Mill-Wide COD Balance to Identify Important COD Point Sources
(Interim Report for IP XL-2 Project)

By

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MANAGEMENT SUMMARY

Background. An XL-project is being conducted at the International Paper Company in Jay, Maine. The report summarizes work performed by the Collaborative Team as part of that project. The primary goal of the XL project is to achieve reductions in COD and color in the mill effluent through process modification to the black liquor cycle. The COD goal of the project is to achieve emission levels of 26 Kg COD per 1000 tons AD pulp. The total capital budget available to achieve the COD and color goals is $780,000. Current COD discharge in the mill effluent is approximately 30 to 35 Kg COD/k Kg ADMT pulp, but unfortunately has been trending upward in recent months.

Methodology for COD Survey. As part of the IP-XL project, a mill-wide survey was performed to identify important sources of COD going to the waste treatment plant. This survey was done to identify potential COD sources that could be reduced through appropriate process modifications. Sewer samples and flow rate measurements were taken for all of the major streams going to the wastewater treatment system. The liquid samples were analyzed for both COD and BOD and when coupled with the flow rate measurements permitted mill-wide COD and BOD balances to be performed. Additionally, toxicity tests were performed on selected samples of wastewater originating from the black liquor cycle and the paper mill.

Results of COD Balance. The total mass (flow) balance closes within approximately 86%%, that is, there was a 14% error between the flow rate in the mill sewer and the flow rate of the mill effluent. Similarly, the COD balance closed within about 80%, that is, there was a 20% discrepancy between the measured influent to the waste treatment plant and that measured as sum of all of the sewer streams. The results of the survey further indicated that approximately 64% of the COD and 47% of the BOD in the influent to the waste treatment plant originated from the paper mill. By comparison only 28% of the COD and 46% of the BOD originated from the black liquor cycle, which is the focus of this project. Discharges of raw materials and coating solids from the paper machines were thought to contribute significantly to the high COD values measured in the survey. However, toxicity testing, although limited in scope, showed that the effluent streams originating from the black liquor cycle were significantly more toxic than effluent originating from the paper machines.

The ratio of COD to BOD in the effluent streams was taken as an indication of the presence of recalcitrant organic compounds being discharged during the pulp and papermaking process. This ratio, and also the difference in mass flow rate (pounds per day) between the COD and BOD in an effluent stream, was higher in the paper machine sewer streams when compared to effluent streams originating from the black liquor cycle, indicating that the former stream is not only the major contributor to the effluent COD, but also contains a higher fraction of recalcitrant organic material.

COD Reduction Projects Implemented and Approved. To date, approximately $240,000 has been spent or approved for spending on process modification projects to reduce COD discharge to the waste treatment plant. These projects pertain primarily to closing up the screen room in the "A" and "B" pulp mills. It is estimated that when fully implemented, these projects would result in a reduction in COD in the mill effluent of approximately 2.06 Kg COD per 1,000 Kg ADMT. Since the current level of discharge is 30 to 35 Kg COD per 1000 ADMT, implementing the current list of projects is insufficient to achieve the COD goal of 26 Kg per 1000 ADMT identified on the XL-project.

New Projects Involving Black Liquor. Two significant projects identified by the Collaborative Team that involve the black liquor cycle are a demister project and turpentine recovery project, both associated with the "A" (softwood) kraft mill. These projects if successful would reduce black liquor effluent and reduce volatile organic compounds currently going to the waste treatment plant. Both projects are under study but would most likely exceed the capital funds remaining uncommitted in the budget. Also, it is estimated that if the projects were implemented, they would only bring the total reduction of COD in the effluent to about 3.6 Kg COD per 1000 Kg ADMT pulp, from the current reduction level of 2.06 Kg COD per 1000 ADMT pulp. Thus, implementation of the demister and turpentine recovery project would not permit the goal of 26 Kg COD per 1000 Kg ADMT pulp to be met.

Maximum Possible Reduction in COD Originating from the BL Cycle. If all of the COD coming from the black liquor cycle were contained and kept within the process, this would achieve a COD reduction in the mill effluent of approximately 13 Kg COD per 1000 ADMT of pulp. If such results could be achieved, the target on the project could be met. However, achieving such a high level of containment is impractical. Moreover, the capital budget is insufficient to make the necessary process improvements in the black liquor cycle to meet the goal of 26 Kg COD per 1000 Kg ADMP pulp.

COD Reductions in the Paper Mill. Since the COD discharges from the paper mill far exceed those of the black liquor cycle, the COD level in the mill effluent will be determined by releases from the paper mill, and thus will dictate the success of the XL-project. Reducing the COD discharges from the papermachines by 14 to 32% would ensure that the COD discharge goal of the project was achieved. Moreover, it is in the best interest of IP to reduce these discharges since these solids represent the raw materials used in the papermaking process.

Recommendations. It is strongly recommend that the IP management team take steps to reduce the COD discharge from the papermachines, without which it is unlikely that the COD goal of the project will be met. It is further recommended that the Collaborative Team concentrate on COD reductions in the pulp mill since this objective is commensurate with the spirit and intent of the original XL-project agreement. Because of the large COD load coming from the paper machine, implementation of smaller projects, such has been done to date, cannot be documented by looking for changes in the mill effluent. Rather, it is recommended that the collaborative team evaluate the effectiveness of COD reduction projects by making appropriate measurements at the discharge point of the process.

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INTRODUCTION

IP XL-Project

An XL-Project is being conducted at the IP paper mill in Jay, Maine. A detailed description of this project is given in the Final Project Agreement.[1] Under the terms of this project, the IP mill is exempt from Best Management Practice (BMP) in the water pollution portion of the Cluster rules. In exchange for this exemption, IP has agreed to take a number of steps designed to improve the quality of the mill effluent for COD and color beyond the levels likely to be attained through implementation of the BMP requirements. There are two groups that are actively participating in this project. These are the Technical Assessment Subgroup and the Collaborative Process Team.

Technical Assessment Subgroup

The Technical Assessment Subgroup is comprised of personnel from the EPA, the Maine DEP, the University of Maine and IP staff. This technical group is charged with identifying a list of potential effluent improvement projects at the IP facility primarily in the pulping operation, which when implemented will reduce color and COD discharges to meet the goals of the XL project.

Collaborative Team Concept

The Collaborative Process Team involves members from the EPA, IP, Maine DEP, the Town of Jay, Maine and other active stakeholders. The function of the Collaborative Process Team is to evaluate and recommend effluent improvement projects from the list generated by the Technical Assessment Subgroup and assess their pollutant reduction potential as well as their overall cost. The projects to be implemented will be chosen by the Collaborative Process Team to best meet the performance goals established in the XL projects. IP will implement the effluent improvement projects as determined through the collaborative process.

Mill Layout

Important unit processes found at the IP mill site for producing groundwood and Kraft pulp are the wood yard and wood room for preparing roundwood and chips, a groundwood facility for preparing groundwood pulp, and two Kraft pulp mills (designated Mill "A" and Mill "B") for preparing Kraft brownstock chemical pulp.

The hardwood and softwood Kraft brownstock pulps are bleached to high brighness in a bleach plant consisting of two separate lines. In the softwood ("A") kraft mill the pulp is delignified using an oxygen stage which is bleached to high brightness using the $D_0E_{OP}D$ bleaching sequence, where D_0 represents a chlorine dioxide (ClO_2) stage, E_{OP} represents an extraction stage reinforced with oxygen and hydrogen peroxide, and D represents a final chlorine dioxide stage. In the hardwood ("B") mill, the hardwood is bleached also using the $D_0E_{OP}D$ bleaching sequence. Chlorine dioxide (ClO_2) used in the bleaching process is generated in a SVP plant.

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[1] "International Paper XL Project: Effluent Improvements", Final Project Agreement, Androscoggin Mill, Jay, Maine. (June 29, 2000)

There is also a power island consisting two recovery boilers for generating steam and electrical power for the mill and recovering the chemicals used in the cooking operation. In addition to the two recovery boilers, the mill operates a bark boiler for burning bark and sludge, and a natural gas fired co-generation facility. There are two idle power boilers at the site that use bunker-C oil as fuel. To reconstitute the cooking chemicals and concentrate the black liquor prior to firing in the recovery boilers, the mill operates two trains of evaporators and a recaustization plant for generating the NaOH and Na_2S for use in the Kraft digester.

The paper mill consists of five (5) paper machines. Three (3) of the papermachines produce coated paper while two (2) of the machines produce uncoated paper. To facilitate preparation of the coating or "paint" used on the three (3) coated machines, the mill operates a coating preparation plant. In addition there is a roll finishing department for converting the paper produced on the machines to the proper size and shape sold to customers. At the site, there is a precipitated calcium carbonate plant used to prepare $CaCO_3$ used as a filler and in the coating preparation used on the machines.

Utilities operations found at the site are a water treatment plant, fuel oil storage, waste reclaim operation, a landfill and a wastewater treatment facility. The mill also treats waste produced at a neighboring mill located in Otis, Maine.

Intent of the XL-Project

The intent of the XL –Project is to provide excellence, leadership in environmental stewardship foremost to protect the quality of the Androcsoggin River. A very important secondary objective of the XL- Project is to develop a methodology and technology that is transferability to other sites and projects.

Objective and Scope

The objective of this report is to summarize the COD balance performed for the entire Androscoggins mill and to provide direction to the project. A very important question to be addressed in the COD balance to be determined is where the important sources of COD arise in the Androscoggin mill. A corollary question to be addressed is whether the goals of the XL-project can be met predicated upon implementation of a list of projects identified by the Technical Assessment Subgroup.

JUDGEMENT OF PROJECT SUCCESS

The IP-XL project will be conducted over a three-year period. At the end of this three-year period, the overall project will be judged a success provided the environmental results are superior to what might have been attained as the result of compliance with the Best Management Practice provisions of the Cluster rules.

Limits on Mill Efflent

The limits that were agreed upon for the mill effluent are shown in Table 1.

Table 1
Baseline Performance, New Permit Limits and Performance Goals for the IP- XL at the Androscoggin Mill

	A	B	C
Pollutant	Baseline Performance July-Dec. 98	New NPDES Permit Limits Under IPXL Project	Performance Goals and Potential Future NPDES Limits (3 Yrs after FPA Signing)
COD	46.7 Kg/1000 Kg AD Pulp	50 Kg/1000 Kg (Long-Term Average)	26 Kg/1000 Kg
Color	106 Pounds per AD U.S. Ton	120 Pounds per AD U.S. Ton	50 Pounds per AD U.S. Ton

The COD measurements will be made at the end of the pipe in the effluent. The goal following the three year project is 26 kg COD per unbleached ADMT (air-dried) metric ton based upon a monthly average. The long-term color goal is 50 pounds per U.S. ton (air dried) of Kraft pulp produced as a quarterly average limitation. No toxicity standards are contained in the performance goals

Financial Obligations

During the course of the study, IP has agreed to spend $780,000 in capital and engineering cost to implement process modification projects to meet the goals of the project. This amount is the equivalent financial obligation that would have been spent to comply with the Best Management Practice provisions of the Cluster rules.

Transfer of Methodology

An important component of the XL project is transfer of the methodology and techniques used in this project to other mill sites. The methodology being developed by the Technology Subgroup and the Collaborative Team involves four steps.

1. ***Identification of Major COD and Color Point Sources.*** The first step in the methodology involves the identification of the major point sources of COD and color in the various sewer streams going to the wastewater treatment system.

2. ***Identification of Potential COD and Color Reduction Projects.*** The second step in the methodology is the identification of potential COD and color remediation projects. All projects identified are predicated upon process modification rather than end of pipe treatment.

3. ***Project Implementation***. The most practical and cost effective projects judged by the Collaborative Team would be implemented commensurate with the $780,000 budget.

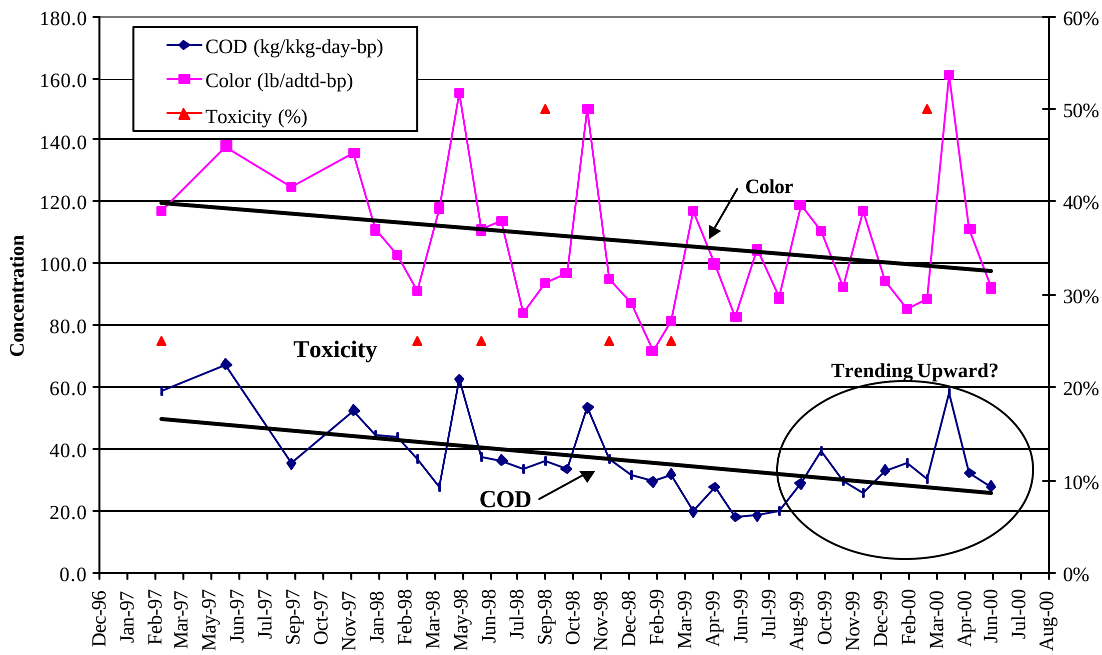
4. ***Effluent Monitoring***. The last element to the methodology involves monitoring of mill sewer streams and final effluent to judge whether the emissions goals have been met following implementation of the most cost effective projects.

CURRENT MILL DISCHARGE LEVEL

Figure 1 summarizes data for the mill effluent. The COD data used to construct the plot is summarized in Appendix B. This figure shows data based upon monthly averages for COD and color. Data are also presented for chronic toxicity as percent survival using the Acute Ceriodaphnia *dubia* test. The mill is presently discharging COD of approximately 30 to 35 Kg/air dry metric ton (pulp) and color of about 100 pounds per air dry short ton.

- Amount of COD is ≅30 to 35 Kg/air dry metric ton pulp
- Amount of Color is ≅100 pounds per air dry short ton pulp
- Toxicity ≅ LC50 = 80% (dilution) chronic Ceriodaphnia *dubia* test

Figure 1. Summary of Current Mill Effluent



Using Figure 1 as a guide, there has been a long-term downward trend in COD and BOD. Recently the COD and color measurements have been trending upward. During the period June, July and August 1999 the COD emissions in the mill effluent were below the 26 Kg per air-dry metric ton of pulp (see Appendix B). Similarly, there seems to be a correlation between COD and Color.

The upward trend in the COD in the mill effluent has been particularly disturbing since process improvements have been made in the pulp mill yet the COD in the effluent has been constant or trending upward in recent months. This raises speculation that the increase in COD and perhaps color is coming from discharges from the paper machine that are outside the scope of the present XL project. If this is the case then improving performance of the papermachines would assist in lowering the COD. This would also be beneficial from an economical point of view if the COD coming from the papermachines originates from loss of fiber, which has a cost of approximately $800 per ton, including costs of waste treatment, pressing and landfilling.

MILL-WIDE COD BALANCE

Objective

The objective of the COD and BOD balance conducted at the IP Androscoggin mill in Jay, Maine is to identify and rank the relative contribution of the various COD point sources going to the waste treatment plant. A secondary objective was to develop a baseline to estimate the impact of various COD remediation projects designed to improve the final quality of the mill effluent.

Methodology

Figure A1 in the appendix is a schematic diagram of the sewer system for the mill. Samples points are designated on the diagram. Flow measurements were made primary using Parshall flumes and weirs following calibration using a portable velocity meter as a secondary standard. In those cases where Parshall flumes and weirs were not present, velocity measurements were made and the cross sectional area determined. In a few instances, where physical estimates were made, the flow rate was estimated using appropriate mathematical models.

Sampling

Sampling was done over a three-day period of time from August 8 through August 10, 2000. Composite samplers were set up at the sample points wherever possible. Composite samples were collected over a 24 hour period. In a few locations, where it was not possible to gather a composite sample, grab samples were collected. The samples were then sent to the Acheron Laboratory located in Newport, Maine for COD and BOD evaluation. Selected samples were sent to the Acheron Laboratory for toxicity testing.

The results of the COD balance are summarized in Appendix A. Table A1 presents the raw data. Table 2 in the text presents a summary of the results.

Total Mass Balance

The fresh water input to the mill (41.76 MGD) agrees very well with the total from all sources (37.4 MGD) and the influent to the waste treatment plant (37.9 MGD). This may be compared to the mill effluent of 43.4MGD. Figure A2 shows the various sources of effluent going to the waste treatment plant and illustrates that approximately 59% of the total flow arises from the papermachines. The mass balance closes within approximately 86%, which means there is about a 14% difference between the mill sewer and that of the mill effluent.

$$\% \ Closure = [1 - (\frac{Mill\ Sewer - Mill\ Effluent}{Mill\ Effluent})]x100$$

$$= [1 - (\frac{37.9 - 43.4}{43.4})]x100 = 87.3\%$$

The mill sewer and the sum of the individual sources are very close, that is, 37.4 MGD as the sum of the input streams and 37.9 MGD for the measured mill sewer.

$$\% \ Closure = [1 - \frac{(Total\ Sources - Mill\ Sewer)}{Mill\ Sewer}]x100$$

$$= [1 - \frac{(37.4 - 39.7)}{39.7}]x100 = 94.2\%$$

COD and BOD Balances

The COD measured in the influent to the waste treatment plant was 399,287 pounds per day. This value may be compared to the COD values measured in the sewer system that were summed together to give the estimate for the influent to the waste treatment plant 495,026 pounds per day.

$$Measured\ Influent\ to\ Waste\ Teatment\ Plant = 399{,}287\ Pounds\ per\ Day$$

$$Estimate\ Influent\ to\ Waste\ Teatment\ Plant = \sum_{i=1}^{n} COD_{i,\ All\ Sewer\ Stream} = 495{,}026\ Pounds\ per\ Day$$

There is an approximate 20% discrepancy between the measured influent to the waste treatment plant and that measured as sum of all of the sewer streams. This 20% discrepancy most likely results from errors in the COD and flow rate measurement. Another possibility, although less likely, is that the COD solids measured in the sewer system are lost or destroyed as they flow to the waste treatment plant.

Figure A3 and A4 summarized the distribution of COD and BOD going to the waste treatment plant. A surprising result from the COD measurements is that approximately 64% of the COD (Figure A2) and 47% of the BOD (Figure A3) are coming from the paper mill. This represents a significant amount of the total COD load to the waste water treatment system, especially since the focus of the XL project is control of the COD originating from the black liquor cycle.

Major sources of COD, excluding the paper mill, are shown in Figure A5. This figure shows that the major sources of COD arising from the black liquor cycle are:

i. Caustic Sewer (27%)
ii. Acid Sewer (22%)
iii. Pulp Mill (14%)
iv. Power Plant (14%)

The sewer streams from the Otis mill contribute 6% and miscellaneous sources contribute another 4%. One surprising source of COD going to the waste treatment plant is COD contained in the backflushed water from the water treatment plant which comprises 13% of the total load to the waste treatment system, excluding the paper mill.

Recalcitrant Organic Compounds

The parameter COD minus the BOD might be taken as a measure of recalcitrant compounds. This parameter is shown in Table A1 and summarized in Table 2. It is clear that the major amounts of recalcitrant organic compounds (71.5%) are coming from the paper mill (Table 2).

Table 2
Summary of COD Balance

Source	Flow Rate	COD		BOD		COD-BOD	
	MGD	Lbs/Day	%	Lbs/Day	%	Lbs/Day	%
Raw Water	41.76	24,687		4288		20,399	
Paper Mill	22.3	324,019	65.5	59636	47.6	264,383	71.5
BL Cycle	11	150,997	30.5	59546	47.5	91,451	24.7
Other	1	8673	1.8	1986	1.6	6686	1.8
SMI and Otis	3.1	11,338	2.3	4227	3.4	7,110	1.9
Total Sources	37.4	495,026	100.0	125395	100.0	369,631	100.0
Mill Sewer	37.9	399,287		103249		296,038	
Mill Effluent	43.4	75,479		2778		72,702	

Efficiency in the Waste Treatment Plant

The data in Table A1 in the Appendix and Table 2 in the text permit an estimation of the efficiency of the waste treatment plant for the breakdown of COD and BOD. Taking the ratio of COD to BOD going to the waste treatment plant from the measured sources is about 3.87.

$$R = \frac{COD}{BOD} = \frac{399{,}287\, lbs/day}{103{,}249\, lbs/day} = 3.87$$

Likewise the efficiency of removing COD and BOD in the waste treatment plant can be readily estimated from the COD and BOD in the measured mill sewer and effluent numbers, that is:

$$E_{COD} = \frac{(399{,}287 - 75{,}479)}{399{,}287} x100 = 81.1\%$$

$$E_{BOD} = \frac{103{,}249 - 2{,}778}{103{,}249} x100 = 97.3\%$$

Thus the estimated efficiencies for the degradation of COD and BOD in the waste treatment facilities are 81.1% and 97.3% respectively

Toxicity Tests

Three tests were done on the toxicity of the effluent from the black liquor cycle, the paper mill and the mill effluent. Coastal Bioanalysis Inc. (CBI), of Gloucester, Virginia, performed the analysis. The report from CBI is attached in Appendix B. Important data are summarized in Table 3. The acute Ceriodaphnia dubia test was taken as an indication of wastewater toxicity. In the test, the effluent sample is diluted until 50% of the population dies. The data are reported as the lethal (L) concentration (C) for 50% of the population to expire at the stated dilution.

A sample of effluent from the B General Sewer was taken as representative of effluent from the black liquor cycle. Similarly, a sample of wastewater from the No. 4 paper machine was taken as representative of the effluent from the coated paper machines. Lastly a sample collected at the bar screens was taken as representative of the influent to the waste treatment plant.

Table 3
Results of Toxicity Tests for Androscoggin Mill
8/16/2000 Samples

SAMPLE	TEST	RESULTS
Bar Screen	Acute C. dubia	LC50 = 21.4% (intermediate toxicity)
B General Sewer	Acute C. dubia	LC50 < 6.25% (most toxic)
No. 4 Paper Machine	Acute C. dubia	LC50 = 100% (least toxic)

The analysis showed that the most toxic effluent was the sample from the B General Sewer, while the least toxic effluent came from the No. 4 paper machine. Based upon these results it suggests that the Collaborative Team should continue to focus on reducing COD effluent originating from the black liquor cycle. However, it would be prudent to perform some additional tests to confirm the above results.

DISCUSSION OF RESULTS

Table 4 summarizes a list of COD reduction projects that have been identified to date. All of these projects involve reducing COD to the sewer on the black liquor cycle side, mainly by closing up the screen room and improved handling of assorted black liquor streams. No attempt has been made to reduce the COD going to the waste treatment system from the papermill.

The measured COD data were used to estimate the impact of the proposed process changes on the COD discharged in the effluent from the mill wastewater assuming the change is successfully implemented. The anticipated COD reduction was estimated for four different cases.

Case 1. Implemented and approved projects,
Case 2. Identified projects plus projects under study,

Case 3. Maximum Possible COD reduction from black liquor cycle, and
Case 4. Reduction in COD discharges from the paper mill.

Table 4
List of Potential Projects Identified to Reduce COD

Source	Potential Projects	Est. COD Reduction, (lbs/Year)	Est. Cost
1. "A" Knot Sluice Filtrate	Use cyclone water divert & substitute mill water	690,000	4,000
2. "B" Knot Sluice Filtrate	Pipe to process/"B" screen trial"	1,100,000	0
3. "A" Screening Sluice	Replace with PM white water	2,060,000	40,000
4. "B" Screenings Sluice	Use cyclone water	510,000	3,000
5. "B" Cleaner Rejects	1. "B" screen upgrade,	3,300,000	120,000
	2. Time dump cleaner/flat schreen	1,100,000	35,000
Total Projects Implemented & Approved	Projects 1 thru 5 above.	8,760,000	202,000
"A" Flash Steam Condenser	1. Demister	2,100,000	Undetermined
	2. Turpentine recovery	4,200,000	Undetermined
"B" Digester Heater Drains	Pipe heater drains to SRV tank	53,000	40,000
Power House Sump Drains	1. Install sump pump & diversion system	8,000	No Action
	2. Install conductivity indication	Not determined	No Action
Knot/Screening Entrained Filtrate	Knots/screening press	160,000	
Miscellaneous Spill Detection	Computerized sewer conductivity display	Minimal	
Total Projects Identified		15,281,000	Not Available

Case 1. Anticipated COD reduction from implemented and approved projects

To date, approximately $240,000 in projects have either been implemented or approved for implementation. These projects could potentially reduce COD emission to the sewer by approximately 8,760,000 pounds of COD per year (Table 4). This amounts to 24,000 pounds per day assuming 365 days of operation. Since the waste treatment plant is approximately 81.1% efficient, the anticipated reduction in the COD in the mill effluent is estimated to be 4,536 pounds per day.

$$Anticipated\ COD\ reduction\ to\ river = (24{,}000\ lbs/day) * (1 - 0.811) = 4{,}536\ lbs\ COD/day$$

Since the mill produces about 2200 tons of pulp per day (air dry basis) or approximately 1000 metric tons, the anticipated changes should translate into a reduction of approximately 2.06 Kg COD/1000 Kg Pulp.

$$COD\ reduction\ to\ river = \frac{4{,}536\ lbs/day * (1\ Kg\ COD/2.2 lbs)}{1{,}000\ MT\ \ pulp/day} = 2.06\ Kg/1000\ Kg\ Pulp$$

Lastly, the current level of discharge is 30 to 35 kg COD per k kg AD pulp. Thus, if we solely implement the current list of identified COD reduction projects, we will most likely not meet the goal of 26 kg COD per 1000 kg AD pulp set forth in the XL agreement, that is,

$$Anticipated\ COD\ to\ River = [(30\ \ to\ \ 35) - 2] = 28\,to\,33 Kg\ COD / k\ Kg\ AD\ metric\ ton)$$

Finally, it should be noted that the efficiency of 81.1% for COD removal in the waste water treatment system used in the COD reduction calculations is based on the mixture of COD values coming from ***all*** sources. Since the COD/BOD of the black liquor cycle (3.0) is lower than that of the paper mill (5.4), it is likely that the COD removal efficiency of the COD originating from the black liquor cycle will be higher that the calculated 81.1%. Therefore the value of 2.06 Kg COD per 1000 Kg pulp represents an optimistic value of the estimated reduction in COD for Case 1. The major conclusion drawn from this analysis is that without additional projects the COD goal will not be met.

Case 2. Implementation of all projects so far identified (including demister and turpentine projects)

If all projects identified to date were implemented, the total reduction in COD going to the sewer could be reduced by approximately 15,281,000 pounds of COD per year. This corresponds to all projects shown in Table 4. The two most significant projects identified, but not implemented or approved in the black liquor cycle are (1) adding a demister to the flash tanks to reduce carryover, and (2) adding a turpentine recovery system. Both of these potential projects would be in the “A” (softwood) mill and would most likely exceed the $780,000 capital budged available for this project.

This limitation, not withstanding, implementation of all additional identified projects for the black liquor cycle would increase the COD reduction level to 41,866 pounds per day, again assuming 365 days of operation.

$$Anticipated\ COD\ reduction\ to\ river = (41{,}866\ \ lbs / day) * (1 - 0.811) = 7{,}913\, lbs\ \ COD / day$$

Here again, the estimated reduction going to the Androscoggin river in the mill effluent would be based upon 2200 tons of pulp per day (air dry basis) or approximately 1000 metric tons. The anticipated changes under Case 2 should translate into a reduction of approximately 3.62 Kg COD/1000 Kg Pulp.

$$COD\ reduction\ to\ river = \frac{7{,}913\ \ lbs / day * (1\ Kg\ COD / 2.2 lbs)}{1{,}000\, Kg\ \ pulp / day} = 3.60\, Kg / 1000\, Kg\ Pulp$$

Lastly, the estimated discharge to the river following implementation of the projects in Table 4 is approximately 26 to 31 Kg per 1000 kg pulp production, that is

$$Anticipated\ COD\ to\ River = (30\ \ to\ \ 35 - 4) = 26\ \ to\,31 Kg\, COD / k\ Kg\ AD\, metric\ ton)$$

The conclusion drawn from Case 2 is that meeting the goal of the project would be marginal at best.

Case 3. Maximum possible COD reduction from black liquor cycle

An interesting analysis is to estimate the maximum possible reduction in COD going to the river (kg COD/k kg AD pulp) if all of the COD in black liquor sources were contained and diverted from going to the waste treatment plant. This of course is not possible but sets the limit to focusing on the black liquor cycle for meeting the COD goal of the project. Under this scenario, all 150,997 pounds per day measured in the COD balance coming from the black liquor cycle would be contained and kept from going to the waste treatment plant.

$$\begin{aligned}&\textit{Max Possible COD reduction to river from Black Liquor Cycle} = \\ &(150{,}997\, lbs/day) * (1 - 0.811) = 28{,}538\, lbs\ COD/day\end{aligned}$$

$$\begin{aligned}&\textit{Max Possible COD reduction to river} = \\ &\frac{28{,}538\, lbs/day * (1\ Kg\ COD/2.2 lbs)}{1000\, Kg\ pulp/day} = 13.0\, Kg/k\ Kg\ Pulp\end{aligned}$$

$$\begin{aligned}&\textit{Minimum Possible COD to River from Black Liquor Cycle} \\ &= [(30\ to\ 35) - 13] = 17\ to\ 22\ Kg\ COD/k\ Kg\ AD\ metric\ ton)\end{aligned}$$

The conclusion drawn from Case 3 is that a large improvement would be required on the black liquor side to achieve the goal of 26 Kg COD per 1000 Kg pulp (AD basis). Although the goal is possible under this scenario, it is impractical given the restrictions on the capital budget and the state of the technology presently available to implement Case 3.

Case 4. Reduction in COD discharges from the paper mill

Case 4 considers the question what is the required reduction in COD discharge from the papermachines to meet the goal of 26 kg per 1000 metric AD pulp. Under this case, the estimated reduction in COD would be approximately 74,000 to 166,400 pounds per day or approximately 23% to 51% of the total 324,000 pounds per day of COD discharged by the paper machines.

$$\begin{aligned}&\textit{Change in COD in effluent} = (\textit{present dischagre} - \textit{goal}) \\ &= [(30\ to\ 35) - 26]\ Kg/k\ Kg\ ADMT = 4\ to\ 9\ Kg/k\ Kg\ ADMT\end{aligned}$$

$$\begin{aligned}&\textit{COD reduction required from paper machines} = \\ &(4\ to\ 9\ Kg/k\ Kg\ ADMT)\, x (1000\ MT/Day)\, x (2.2\, lbs/1\, Kg)\, x \\ &(1\ pound\ from\ process/0.189\, lbs\ to\ waste\ treatment) = \\ &46{,}561\ to\ 104{,}762\ lbs\ COD\ per\ day\ from\ paper\ machines\end{aligned}$$

Although a 14 to 32% reduction in COD from the paper machines is large, it is within the realm of possibility and not completely impractical. Much of the COD being discharged to the effluent treatment system coming from the paper machines represents pulp and other raw materials used in the paper making process. Good economic operation would dictate that this material be kept within the papermaking process. Also, some of the COD discharge may also stem from low machine efficiency resulting from breaks on the papermachines. Thus, as the efficiency of the machines is raised, the COD discharges to the sewer will be reduced.

ALTERNATIVE STRATEGIES

Predicated upon the results of the COD measurements and the above analysis, three strategies have been discussed. There are advantages and disadvantages to each.

Alternative No. 1. Stay With Stated Agreement

The first alternative is to stay with the current agreement on color and COD limits. The measurement would be made at the end of pipe. Because the greatest share of the COD arises from the papermill, it is imperative that discharges from the papermill be reduced. This alternative would change the focus of the XL project. There are some inherent conflicts with this strategy. It would get away from original intent of agreement, which focuses on the black liquor cycle. More importantly, the funds ($780,000) allocated for the process modification to mitigate COD and color discharges from the mill are insufficient to reduce the discharges from the paper machines. Lastly, the COD discharges from paper machine most likely are ***not*** toxic, while those originating in the pulp mill effluents are toxic. Also, it is in the interest of IP, independent of the XL-project, to reduce the discharge of COD and color coming from the machines.

Alternative No. 2. Move to Toxicity Standard

The second alternative is to move away from COD and color standard and move to a toxicity standard based upon the end of pipe measurement. Implementation of processes changes would be made to the pulp mill in an effort to decrease the toxicity of the wastewater effluent. If such changes to pulp mill were successful, they should decrease toxicity at end of pipe and be measurable. If most of the toxicity comes from the pulp mill and bleach plant, then the Collaborative Team should be able to measure and document such changes. Unfortunately, toxicity measurements are costly, and sometimes equivocal. A significant portion of the budget could be used solely for toxicity testing leaving little for the process modification. Lastly, the COD at the end of pipe will not be significantly affected and the goals of the original XL project would not be met.

Alternative No. 3. Change the System Boundaries

The third alternative is to change the system boundaries used in the measurement scheme. In this strategy, the Collaborative Team would retain the COD and Color Standards as defined in the original XL agreement but the system boundaries would be modified accordingly to permit documentation of the process changes made on the black liquor cycle. The focus of the team would be point sources of COD discharge from the pulp mill, bleach plant and recovery area. When process changes are implemented, the point of measure would be the appropriate sewer system where the changes were made. Significant process changes could be documented in this way although they may not be seen in the end of pipe. Changes made in the black liquor handling should be measurable and stays with the original intent of the XL agreement. The major difficulty with this approach is that the COD goal at end of pipe may not be significantly reduced and the project goals met unless the Collaborative Team identifies more projects with a larger impact than heretofore have been identified, or the paper machines contribute less COD to the sewer system.

CONCLUSIONS

Current COD discharge from the effluent treatment plant is approximately 30 to 35 Kg COD/k Kg ADMT pulp, and has been trending upward in recent months. The primary goal of the XL-project is to achieve reductions in COD in the process sufficient to meet a 26 Kg COD per 1000 tons AD pulp in the mill effluent. Capital funds available for COD reduction projects under this project are $780,000.

Based on the COD and BOD testing done under the XL-project by the collaborative team, it is apparent that COD discharges come from both the black liquor cycle and the paper machines. It is also apparent that the COD discharges from the papermachines going to the waste treatment plant far exceed the discharge of the black liquor cycle, although the black liquor solids have much greater toxicity.

Since the COD discharges from the paper mill far exceed those of the black liquor cycle, the COD discharged to the sewer system will dictate the level of COD in the mill effluent, and thus the success of the XL-project. COD discharges from the paper mill appear to be less biodegradable and are characterized by a high COD to BOD ratio. These long-lasting components in the effluent from the machines are thought to originate from Styrene Butadiene Latex (SBR) and other coating solids that have high molecular weight. Because of the high molecular weight SBR would not be expected to be toxic to aquatic life in the Androscoggin River however. Discharges of TiO_2 and coating solids would be expected to interfere with the standard color test however.

A number of projects have been identified and implemented dealing with the black liquor cycle. To date, approximately $240,000 has been spent or approved for spending on process modification to reduce COD discharge to the waste treatment plant. These projects pertain primarily to closing up the screen room and would if implemented result in anticipated reductions in COD leaving in the mill effluent. After correction for the efficiency in the treatment plant, the maximum reduction would amount to approximately 2.06 Kg COD per 1,000 Kg ADMT. Therefore, implementation of the current list of projects is insufficient to achieve the COD goal of the XL-project.

The two most significant projects identified by the Collaborative Team that involve the black liquor cycle, that have not been implemented, are the demister project and turpentine recovery, both in the softwood kraft mill. However, both of these projects are expensive and most likely exceed the capital funds remaining in the budget. Also, even if the projects were implemented, they would only achieve a maximum total reduction of COD in the effluent of about 3.6 Kg COD per k Kg ADMT of pulp. Capturing this material would not permit the goal of 26 Kg COD per k Kg ADMP of pulp however.

It is theoretically possible to achieve the goal of 26 kg COD per k Kg ADMT if a very large fraction of the COD coming from the black liquor cycle were contained and kept within the cycle. This is clearly impractical however and the capital budget is insufficient to achieve such results. Reducing the COD discharges from the papermachines by 14 to 32% would ensure that the COD discharge goal of the project will be achieved. Moreover, it is in the best interest of IP to reduce these discharges since they represent costly raw materials used in the papermaking process and low machine efficiency.

RECOMMENDATIONS

Overall Strategy. The overall strategy recommended by the Collaborative Team to follow both Alternative 1 and 3 appears to be the appropriate choice. This allows both the goals of the project to be met as well as to document the progress in reducing black liquor emissions from the mill.

Reduce COD Discharges from Papermachines. It is strongly recommend that the IP management team take steps to reduce the COD discharge from the papermachines since it is unlikely that the COD goal of the project will be met without significant reductions of COD from the papermachines.

Focus of Collaborative Team. The Collaborative Team should continue to concentrate on COD reductions in the pulp mill since this objective is commensurate with the spirit and intent of the original XL-project agreement.

Measuring Success on Implemented Projects. Because of the large COD load coming from the paper machine, implementation of smaller projects, such has been done to date, cannot be documented by looking for changes in the mill effluent. Rather it is recommended that the collaborative team move the boundaries for measurement into the appropriate sewer system to document the effectiveness of the implemented project. COD reductions should be documented before and after the changes are made.

Perform Mill-Wide Color Balance. A notable shortcoming in work performed to date is that no color measurements were made during the mill-wide sampling program. It is strongly recommended that this shortcoming be rectified and a color balance performed.

Additional COD Balance Work. Also, it is recommended that addition work be done on COD sampling. The COD balance should be repeated at a later date after more COD reduction projects have been identified and implemented. This would also permit a check on possible progress made on the papermachines in reducing COD going to the waste treatment plant.

Sewer Monitoring. Since the COD coming from the papermachines is such a large contributor to the total COD load going to the waste treatment system, the Collaborative Team may wish to investigate methods of monitoring the discharge of COD in the sewer system that are applicable to the paper machine.

Toxicity Testing. Some modest level of toxicity testing is currently being done on the mill effluent by the mill. This work should be encouraged. However, developing a toxicity database is costly and outside of the scope of the XL-project. It is recommended that some modest level of additional testing on specific effluent streams be conducted to confirm the results reported here that the effluent from the papermachines is not toxic. Alternatively, it may be possible to obtain additional information from the open literature to substantiate this premise.

APPENDIX A
RESULTS OF MILL-WIDE COD BALANCE

Figure A1
Layout of Mill Sewer System

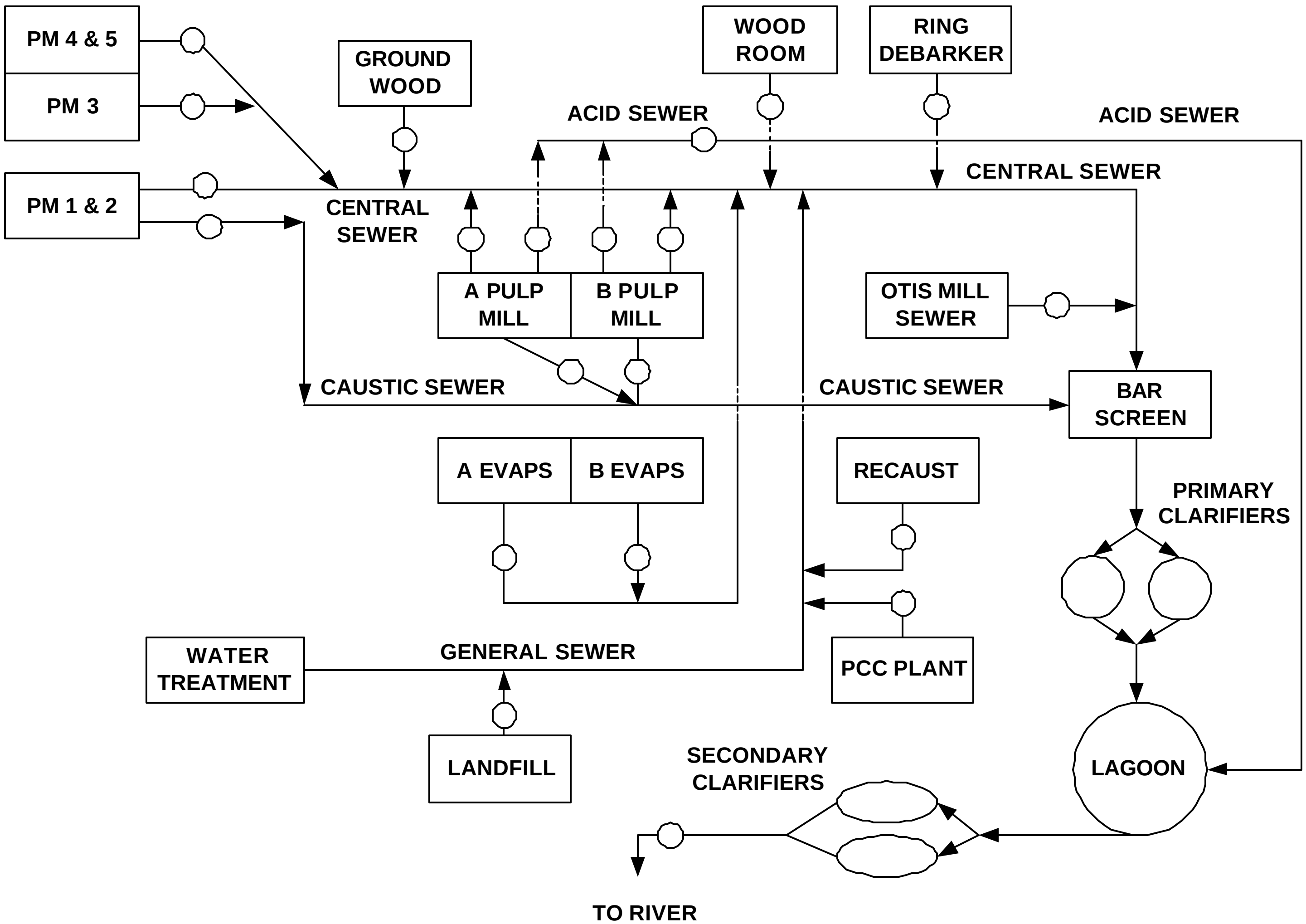


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Table A1
Summary of Data From Mill-Wide COD Balance

			Three Day Average					COD-BOD
Sample	Flow (gpm)	Flow (MG/D)	COD (mg/L)	BOD (mg/L)	COD (#/Day)	BOD (#/Day)	Ratio	#/Day
Raw Water	29000	41.76	71	12	24687	4288	5.8	20399
PM3 & Ctg. Prep.	5820	8.4	2450	285	170965	19911	8.6	151054
PM4 & PM5	4247	6.1	2097	611	106757	31094	3.4	75663
PM1 & PM2 Gen.	2095	3.0	819	173	20578	4345	4.7	16233
PM1 & PM2 Caus.	3300	4.8	650	108	25719	4286	6.0	21432
Paper Mill	15461	22.3			324019	59636	5.4	264383
A General	887	1.3	1033	252	10994	2685	4.1	8309
A Caustic	630	0.9	4227	972	31927	7342	4.3	24585
B General	362	0.5	3540	2160	15365	9377	1.6	5988
B Caustic	580	0.8	3227	1357	22439	9437	2.4	13002
Acid	3820	5.5	937	321	42901	14718	2.9	28183
Evaporators	1210	1.7	1887	1102	27372	15988	1.7	11384
Total BL Cycle	7489	11			150997	59546	3	91451
Landfill	63	0.1	1660	584	1247	439	2.8	808
Groundwood	209	0.3	778	128	1946	319	6.1	1626
Recaust	80	0.1	1731	722	1660	693	2.4	967
Ring Debarker	70	0.1	2117	340	1777	286	6.2	1491
Woodroom	150	0.2	1136	139	2043	249	8.2	1794
Other	571	1			8673	1986	4.4	6686
SMI (PCC)	134	0.2	13	6	20	10	2.1	11
Otis	2014	2.9	469	175	11317	4218	2.7	7099
SMI & Otis	2148	3.1			11338	4227	2.7	7110
Total Inflow	54670	37			495026	125395	3.9	369631
Mill Sewer	26320	37.9	1262	326	399287	103249	3.9	296038
Mill Effluent	30139	43.4	208	8	75479	2778	27.2	72702

SOURCE. MR. PHIL SEKERIK OF IP-ANDROSCOGGIN, JAY, MAINE

Figure A2. Sewer Flow Percentages

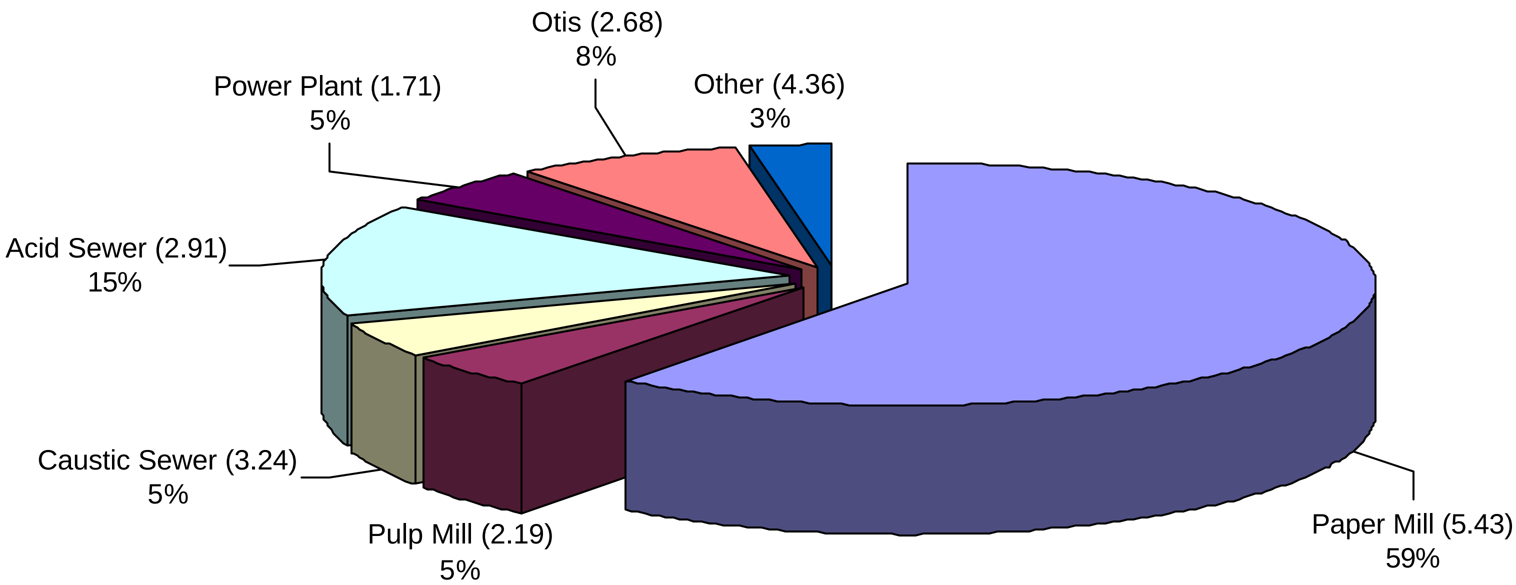


Figure A3. COD source percentages

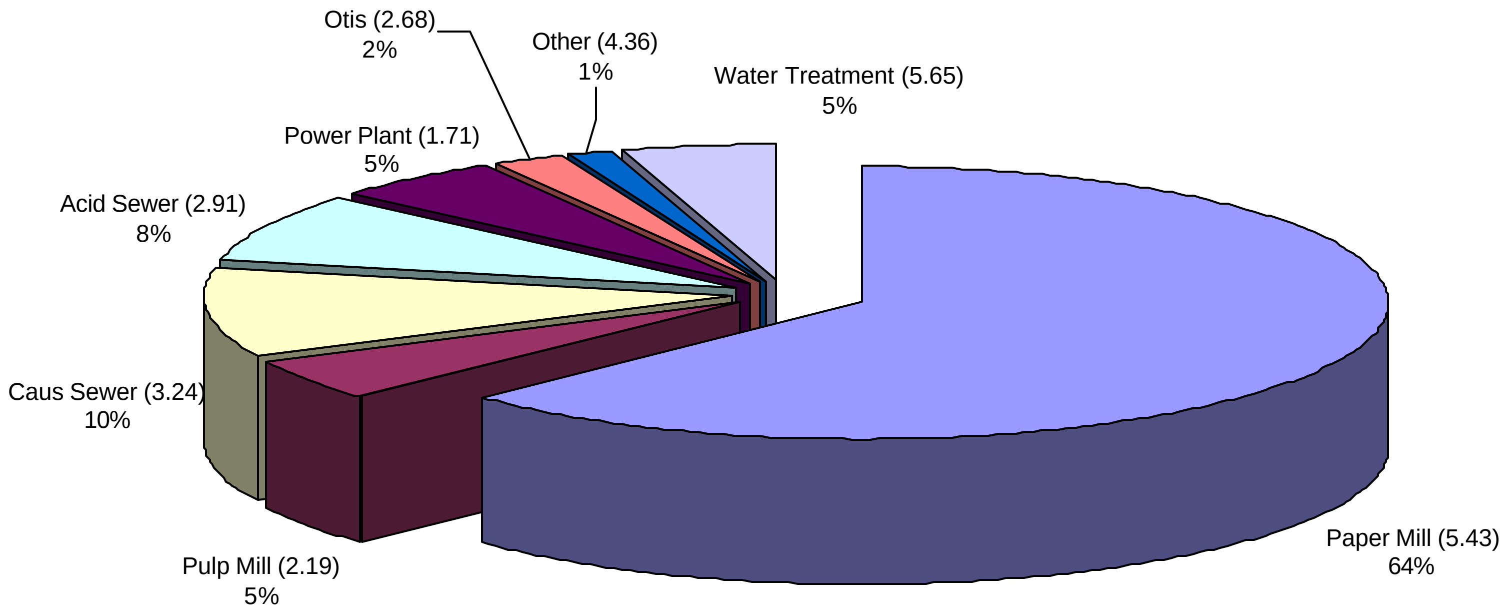


Figure A4. BOD Source percentages

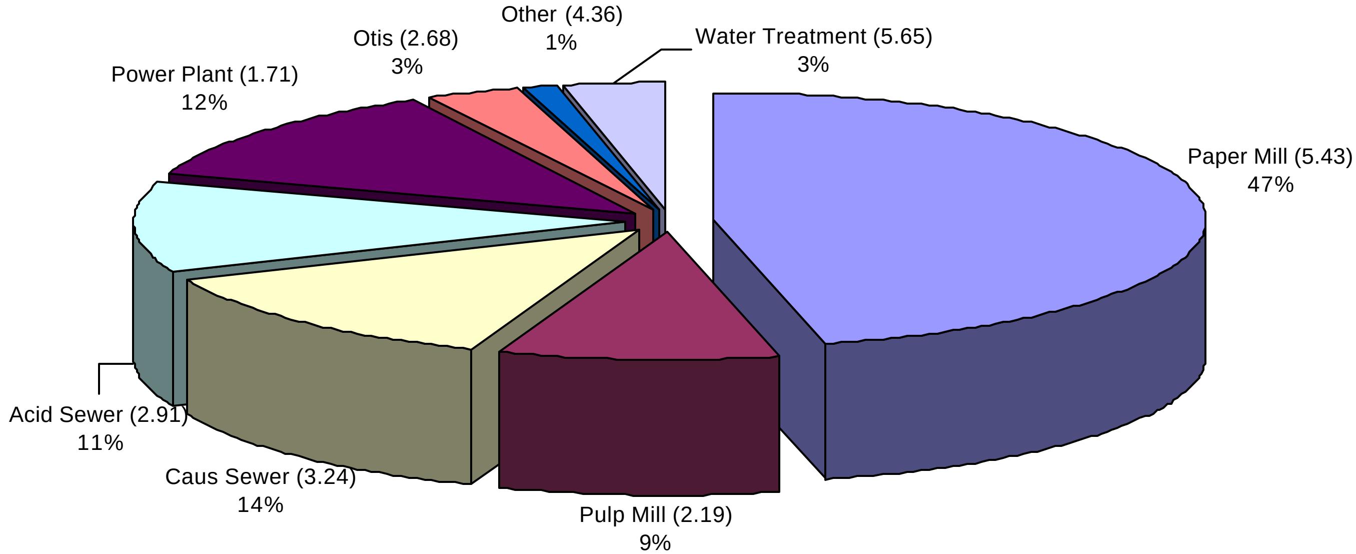
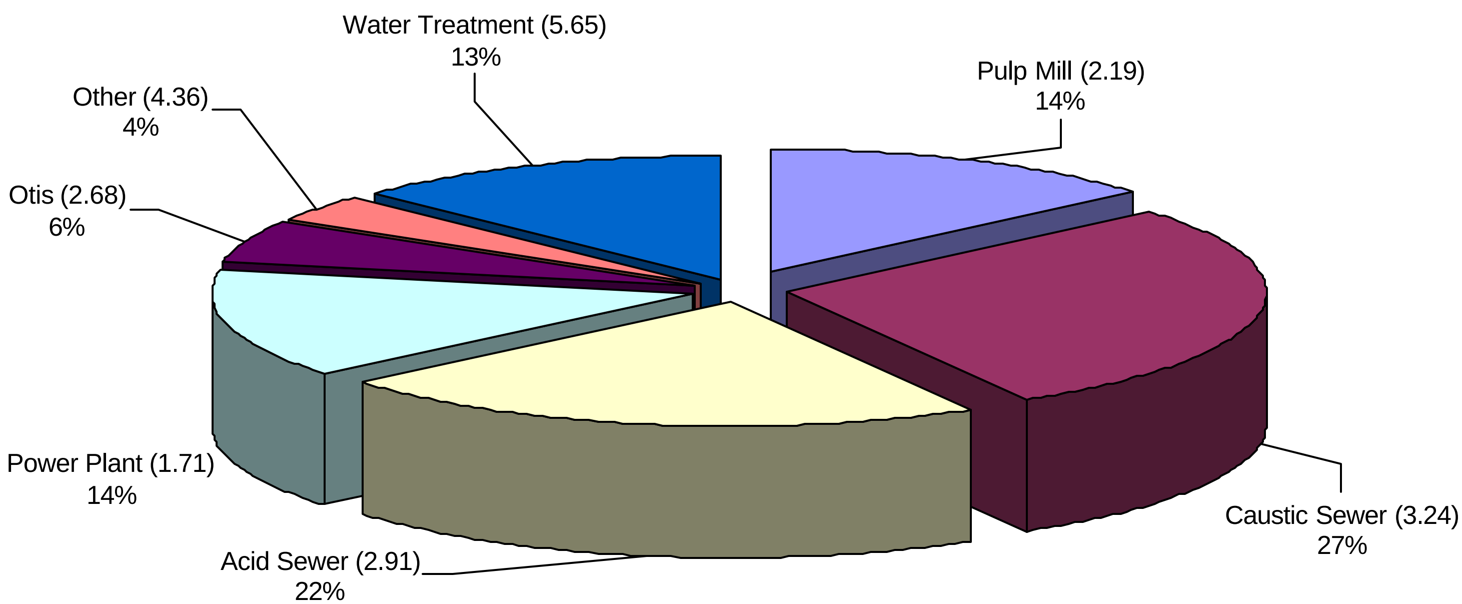


Figure A5. COD source not including papermill



APPENDIX B
Final Effluent Treatment Data