UNOX System Evaluation

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Objectives

In November 2007, EBS and Paul Klopping spent several days on site addressing wastewater treatment system (UNOX system) problems associated with increased BOD loading from mill production and an auxilary manufacturing process. The auxillary process is no longer included in the wastewater influent, but BOD loadings remain well above historical norms. EBS was asked to come back in with Paul to assess the system under what would now be considered normal long-term operating conditions and make recommendations regarding operation and optimization of the UNOX system. This work was undertaken to review the performance of the wastewater treatment system and recommend changes in operating tactics that will improve the capacity and reliability of the system. The work was performed March 10-13, 2008, and consisted of an on-site sampling and analysis, review of operating records, verbal discussions with operating personnel, and a physical inspection of the facility.

UNOX Profile

A dissolved oxygen profile was performed on each of the four cells in each UNOX train. This work was done to evaluate the vertical mixing regime and identify possible oxygen distribution problems. Results are summarized in the tables below.

Based on the findings of the D.O. profiles, I suggest you drain and inspect Train #1, Cell #4, as there appears to be an accumulation of sludge in the vicinity of the sampling port. I also suggest you inspect the weirs on the UNOX basins to insure they are intact and are set at the proper elevation.

A review of past EBS Service Reports shows the Specific Oxygen Uptake Rate (SOUR) measurements of Train 1 are sometimes higher than adjacent trains. If solids have accumulated in the back end of this train this may be causing short-circuiting, poor oxygen transfer and elevated SOURs.

D.O. Profile Train 1

	Cell 1	Cell 2	Cell 3	Cell 4	Effluent	Vent Purity
Top	4.7	1.9	0.9	No reading, sludge deposits top to bottom	0.9	22.0%
Middle	2.4	1.2	1.0			
Bottom	1.0	1.2	1.2			

D.O. Profile Train 2

	Cell 1	Cell 2	Cell 3	Cell 4	Effluent	Vent Purity
Top	7.2	11.6	5.4	1.6	0.8	34.0%
Middle	6.6	10.7	5.5	1.3		
Bottom	4.7	8.0	4.8	1.2		

D.O. Profile Train 3

	Cell 1	Cell 2	Cell 3	Cell 4	Effluent	Vent Purity
Top	10.5	1.3	No reading, cap stuck	1.5	0.7	24.0%
Middle	8.5	1.0	No reading, cap stuck	1.0		
Bottom	5.4	0.9	No reading, cap stuck	1.3		

D.O. Profile Train 4

	Cell 1	Cell 2	Cell 3	Cell 4	Effluent	Vent Purity
Top	13.2	10.4	8.4	5.1	3.9	21.0%
Middle	12.9	10.3	8.6	5.2		
Bottom	12.6	10.0	7.9	4.7		

D.O. Profile Train 5

	Cell 1	Cell 2	Cell 3	Cell 4	Effluent	Vent Purity
Top	13.7	13.8	10.8	6.2	5.1	21.0%
Middle	10.5	10.2	10.5	5.9		
Bottom	9.0	9.9	9.8	5.4		

D.O. Profile Train 6

	Cell 1	Cell 2	Cell 3	Cell 4	Effluent	Vent Purity
Top	13.5	13.7	10.3	6.3	3.8	23.0%
Middle	11.8	12.2	9.3	5.9		
Bottom	8.6	11.0	8.4	5.6		

State Point Analysis

When more solids are put into a secondary clarifier than can be successfully transmitted to the floor, collected, and removed in the return activated sludge, the clarifier is said to be overloaded. The result of this overloaded condition is that solids will accumulate in the secondary clarifier, increasing the blanket depth.

An overloaded condition can be severe enough that the surface of the sludge blanket reaches the water surface, resulting in a gross loss of solids to the effluent.

Even without the blanket actually reaching the water surface, high sludge blankets deteriorate effluent quality because solids can easily be scoured from the surface of the blanket into flow streams exiting the clarifier.

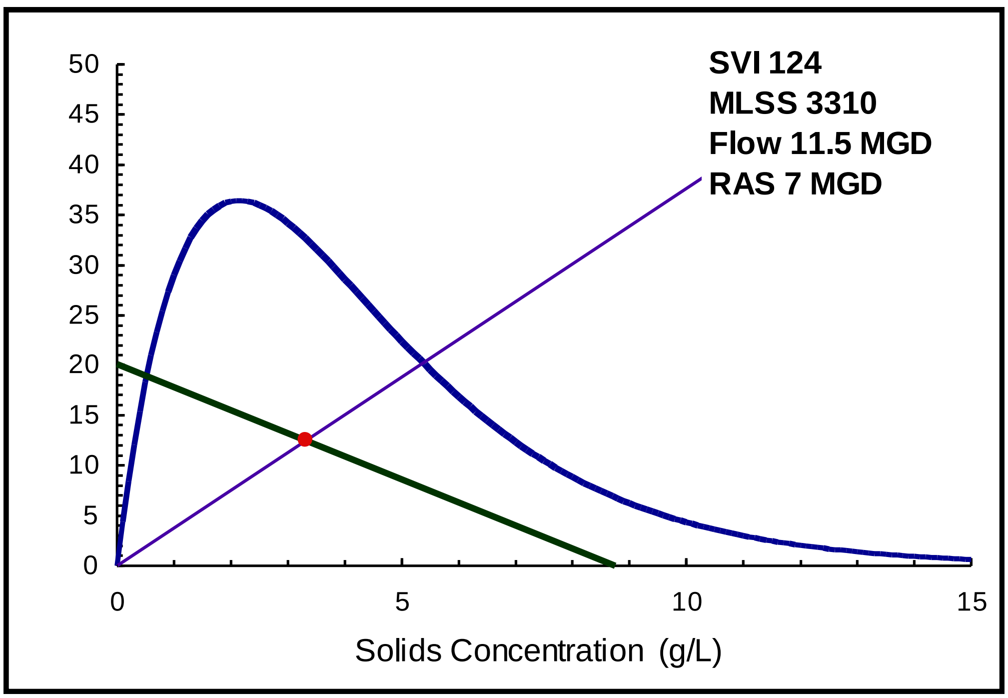
A series of clarifier state point analyses were performed to evaluate the loading and predict the performance of the secondary clarifiers. Based on your historical experience, an SVI of 150 mL/g was chosen as a realistic value that represents the settling properties of the MLSS. A range of MLSS values were then evaluated at a fixed SVI of 150 and flow rate of 11.5 MGD per clarifier.

Under these conditions, it appears that a MLSS range of 4,000-4,500 mg/L produces an acceptable clarifier solids flux (prevents the clarifiers from becoming overloaded.) I suggest keeping the MLSS in this range unless the SVI drops. The system can be operated at a MLSS of 5,000-5,500 mg/L if the SVI is 100 mL/g or lower.

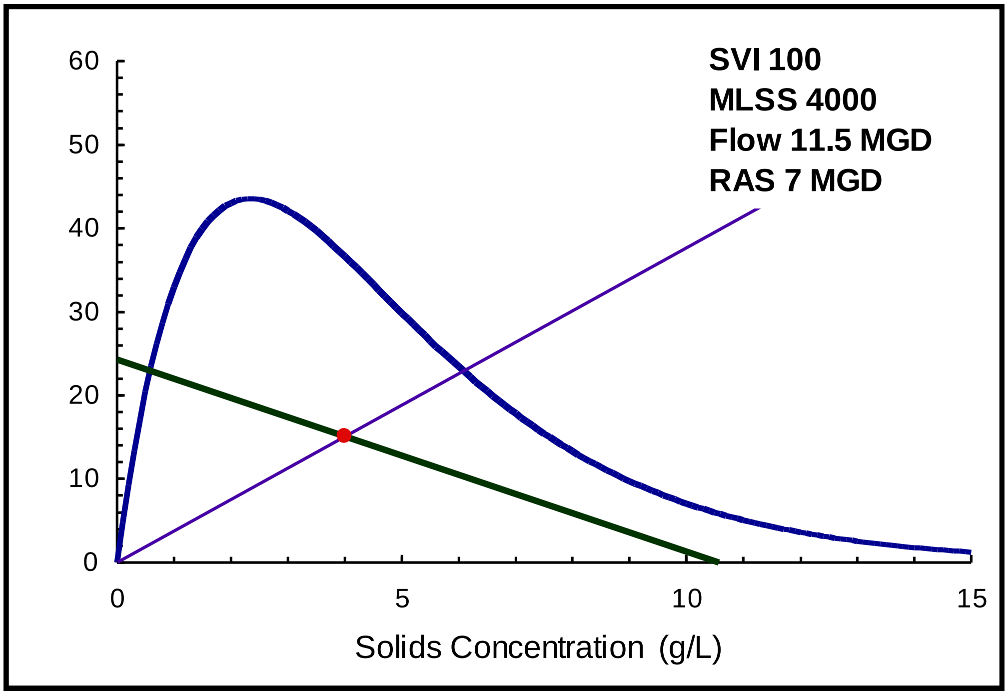
State point graphs for Clarifier #1 and Clarifier #5 are included below to illustrate the effect of SVIs at 100, 150, 200 and 250 mL/g. Clarifiers #1, #2 and #3 are 180 feet in diameter, while Clarifiers #5 and #6 are 200 feet in diameter. The first set of graphs illustrates the results for the smaller clarifiers and the second set of graphs illustrates the results for the larger secondary clarifiers.

Clarifier #1 State Point Analysis
Conditions as of March 13, 2008

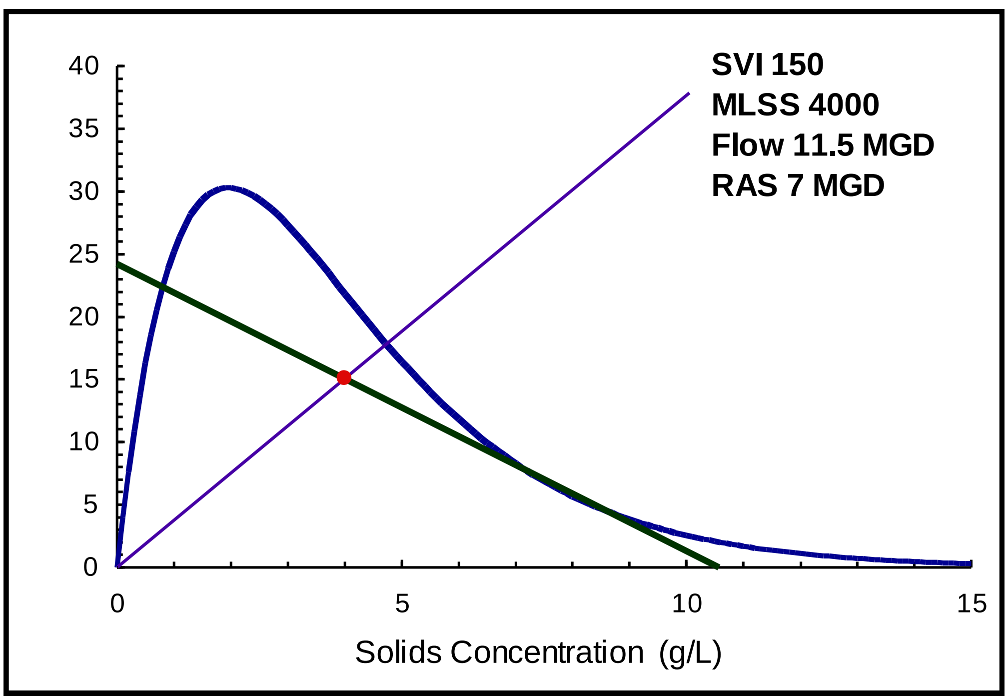
Underloaded



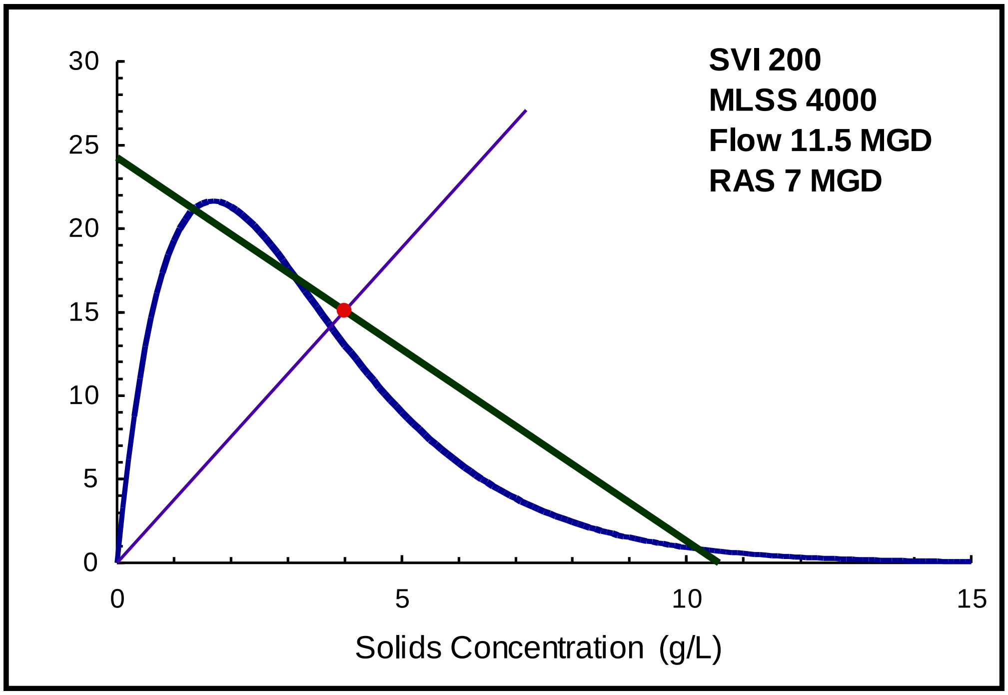
Clarifier #1 State Point Analysis
Underloaded



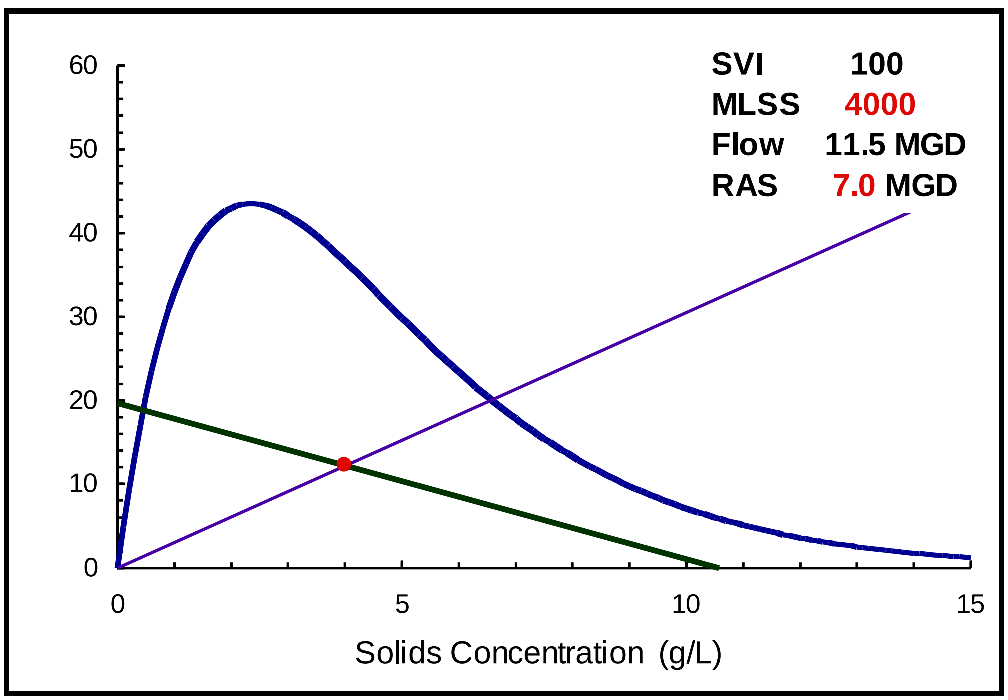
Clarifier #1 State Point Analysis
Critically Loaded



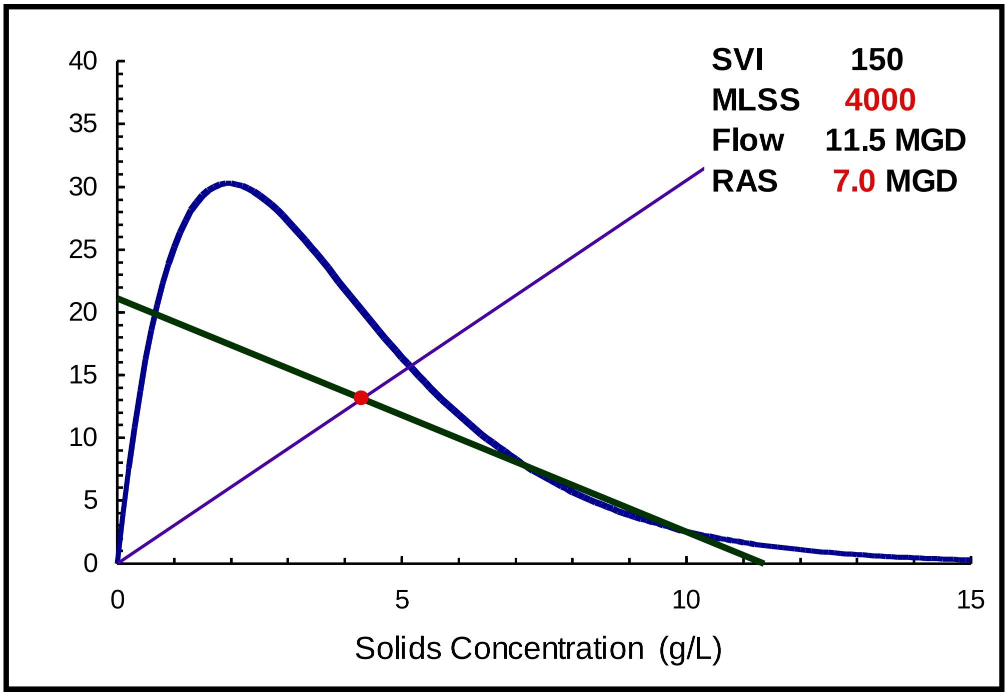
Clarifier #1 State Point Analysis
Overloaded, Clarification Failure



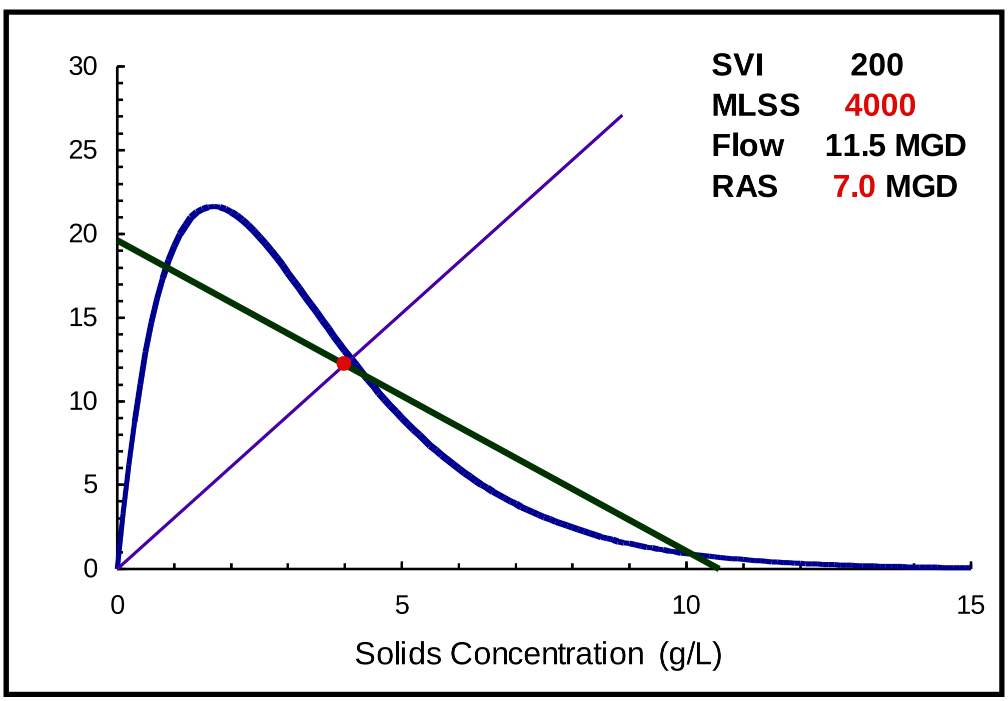
Clarifier #5 State Point Analysis
Underloaded



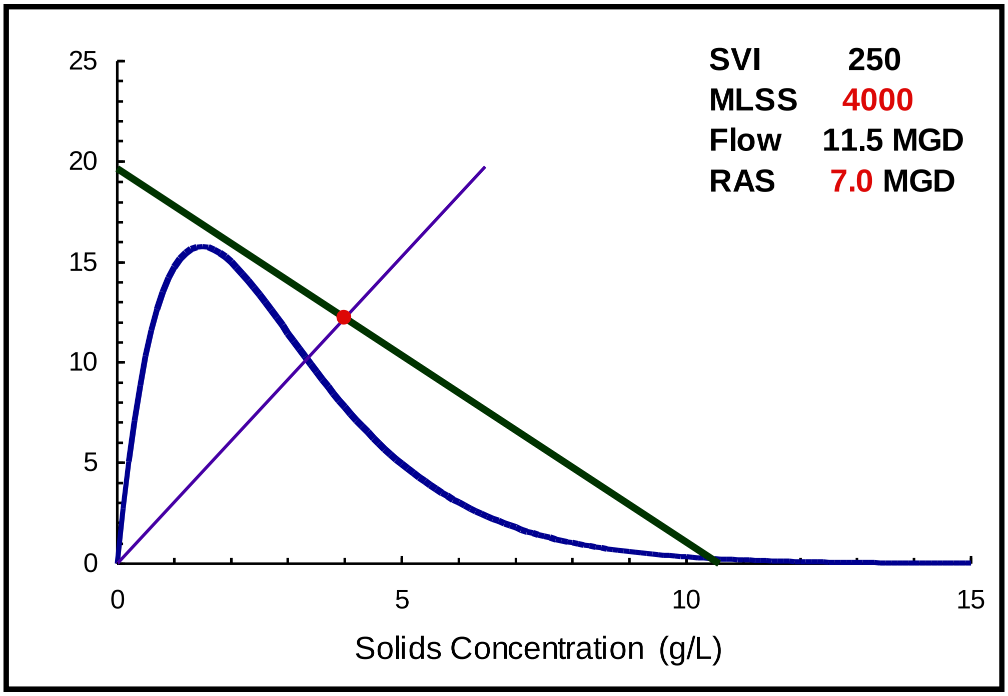
Clarifier #5 State Point Analysis
Critically Loaded



Clarifier #5 State Point Analysis
Overloaded, Thickening Failure



Clarifier #5 State Point Analysis
Overloaded, Clarification Failure



Sludge Age and F/M Spreadsheet

We reviewed your Sludge Age-F/M spreadsheet and appreciate the thoughtful method you use to account for and control the sludge age and inventory.

One of the most difficult measurements to perform accurately is the secondary clarifier inventory. The current clarifier inventory calculation assumes the entire blanket is the concentration of RAS. This overestimates the clarifier inventory and consequently skews the sludge age value upward. I suggest modifying the formula to use the average of MLSS + RAS to estimate the blanket concentration.

This will reduce the clarifier inventory and therefore cause the calculated sludge age value to drop. While the actual age of the biology doesn't change at all, the calculated value will be lower. I am including a modified version of your Excel Sludge Age - F/M Spreadsheet that contains the recommended changes.

Nutrient Management

Nitrogen is chronically low while phosphorus is not. If improvement in BOD removal becomes an important issue, the first step I suggest taking is to increase the feed rate of nitrogen and maintain a residual of 1-2 mg/L total inorganic nitrogen (TIN). This could be accomplished by maintaining your use of ammonium polyphosphate and adding a supplemental feed of urea ammonium nitrate.

Mass Balance

I suggest reducing the clarifier sludge detention time to less than 3 hours. Because of the relatively large clarifier volume of your system (relative to the aeration volume), solids naturally shift toward the clarifiers. Ideally, more than 60% of the total secondary inventory should be under aeration, with a higher percentage being better. You will see BOD removal and sludge quality improve as solids are redistributed in favor of aeration rather than clarification. I suggest a goal of 70% of the inventory under aeration, with a minimum of no less than 60%.

Sludge Handling

At times the system becomes wasting limited resulting in aeration basin MLSS values exceeding the maximum levels that the clarifiers can handle based on the State Point Analyses. This also results in excess solids buildup in the clarifiers with all of the associated problems previously mentioned. Under ideal conditions (all presses operating and 100% capture) the mill can dewater 200 – 220 dry tons of solids, primary and secondary combined. Based on 2007 data, the amount of solids that must be dewatered on average are as follows. With an average BOD loading of 225,000 pounds per day, a sludge yield of 0.5 lbs TSS/ lb BOD converted, and an average effluent TSS to the river of 40,000 pounds per day, 72,500 pounds (36.25 tons) of secondary sludge must be removed on average daily. An average of 132 tons per day of primary solids enters the primary clarifiers each day. Ultimately almost all of these solids reach the thickeners, via primary clarifier underflow or through the UNOX system wasting.

The total sludge that must be wasted is ~168.25 tons per day. Actual sludge dewatering for 2007 was 165 tons per day. This means that the dewatering equipment must continually be operating at 75 – 85% capacity for all five presses (four belt presses and one screw press). This also assumes a constant sludge generation scenario, which is far from reality. The highest primary solids month in 2007 (June) averaged 52% higher solids than the lowest month (September). Unfortunately the capacity not utilized in one month cannot be made available in months where it is needed. A similar situation exists with secondary sludge. In addition to periods where actual sludge generation is below average due to low BOD loading, the practice of utilizing sludge age (MCRT) as the overriding parameter for wasting control results in low wasting rates at times when MLSS values would indicate that higher wasting rates are appropriate. In addition to potentially overloading the clarifiers, this results in excess sludge inventory buildup that exceeds the capacity of the dewatering system to rapidly remove the solids in the event of high BOD loading (high sludge production) or high fiber losses from one or more processes.

The key action items for this area are:

- to maintain a proactive wasting strategy using both sludge age and MLSS as control parameters,
- maintaining the dewatering equipment to maximize “up time”, and
- explore any options to improve solids recovery or reduce losses upstream.