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REPORT ON DEVELOPMENT OF COMPUTER SIMULATION PROGRAMME FOR CONSERVATION OF WATER IN PULP & PAPER INDUSTRY BY RECYCLING OF WASTEWATER

Sponsored by:

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DEVELOPMENT OF COMPUTER SIMULATION PROGRAMME FOR CONSERVATION OF WATER IN PULP AND PAPER INDUSTRY BY RECYCLING OF WASTE WATER

1. INTRODUCTION

Water consumption for Indian pulp and paper mills is very high in comparison to the paper mills in the major paper producing countries. The consumption of water in an integrated pulp and paper mill vary from 220-300 M^3 per tonne of paper. But the developed countries with their R&D support and technological development have brought down the consumption of the fresh water to around 20-40 M^3 per tonne of paper.

Higher water consumption in the paper mills has many adverse impacts like higher cost of water treatment, generation of higher quantity of wastewater, higher cost of effluent treatment and adverse environmental impact. Moreover, the water is scarce commodity and its conservation is essential.

Because of the complex nature of wastewater generated from different sectors of the mill, recycling in the mill is normally restricted. With a computer simulation programme, the characteristics of wastewater at different stages can be ascertained on-line and a network system can be developed for maximum utilization of wastewater without affecting quality of product and equipments.

2. PROJECT OBJECTIVES

Pulp and paper making processes required dilution & dewatering at various stages resulting in requirement of large quantity of fresh water and discharge of wastewater. However, some wastewater streams either individually or mixed with others can be judiciously recycled. The main objective of the project is to reduce the water consumption in the Indian paper industry with the help of computer simulation in the mills. A system design to be developed for the software by mathematical modeling and to be applied in the mills with network system.

3. SELECTION OF MILL FOR THE STUDY

After having some preliminary exercise on selection of a willing mill, M/s. Shree Vindhya Paper Mills Limited, located at Jalgoan, Maharashtra was selected for the study. This is a 100 TPD mill based on conventional raw materials like hard wood and non conventional raw materials like bagasse, the details of the same is given in Table 1. The high cost of water in the mill was considered as one of the major criteria to select the site of this mill for the study. M/s. KLG Systels Limited, one of the India's competent scientific and engineering software development organizations was engaged in the project.

Table 1
INSTALLED CAPACITY (PAPER) IN TPA

INSTALLED CAPACITY (PAPER) IN TPA	33000	
Raw Material	Bagasse	Wood (Eucalyptus)
Current Production TPA	18000	6000
Type of Digesters	Spherical Rotary	Vertical stationery
No. Of digesters	5	1
Raw Material consumption TPD	300	50
Bleaching sequence	C,EH,H	C,EH,H

4. METHODOLOGY

In order to achieve the maximum recycling wastewater, the following steps were adopted for simulation exercise: -

- Modeling all major equipment, which affect the water flow system in paper mill as objects attributes such as consistency at inlet/outlet/vat. Process equipment in the chemical recovery section has been omitted from the initial study; however, surface condenser discharge flow has been included in the system.

- Extracting and encapsulating required parameter ranges/values for water inlet to each equipment. The parameters included for consideration include pH, Solids Content (Dissolved), Clarity and Fiber Content.
- Measure/obtain average values of parameters in the outlet streams for each equipment. The parameters included pH, solids, clarity and fiber content. The pollution load parameters at each outlet viz. BOD, COD were also decided to be considered for optimization.
- Expert rules on infeasibility of certain recycles to be extracted and encapsulated.
- Ability to use the system in manual simulation mode to allow expert users to visually see the effect of any stream as chosen for recycle interactively.
- Based on consistency, values fed as input calculation of the mill water balance dynamically.
- Robust non-linear optimization technique for selecting the most optimal recycle stream combination considering all of the above constraints and factors.

5. SOFTWARE FEATURES

The software application developed by KLG Systel Limited is based on proven expert system technology and will cover all of the objectives as laid out for the application.

Salient features of the package are detailed below: -

1. Representation of all process equipment in a typical mill as graphical objects, which have attributes with user definable values.
2. Calculation of water balance at the mill in a dynamic fashion based on consistency and pulp throughput.
3. Easy to use input screens for specifying the required parameter value/ranges for water inlet at each equipment.
4. Effect of manufacturing colored paper on water balance considered.
5. Encapsulated expert rules on certain forbidden recycle combinations.
6. GUI based, Mouse Driven manual recycle simulation selection.
7. Real-time input from field sensors (digital sensors only) for outlet parameters and flow values,
8. Real-time control of recycle flow through direct interfacing with field level controllers/control valves,
9. Real-time monitoring of various other process parameters from digital sensors as attributes of graphically modeled equipment objects.
10. Validation of sensor values within specified ranges to ascertain sensor failures etc.

6. INITIAL ASSUMPTION FOR RECYCLING OPTIONS

(i) Chemical Recovery

The condensate from the multi effect evaporator is a reasonably clear stream with some mercaptan presence.

(ii) Brown Stock Washer

The pH of the pulp stream in this section is alkaline and the unbleached pulp is to be sent to the chlorine tower for chlorination. Proposed to use the hypo washer outlet stream for the first 2 stages of BSW and fresh water for the last stage showers.

(iii) Dilution

In going with the principle of establishing countercurrent flow of streams in the pulping washers with the exception of chlorine rich stream, it has been proposed to utilize hypo-washer outlet stream instead of fresh water in this area.

(iv) Chlorine washer

Since semi bleached pulp after chlorine washer is sent to the caustic washer, we can afford to add the caustic washer outlet flow in the chlorine washer.

(v) Caustic washer

The caustic stage at present utilizes a large amount of backwater from the hypo stage and fresh water input is required only for some showers.

(vi) Hypo washer

The flow of machine backwater to this section needs to be increased for the hypo washer to be completely fresh water independent.

(vii) In arriving at all of the above recommendations, care has been taken to ensure that shorter recycled loops are given priority over longer loops. This would avoid any perpetual solids build up in the system.

7. WATER CONSUMPTION BREAK-UP (PRESENT VS PROPOSED)

WATER CONSUMPTION BREAK-UP
Present VS proposed

Equipment	Present Fresh Water Consumption	Proposed Fresh water requirement
Boiler	450	450
Chemical recovery	860	570
Wood Pulp Mill	1230	1230
Digester	10	10
BSW	2996	1584
Screening/Centricleaning	400	484
Dilution	440	300
Chlorine Washer	400	660
Dilution	0	0
Casutic Washer	400	0
Dilution	0	0
Hypo Washer	2550	1350
Stock Preparation	540	540
Centricleaning	0	0
Wire Part Shower	1875	1075
Compressor glands, cleaning	900	400
Total	8405	4775
m^3/ton consumption	112.07	63.67

8. IMPLEMENTATION OPTIONS

- Implementation as real-time control software for flow control for minimal fresh water utilization based on inputs from sensors for pH, solids, clarity etc. This form of implementation would require digital control equipment/PLCs, control valves and field level electronic sensors. If implemented in this mode the software will also provide the additional features of real –time monitoring of certain parameters as described in the software features section.

- Implementation in an off-line mode for suggesting recycles flow strategy that would be implemented by manual/automatic control of flow valves.

9. ECONOMICS OF THE SYSTEM

At Glance

Present water consumption	-	112 m^3/ton
Envisaged water consumption after recommendations	-	90 m^3/ton
Savings in Water Consumption	-	22 m^3/ton
Annual cost of savings in water consumption	-	Rs.72,60,000
Operating costs, effluent treatment, pumping etc.	-	Rs. 44,55,000
Net savings realized	-	Rs.28,05,000
Cost of modifications and software implementation	-	Rs. 14,10,000
Pay back period	-	6 months

10. Details made for present water consumption is shown in Annexure - I (1-9) and proposed after reuse and recycling are shown in Annexure –II (1-9).

11. PRESENT STATUS

After completion of the basic studies, the project was to be implemented in the mill. But Sri Vindhya Paper Mills Limited was closed due to labour strike and it continued for a number of months. It was therefore, decided to take up this project to M/s. Amrit Papers (A unit of ABC Group). They have given their consent for demo plant study on computer simulated water conservation project.

The basic studies have been completed at Amrit Paper Mills as given in the enclosed project report.

12. AMRIT PAPER AT A GLANCE

Amrit Paper, a division of the Amrit Banaspati Co. Ltd, is located at Saila Khurd, Distt, Hoshiarpur in Punjab. It is a medium sized agro based mill with an installed capacity of 26,400 tonnes per annum of paper and has a pulp mill producing 75 tonnes per day of bleached pulp from agro wastes such as Kahi grass, wheat and rice straw. The unit primarily manufactures writing and printing papers. The mill has made constant endeavor for improvement in the past.

13. Actual and proposed fresh water consumption (m^3/t) as measured and projected in Annexure-III. Initially the details were worked out only for the pulp mill.

14. IMPLEMENTATION OPTIONS AT AMRIT

- **Option 1:** Pilot implementation of results as obtained after a simulation run is carried out by KLG using the average parameters of a mill. This would not necessitate major additional equipment installation at the mill except for some additional piping work that would have to be carried out.
- **Option2:** Implementation in an off-line mode for suggesting recycle flow strategies that would be implemented by manual/automatic control of flow valves. The inputs on pH and other parameters would be fed as user input into the system from a remote/central computer station after laboratory results for these tests are obtained. The recycle strategy may need to be changed in a batch mode, i.e., with every change in grade of paper and other process related changeovers the optimal recycle combination might vary.

At this stage the project has been divided into 2 phases. 1st Phase for monitoring basic parameters of different back waters generated at source, to find out which back water can be a source for other stream like wise for setting of characteristics of influent and effluent. Two pipelines have been changed as desired as per the above schedule.

The control valves have been placed in position and fresh water supply has been restricted in the plant. Only re-circulated water is being used which has resulted in reducing fresh water consumption from 88 to 50 in pulp mill. The valves are working on manual mode at present but after putting up the software it will be working on automatic mode. Hence the fresh water reduction will go to a level of $36m^3$/day in the pulp mill.

As the Krofta Saveall installed in the mills are not working properly, the suspended solids for white water is more than 200 mg/l and therefore no online micro filter can work at such a high level of suspended solid. The mill has decided to put up MARKS SAVALL, which is expected to run at the efficiency of 95-96% and the SS load, below 50 mg/liter.

Accordingly the micro filter designed for filtering this water will work and the SS load will come to about 10 PPM or below. As soon as this phase (Phase II) is completed recycling system for the entire will be worked out. With the initial step of recycling, the mill has already reduced water consumption from $170m^3$/tonne to $130m^3$/tonne by way of recycling and restructuring the fresh water use.

Options 3: Implementation as a real control software for flow control for minimal fresh water utilization based on inputs from sensors for pH, solids,

clarity etc. This form of implementation would require digital control equipment/PLCs, control valves and field level electronics sensors. If implemented in this mode the software will also provide the additional features of real time monitoring of certain parameters as described in the software features section.

However, the mill with their available resources could not take up immediately the Phase II activity of option 2. The construction of mark saveall was likely to be delayed. The mill was also reluctant to invest the amount for installation of PLC & Digital control equipments. As a result the project could be completed only for option I and phase I of the option II and could gain the savings of around 40 m^3 of water per tonne of paper with very little investment. Since the project was likely to be abnormally delayed, it was decided to stop the project at this stage.

15. CONCLUSION

The study carried out at Shree Vindhya Paper Mills for implementing the computer simulation programme reflected that, the mill could save 22 M^3 water/Tonne paper, saving Rs. 28,05,000/Year with investment of Rs. 14,10,000/- thus providing the pay back period of around six months. Since the mill was shut for a very long period due to labour trouble, it was unfortunate that this could not be implemented although the mill was fully co-operative in the study and was quite keen for implementation of the project.

After Shree Vindhay's closer, this project was transferred to M/s. A B C Paper Mills, Saila Khurd, Punjab. Part of the project was implemented with manual controls & slight change in routing of pipelines, resulting in saving of

about 40 m^3 of water per tonne of paper. The mill, however, could not take interest in implementation of the scheme in near future due to their own limitation; the project was not followed further.

The schematic details on water use as worked out for Sri Vindhya Paper Mills for existing condition as well as for projected stage after implementation of the scheme are enclosed along with this report. The present & proposed water consumption for Amrit Paper mills for pulp mill is also enclosed.

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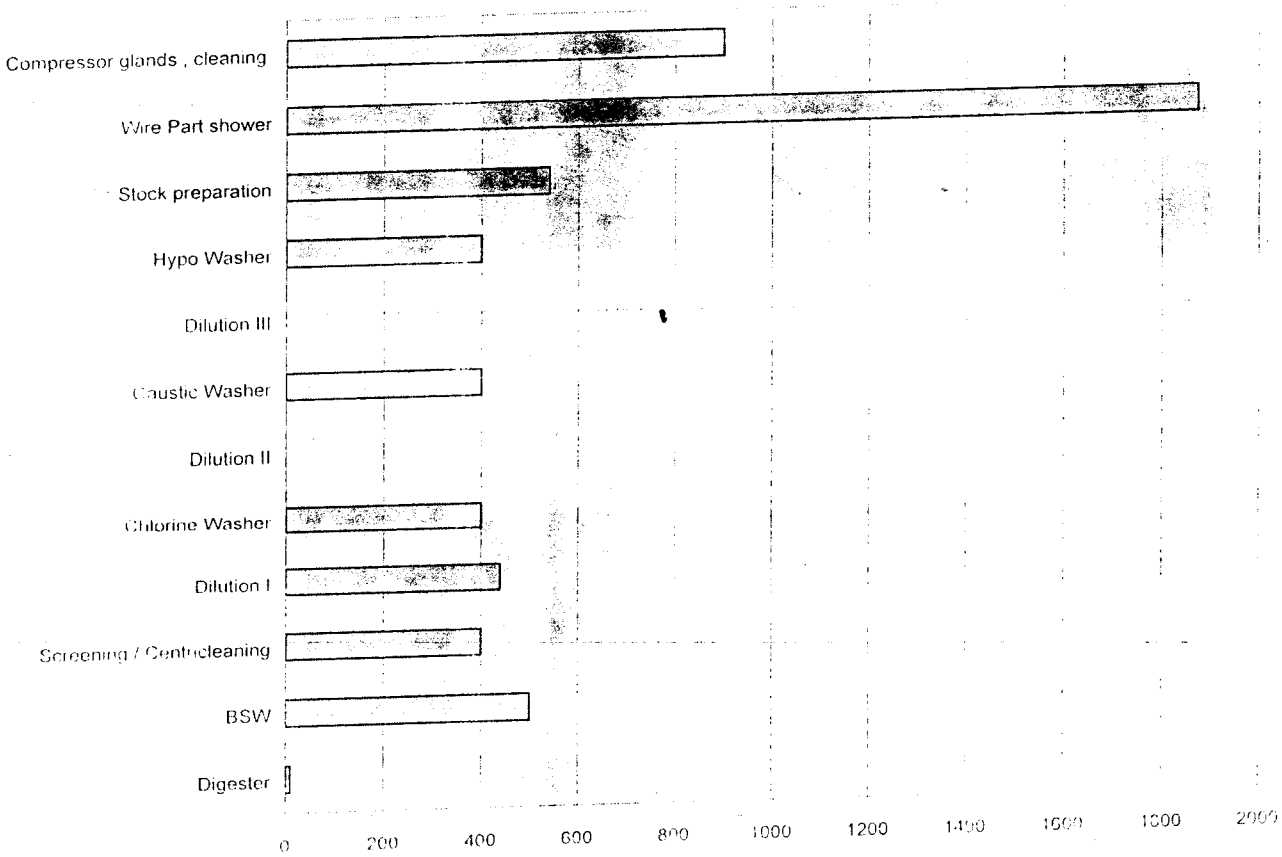
SVPM

Present Water Flow System

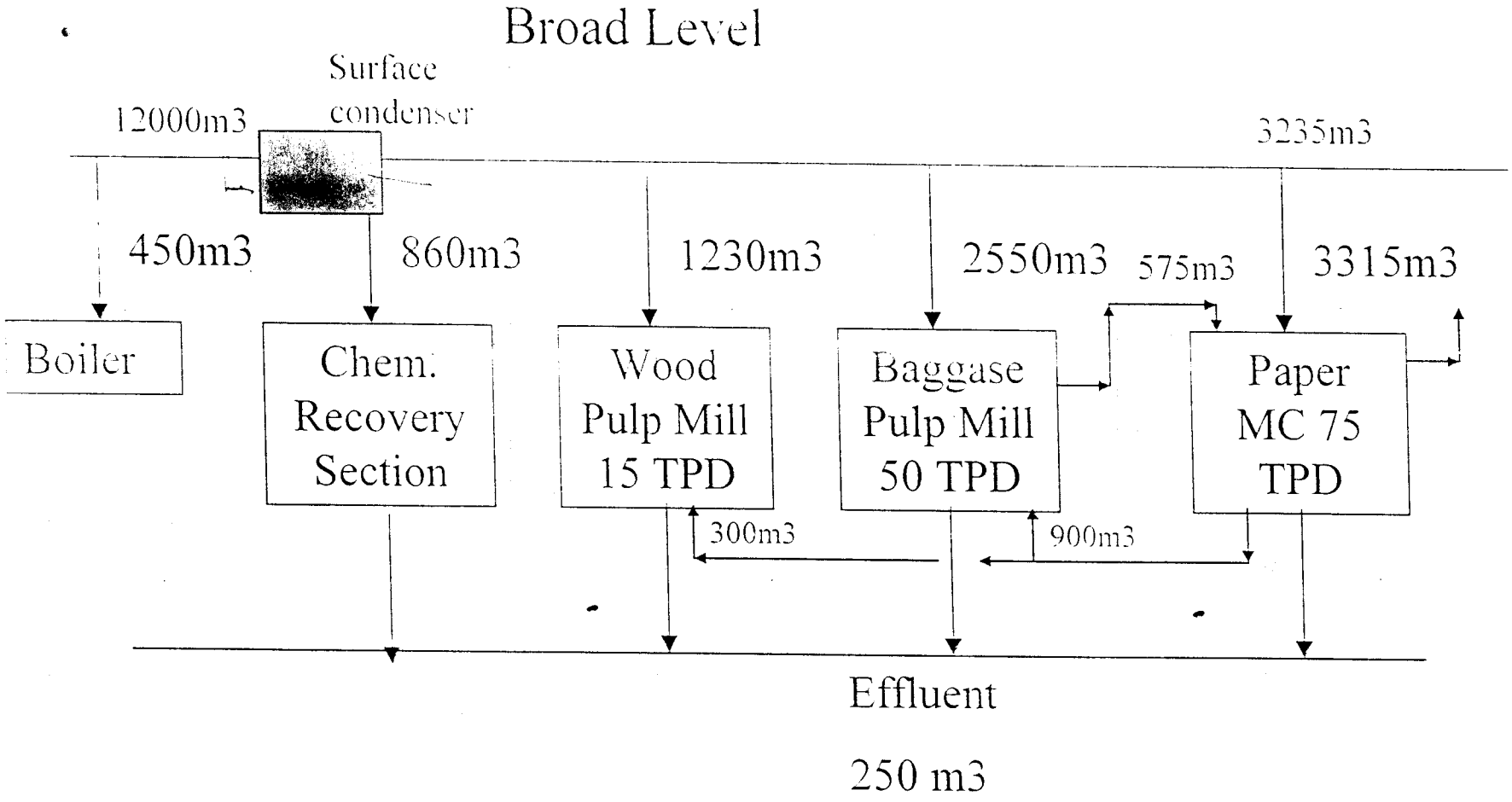
SVPM
Water Consumption Break-Up
Present



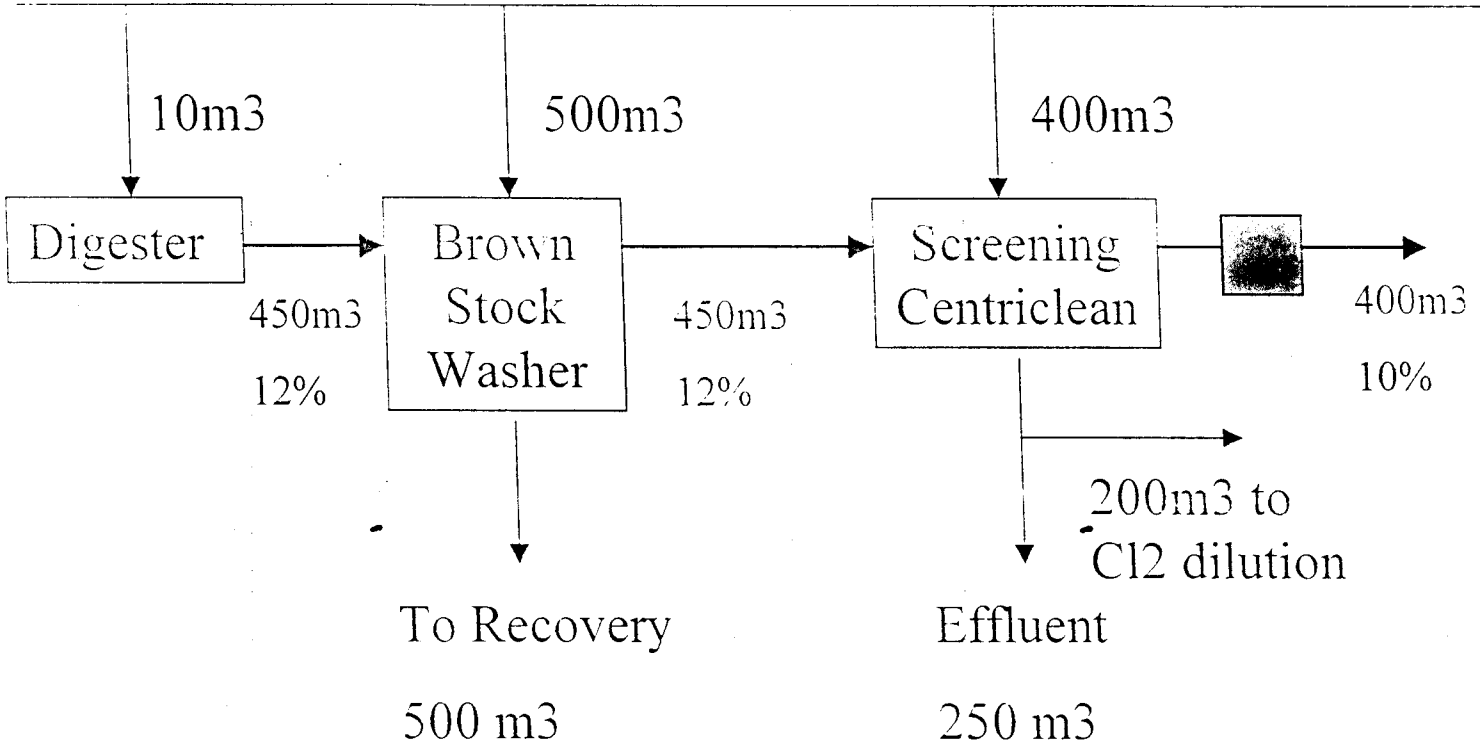
m3/day

SVPM
Water Consumption Break-Up
Present

Equipment	m3/day
Boiler	450
Chemical recovery	860
Wood Pulp Mill	1230
Bagasse Pulp Mill	
Digester	10
Brown Stock Washer	500
Screening / Centricleaning	400
Dilution	440
Chlorine Washer	400
Dilution	0
Caustic Washer	400
Dilution	0
Hypo Washer	400
	2550
[illegible]	
Stock preparation ,Filler chemicals	540
Wire Part shower	1875
Compressor glands , cleaning	900
	3315
TOTAL	8405

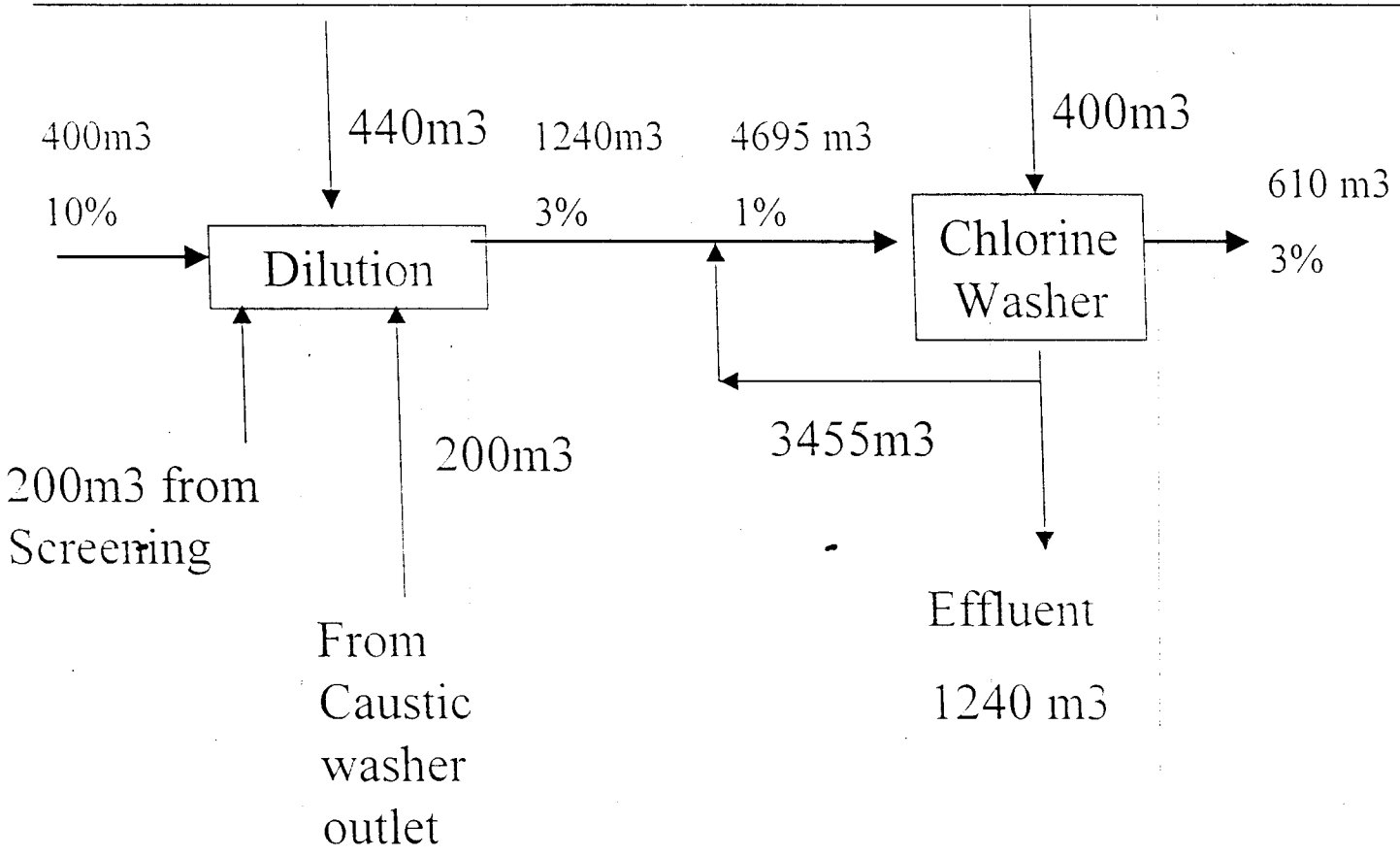

Broad Level
Surface condenser
12000m3
3235m3
450m3
860m3
1230m3
2550m3
575m3
3315m3
Boiler
Chem. Recovery Section
Wood Pulp Mill 15 TPD
Baggase Pulp Mill 50 TPD
Paper MC 75 TPD
300m3
900m3
Effluent
250 m3

Bagasse Pulp Mill

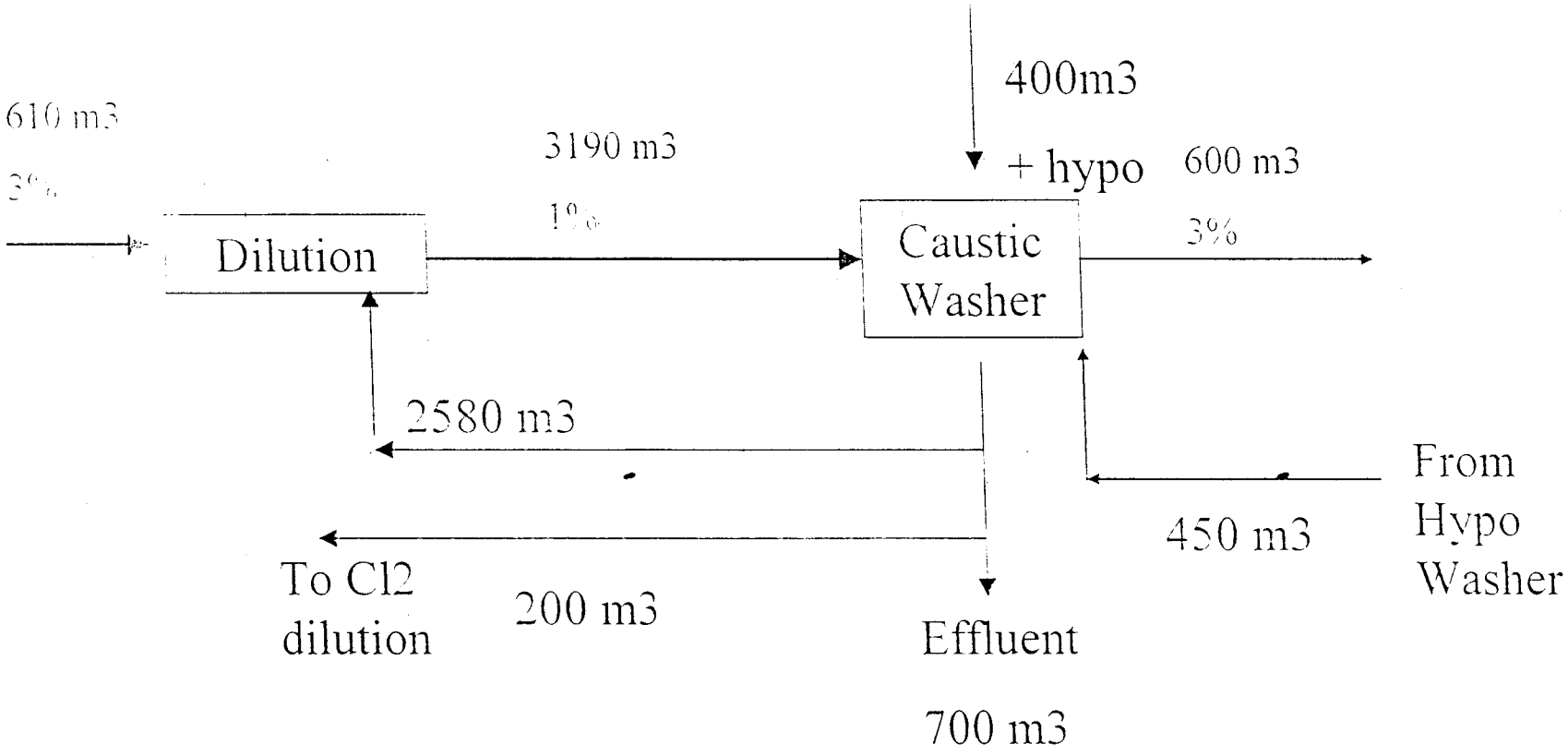


S-1

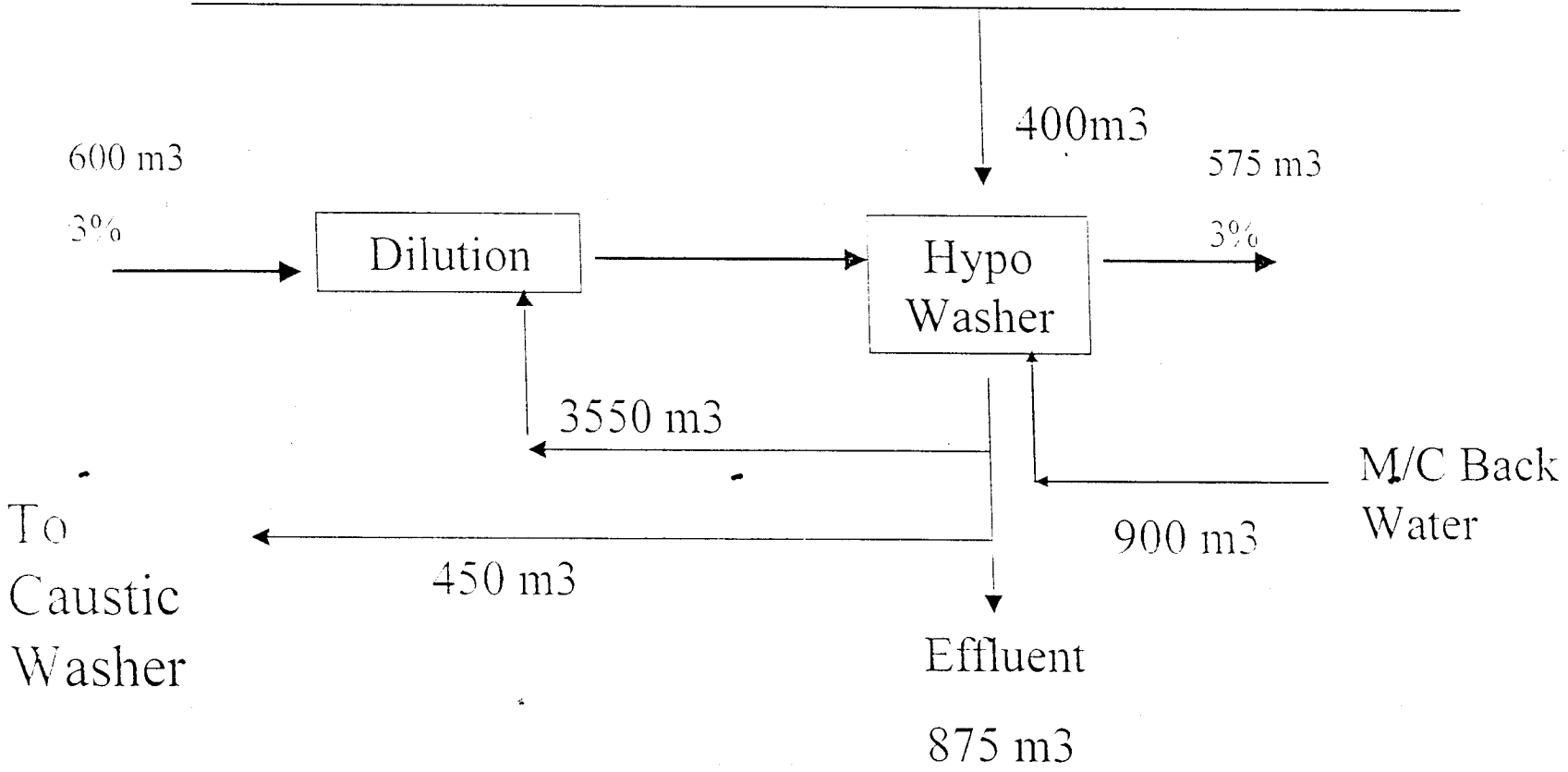
Bagasse Pulp Mill



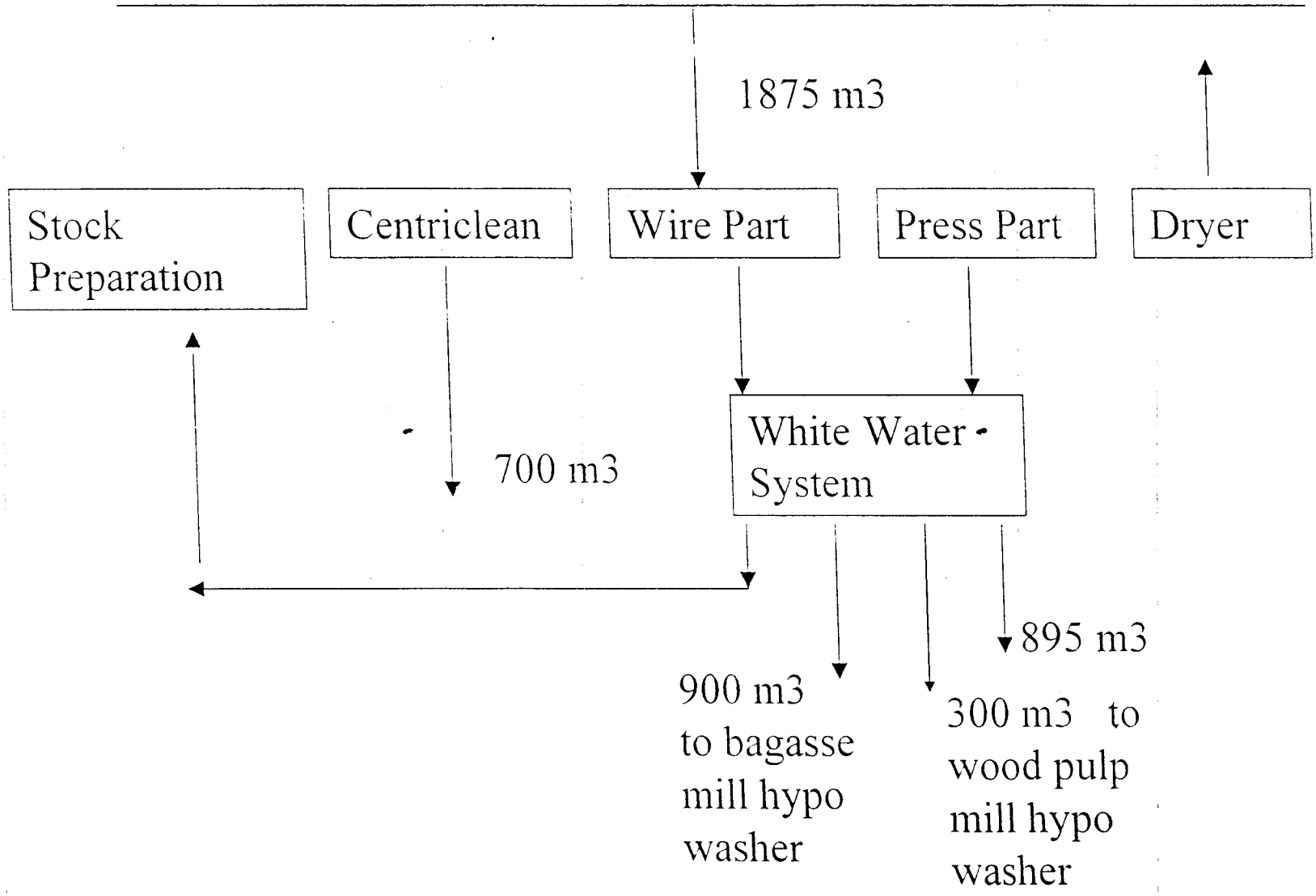
Bagasse Pulp Mill



Bagasse Pulp Mill



Paper Machine

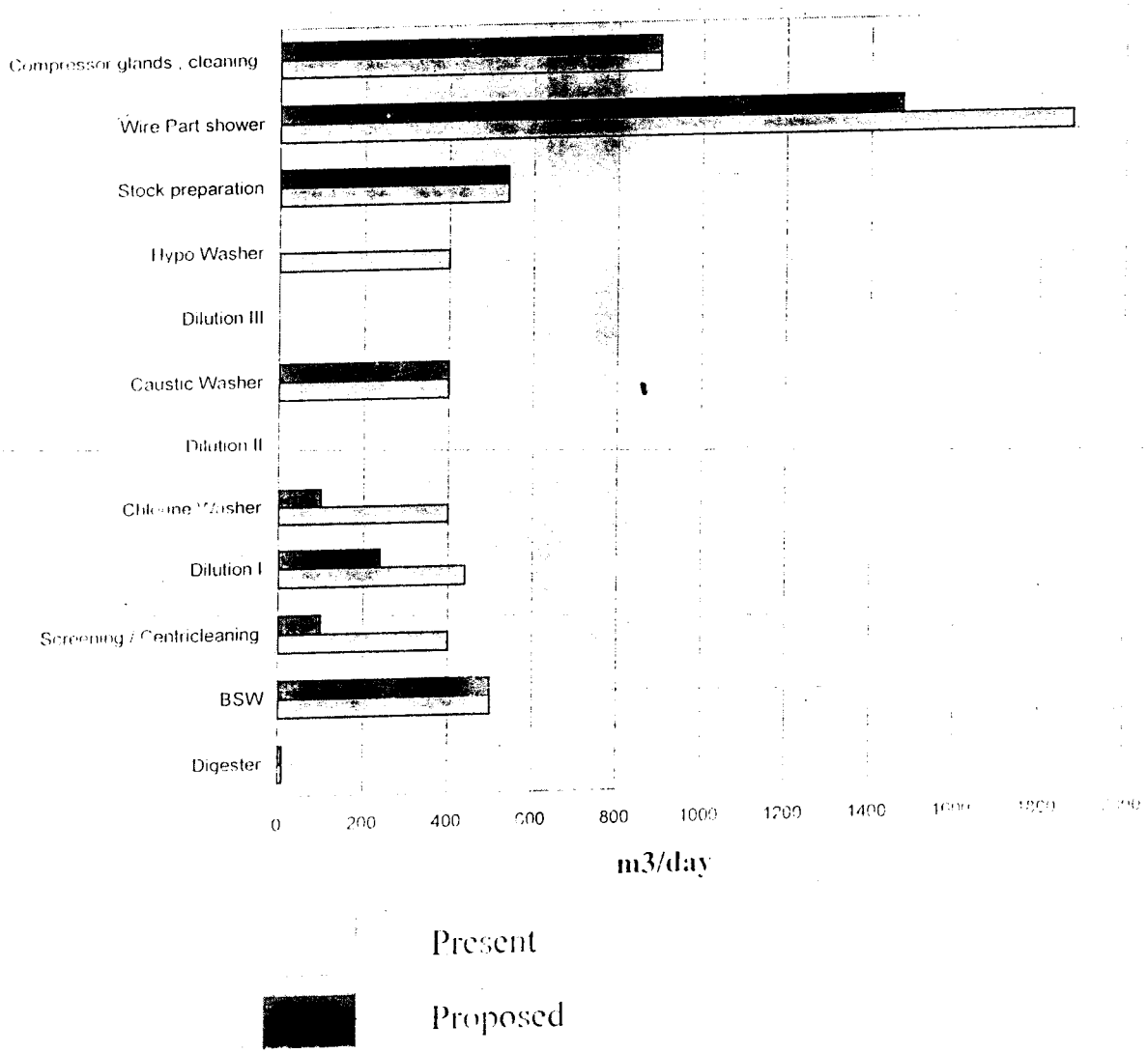


ANNEXURE-II

SVPM

Proposed Water Flow System

SVPM,
Water Consumption Break-Up
Present V's Proposed



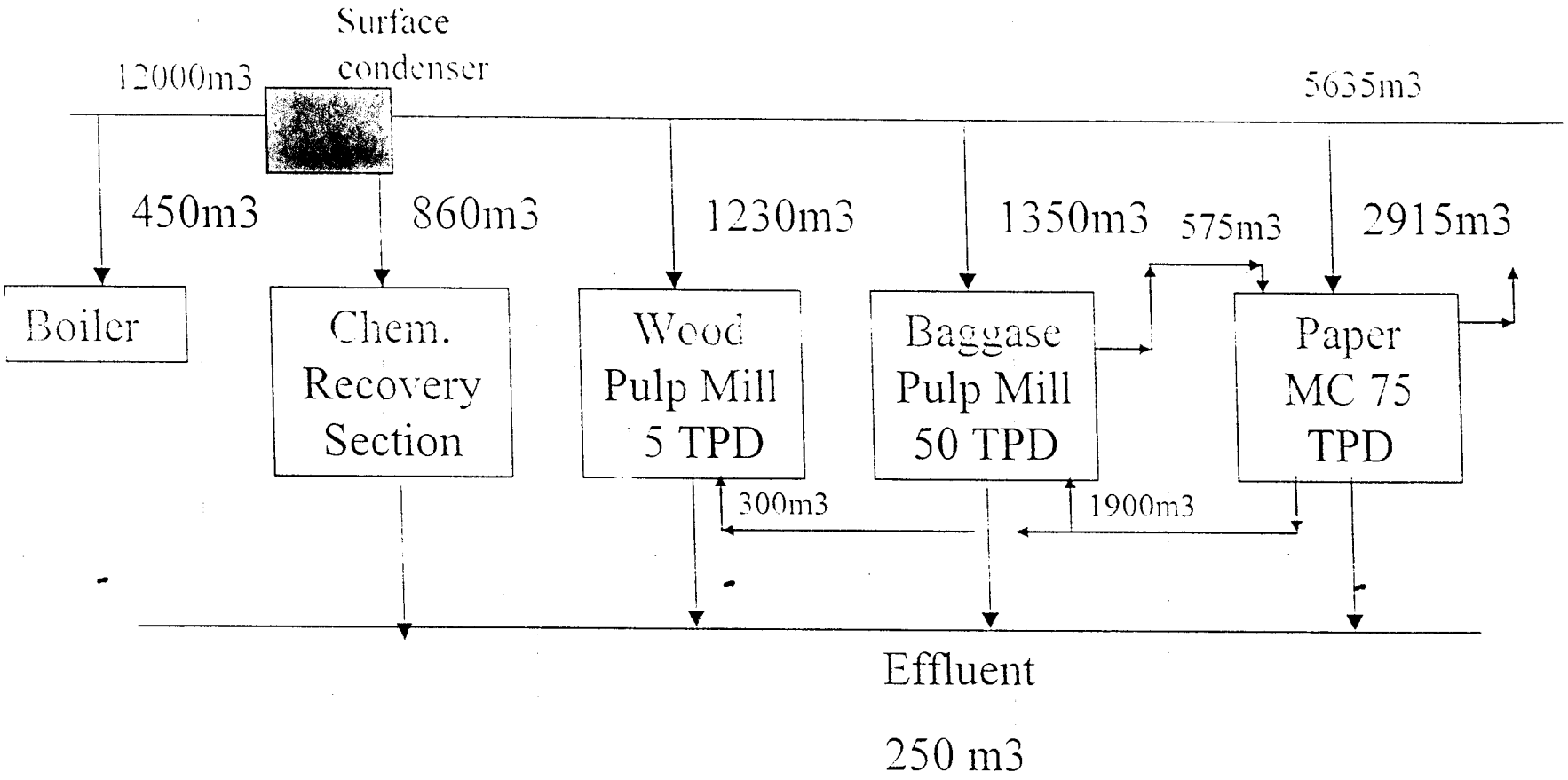
SVPM

Water Consumption Break-Up

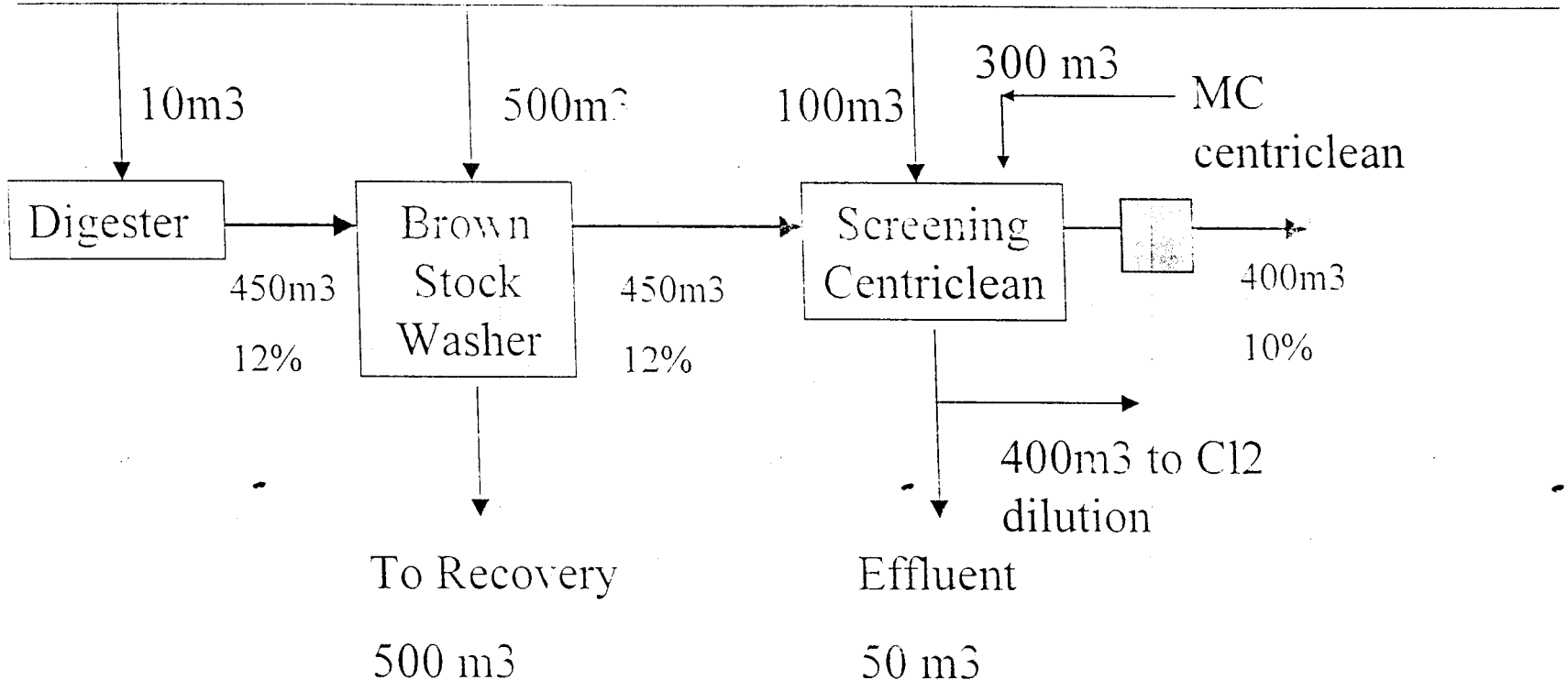
Present Vs Proposed

Equipment	m3/day Present	Proposed
Boiler	450	450
Chemical recovery	860	860
Wood Pulp Mill	1230	1230
[illegible]		
Digester	10	10
Brown Stock Washer	500	500
Screening / Centricleaning	400	100
Dilution	440	240
Chlorine Washer	400	100
Dilution	0	0
Caustic Washer	400	400
Dilution	0	0
Hypo Washer	400	0
	2550	1350
[illegible]		
Stock preparation ,Filler chemicals	540	540
Wire Part shower	1875	1475
Compressor glands , cleaning	900	900
	3315	2915
TOTAL	8405	6805

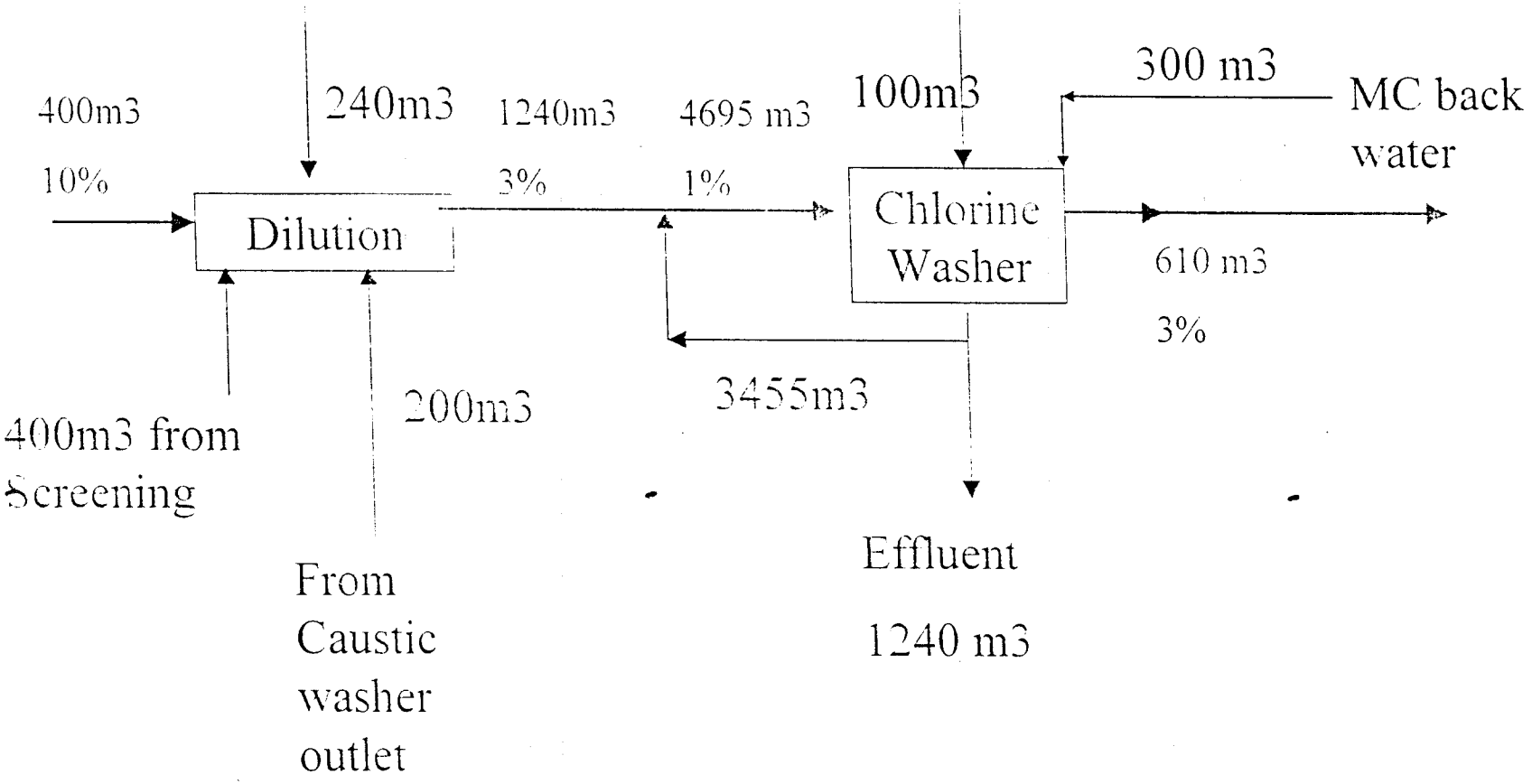
Broad Level


Surface
condenser
12000m3
5635m3
450m3
860m3
1230m3
1350m3
575m3
2915m3
Boiler
Chem.
Recovery
Section
Wood
Pulp Mill
5 TPD
Baggase
Pulp Mill
50 TPD
Paper
MC 75
TPD
300m3
1900m3
Effluent
250 m3

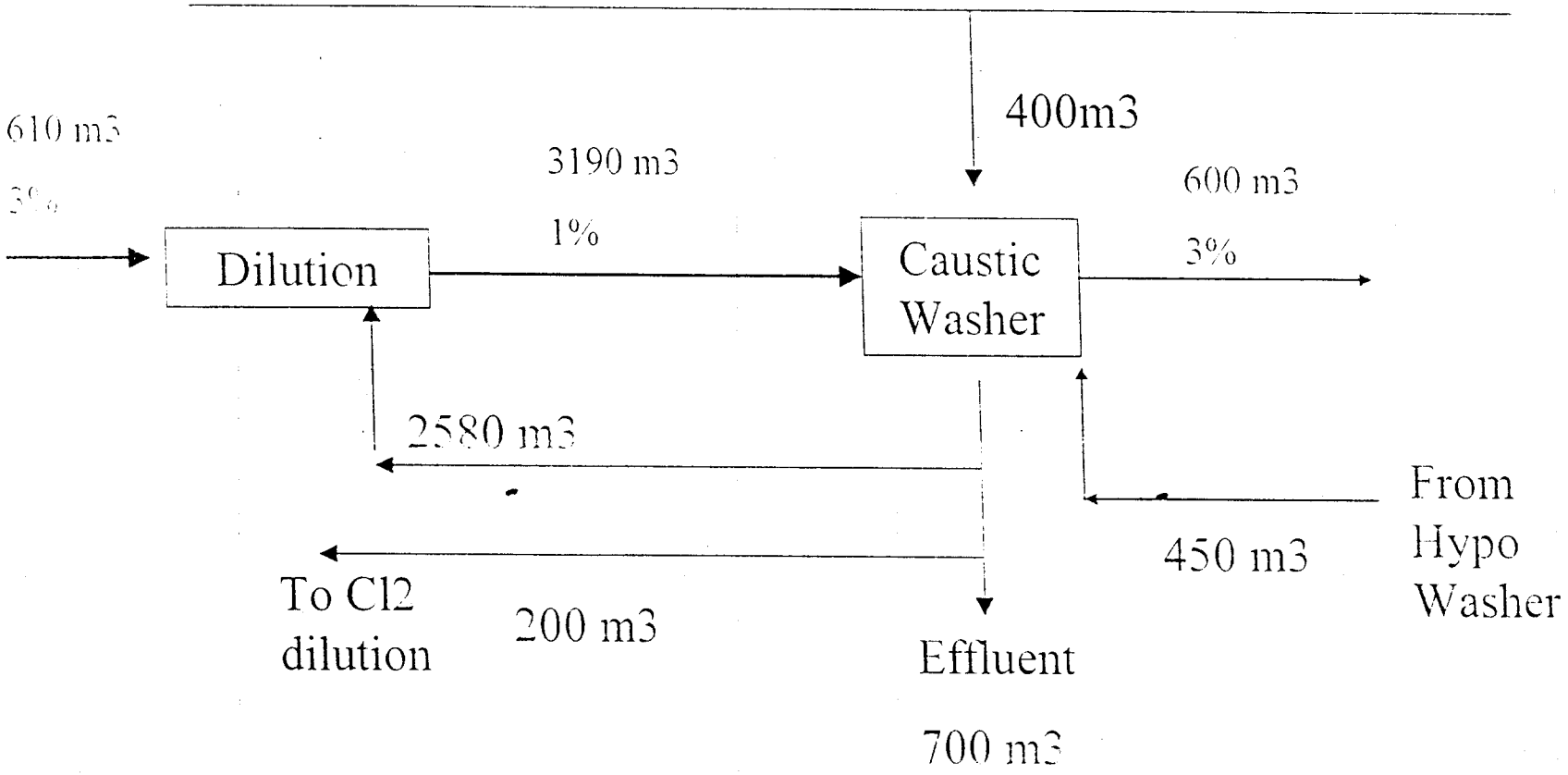
Bagasse Pulp Mill



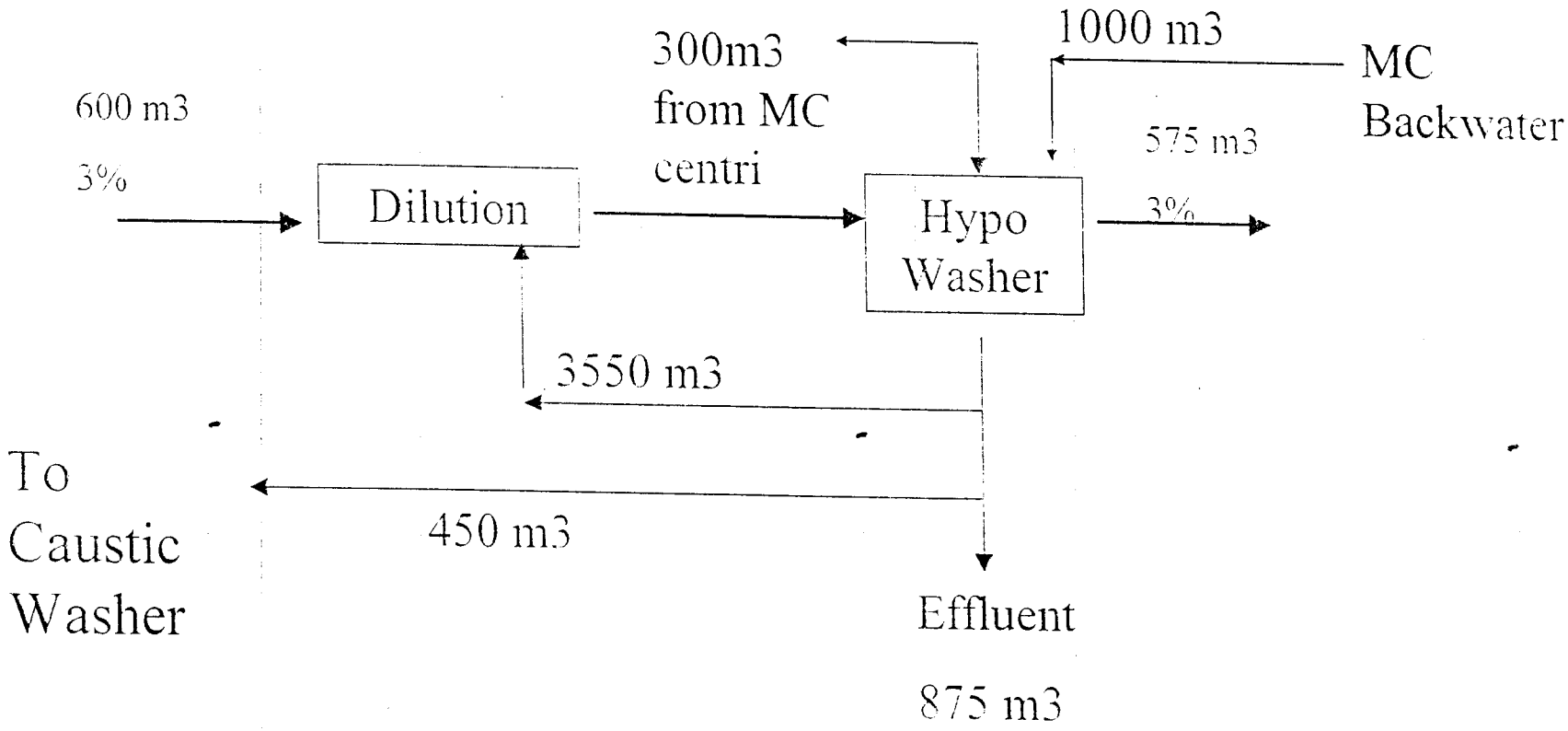
Bagasse Pulp Mill



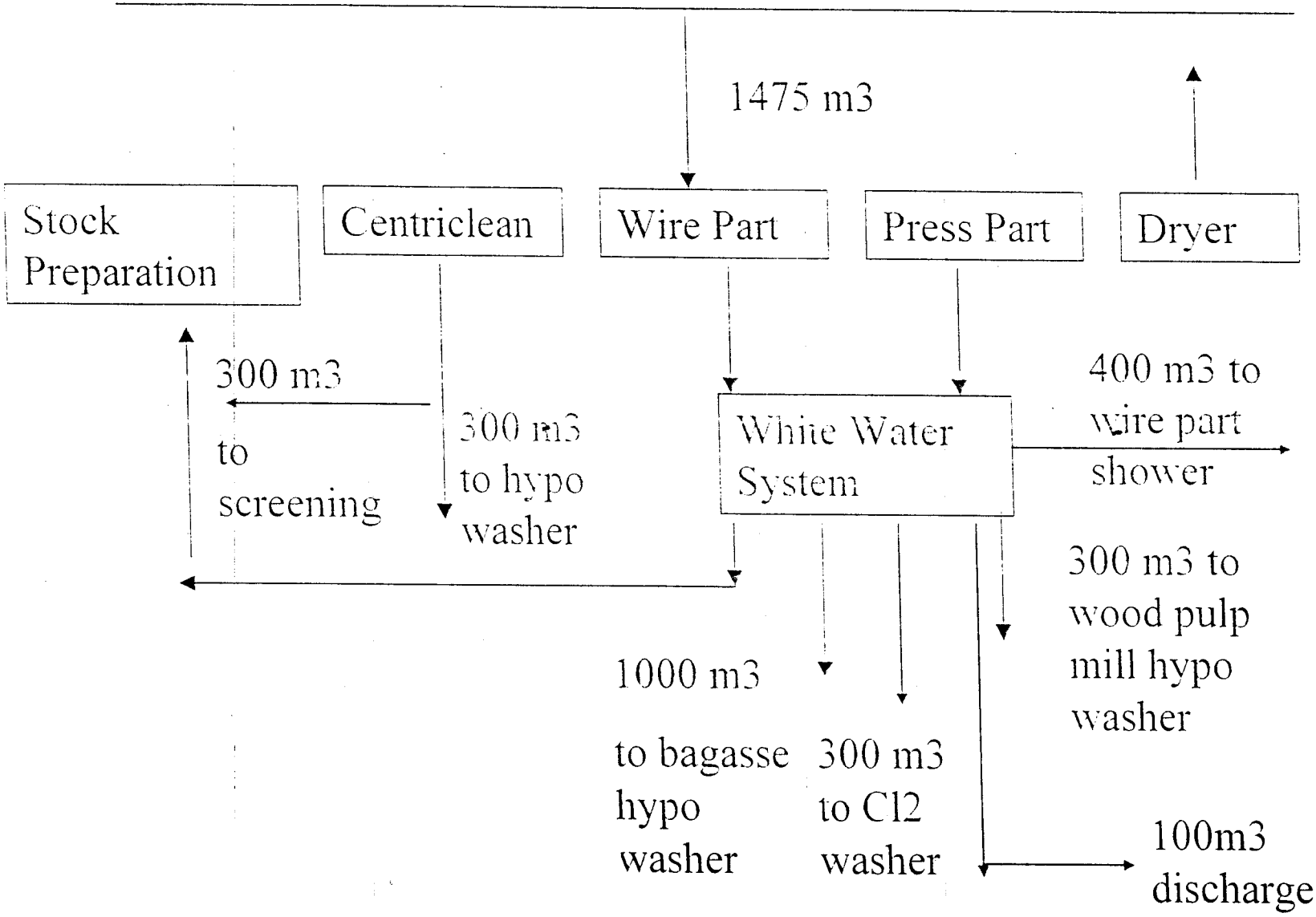
Bagasse Pulp Mill



Bagasse Pulp Mill



Paper Machine



Amrit Paper
Fresh Water Consumption Break-Up
Present Vs Proposed

(all figures: m3/day)

Equipment	Present	Proposed	Saving
Pulp Mill			
Brown Stock Washing	1584	0	1584
Screening / Centricleaning	484	484	0
Chlorine Tower Dilution	300	0	300
Chlorine Washer	660	660	0
Alkali Washer	1320	440	880
Hypo Washer	2244	1140	1104
Total	**6592**	**2724**	**3868**

Amrit Paper: COMPARISON OF WATER FLOWS - MODEL (PROPOSED) AND ACTUAL

	BT-D model	BT-D actual	R-D model	R-D actual	VS-D model	VS-D actual	BS14-C model	BS14-C actual	BS14-M model	BS14-M actual	BS25-ID model	BS25-ID actual
F								528				
MC												
HRT												
BSW14	1913	1913	547	547	1508	1508	528					
BSW25									1056	1056	4324	4324
BSW36												
UBPCC												
DW												
CL												
AW												
BLPCC												
HW												

	BS25-C model	BS25-C actual	BS25-M model	S25-M actual	BS36-ID model	BS36-ID actual	BS36-C model	BS36-C actual	BS36-M model	BS36-M actual	BHD-D model	BHD-D actual
F		528						528				
MC												
HRT									1056	1056		
BSW14												
BSW25	528											
BSW36			1056	1056	4324	4324	528					
UBPCC											1810	1810
DW												
CL												
AW												
BLPCC												
HW												

	CS-ID model	CS-ID actual	CS-D model	CS-D actual	DCW-C model	DCW-C actual	CLT-ID model	CLT-ID actual	CLW-M model	CLW-M actual
F					484	484		300		
MC			2667	2667						660
HRT										
BSW14										
BSW25										
BSW36										
UBPCC										
DW										
CL	1005	1005					2651			
AW										
BLPCC										
HW								694	660	

	CLW-D model	CLW-D actual	CLW-C model	CLW-C actual	ALW-ID model	ALW-ID actual	ALW-M model	ALW-M actual	ALW-C model	ALW-C actual	VBS-ID model	VBS-ID actual
F			880	660				880	440	440		
MC												
HRT												
BSW14												
BSW25												
BSW36												
UBPCC												
DW												
CL	660											
AW					1971	1971						
BLPCC												
HW		660					880				2314	2314

	BLPCC-ID model	LPCC-ID actual	HYW-M model	HYW-M actual	HYW-C model	HYW-C actual		ETP model	ETP actual		
F			392	1496	748	748					
MC			660								
HRT											
BSW14								1412	1940		
BSW25									528		
BSW36									528		
UBPCC											
DW											
CL											
AW											
BLPCC											
HW	1388	1388	444								
	ETP model	ETP actual			DRAIN model	DRAIN actual		CONSUMPTION model	CONSUMPTION actual		SAVINGS actual - model
F								2724	6592		3868
MC								3327	3327		0
HRT								1056	1056		0
BSW14	1412	1940						5908	5908		0
BSW25		528						5908	5908		0
BSW36		528						5908	5908		0
UBPCC					550	550		0	0		0
DW					2333	2333		1810	1810		0
CL					353	3664		4316	1005		-3311
AW					1320	1320		1971	1971		0
BLPCC					1110	1110		0	0		0
HW						630		5686	5056		-630
Total	1412	2996			5666	9607		38614	38541		-3941

Note In the model, the bigger filter which will be installed in Decker Washer is considered. So UNBL-ID is not needed.
Inlet dilution of Chlorine tower (CLT-ID) for the model and actual is not comparable as the actual figures are the existing