concept, 1] required number of the cyclone N will be

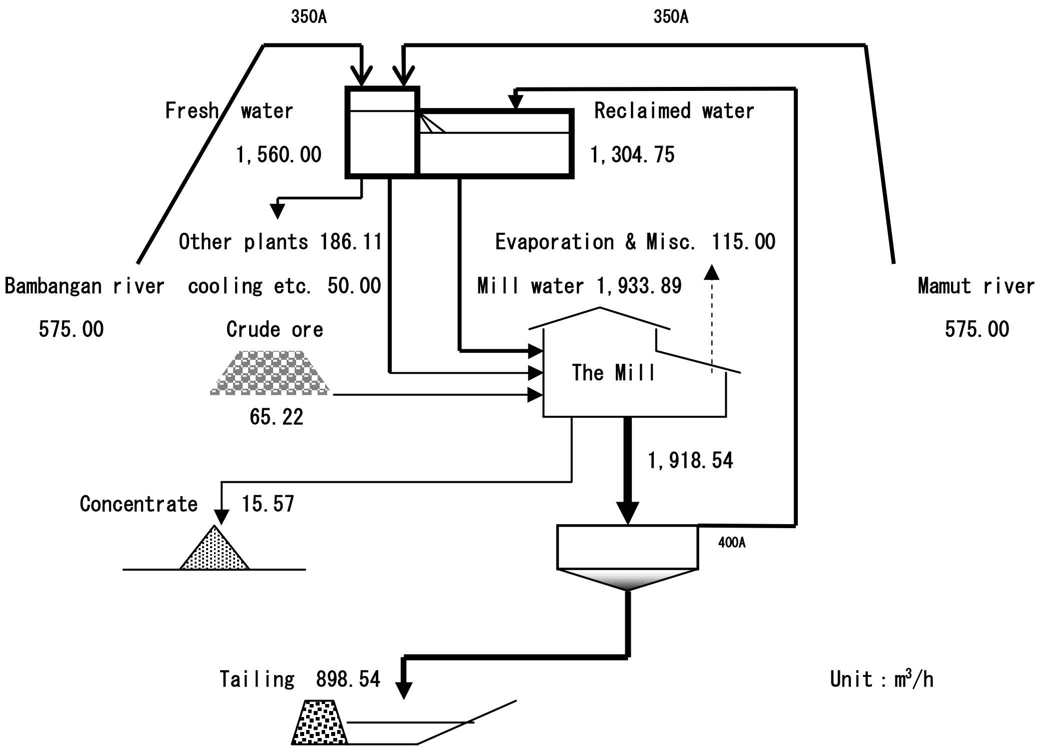
$$N = 1{,}166.51\ m^3/h / (1.90\ m^3/min \times 60\ min/h) = 10.2 \rightarrow 10\ sets.$$

Surplus units of the cyclone will be not necessary, because spigot density of the tailing thickener will be probably higher. Besides that, two lines of the cyclones will be installed actually running only one line, several sets will serve as stand-by.

14. Water facilities

14-1. Water program

1] Water balance



Flow-in : 575.00＋575.00＋65.22＝1,215.22 m^3/h

Flow-out : 186.11＋15.57＋898.54＋115.00＝1,215.22 m^3/h…OK

2]Design concept

Fresh water will be pumped up from both the Mamut River and the Bambangan River and cover whole demand of the mine except drinking water. Because of topography of rugged mountains in near district of the mine, there is no big river and seasonal fluctuation of flow rate between dry and rainy season and hourly change between fine and rainy weather are both extremely big. Survey of water flow rate, location of pump stations, planning of water taking-in will be very important to maintain stable water supply. Lack of the fresh water should be appropriated by recycled water as thickener over flow.

The ratio of fresh water to recycled water is 53% to 47%, respectively.

As the flow-out points, 10% of the fresh water should be estimated at miscellaneous losses including evaporation. A part of the fresh will be used for other office and plants except the mill, also for cooling, washing, solvent for slime milk at the mill. The rest will over flow into the recycle water tank. Hourly fluctuation of water demand will be big and especially the demand of other sections beside the mill will be expected to drop extremely at night. Plural number of water pumps should be installed at each pump station to cope with hourly demand fluctuation.

14-2. Selection of water pumps

1] Diameters of pipings

The flow rates of standard water pumps are designed at the rate of 2～3m³/second on both of suction and delivery sides. Generally speaking, diameters are same on both sides or suction side is bigger. The standard flow rates are shown in the following table.

Relationships between pump diameters and standard flow rates

Diameters (mm)	38	50	65	75	100	125	150	175	200
Flow rates (m^3/min)	0.13	0.23	0.42	0.56	1.1	1.7	2.5	3.6	4.8
Diameters (mm)	250	300	400	500	600	700	800	900	1,000
Flow rates (m^3/min)	7.5	11.0	21	33	47	65	84	105	130

Based on the above table, 300A of diameter of the Mamut and Bambangan pumps may be appropriate for the flow rate of 575.00m^3/h=9.58m^3/min. 350A, however, should be adopted to decrease friction loss for long distance. The piping diameter of the recycled water should be 400A because of the flow rate of 1,020 m^3/h=17.0m^3/min.

2] Calculations for pump type selection

Because of large capacities and higher heads, we should select turbine type. Calculations on the Bambangan river pumps is shown here.

[1] Friction head loss by straight piping

Darcy's equation

$$H_S = f\frac{L}{D}\frac{V^2}{2g} \quad [m]$$

where L: length of strait piping 6,000 [m]
D: inner diameter of straight piping 0.35 [m]
V: Averaging flow velocity 1.66 [m/sec]
G: gravitational acceleration 9.8 [m/sec²]
f: friction loss coefficient
$f=0.02+1/2000\ D=0.0214$
$H_S = 0.0214\times6000/0.35\times1.66^2/(2\times9.8)=51.6$ m

[2] Friction head loss by bending piping, valve, & suction mouth

A] Bending piping

$$H_B=\zeta_B\cdot\frac{V^2}{2g}$$

where ζ_B: Total friction loss coefficient by bending
90° bend ζ_B=0.2～0.3 , 45° bend $0.7\zeta_B$,
30° bend $0.7\zeta_B$, 15° bend $0.42\zeta_B$

Then assumed averaging ζ_B as 0.25 and number of bends as 20,

$$H_B=0.25\times 20\times 1.66^2/(2\times 9.8)=0.70\ \mathrm{m}$$

B] Valves

Check valv $H_{ch}=\zeta_{ch}\cdot\dfrac{V^2}{2g}$

where ζ_{ch}: friction loss coefficient 0.8～1.2→ 1.0

then $H_B=1.0\times 1\times 1.66^2/(2\times 9.8)=0.14\ \mathrm{m}$

On sluce valve, the friction loss can be neglected in the case of larger than 300A.

C] Divergent-nozzle

$$H_D=\zeta_D\cdot\frac{V_1^2-V_2^2}{2g}$$

where ζ_D: friction loss coefficient 0.15

V_1 : inlet friction loss coefficient 250A 1.63 [m/sec]

V_2 : outlet friction loss coefficient 350A 0.83 [m/sec]

Then $H_D=0.15\times(1.63^2-0.83^2)/(2\times 9.8)=0.015\ \mathrm{m}$

D] Total friction head loss Ht

$$Ht=Hs+H_B+H_{ch}+H_D$$
$$=51.6+0.70+0.14+0.015=52.455\ \mathrm{m}$$

[3] Total head H:

$$H=H_A+Ht=(1,640-1,400)+52.455\ \mathrm{m}=292.455\ \mathrm{m}$$

3] Calculation of required shaft power Kw

$$Kw=\frac{Q\cdot H\cdot\gamma}{6,114\eta}$$

where	Q: pumping capacity	9.58	[m^3/min]
	H: total head	292.455	[m]
	γ : liquid density water→	1,000	[kg/m^3]
	η : pump efficiency	74	[%]

Relationship between pump diameter and efficiency is shown in the following table.

Pump diameter and standard efficiency

D mm	50	75	100	150	200	250	300	400	600	1,000	1,500
η %	45	55	60	70	73	74	75	76	78	80	82

Total required power: Kw＝9.58×292.455×1,000/(6,114×0.74)＝619 kw

Installed power: 619 kw×2.5/3＝515.8→520 kw

Motors of pumps to be installed should be enforced to 2.5 times stronger in order to be able to pump up introduced water from the Mesilau River in the case of water shortage at the Mamut River. So pump specifications should be 250A×6 m^3/min×30.8kg/cm^2×520kw×3sets, 2 sets operating and 1 set stand-by. Besides that, since outlet of the delivery pipe will locate at 1,355m level, after pumped water would cross over the utmost point, it is expected that situation will change to almost no load.

4] Mamut river pumps

Omitting calculations, only specifications are shown here.

Pumps：250A×7 m^3/min×15.5kg/cm^2×300kw×2 sets

Piping: 350A×1,500m

5] Recycled water pumps

Omitting calculations, only specifications are shown here, too.

Pumps：300A×8.5 m^3/min×7.5kg/cm^2×180kw×3 sets

Piping: 400A×800m

End