

City and County of San Francisco
2030 Sewer System Master Plan

TASK 200
TECHNICAL MEMORANDUM NO. 202
BIOWIN MODELING AND SECONDARY CLARIFIER
STRESS TESTING AT THE SEP AND OSP

FINAL DRAFT
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CITY AND COUNTY OF SAN FRANCISCO
2030 SEWER SYSTEM MASTER PLAN

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BIOWIN™ MODELING AND SECONDARY CLARIFIER STRESS TESTING AT THE SEP AND OSP

Please note this memo was created in February of 2007 and was not updated. It was determined by the SFPUC and the consultants that it was important to capture the information at the time of development so the reviewers could see the progression of information and decisions made at the time of the memo development. Please also note that the word 'alternative' was used instead of 'configurations' for the memos reflecting the existing wording at the time it was written. In the Comprehensive Report, the term was updated to 'configuration' so as not to confuse the CEQA review process. The configurations mentioned herein may have changed or been eliminated and are not considered full CEQA alternatives.

1.0 INTRODUCTION

During the master planning process, calibrated *BioWin*™ models were developed for both the Southeast Water Pollution Control plant (SEP) and the Oceanside Water Pollution Control plant (OSP). In conjunction with the *BioWin*™ modeling, stress testing of the secondary clarifiers was also undertaken to allow plant specific ratings to be developed. This technical memoranda provides a brief summary of the work that was undertaken for the modeling and stress testing and other *BioWin*™ work and provides the detailed reports in the Appendices. If further use of the models are needed it is recommended that the models be updated and/or further calibrated depending upon model version and current operating practice at the plants.

2.0 SEP PLANT RATING

A calibrated *BioWin*™ model was developed for the SEP. Model calibration was achieved through routine and special sampling of the wastewater characteristics and recycle streams and comparison of operational data with predicted model values. This work is detailed in *Sierra, et al*⁽¹⁾ "Whole-plant simulations for two pure oxygen activated sludge plants in San Francisco" and presented in Appendix A. As part of the calibration effort, influent flow and load data along with actual operational data was compared with predicted model values as detailed in Appendix B. Also detailed in the paper is the secondary clarifier column settling tests, stress testing and the clarifier state point analysis.

SEP secondary clarifier state point curves were developed for average and maximum flows for the hypothetical cases of eight and four clarifiers on line compared to normal operation of sixteen clarifiers on line. For eight clarifiers on line it was shown that stable operation was achieved for all practical RAS concentrations. For four clarifiers on line overloading with respect to sludge thickening was predicted at SVIs above 110 ml/gm.

From a combination of the *BioWin*TM modeling and secondary clarifier stress testing it was stated that the current capacity of the secondary system at the SEP plant was 190 MGD with all secondary clarifier on-line.

2.1 Preliminary Nitrification Analysis, 2007

A set of conservative preliminary *BioWin*TM models were undertaken to investigate the secondary infrastructure required for full nitrification of the influent to the SEP, using average and maximum month flows and loads.

Assumptions in the analysis included a maximum exit MLSS value of 3,500 mg/L, an influent wastewater temperature of 16°C, converting the pure oxygen reactors to air running at 2 mg/L DO in each aerobic zone, and a target aerobic SRT of 6 days. The results, presented in Appendix C, indicated the following secondary infrastructure would be required for full nitrification.

- Aeration Basin Volume Required = 25 MG
- Current Basic Volume = 7.7 MG
- New Basin Volume = 17.3 MG
- Secondary Clarification Area Required = 240,000 ft²
- Current Surface Area = 200,000 ft²
- Require Area = 40,000 ft²
- Total Number Required = 18 secondary clarifiers

Step feed capabilities would also probably be needed for peak flow conditions.

2.2 Wet Weather BioWinTM Modeling April, 2008

A set of conservative preliminary *BioWin*TM models were undertaken to investigate the treatment of peak wet weather flows at the SEP. A copy of the report is contained in Appendix D.

For this analysis *BioWin*TM 3.1 the updated version of the model was used. The plant was modeled as a pure oxygen activated sludge system. For wet weather all basins and secondary clarifiers were placed on-line. The analysis indicated that switching to a contact stabilization mode during wet weather events would increase the wet weather rating of the secondary system from 150 to 180 MGD.

3.0 OSP

A technical memoranda entitled “*Wastewater Sampling Analysis for Use in the Oceanside Water Pollution Control Plant Specific BioWin™ Process Model*” was produced in October 2005 and is contained in Appendix E. This technical memorandum detailed the special sampling at the plant, recommended influent fractionation from the sampling and determined recommended *BioWin™* input values derived from the specifier spreadsheet.

The *Sierra et al* paper utilized this work along with site specific secondary clarifier column testing, stress testing and the clarifier state point analysis to determine plant ratings.

For five clarifiers on line at the OSP, the solids flux analysis indicated that for most cases the clarifiers would be underloaded at average flows. At peak flows the clarifiers would be overloaded with respect to thickening for SVIs greater than 350 ml/gm. For four clarifiers on line the state point analysis indicated that for a RAS value of 7,000 mg/L and SVIs less than 350 ml/gm the clarifiers are underloaded. However, maximum flow conditions indicate a situation when the clarifiers are overloaded in most cases.

From a combination of the *BioWin™* modeling and the secondary clarifier stress testing it was stated that the current capacity of the secondary system at the OSP was 36.4 MGD for dry weather flow and 54 MGD for wet weather flow with six clarifiers on line.

3.1 Cayuga Diversion BioWin™ Modeling, February 2007

A series of *BioWin™* models were undertaken to determine the potential impacts of an extra 10 mgd of dry weather flow (Cayuga diversion) to the OSP. Initial model runs were conducted at the plant for future flows and loads without the Cayuga diversion (base case runs). The results indicated that the plant could process these future flows and loads within the existing infrastructure. Details of the analyses are contained in Appendix F.

Modeling was then undertaken with the additional dry weather flow due to the Cayuga diversion. The results indicated that maximum month conditions necessitated all three (3) aeration basins be on-line to keep the MLSS values within reasonable target values. However, maximum week conditions dictated a more aggressive (lower) SRT operation. It was recommended that a more detailed process analysis be undertaken to evaluate the Cayuga diversion from a whole treatment plant perspective.

REFERENCES

REFERENCES

Sierra, N., Huang, G., Jones, B., Velasco, A. Haddad, D., Chan, R. Chu, I., Feng, Y. Jolis, D. *Whole-Plant Simulations for Two Pure-Oxygen Activated Sludge Plants in San Francisco*, WEFTEC Proceedings, 2006.

**APPENDIX A - WHOLE PLANT SIMULATIONS FOR TWO PURE
OXYGEN PLANTS IN SAN FRANCISCO**

WHOLE-PLANT SIMULATIONS FOR TWO PURE-OXYGEN ACTIVATED SLUDGE PLANTS IN SAN FRANCISCO

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ABSTRACT

This paper discusses the usage of settling column tests, full-scale stress tests, and whole-plant simulators as planning tools to assess the ultimate treatment plant capacity as well as impacts of process changes to effluent quality, process performance, side streams, and biosolids production rates. These planning tools are described in detail and the results of their implementation are presented for the two pure-oxygen activated sludge plants in San Francisco, California.

KEYWORDS

Clarifiers, whole-plant simulations, settling columns, stress tests, capacity assessment

INTRODUCTION

The City and County of San Francisco (City) has embarked on a thirty-year Master Plan to plot the future course of wastewater treatment in the City. This necessarily involves assessments of the future of the City's two secondary treatment plants - Southeast Water Pollution Control Plant (SEP) and Oceanside Water Pollution Control Plant (OSP). One goal of the Master Plan is to assess the treatment capacities of these two plants. BioWin, a biological process simulator has been chosen to work side by side with the full-scale plant studies to achieve this goal. The work detailed in this memorandum is based on the Water Environment Research Foundation (WERF) document, "Protocols for Evaluating Secondary Clarifier Performance" (WERF, 2001).

Both SEP and OSP are pure oxygen activated sludge plants. OSP treats flow from the western side of the City and has a design secondary treatment capacity of 43 MGD, with room for primary treatment of an additional 22 MGD. SEP treats wastewater from the eastern side of the City, providing 100 MGD of primary treatment and 150 MGD of secondary treatment. At the time of this analysis, SEP, unlike OSP, had implemented anaerobic selectors, which has greatly aided in improving sludge settleability. Features of both plants are listed in Table 1.

Table 1. Features of SEP and OSP Liquid Treatment

	OSP	SEP
Number of Primary Clarifiers	5 (3 on line)	7 (6 on line)
Capacity of Each Primary Clarifier (MG)	0.65	0.71
Number of Aeration Trains	3	6
Number of Secondary Clarifiers	7 (6 on line)	16 (16 on line)
Capacity of Each Clarifier (MG)	0.92	1.27
Discharge Location	Pacific Ocean	San Francisco Bay

MATERIALS AND METHODS

Sludge Settling and Clarifier Stress Test

The settling columns (Figure 1), used to calculate the settling velocity of the plant sludge, were constructed of cast acrylic tubes; these tubes were approximately eight feet tall and nine inches in diameter. The columns were outfitted with a drain at the bottom through which either the contents could be emptied or a sample could be extracted. Thin paddles were installed and attached to a motor, allowing them to turn slowly (approximately 1 rpm), thereby reducing wall effects within the columns. To provide air for gentle mixing, a regulator was installed on a plant air line, and flexible tubing was run from the regulator to the columns. Air stones at the end of the tubing allowed for more diffuse bubbling, which provided gentle mixing to the columns without breaking up the floc.

In order to test settling at different solids concentrations, a test run protocol was established, providing mixtures of mixed liquor suspended solids (MLSS), return activated sludge (RAS), and final effluent that would span a range of total suspended solids (TSS) values. For OSP, the TSS target values of the mixtures ranged from 1,000 to 8,000 mg/L. For SEP, the values ranged from 1,000 to 15,000 mg/L.

Figure 1. Settling columns installed at SEP during the testing event.



The procedure for the settling column tests is as follows. A tape measure was attached to the side of each of the two columns. The column was filled with a mixture of RAS, mixed liquor, and/or secondary (unchlorinated) effluent. Air mixing was turned on for five minutes, at the end of which time a sample was gathered. At OSP, the samples were collected using the drain at the bottom of the column. At SEP, samples from the columns were extracted using a small zone sampler dropped into the column immediately after cessation of the air mixing. While the port was simpler to use, it also allowed for the possibility of cross contamination between samples unless a sufficient volume of sample was flushed through the port. All samples were placed in a pre-chilled, insulated cooler. The air line was then removed from the column and the mixing paddles were turned on at a speed of 1 rpm. As soon as the mixing paddles were turned on, the experiment was begun, with measurements of the settling interface height recorded every minute. Measurements were recorded for a minimum of thirty minutes and no more than forty-five minutes.

Interface height was plotted as a function of time for all test runs. The slope of the linear portion of these plots is the initial settling velocity. The initial settling velocity could then be paired with the analytical TSS results for each test run (Table 2). The natural log of these velocities was then plotted against TSS in order to extract the Vesilind coefficients (WERF 2001). Once the Vesilind coefficients were found, fluxes at different TSS concentrations were determined, using the Vesilind equation. The resulting flux curves were used in a state point analysis that allowed the setup of the experimental parameters for the full-scale clarifier stress test.

For the stress test, sampling and observations involved sludge judging, turbidity monitoring, TSS monitoring, and solids sampling and analysis. TSS was measured using a portable TSS meter, which was submerged in the mixed liquor channel upstream of the secondary clarifiers. Turbidity was measured by collecting a grab sample from the secondary effluent channel; the sample was analyzed using either a portable turbidimeter. Sludge blanket level was measured using a standard sludge judge. Periodic grab samples were taken from the effluent end (near the weir) of each clarifier. These samples were analyzed for turbidity and TSS. This allowed researchers to track whether one clarifier was more “stressed” than the others.

Additional samples were collected and analyzed for TSS. These samples are known as DSS_{in} , DSS_{eff} , ESS, and FSS. Definitions of each sample can be found elsewhere (WERF 2001). By comparing their values relative to one another, one can determine whether the clarifiers have sufficient flocculation and settling time. The samples for DSS_{in} , DSS_{eff} , and ESS were collected using a 4.2 L Kemmerer sampler and were collected twice daily.

BioWin™ Modeling

Concurrent with the stress testing at both plants, work was begun on a process model for each plant. The goal of this effort was to compare the predictions of the full-scale work described above with the model predictions. The model selected was BioWin™, a biological process model that merges both activated sludge and anaerobic biological processes. The model can be built with unit processes and is capable of simulating the plant treatment process based on required influent inputs, which include plant influent parameters and recommended COD influent fraction. The BioWin™ simulator includes two modules, a steady state simulation and a dynamic simulation. The steady state simulation analyzes systems based on constant influent loadings or flow-weighted averages of time-varying inputs. In this, it's able to present an overview of the treatment process. The dynamic simulator allows the user to operate and manipulate the treatment system in order to analyze the system response when subjected to time-varying inputs or changes in operating strategy.

In order to derive accurate data to input into the BioWin™ model, an extensive dry-weather sampling program was conducted at OSP in May and June 2005. The original plan was to collect three flow-paced “composite” samples during normal weekday operations, one hourly “diurnal” sample during weekday operations and a second hourly “diurnal” sample during weekend operations. Analyses undertaken are listed in Table 2. Three composite sample events were scheduled to be “fractionated” (i.e., filtered and/or flocculated through the series of membranes to estimate the colloidal and soluble fractions). This same plan was followed at SEP in September and October of 2005.

Table 2. Sample parameters for analysis.

Alkalinity	TKN	NH ₃ -N	Total Sulfide
Total BOD	PH	NO ₂ -N	NO ₃ -N
COD	Soluble COD	TS	TVS
Total PO ₄ -P	Ortho-PO ₄	TSS	TVSS

Composite samples: ISCO samples capable of being programmed over a 24 hour period were used to collect calculated flow-paced samples. Samplers were placed to collect the influent flow directly from the influent channel upstream of the fine bar screens, the primary effluent flow directly from the effluent channel, and secondary effluent from the trough of the secondary effluent sampler.

Diurnal samples: ISCO samplers capable of sampling equal aliquots were programmed so that each hourly sample was delivered to a unique Nalgene sample bottle and samples were collected at equal hourly intervals throughout the sampling day. ISCO samplers were installed at the three locations described above.

Samples of Mixed Liquor (ML), RAS, Primary Sludge (PS), Thickened Primary & Waste Activated Sludge (TPAS), Gravity Belt Filtrate, Dewatered Biosolids (Cake) and Belt Press Filtrate were collected at three equal intervals through the day and evening and composited by mixing equal aliquots of each sampling event. These hand-composited samples were collected as part of both the Composite and Diurnal sampling days. At SEP, the only difference was that samples were taken of centrate (instead of belt press filtrate) and two additional recycle streams (pumped plant recycle and plant recycle) were sampled. Select results of the special sampling events for OSP and SEP are detailed in Tables 3 and 4.

Table 3. Comparison of OSP special sampling results and average plant dry weather values

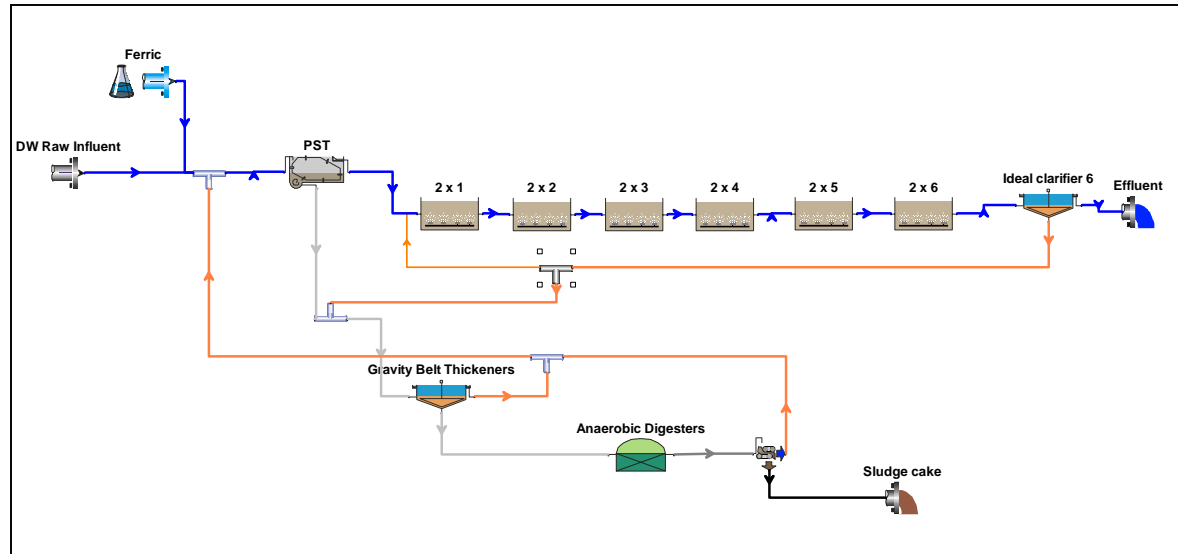
OSP		Raw		Final	
Parameter	Units	2004 DW Value	BioWin™ Sampling Value	2004 DW Value	BioWin™ Sampling Value
BOD	mg/L	242	337	16.3	13.8
COD	mg/L	308	675	54	59
COD/BOD ratio		1.3	2.0	3.5	4.4
TSS	mg/L	192	249	11.9	10.1
Alkalinity		172.8	215	197.6	241
pH	s.u.	7.7	6.8	6.4	6.6

Table 4. Comparison of SEP special sampling results and average plant dry weather values.

SEP		Raw		Final	
Parameter	Units	2004 DW Value	BioWin™ Sampling Value	2004 DW Value	BioWin™ Sampling Value
BOD	mg/L	247	219	16.0	17.4
COD	mg/L	517	602	59	67
COD/BOD ratio		2.2	2.3	4.7	4.6
TSS	mg/L	269	205	17.0	29.0
Alkalinity		186	258	180	222
pH	s.u.	7.2	7.1	7.1	7.2

The Biowin™ model layout was constructed as shown below in Figure 2 using the configuration elements provided in the program. The required infrastructure and process inputs are specified for each configuration element along with some process assumptions.

Figure 2. OSP Biowin™ Steady State Model



The steady state model was developed with constant influent inputs that were obtained from the special sampling events and actual plant dry weather average value, as detailed in Table 5.

Table 5. Steady State influent inputs.

Parameter	OSP Values	SEP Values
Flow	16.5	66.0
Total COD mg/L	484	566
Total Kjeldahl Nitrogen mg N/L	42.3	45.2
Total P mg P/L	8	7.5
Nitrate N mg N/L	4.7	1.0
PH	6.9	7.2
Alkalinity mmol/L	4.32	3.72
Inorganic S.S. mg TSS/L	30	25

The recommended BiowinTM input variables for COD (calculated by the special sampling results) along with a few other important input variables are detailed in Table 6.

Table 6. Calculated BiowinTM Input parameters.

COD Influent Fraction	Default	OSP Values	SEP Values
Fbs – Readily biodegradable (including Acetate) (g COD/g of total COD)	0.2	0.17	0.17
Fxsp – Non colloidal slowly biodegradable (g COD/g of total COD)	0.75	0.69	0.38
Fus Unbiodegradable soluble (g COD/g of total COD)	0.05	0.05	0.058
Other Influent Fractions			
Fna Ammonia (gNH ₃ -N/gTKN)	0.66	0.78	0.78
F _{PO4} phosphate (gPO ₄ /gTP)	0.5	0.74	0.60

The most important part of simulating an activated sludge system is the wastewater characterization. Chemical oxygen demand (COD) is used to indirectly measure the amount of organic pollutants in the wastewater. By inputting the data from the fractionated samples, the model is able to simulate the biological conditions in the plant based on the biodegradable and inert fractions in the influent.

RESULTS AND DISCUSSION

Settling Column Tests

The results of the settling column tests at both plants are summarized in Table 7. The velocities are based on the linear portion of the settling curve derived from the settling column experiments. The natural log of these initial settling velocities was plotted against the corresponding TSS values in the table. This allowed for extraction of the Vesilind coefficients, summarized in Table 8. Settling velocities were then calculated for TSS values ranging from 1 to 11 g/L (1,000 to 11,000 mg/L), using the Vesilind equations. The resulting flux generated from these calculated velocities is shown as Figure 3.

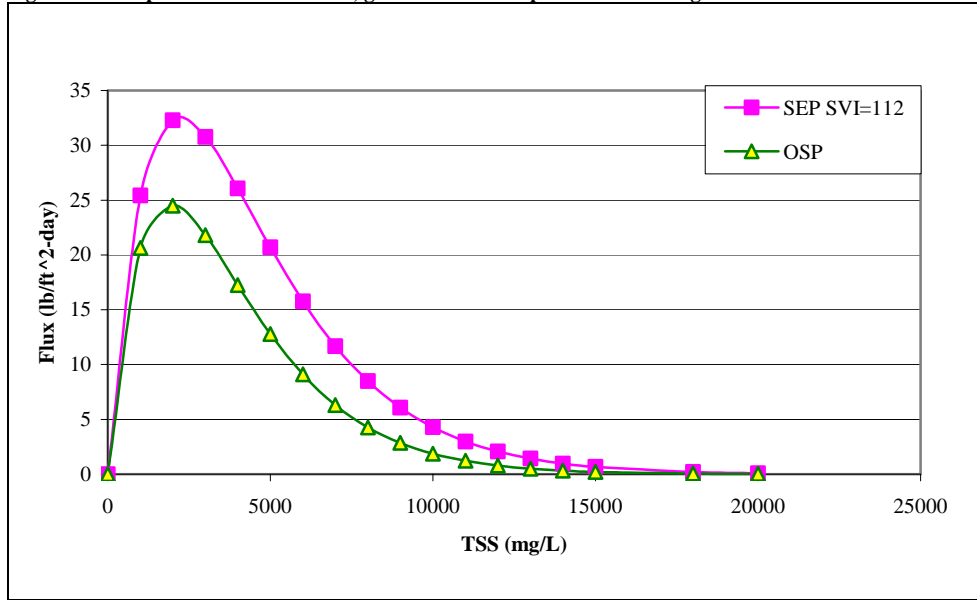
Table 7. Comparison of initial settling velocity and solids concentration.

OSP TSS (mg/L)	OSP Initial Settling Velocity (V_o), m/h	Trial 1 SEP TSS (mg/L)	Trial 1 SEP Initial Settling Velocity (V_o), m/h	Trial 2 SEP TSS (mg/L)	Trial 2 SEP Initial Settling Velocity (V_o), m/h
680	5.97	1160	4.8	1015	6.2
1155	4.01	2185	4.9	1703	3.3
1185	3.37	8388	1.0	2990	2.0
2360	2.44	10650	0.4	4595	0.9
3150	1.28	14925	0.3	8575	0.2
6450	0.34				
7010	0.13				

Table 8. Settling parameters for SEP and OSP, experimentally determined from settling column tests.

	SEP		OSP
SVI	102	112	286
K	0.0002	0.0005	0.0005
V _o	6.6 m/h	8.14 m/h	7.1 m/h

Figure 3. Flux plots for OSP and SEP, generated from experimental settling column data.



For the OSP state point analysis, additional flux plots were generated at SVIs of 300, 350, and 400. For SEP, theoretical flux plots were generated for comparison at an SVI of 112.

State Point Analysis

State point curves were generated for average and maximum flows for the hypothetical cases of five clarifiers on line and four clarifiers on line. 90% of the available clarifier area was used in the analysis, in order to account for dead space and other inefficiencies in the clarifier and center well area. The overflow rate, state point, and underflow rate were also plotted. An identical process was followed for SEP, but with hypothetical scenarios of eight and four clarifiers on line. Other key conditions of the state point analyses for the two plants are detailed in Table 9.

Table 9. Conditions for State Point Analyses at SEP and OSP

	Average Dry Weather Flow (MGD)	Peak Dry Weather Flow (MGD)	Clarifier Dimensions (ft)	Clarifier Available Area (ft ²)	State Point (mg/L)	SVIs Used
OSP	20	40	202 (l) x 38 (w)	6908	1500	350, 400
SEP	70	96	120 (diameter)	10,179	2200	112

State Point Analysis – OSP

The five clarifier state point analysis for OSP is shown in Figure 4. The clarifier(s) are considered underloaded with respect to thickening if the underflow rate operating line passes below the descending limb of the settling flux curve. For example, on Figure 4, the clarifiers are

underloaded for the underflow rates associated with a RAS concentration of 6000 mg/L at the average flow condition. A clarifier is overloaded with respect to thickening if the underflow rate operating line passes above the descending limb of the settling flux curve. This can be seen on Figure 4 for a RAS concentration of 7000 mg/L at the maximum flow condition. Provided the peak flows are of short duration, as they are at OSP, this condition will result in the development of a sludge blanket, but not in a clarifier upset. The clarifier is considered critically loaded with respect to thickening if the underflow rate operating line is just tangent to the settling flux curve. This is demonstrated in Figure 4 for the underflow rate associated with a RAS concentration of 7000 mg/L and the flux plot for an SVI of 400.

Figure 4. State point analysis for OSP with five clarifiers on line

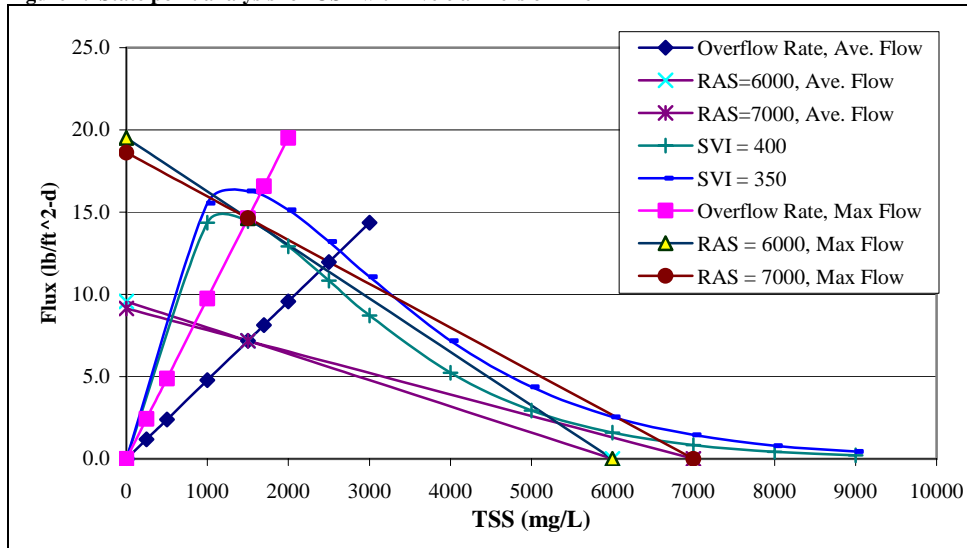
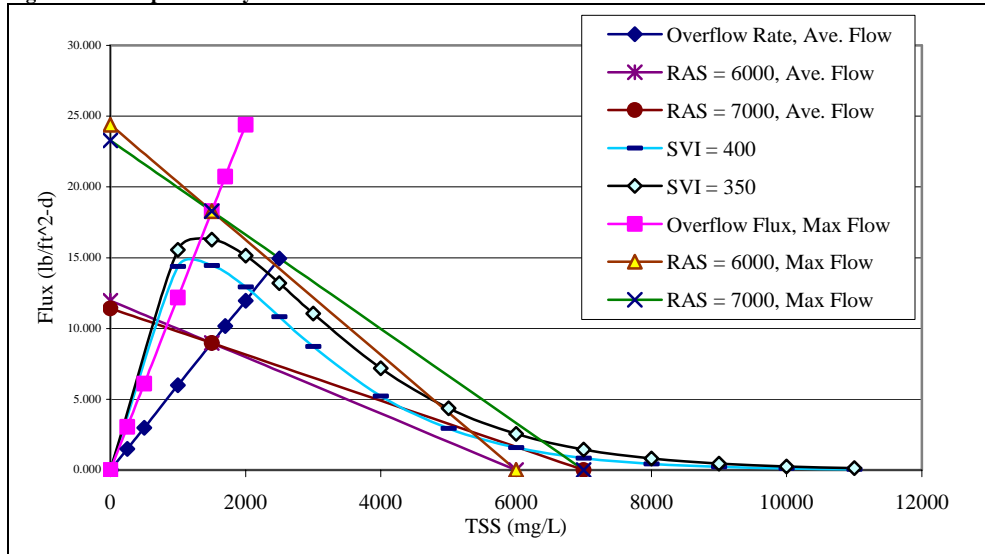


Figure 4 therefore demonstrates that in most cases the clarifiers will be underloaded at average flows. Clearly, if the SVI were to go much above 400, there exists the potential for a critically loaded or overloaded condition. At maximum or peak flows, the clarifiers will be overloaded with respect to thickening for SVIs greater than 350. Since peaks are short-lived at OSP, this means there will be some development of a sludge blanket in the clarifiers, but the clarifiers are not expected to fail.

Figure 5, the state point analysis for four clarifiers on line, indicates that for RAS values less than 6000 mg/L and SVIs less than or equal to 350, the clarifiers will be underloaded with respect to thickening at average flows. For the situation in which RAS values are between 6000 and 7000 mg/L, the clarifiers will be overloaded for SVIs greater than 400. For SVIs under 400, the clarifiers will be underloaded at a RAS value of 6000 mg/L. For a RAS value of 7000 mg/L, the clarifiers are underloaded for SVIs less than or equal to 350. The maximum flow scenario indicates a situation in which the clarifiers will be overloaded in most cases. If the SVI at OSP were to drop considerably, it is possible that there would be a case for which the clarifiers would be critically loaded or underloaded.

Figure 5. State point analysis for OSP with four clarifiers on line



SEP State Point Analysis

For SEP, state point curves were generated for average and maximum flows for the hypothetical cases of eight and four clarifiers on line (instead of the typical sixteen). These are presented as Figures 6 and 7. Figure 6 shows the state point analyses for the average and maximum flow cases with eight clarifiers on line, respectively. These analyses indicate that the clarifiers will be underloaded at all practical RAS concentrations. Stable operation is therefore assumed for the eight clarifier stress test.

Figure 6. State point analysis for SEP with eight clarifiers on line

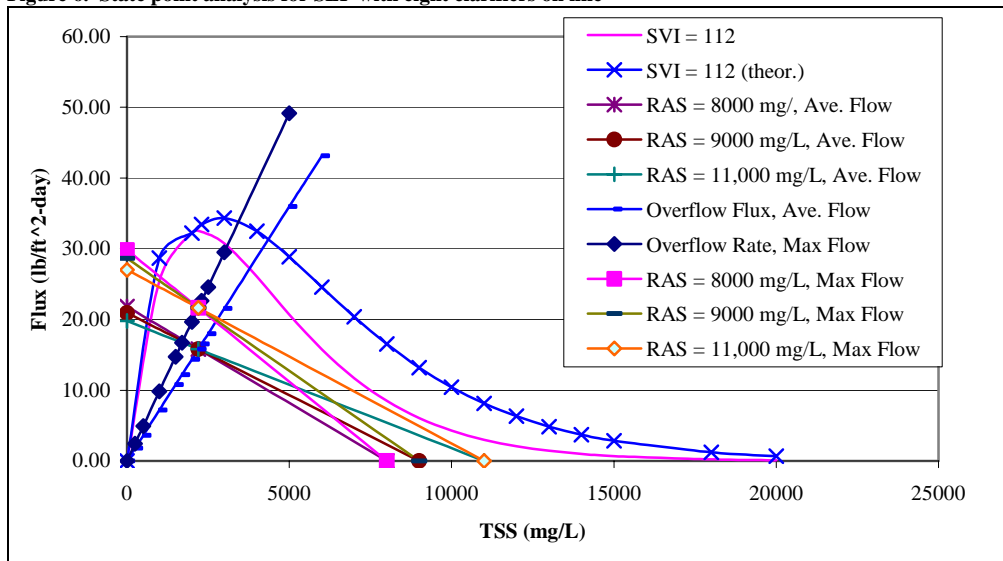
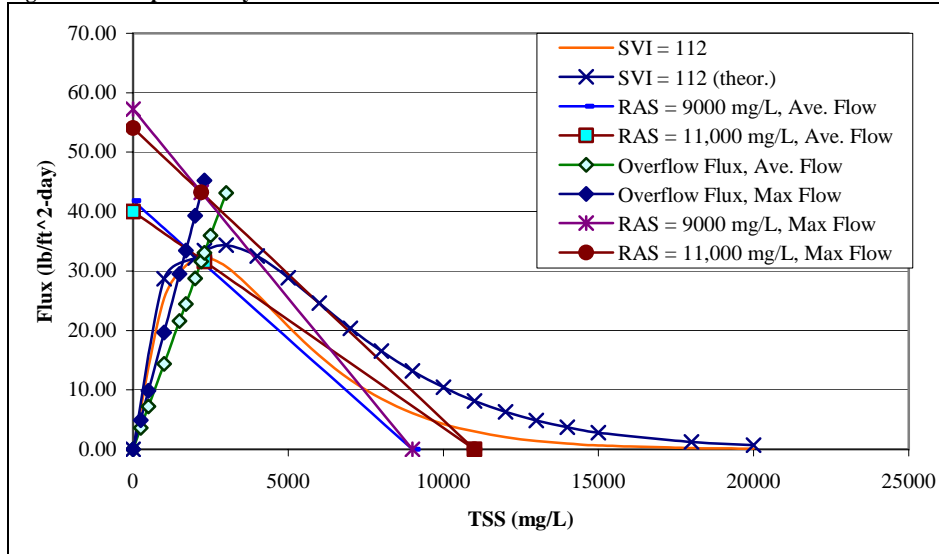


Figure 7 indicates that for RAS values of 9,000 mg/L or less, the four clarifiers on line will still be underloaded with respect to thickening at average flows. For an SVI of 112, the clarifiers will be overloaded and would likely fail at RAS values at or above 10,000 mg/L. Moreover, the maximum flow scenario indicates that the clarifiers will be overloaded in all possible cases. Even if the SVI were to be somewhat lower, this would still be the case.

Figure 7. State point analysis for SEP with four clarifiers on line.

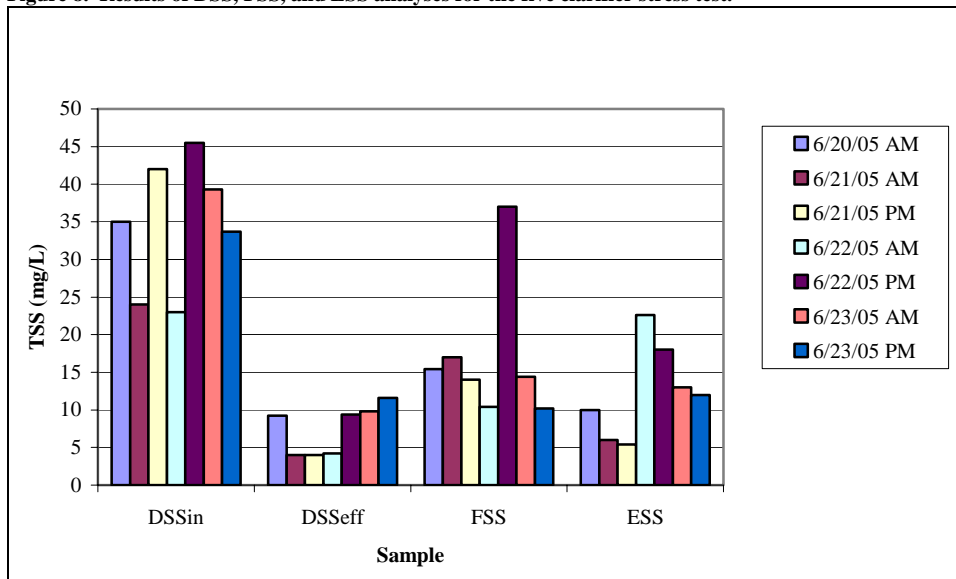


OSP Clarifier Stress Test

Beginning on June 20, 2005, one of six operational secondary clarifiers was taken off-line. Based on average blanket height, MLSS concentration, and effluent TSS, the clarifiers appeared to stabilize after the first day of the test. As would be expected, the blanket heights rose as flow to the clarifiers (primary effluent) rose, although at no point did the blanket levels get high relative to the 16 foot depth of the clarifiers. Although the turbidity rarely exceeded 10 NTU, it did increase with increased flow. Additionally, after the first day of the test, when the system stabilized, the turbidity levels began to stabilize somewhat. The average SVI during this test was 247, based on samples collected twice daily.

The other solids sampling results are summarized in Figure 8. An FSS value greater than 10

Figure 8. Results of DSS, FSS, and ESS analyses for the five clarifier stress test.



mg/L indicates either that dispersed growth is occurring due to a low MCRT or that deflocculation is occurring. In addition, because the DSS_{in} is significantly greater than the FSS, this confirms that the mixed liquor is poorly flocculated as it enters the clarifiers. However, the fact that the FSS is greater than the ESS and the DSS_{eff} indicates that the clarifiers are large enough that sufficient flocculation is being provided during this treatment stage. That the DSS_{in} is greater than both the DSS_{eff} and the ESS, and that the DSS_{eff} is less than the ESS indicates that the secondary clarifiers provide good flocculation (despite the poorly flocculated condition of the mixed liquor entering the clarifiers), but that there were some hydraulic problems, no doubt resulting from the increased flow.

On the morning of June 27, an additional clarifier was taken off line, and the four clarifier stress test began. As with the five clarifier stress test, the average blanket height, mixed liquor TSS concentration, and effluent turbidity were all measured (Figure 9). The average blanket height approximately doubled between the two stress tests, and changes in average blanket height seemed to be more sensitive to changes in flow than in the five clarifier test. The RAS rate was fairly constant until around noon on June 28th, when WWE Operations decided to increase the RAS rate by bringing it up sharply, and then kept it around 35% for the remainder of the day. This had the effect of dropping the sludge blanket levels considerably. By June 29th, the RAS rate was returned to around 30%, and the blanket levels began to rise again. The stress test was then cut short.

As with the five clarifier test, the turbidities rose and fell in correspondence with the flow. In addition, the secondary effluent turbidity rarely exceeded 10 NTU. Again, after the first day, the turbidity values were lower, and had begun to stabilize by the third day. The highest turbidity values were recorded around the peak flow on the second day of the test; turbidity values neared 20 NTU, which is approximately equal to a TSS value of 34 mg/L. Grab samples taken from the area adjacent to the effluent weir of the clarifiers were also analyzed for TSS. These are presented in Table 9. As was observed with turbidity values, the highest values occurred during the morning peak flow on June 28th. These TSS values are sufficiently high as to indicate that the clarifiers were severely stressed, though still in compliance with NPDES permit limits (weekly maximum TSS of 45 mg/L). It can also be observed that in terms of turbidity, Clarifier 3 appeared to be the most “stressed.” As seen on Figure 8, the RAS rate was increased on June 28th in an effort to decrease some of the stress on the clarifiers. The system responded rapidly and effectively to this change in operation, as the TSS values dropped considerably by the afternoon of the 28th. By the evening of the 28th, as flow decreased, the clarifiers stabilized.

Further information on solids dynamics in the system was gathered from the DSS, ESS, and FSS sampling. These results are summarized in Figure 10 and are similar to those for the five clarifier stress test. The FSS is greater than or equal to 10 mg/L and the DSS_{in} is significantly greater than the FSS, indicating that the mixed liquor is poorly flocculated upon entering the clarifier. The fact that the DSS_{in} is greater than both the DSS_{eff} and the ESS, and that the DSS_{eff} is less than the ESS indicates that the secondary clarifiers provide good flocculation, but that there were some hydraulic problems (probably largely due to the increased flow). The TSS and turbidity values, taken together with these results, may indicate that hydraulic problems resulted in increased solids in the effluent. For the system, the problems may simply be attributed to the increased flow through the clarifiers.

Figure 9. Relationship between effluent turbidity, flow, and RAS recycle rate.

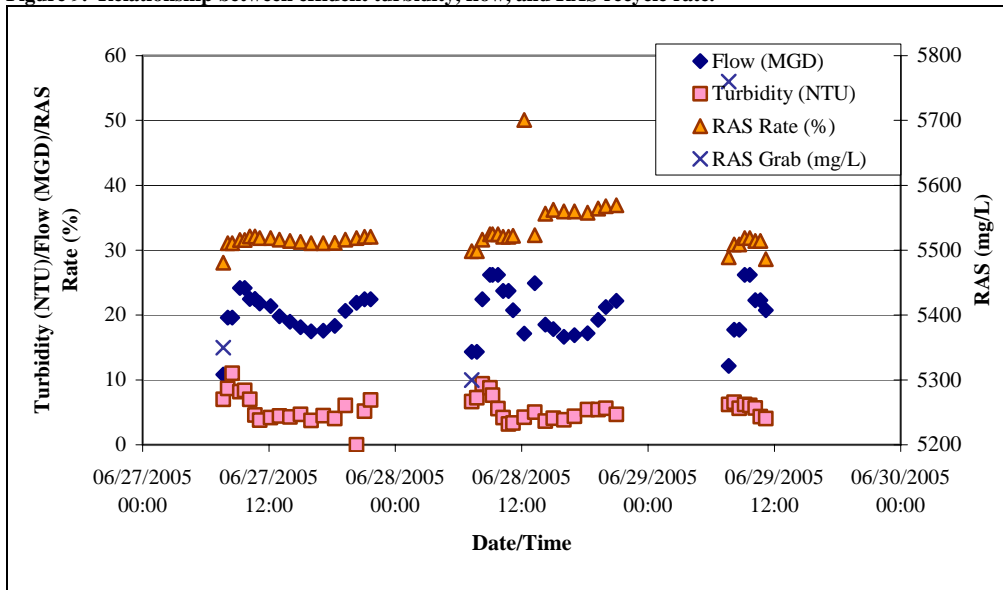
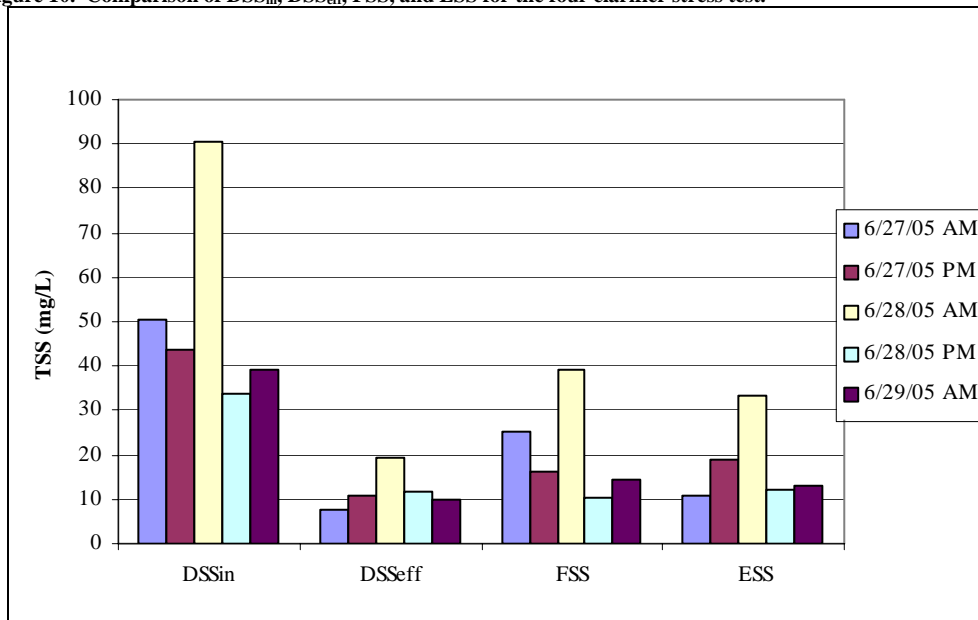


Table 9. Results of TSS analysis on grab samples collected during four clarifier stress test.

	Clarifier 2	Clarifier 3	Clarifier 4	Clarifier 5
6/27/05 AM	10.25	6.2	7.0	11.0
6/27/05 PM	9.8	9.2	9.0	16.2
6/28/05 AM	27.0	43.5	33.25	11.3
6/28/05 PM	13.6	12.0	13.0	4.6

Figure 10. Comparison of DSS_{in} , DSS_{eff} , FSS, and ESS for the four clarifier stress test.



With respect to individual clarifiers, if there is, in fact, an unequal distribution of flow to the clarifiers, certain clarifiers may have received more flow than others, stressing them more. Instabilities may also have resulted simply as a result of the transition from five to four clarifiers. During the five clarifier test, after the first two days, the turbidity values decreased and the highest values, which correlated with peak flow, were lower in the last two days of the test, once the system had stabilized. In addition, the blankets that developed during the stress test were thicker than is typical for OSP, so it is also possible that the scraper mechanism may have stirred up the blankets at the sampling point, affecting the results for that time interval. During previous tracer studies at OSP, some short circuiting and density currents were observed to varying degrees in all of the clarifiers. Some flow imbalance between the clarifiers was also noted, which may be why some clarifiers appeared more “stressed” than others.

SEP Clarifier Stress Test

The north side of the plant was kept fully operational while half of the clarifiers on the south side of the plant were shut down. Beginning in the early morning on December 6th, 2005, four of eight operational secondary clarifiers on the south side were taken off-line. Data collection began at 8:50 AM and continued data collection efforts through 3:10 PM on December 7th. On the evening of the 7th, it began to rain, and the test was terminated to allow for the possibility of increased flow through the plant.

Initially, very little effect was observable in the clarifiers. By the afternoon of December 6th, however, pin floc could be seen at the scum baffles. This effect was the most pronounced on Clarifiers 12 and 16, which are located at the end of the mixed liquor channel that feeds the clarifiers. Occasionally, some grab samples collected for turbidity during the two-day test did have visible particulate matter, but for the most part, the samples were scarcely distinguishable from similar samples taken from the north side clarifiers. The position of the scum skimmer may have affected the quality of the samples.

The blanket heights rose as flow to the clarifiers rose, although at no point did the blanket levels get high relative to the 15 foot depth of the clarifiers. Turbidity levels, particularly during the higher flow periods, are elevated above normal levels. For reference, the average turbidity value of grab samples taken from the north side clarifiers was 4.5 NTU.

The overall effect of the stress test is demonstrated in Table 10, which values for secondary effluent TSS and mixed liquor SVI on the north and south side of the plant for the week of the stress test. The two days of the stress test are highlighted. The TSS values on the south side were higher than those on the north side, but were not much outside the range of values seen that week. For example, on the 19th, the effluent TSS value on the north side was 17.8 mg/L. The values on the south side were 15 and 20.3 mg/L on the 6th and 7th, respectively. SVI tends to vary day to day, so it is impossible to conclude any effect of the stress test on the SVI.

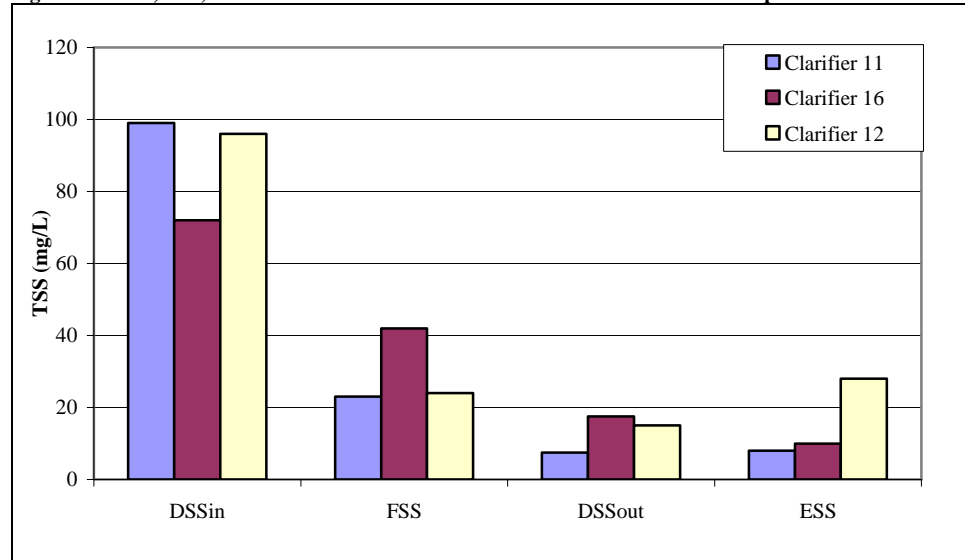
The solids sampling results are summarized in Figure 11. An FSS value greater than 10 mg/L indicates either that dispersed growth is occurring due to a low MCRT or that deflocculation is occurring. In addition, because the DSS_{in} is significantly greater than the FSS, this confirms that the mixed liquor is poorly flocculated as it enters the clarifiers. However, the fact that the FSS is greater than the ESS and the DSS_{eff} indicates that the clarifiers are large enough that sufficient

flocculation is being provided during this treatment stage. That the DSS_{in} is greater than both the DSS_{eff} and the ESS, and that the DSS_{eff} is less than the ESS indicates that the secondary clarifiers provide good flocculation (despite the poorly flocculated condition of the mixed liquor entering the clarifiers), but that there were some hydraulic problems, no doubt resulting from the increased flow. For Clarifier 12, the ESS was nearly double the value of DSS_{out} , which indicates that the wastewater in this clarifier did not have sufficient time to settle. It is possible that the flow distribution among the clarifiers is not exactly equal; unfortunately, individual flow meters for each clarifier do not exist.

Table 10. Selected plant effluent data for the week of December 5, 2005. The stress test time periods are highlighted.

DAY	Secondary Effluent TSS (mg/L)		Mixed Liquor SVI Grab (mg/L)	
	North	South	North	South
5	14.3	11	120	90
6	9.5	15	145	86
7	12	20.3	113	104
8	10.3	9.5	118	105

Figure 11. DSS, FSS, and ESS results for SEP stress test. Clarifier 15 was not sampled.



BioWin™ Steady State Model

After all the required inputs were specified, the steady state simulation was undertaken. Overall, the BioWin™ model generated promising results when compared to the actual plant process data. Table 11 compares the historical and simulated outputs of effluent quality and sludge cake production.

Table 11. Historical and BioWin Simulated Outputs Comparison Summary

Process	Parameter	Unit	OSP 2004 DW	BioWin Model	SEP 2004 DW	BioWin Model
Final Effluent	2 Effluent TSS	mg/L	11.9	9.1	16.1 (N)/15.5 (S)	14.4 (N)/11.7 (S)
	2 Effluent COD	mg/L	54.0	39.6	58.9	70.6 (N)/66.8 (S)
	2 Effluent BOD	mg/L	16.28 - BOD5	8.1 - CBOD	15.7 - BOD5	9.55 (N)/7.95 (S) CBOD
	Final effluent pH		6.4	6.4	7.1	6.3
	WAS Flow	MGD	0.43	0.42	0.59 (N)/0.55 (S)	0.59 (N)/0.55 (S)
	WAS Production	1000lb TS/day	18	20	90	78
	WAS TSS	mg/L	4,954	5,626	8900 (N)/10,200 (S)	8615 (N)/7757 (S)
Dewatering	Cake TS	%	15.1	15.2	23.5	19.4
	Filtrate TSS	mg/L	135	100	990	988
	Solids Capture	%	99.57	99.57	95.5	95
	Cake Production (dry)	tons/day	11.4	8.5	33	35.7

Dynamic Simulation Calibration

A dynamic model has been developed, based on the steady state model, for further evaluation of the modeling performance. For OSP, daily plant data from May to July 2005 were input; a period of time that includes the special sampling. Similarly, for SEP, daily plant data from July to October 2005 was input, as this includes the time period for the SEP special sampling events. For both plants, an SVI of 112, with $k = 0.0005$ and $V_o = 26.7\text{ft/hr}$ was specified for the clarifiers.

The model was run for three months of dynamic simulation. Solids calibration has been done to evaluate the accuracy of the model. The key consideration for solids calibration is the solids concentration in the aeration tanks. Therefore, a comparison between the simulated mixed liquor concentration and the plant actual concentration has been done and is shown on Figures 12 and 13.

These figures demonstrate that despite errors in some day-to-day predictions, the model is generally able to accurately predict the longer-term variation over the three month period. At OSP, there are two possible reasons for the poorer correlations: 1) poor sludge settling ability in the existing clarifiers; 2) at OSP, foam events in digesters during the special sampling period lead to poor sludge dewatering so that higher TSS filtrate recycled back to primary influent. In addition, there is one general deficiency of the model in controlling the return activated sludge rate. It only can be flow paced with raw influent, while the actual plant is flow pacing with primary influent.

Figure 12: Comparison of Modeled and Existing Plant MLSS.

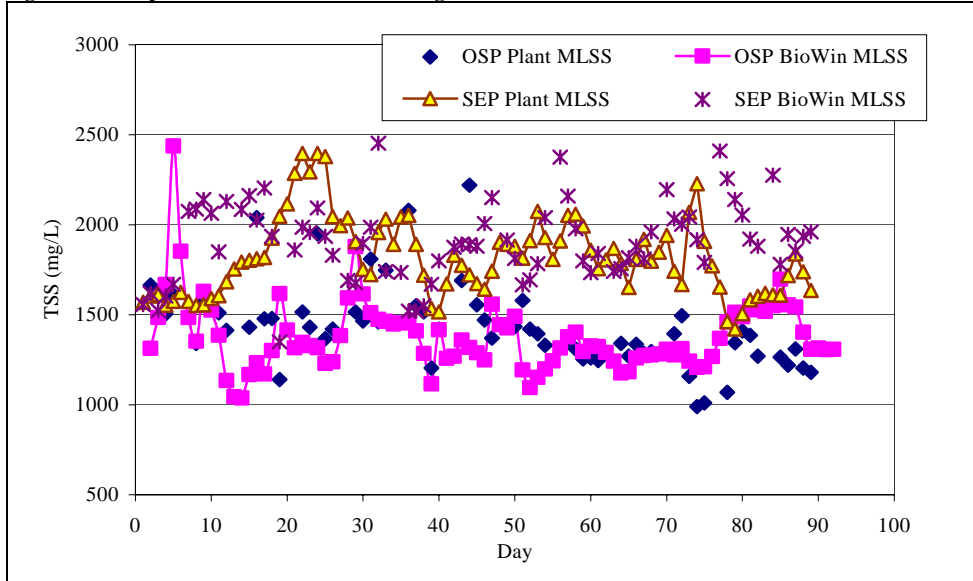
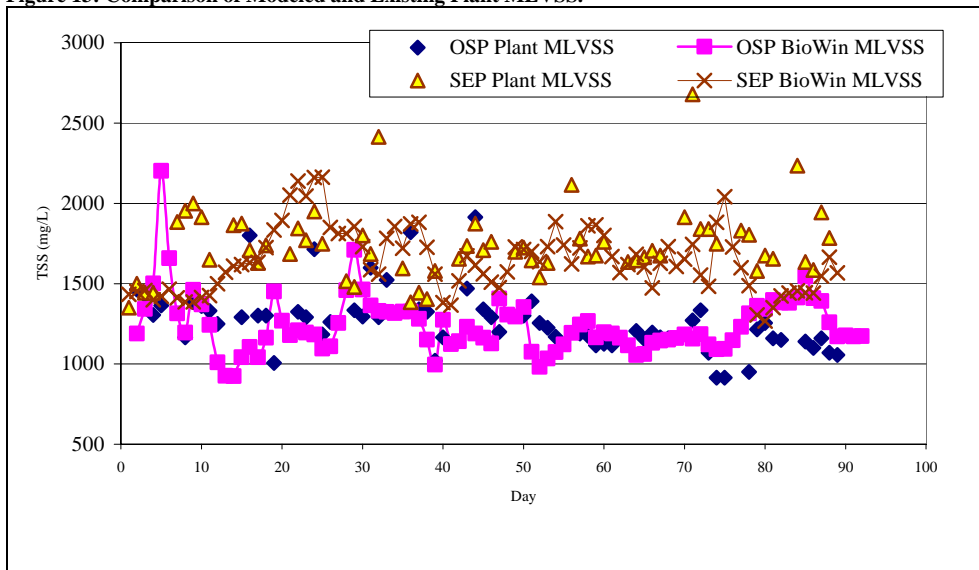


Figure 13: Comparison of Modeled and Existing Plant MLVSS.



Summary tables below compare the average actual plant and modeled MLSS and MLVSS concentration.

Table 12. OSP Comparison of Actual Plant and Modeled MLSS and MLVSS Concentration.

Average	Actual Value	Modeled Value	Ave % of Error
MLSS (mg/L)	1454	1377	5.6
MLVSS (mg/L)	1283	1241	3.4
Volatile fraction (%)	88	90	

Table 13. SEP Comparison of Actual Plant and Modeled MLSS and MLVSS Concentration.

Average	Actual Value	Modeled Value	Ave % of Error
MLSS (mg/L)	1844	1817	1.5
MLVSS (mg/L)	1614	1643	1.8
Volatile fraction (%)	88	90	

To further evaluate the model performance, mass balance summary tables are presented as Tables 14 and 15. With a lower volatile solid reduction percentage in Biowin™ as compared to plant data, Biowin™ has higher sludge cake production.

Table 14. OSP Mass Balance Comparison Summary Table.

	Influent Solids Loading (1000lbs)	Effluent Solids Loading (1000lbs)	Volatile Solid Reduction %	Sludge Cake Production (1000lbs)
OSP	29.2	1.76	64	14.2
BioWin	29.8	1.66	62	17.5

Table 15. SEP Mass Balance Comparison Summary Table.

	Influent Solids Loading (1000lbs)	Effluent Solids Loading (1000lbs)	Volatile Solid Reduction %	Sludge Cake Production (1000lbs)
SEP	154.0	8.70	58	66.0
BioWin	125.5	7.18	55	71.4

All the results shown above are sufficient to conclude that the Biowin™ process simulator has accurately predicted the actual plant solids in longer-term runs. After model calibration was completed, the Biowin™ simulator was used to evaluate the ultimate secondary capacity of the plants. For OSP, the stress test was simulated using an average flow of 18.2 MGD for all runs. Five runs were performed with varying numbers of clarifiers in operation. The optimal capacity is determined and detailed in the table below. The results in Table 16 indicate that even with only three clarifiers in operation, OSP is still capable of maintaining good effluent quality. In the other words, with six clarifiers online, the plant is capable of treating an average of 36.4 MGD and a peak flow of approximately 54 MGD. The simulated results correlate well with the stress and sludge settling tests conclusions that have been described earlier in this report. For the full-scale stress test, with the SVI of 380, the four clarifiers were still underloaded and a minimum increase of 14.1 MGD was predicted.

Table 16: OSP Biowin™ Simulated Stress Tests Results.

Number of Clarifiers Online	Monthly Ave. FE TSS (mg/L)	Monthly Ave. FE BOD (mg/L)	TSS Removal (%)	BOD Removal (%)	Hydraulic Loading Capability (MGD)
3	19.9	20.2	88.6	91.9	36.4

The stress test at SEP indicated that the plant could either operate with half the clarifiers on line, or a total flow of about 140 MGD. Model simulations at SEP began by running the plant at this

flow rate, and ramping up from there until the permit limits, which are identical to those at OSP, was approached. The results for this are summarized in Table 17 below.

Table 17. SEP Plant Capacity Assessment in BioWin™

Number of Clarifiers Online	Monthly Ave. FE TSS (mg/L)	Monthly Ave. FE BOD (mg/L)	TSS Removal (%)	BOD Removal (%)	Hydraulic Loading Capability (MGD)
16	22.7	15.3	90	94	190

CONCLUSIONS

Sludge settling coefficients derived from mixed liquor samples can be used in mathematical clarifier performance models to establish conditions for full-scale secondary clarifier stress tests that accurately reflect the performance of the activated sludge separation process under increased hydraulic and organic loading conditions. These tools, in coordination with whole-plant simulators, can be effectively used as planning tools to determine the ultimate capacity of treatment plants, as well as the effects of various planning scenarios on effluent quality, sidestreams, and biosolids production rates.

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**APPENDIX B - SEP 2004 PROCESS DATA VERSUS BIOWIN™
MODEL PREDICTIONS**

SEP					
Process	Parameter	Unit	SEP 2004 DW	BioWin™ Model - Model Clarifier	BioWin™ Model - Ideal Clarifier
Raw Influent					
	Flow	MGD	66	66	66
	ISS/TSS	mg/L	23/280 ⁽¹⁾	25/228	25/228
	Total COD	mg/L	566	566	566
	Total BOD	-	227	247.8 (cBOD)	247.8 (cBOD)
	TKN	mg/L	-	45.2	45.2
	Total P	mg/L	-	7.5	7.5
	pH	-	-	7.2	7.2
	Fus	-	-	0.086	0.086
	Fup	-	-	0.2	0.2
Primary Treatment					
Primary Clarifiers	Surface Overflow Rate	gpd/ft ²	1,272	1211	1211
	Primary Influent COD	mg/L	no data	568	567.8
	Primary Influent TSS	mg/L	no data	233	232.6
	1 Effluent TSS	mg/L	119	101	101.3
	1 Effluent pH		-	-	-
	1 Effluent COD	mg/L	359	381	381.4
	COD removal %	%	34	33	33
	TSS removal %	%	57.0	57	56.5
	1 Sludge	mgd	0.2	0.20	0.2
	1 Sludge Production	1000 lb TS/day	76.6	74.0	74
	1 Sludge Concentration	mgTSS/L	4,5947 (calc)	44,318	44,327
Secondary Treatment					
Pure-O2 Aeration Trains	MLSS	mg/L	2,216 (N)/ 2078(S)	1,924 (N)/1,740 (S)	1,942 (N)/1,744 (S)
	MLVSS	mg/L	2,033 (N)/ 1877 (S)	1,699 (N) / 1,532 (S)	1,714 (N)/ 1,536 (S)
	Aeration MCRT	days	1.07	1.44	1.45
	pH	-	-	-	-
	System MCRT	days	2.2	3.3	3.3
Secondary Clarifiers	RAS Flow	MGD	9.6 (N) / 8.1 (S)	9.6 (N) / 8.16 (S)	9.6 (N) / 8.16 (S)

SEP					
Process	Parameter	Unit	SEP 2004 DW	BioWin™ Model - Model Clarifier	BioWin™ Model - Ideal Clarifier
	RAS TSS	mg/L	8,903 (N)/ 10,163 (S)	8,615 (N) / 7,757 (S)	8,702 (N)/ 7,778 (S)
	RAS Mass TSS	1000lb/day	712 (N)/687 (S)	691 (N)/ 528 (S)	698 (N)/ 530 (S)
Effluent	2 Effluent TSS	mg/L	16.1 (N)/ 15.5 (S)	14.4 (N) / 11.7 (S)	12.5 (N)/ 11.2 (S)
	2 Effluent COD	mg/L		70.6 (N)/ 66.8 (S)	-
	Final Effluent COD	mg/L	58.9		-
	2 Effluent BOD	mg/L		9.55 (N) / 7.95 (S)	8.53 (N)/ 7.67 (S)
	Final Effluent BOD	mg/L	15.7	-	
	Final effluent pH	-	-	6.3	6.3
	WAS Flow	MGD	0.586 (N)/ 0.554 (S) ⁽²⁾	0.59 (N)/0.55 (S)	0.59 (N)/0.55 (S)
	WAS Production	1000lb TSS/day	90	78	78.5
	WAS TSS	mg/L	8,900 (N)/10,200 (S)	8,615 (N)/ 7,757 (S)	8,701 (N)/ 7,778 (S)
Solid handling					
GBTs	Hydraulic Loading	MGD	1.14 ⁽²⁾	1.14	1.14
	Solid Concentration	mg/L	43,588 ⁽²⁾	30,654	30,859
	Solid Loading	1000 lbs/day	89.7 ⁽²⁾	77	77.3
	Filtrate TSS	mg/L	176 ⁽³⁾	178	179
	Total COD	mg/L	269 ⁽³⁾	284	286
	Solids Capture	%	98.9 ⁽²⁾	98.4	98.4
	pH		6.89 ⁽³⁾	6.3	6.3
Sludge Feed	Flow	MGD	0.52	0.5	0.5
	TSS loading	1000 lb TSS/day	177.0	151	151
	TSS concentration	mg/L	43,482	36,120	36246
	TS	%	4.3	3.6	3.6
	VS	%	82	88	88
Anaerobic Digesters	Detention Time	days	16.7	16.6	16.6
Active Digesters	Temperature	-	99	99	99
	Detention Time	-	4.3	4	4
Storage Digesters	Temperature	-	97	97	97
	Digested Sludge TS	%	2.1	1.8	1.8

SEP					
Process	Parameter	Unit	SEP 2004 DW	BioWin™ Model - Model Clarifier	BioWin™ Model - Ideal Clarifier
	Digested Sludge VS	%	69.0	80	80
	VSS Reduction	%	58.3	55.0	55
	pH	-	7.1	7.1	7.1
	Biogas Production	cf/min	NA	725	726
Centrifuges	Centrifuge Feed	MGD	0.522	0.5	0.5
	TS loading	1000lb/day	85.0	75.2	75.5
	Centrate Total COD	mg/L	1,634 ⁽³⁾	1,353	1,358
	Centrate TSS	mg/L	990	988	992
	Cake TS	%	23.5	19.4	19.5
	Solids Capture	%	95.50	95	-
	Cake Production (wet)	tons/day	165	-	-
	Cake Production (dry)	1000lbs/day	-	-	-
	Cake Production (dry)	tons/day	33.0	35.7	-
	pH	-	-	-	-
Notes: (1) Data from September 2004 through March 2005 (reflects new influent sampling point) (2) Data from September 2004 to present (reflects GBT startup) (3) Data from special sampling at SEP (Fall 2005)					

APPENDIX C - PRELIMINARY NITRIFICATION ANALYSIS

APPENDIX C - PRELIMINARY NITRIFICATION ANALYSIS

1.0 BACKGROUND

This preliminary analysis was undertaken to determine the secondary infrastructure necessary to complete nitrification at the SEP.

The original SEP *BioWin*TM file (base case) labeled “SEP Steady state ideal adjust WAS” was utilized as the starting point for this investigation. This file was developed by SFPUC staff during previous *BioWin*TM calibration efforts for the SEP.

The following information was extracted from the base case model.

1.1 Aeration Basin Volumes

North train @ 0.231 MG/stage, volume = 1.386/train (6 stages/train)

South train @ 0.231 MG/stage, volume = 1.386/train (6 stages/train)

(Aeration basin depth = 13.5 ft)

Total modeled volume = 8.316 MG (6 trains) @ 3 North, 3 South trains

1.2 Secondary Clarification

North clarifier area = 89,946 ft²

South clarifier area = 89,946 ft²

(Secondary clarifier depth = 15.1 ft)

Sixteen (16) clarifiers modeled

1.3 Base Case Model Results

The base case influent wastewater flow/load parameters were as follows:

Table 1: Base Case Model, Influent Conditions

Q = 66 mgd	pH = 7.2
COD = 556 mg/L	Alkalinity = 185.8 mg CaCO ₃ /L
TKN = 45.2 mgN/L	DO = 0 mg/L
TP = 7.5 mgP/L	Ca = 160 mg/L
NO ₃ -N = 1 mgN/L	Mg = 25 mg/L

The following output results, for aeration basin and effluent quality were obtained from the base case model.

Table 2: Base Case Model, Average Aeration Basin Results

MLSS ~ 1725 mg/L	SRT (Total) ~ 3.0 days
MLVSS ~ 1523 mg/L	SRT (Aeration) ~ 1.4 days
WAS Q ~ 0.61 mgd	SRT (Reactors) ~ 1.5 days
WAS concentration ~ 8003 mg/L TSS 7064 mg/L VSS	

Table 3: Base Case Model, Predicted Secondary Effluent

BOD ~ 7 mg/L	NH ₃ -N ~ 34.6 mg/L
COD ~ 65 mg/L	NO ₃ -N ~ 0 mg/L
TSS ~ 10 mg/L	Total N ~ 37.4 mg/L
pH ~ 6.3	TP ~ 5.1 mg/L

Note the original file contained slightly different flow conditions for the North and South batteries. Therefore the above results are the numerical average values (not flow weighted) for both batteries.

2.0 NITRIFICATION MODELING

Future maximum month loading flow and load parameters were modeled as follows:

Table 4: Maximum Month Influent Conditions

Q = 79.3 mgd	pH = 6.9
COD ⁽¹⁾ = 680 mg/L	Alkalinity = 186 mg CaCO ₃ /L
TKN = 62 mgN/L	DO = 0 mg/L
TP = 8.0 mg P/L	Ca = 160 mg/L
NO ₃ -N = 1 mgN/L	Mg = 25 mg/L
Notes: ISS = 46.5 mg/L (11% of 423 mg/L)	

2.1 Assumptions

The assumed maximum MLSS concentration in the aeration basin was assumed to be ~ 3,500 mg/L. The following changes were made to the base case model to produce full nitrification of the activated sludge (NH₄-N < 1 mg/L).

- Temperature (assumed) 16oC
- Turn off pH modeling, alkalinity addition may be required
- Convert the pure oxygen reactors to air reactors running at 2 mg/L DO in each aerobic zone
- Keep the first stage of each train unaerated to act as an anoxic zone to recover alkalinity and reduce oxygen demand and to prevent floating sludge in the secondary clarifiers

- Increase RAS to flow pace at 75% of influent flow
- Use target aerobic SRT of 6 days for nitrification
- Ideal secondary clarifiers @ 99.8% removal

2.2 Results

Results with existing aeration tankage infrastructure

TSS = 10,722 mg/L

VSS = 8,726 mg/L

NH₃-N ~ 0.1 mgN/L

NO₃-N ~ 29 mgN/L

2.2.1 Aeration Basin

Aeration Basin volume (total) required = 25 MG @ 3,500 mg/L MLSS

Existing volume = 7.7 MG (7 trains online)

Assume new Aeration tanks @ 25ft deep

New Aeration Tanks

- Area ~ 92,500 ft²

- Say 95,000 ft²

2.2.2 Secondary Clarification

Secondary Clarifier loading rates:

OFR ~ 400 gall/ft²-d

SLR ~ 25 lbs/ft²-d

Area required ~ 200,000 ft²

Current surface area (15 clarifiers) ~ 200,000 ft²

Consider adding 3 clarifier as extra redundancy.

Area required ~ 240,000 ft² (18 clarifiers)

These results are preliminary in nature and more detailed analysis is needed to finalize required facilities. Step feed capabilities would be added to facilitate wet weather peak flow requirements.

Task 200 Technical Memorandum No. 202

**APPENDIX D - WET WEATHER BIOWIN™
MODELING, APRIL 2008**

FINAL DRAFT - August 21, 2009

pw://Carollo/Documents/Client/CA/SFPUC/7240A00/Final Draft PM-TM/200 Existing System Description/Task200TM202_BIOWIN.doc (FinalDraft)

**APPENDIX D - WET WEATHER BIOWIN™
MODELING, APRIL 2008**

1.0 BACKGROUND

A series of *BioWin*™ runs were undertaken in 2007 to investigate the required secondary system infrastructure necessary to meet a proposed ammonia standard for the SEP. Maximum month loads used in the analysis are defined in Table 1.

Table 1: Maximum Month Influent Conditions for 79.3 mgd

Q = 79.3 mgd	pH = 6.9
COD ⁽¹⁾ = 680 mg/L	Alkalinity = 186 mg CaCO ₃ /L
TKN = 62 mgN/L	DO = 0 mg/L
TP = 8.0 mg P/L	Ca = 160 mg/L
NO ₃ -N = 1 mgN/L	Mg = 25 mg/L
Notes: ISS = 46.5 mg/L (11% of 423 mg/L)	

The main assumptions used in the nitrification/denitrification modeling were as follows:

- Temperature (assumed) 16°C
- Turn off pH modeling, alkalinity addition may be required
- Convert the pure oxygen reactors to air reactors running at 2 mg/L DO in each aerobic zone.
- Keep the first stage of each train unaerated to act as an anoxic zone to recover alkalinity and reduce oxygen demand and to prevent floating sludge in the secondary clarifiers.
- Increase RAS to flow pace at 75% of influent flow
- Use target aerobic SRT of 6 days for nitrification
- Ideal secondary clarifiers @ 99.8% removal

2.0 NEW ANALYSIS, MAXIMUM MONTH CONDITIONS, @ 79.3 MGD, PLUG FLOW

The *BioWin*™ model was updated to the new *BioWin*™ 3.1 version. This new analysis was undertaken to predict current plant operational parameters and to determine the maximum

flow that the existing system could treat using the current low SRT operational strategy and step feed during wet weather conditions.

Steady state analysis using the maximum month loading conditions detailed in Table 1 were undertaken.

The main assumptions used in the wet weather modeling were as follows:

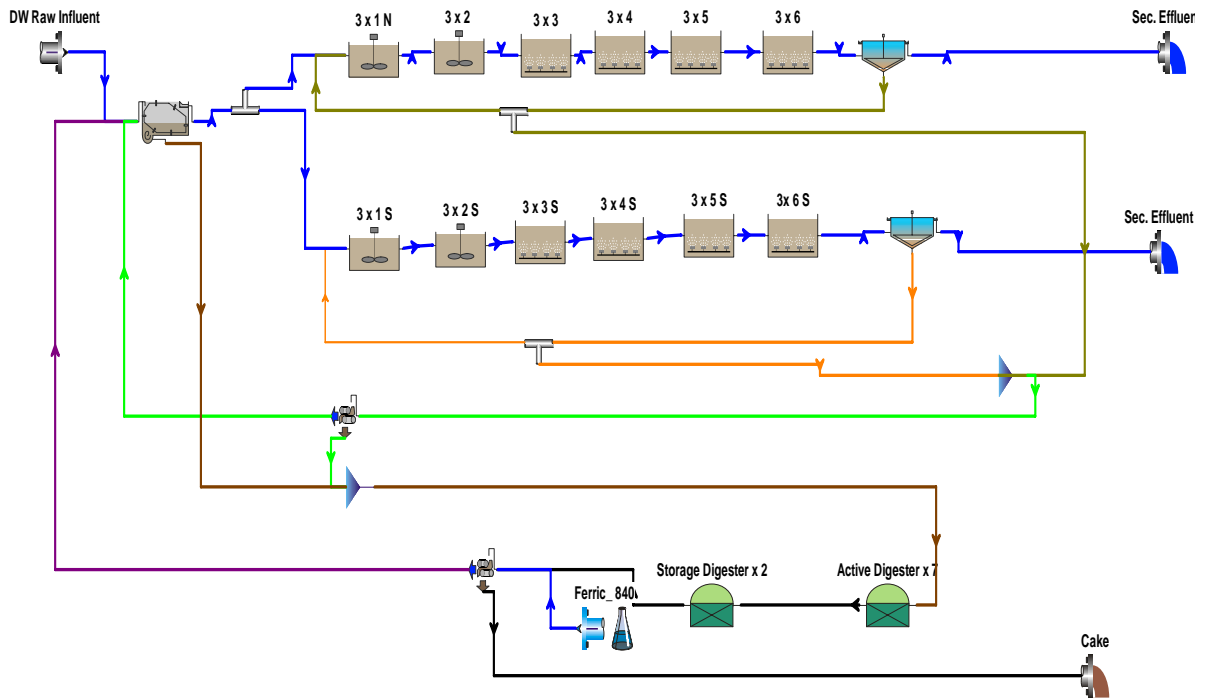
- Temperature (assumed) 16oC
- Turn off pH modeling
- Keep the pure oxygen reactors at 11-13 mg/L DO in each aerobic zone
- Keep the first stage of each train unaerated to act as an anaerobic zone
- RAS to flow pace at 30% of influent flow
- Use target aerobic SRT of 1-1.5 days
- Use model secondary clarifiers
- Flow split set at 54:46 North/South

2.1 Modeled Volume

The aeration basin total modeled volume = 7.4 MG (7 out of 8 basins on line)

Total clarification = 14 clarifiers @ 120ft diameter = 158,357 ft²

Figure 1: *BioWin*TM set up for this scenario



The results from these modeling runs are presented in Table 2 and Table 3.

Table 2: Aeration Basin Results @ 79.3 mgd, Plug Flow

MLSS ~ 2265 mg/L	
MLVSS ~ 1947 mg/L	SRT (Aeration) ~ 1.2 days
WAS Q ~ 2 mgd	SRT (Reactors) ~ 1.3 days
WAS concentration ~ 10,378 mg/L TSS 8,923 mg/L VSS	

Table 3: Predicted Secondary Effluent @ 79.3 mgd, Plug Flow

BOD ~ 11.4 mg/L	NH ₃ -N ~ 48.3 mg/L
COD ~ 83.8 mg/L	NO ₃ -N ~ 0 mg/L
TSS ~ 16.8 mg/L	Total N ~ 51.7 mg/L
pH ~ 6.34	TP ~ 4.8 mg/L

Sludge information obtained from the modeling as follows:

Primary sludge = 0.5 mgd @ 2.7% ~113,799 lbs/d

Secondary sludge = 1.46 mgd @ 1.0% ~126,508 lbs/d

2.2 Secondary Clarifier Results

The adjusted Vesilind parameters were used in the model clarifier. These parameters were presumably obtained from previous site specific testing.

$V_o = 0.1902$ ft/min (default = 0.3873 ft/min)

$K = 0.2052$ L/g (default = 0.37 L/g)

The results of the modeling from a clarifier perspective are:

- Secondary clarifier overflow rate ~ 441 gall/ft²-d
- Secondary clarifier solids loading rate ~ 10.7 lbs/ ft²-d

3.0 MAXIMUM MONTH CONDITIONS @ 150 MGD, PLUG FLOW

The flow was then increased to the current wet weather maximum value of 150 mgd. The influent mass loadings were kept constant as detailed in Table 1 by lowering the influent concentrations. Table 4 details the revised influent concentrations. All the other main assumptions were kept constant.

Table 4: Maximum Month Influent Conditions for 150 mgd

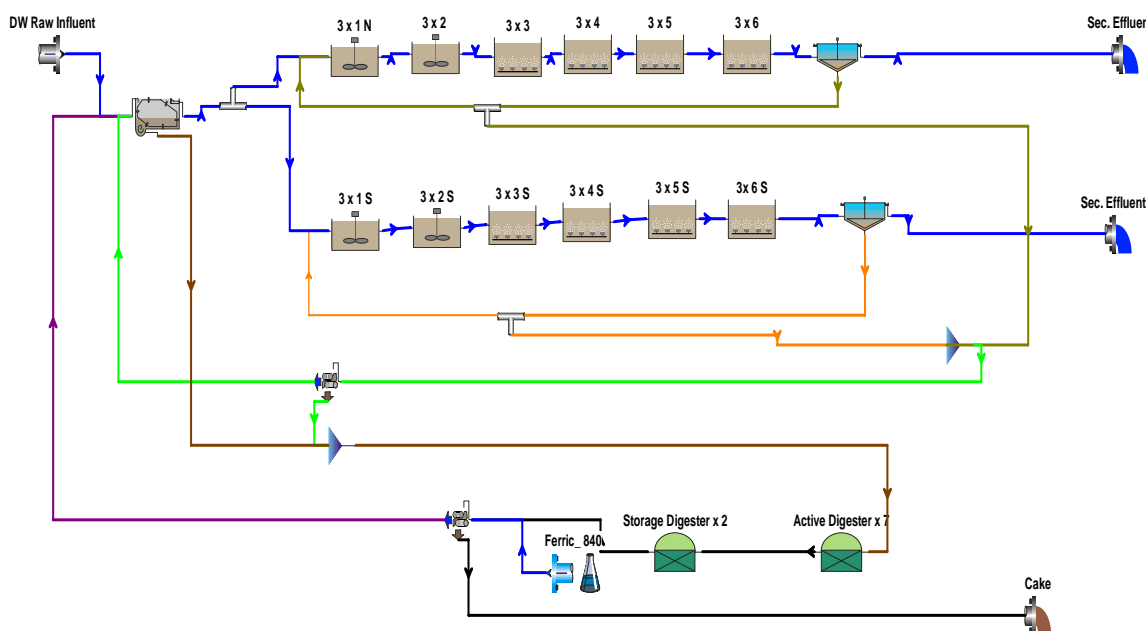
Q = 150 mgd	pH = 6.9
COD ⁽¹⁾ = 359 mg/L	Alkalinity = 98 mg CaCO ₃ /L
TKN = 33 mgN/L	DO = 0 mg/L
TP = 4 mg P/L	Ca = 160 mg/L
NO ₃ -N = 1 mgN/L	Mg = 25 mg/L
Notes: ISS = 25 mg/L	

3.1 Modeled Volume

For wet weather conditions all aeration volume and clarifier area was placed on line as follows.

- The aeration basin total modeled volume = 8.4 MG
- (8 out of 8 basins on-line)
- Total clarification = 16 clarifiers @ 120 ft dia = 180,979 ft²
- RAS to flow pace at 30% of influent flow.
- Flow split set at 54:46 North/South.

Figure 2: BioWin™ set-up for this scenario



The Vesilind V_o parameters for the secondary clarifier model was adjusted as back to the default value as follows.

$$V_o = 0.38 \text{ ft/min}$$

The results from these modeling runs are presented in Table 5 and Table 6.

Table 5: Aeration Basin Results @ 150 mgd, Plug Flow

MLSS ~ 2,147 mg/L	
MLVSS ~ 1,852 mg/L	SRT (Aeration) ~ 1.0 days
WAS Q ~ 1.46 mgd	SRT (Reactors) ~ 1.3 days
WAS concentration ~ 9,845 mg/L TSS 8,490 mg/L VSS	

Table 6: Predicted Secondary Effluent @ 150 mgd, Plug Flow

BOD ~ 11.1 mg/L	$\text{NH}_3\text{-N}$ ~ 25.2 mg/L
COD ~ 55.1 mg/L	$\text{NO}_3\text{-N}$ ~ 0.0 mg/L
TSS ~ 15.6 mg/L	Total N ~ 27.9 mg/L
pH ~ 6.4	TP ~ 2.5 mg/L

Sludge information obtained from the modeling as follows:

- Primary sludge = 0.5 mgd @ 2.7% ~ 113,799 lbs/d

- Secondary sludge = 1.48 mgd @ 0.98% ~ 119,954 lbs/d

3.2 Secondary Clarifier Results

The results of the modeling from a clarifier perspective are:

- Secondary clarifier overflow rate ~ 834 gall/ft²-d
- Secondary clarifier solids loading rate ~ 19.2 lbs/ft²-d

4.0 MAXIMUM MONTH CONDITIONS @ 150 MGD, STEP FEED

The flow was kept at the current wet weather maximum value of 150 mgd. The influent mass loadings were kept constant as detailed in Table 4 by lowering the influent concentrations. All influent flow was sent to stage 4 of the oxygen reactors to create contact stabilization operation during the wet weather event.

4.1 Modeled Volume

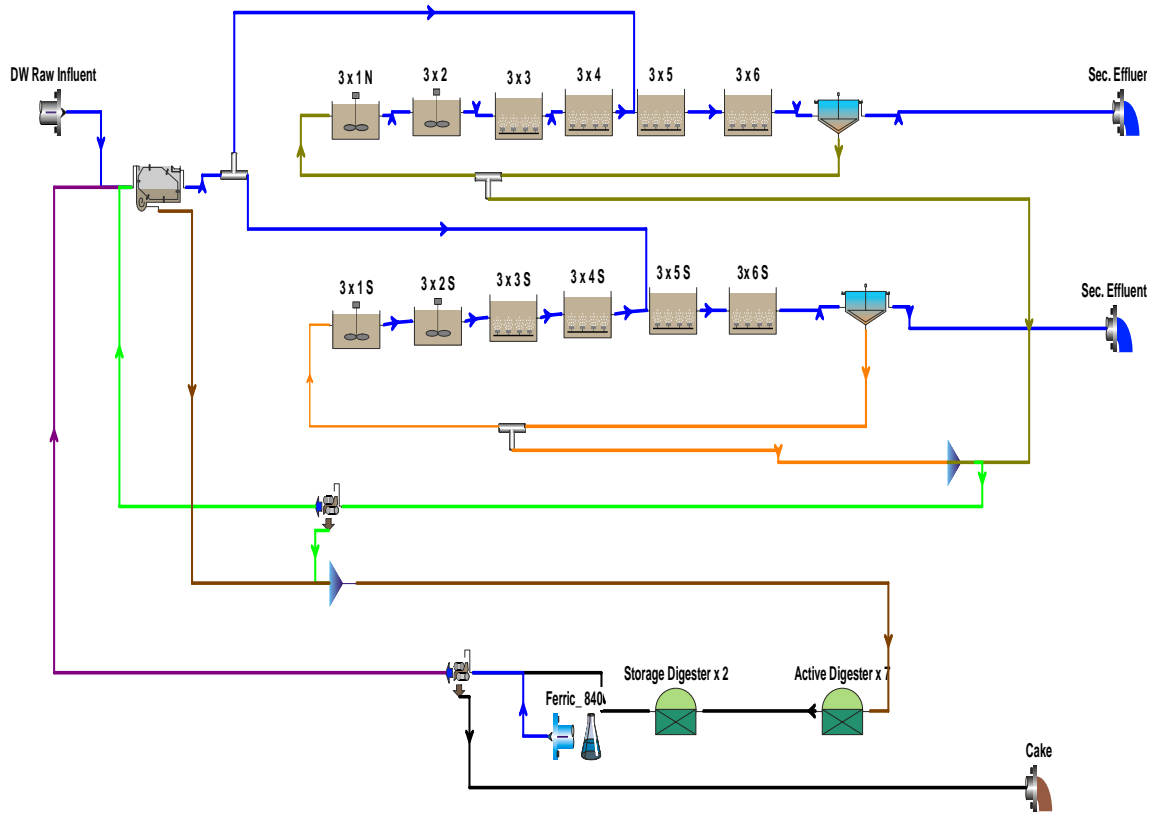
For wet weather conditions all aeration volume and clarifier area was placed on line as follows.

- The aeration basin total modeled volume = 8.4 MG
(8 out of 8 basins on-line)
- Total clarification = 16 clarifiers @ 120 ft dia = 180,979 ft²
- RAS to flow pace at 30% of influent flow.
- Flow split set at 54:46 North/South.

The Vesilind V_o parameters for the secondary clarifier model was adjusted as back to the default value as follows.

$$V_o = 0.38 \text{ ft/mi}$$

Figure 3: Details the *BioWin*TM set-up for this scenario



The results from these modeling runs are presented in Table 7 and Table 8.

Table 7: Aeration Basin Results @ 150 mgd, Step-Feed

MLSS (exit) ~ 1,888 mg/L	
MLVSS (exit) ~ 1,404 mg/L	SRT (Aeration) ~ 3.6 days
WAS Q ~ 1.48 mgd	SRT (Reactors) ~ 4.2 days
WAS concentration ~ 8,283 mg/L TSS 6,137 mg/L VSS	

Table 8: Predicted Secondary Effluent @ 150 mgd, Step Feed

BOD ~ 21 mg/L	NH ₃ -N ~ 24.3 mg/L
COD ~ 70 mg/L	NO ₃ -N ~ 1.0 mg/L
TSS ~ 15.3 mg/L	Total N ~ 28.6 mg/L
pH ~ 6.4	TP ~ 1.8 mg/L

Sludge information obtained from the modeling as follows:

- Primary sludge = 0.5 mgd @ 2.7 % ~ 113,618 lbs/d
- Secondary sludge = 1.46 mgd @ 0.82 % ~ 100,920 lbs/d

4.2 Secondary Clarifier Results

The results of the modeling from a clarifier perspective are:

- Secondary clarifier overflow rate ~ 834 gall/ft²-d
- Secondary clarifier solids loading rate ~ 16.1 lbs/ft²-d

4.0 MAXIMUM MONTH CONDITIONS AT 180 MGD, STEP FEED

The flow was increased to 180 mgd. The influent mass loadings were kept constant as detailed in Table 9 by lowering the influent concentrations. All influent flow was sent to stage 4 to create contact stabilization operation during the wet weather event.

Table 9: Maximum Month Influent Conditions for 180 mgd

Q = 180 mgd	pH = 6.9
COD ⁽¹⁾ = 300 mg/L	Alkalinity = 82 mg CaCO ₃ /L
TKN = 27 mgN/L	DO = 0 mg/L
TP = 3.3 mg P/L	Ca = 160 mg/L
NO ₃ -N = 1 mgN/L	Mg = 25 mg/L
Notes: ISS = 20 mg/L	

5.1 Modeled Volume

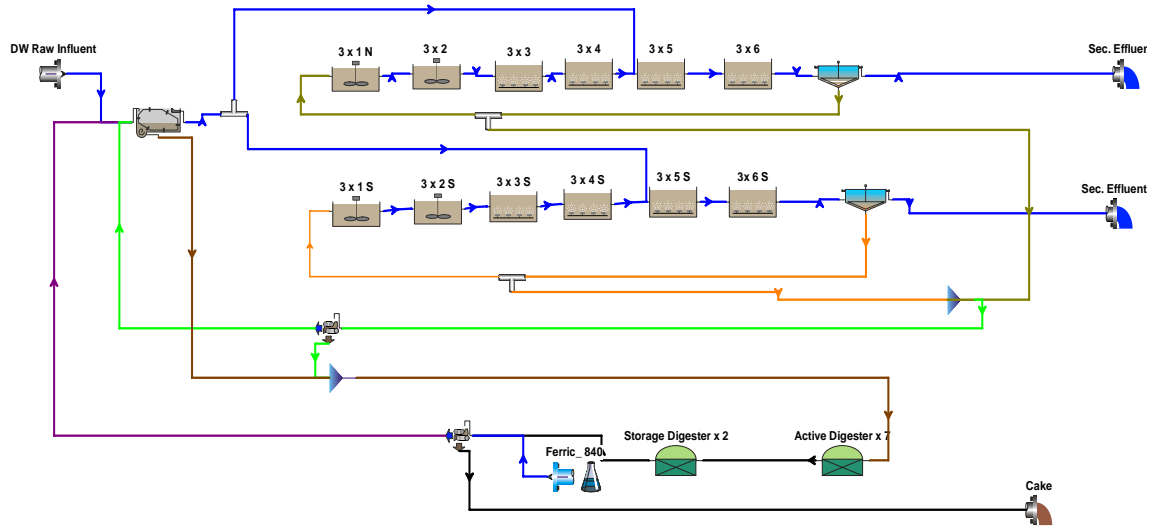
For wet weather conditions all aeration volume and clarifier area was placed on line as follows.

- The aeration basin total modeled volume = 8.4 MG
(8 out of 8 basins on-line)
- Total clarification = 16 clarifiers @ 120 ft dia = 180,979 ft²
- RAS to flow pace at 30% of influent flow
- Flow split set at 54:46 North/South

The Vesilind Vo parameters for the secondary clarifier model was adjusted as back to the default value as follows.

$$V_o = 0.38 \text{ ft/min}$$

Figure 4: Details the *BioWin*TM set-up for this scenario



The results from these modeling runs are presented in Table 10 and Table 11.

Table 10: Aeration Basin Results @ 180 mgd, Step Feed

MLSS (exit) ~ 1,591 mg/L	
MLVSS (exit) ~ 1,213 mg/L	SRT (Aeration) ~ 3.3 days
WAS Q ~ 1.46 mgd	SRT (Reactors) ~ 4.2 days
WAS concentration ~ 7,264 mg/L TSS 5,540 mg/L VSS	

Table 11: Predicted Secondary Effluent @ 180 mgd, Step Feed

BOD ~ 22.4 mg/L	NH ₃ -N ~ 20 mg/L
COD ~ 69.0 mg/L	NO ₃ -N ~ 0.8 mg/L
TSS ~ 19.2 mg/L	Total N ~ 23.9
pH ~ 6.1	TP ~ 1.7 mg/L

Sludge information obtained from the modeling as follows:

- Primary sludge = 0.5 mgd @ % ~ 2.7% ~ 112,819 lbs/d
- Secondary sludge = 1.46 mgd @ 0.73 % ~ 88,505lbs/d

5.2 Secondary Clarifier Results

The results of the modeling from a clarifier perspective are:

- Secondary clarifier overflow rate = 1,000 gall/ft²-d
- Secondary clarifier solids loading rate = 17 lbs/ft²-d

5.0 DISCUSSION

The modeling analysis indicates that switching during wet weather from the current plug flow operation at the SEP to a contact stabilization mode can increase the wet weather rating of the plant. Increasing the peak flow to 180 mgd results in a secondary clarifier loading of 17 lbs/ft²-d compared to 11 lbs/ft²-d during dry weather conditions and 19.2 lbs/ft²-d for 150 mgd and plug flow operation. Greater flow increases may be possible but increased secondary clarification area would probably be required (to reduce overflow rates) and investigations into the minimum bioflocculation time for proper wastewater treatment would be needed.

**APPENDIX E - WASTEWATER SAMPLING ANALYSIS FOR
USE IN THE OCEANSIDE WATER POLLUTION CONTROL
PLANT SPECIFIC BIOWIN™ PROCESS MODEL**

APPENDIX E - WASTEWATER SAMPLING ANALYSIS FOR USE IN THE OCEANSIDE WATER POLLUTION CONTROL PLANT SPECIFIC BIOWIN™ PROCESS MODEL

1.0 SUMMARY

Sampling of wastewater characteristics at the OWPCP was undertaken between 5/12/05 and 6/12/05 to better characterize the inputs required for *BioWin*™ modeling of the plant. This model will be used in the ongoing Master Planning effort. Sampling from 5/12, 5/17, 5/25 and 6/2/2005 were used in the detailed input analysis. This technical memorandum analyses the results of the sampling and utilizes the *BioWin*™ input specifier spreadsheet to determine the required fractionation of the input parameters.

The recommended *BioWin*™ input variables for COD (an average of 4 days of sampling) are detailed in Table 1, along with a few other important input variables. Table 2 details the other measured constituents to be input into the *BioWin*™ model, all other values will be the *BioWin*™ default values.

Table 1: Recommended *BioWin*™ Input Parameters

COD Influent Fraction	Default	Value
Fbs – Readily biodegradable (including Acetate) (g COD/g of total COD)	0.2	0.17
Fac – Acetate (g COD/g of readily biodegradable COD)	0.15	0.15
Fxsp – Non colloidal slowly biodegradable (g COD/g of total COD)	0.75	0.69
Fus Unbiodegradable soluble (g COD/g of total COD)	0.05	0.05
Fup Unbiodegradable particulate (g COD/g of total COD)	0.13	0.13
Other Influent Fractions		
Fna Ammonia (gNH ₃ -N/gTKN)	0.66	0.78
Fnox Particulate organic nitrogen (gN/g organic N)	0.5	0.5
Fnus soluble unbiodegradable TKN (gN/gTKN)	0.0	0.0
F _{PO4} phosphate (gPO ₄ /gTP)	0.5	0.74

Table 2: Average Measured *BioWin*™ Input Variables

Input Variable	Value
TKN (mgN/L)	42.3
Nitrate (mgN/L)	4.7
TP (mgP/L)	5.3
pH	6.9
Alkalinity (mgCaCO ₃ /L)	216
ISS (mg/L)	28

2.0 METHODOLOGY

Sampling of wastewater at the OWPCP was undertaken between 5/12/05 and 6/12/05 to better characterize the inputs required for *BioWin*TM modeling of the plant. Results from the sampling along with long term routine plant monitoring data was analyzed as follows:

2.1 Raw Influent COD and BOD₅ Ratio

Raw influent COD and BOD₅ data was compiled from 1/1/2002 to 12/31/2004. Only days when both sets of data were available were used in the analysis. Results of the analysis are detailed in Table 3 and indicate an average COD/BOD₅ ratio of 2.04, which falls within typical industry standards for domestic wastewaters.

Table 3: COD/BOD5 Ratio

Percentile (%)	COD/BOD ₅ Ratio
5	1.45
50	2.04
95	2.71

The long term average COD/ BOD₅ ratio of 2.04 was utilized for in the *BioWin*TM specifier spreadsheet.

2.2 Special COD Sampling

2.2.1 Special Sampling May 12 and 17, 2005

Results from the special COD sampling on 5/12 and 5/17 are detailed in Table 4, for raw wastewater, primary effluent and final effluent.

Table 4: 5/12 and 5/17/2005 COD Sampling

		5/12/2005	5/12 corrected	5/17/2005	5/17 corrected
OSP_RAW (mg/L)	XX	555	555 ⁽¹⁾	550	550 ⁽¹⁾
OSP_RAW (mg/L)	XG	247	247 ⁽¹⁾	238	234 ⁽¹⁾
OSP_RAW (mg/L)	XM	190	184 ⁽¹⁾	186	177 ⁽¹⁾
OSP_RAW (mg/L)	XF	162	126 ⁽¹⁾	189	122 ⁽¹⁾
OSP_PRI_EFF (mg/L)	XX	380	380	325	325
OSP_PRI_EFF (mg/L)	XG	233	233	217	217
OSP_PRI_EFF (mg/L)	XM	164	146	175	136
OSP_PRI_EFF (mg/L)	XF	168	106	150	99
OSP_FINAL_EFF (mg/L)	XX	49.7	49.7	62	62.0
OSP_FINAL_EFF (mg/L)	XG	40.6	40.6	49	49.0
OSP_FINAL_EFF (mg/L)	XM	57.7	33.8	72	41.0
OSP_FINAL_EFF (mg/L)	XF	84.1	28.0 ⁽¹⁾	84	34.0 ⁽¹⁾
Notes: XX = Not filtered / Standard Methods preparation XG = Filtered with glass fiber filter (1.2 µm) XM = Filtered with 0.45 µm membrane filter XF = Flocculated and filtered with 0.45 µm membrane filter (1) Values were further utilized in the analysis as detailed in Section 3.0.					

As indicated in Table 4, there were problems with the XF (flocculated and filtered through 0.45µm membrane) values being at times higher than the XM values (filtered through 0.45µm membrane). These values should be less as the flocculation method removes additional colloidal COD. It was determined through testing that the 0.45µm membranes were contributing to the COD values and therefore using subsequent sampling results, the data for 5/12 and 5/17 was corrected by using sampling conducted on 5/25 and 6/2 to determine the required fractions, for example COD_(sol)/COD. These fractions were then used to produce the corrected values for 5/12 and 5/17.

2.2.2 Special COD Sampling May 25 and June 2, 2005

The problems with the 0.45µm membrane filters were resolved and *Plant* COD samples were taken and analyzed as detailed in Table 5.

Table 5: 5/25 and 6/2/2005 COD Sampling

		5/25/2005	6/2/2005
OSP_RAW (mg/L)	XX	904	613 ⁽¹⁾
OSP_RAW (mg/L)	XG	233 ⁽¹⁾	240 ⁽¹⁾
OSP_RAW (mg/L)	XM	176 ⁽¹⁾	174 ⁽¹⁾
OSP_RAW (mg/L)	XF	121 ⁽¹⁾	117 ⁽¹⁾
OSP_PRI_EFF (mg/L)	XX	357	349
OSP_PRI_EFF (mg/L)	XG	235	220
OSP_PRI_EFF (mg/L)	XM	147	139
OSP_PRI_EFF (mg/L)	XF	107	103
OSP_FINAL_EFF (mg/L)	XX	54	58
OSP_FINAL_EFF (mg/L)	XG	42	47
OSP_FINAL_EFF (mg/L)	XM	35	38
OSP_FINAL_EFF (mg/L)	XF	29 ⁽¹⁾	28 ⁽¹⁾

Notes:
 XX = Not filtered / Standard Methods preparation
 XG = Filtered with glass fiber filter (1.2 µm)
 XM = Filtered with 0.45 µm membrane filter
 XF = Flocculated and filtered with 0.45 µm membrane filter
 (1) Values were further utilized in the analysis as detailed in Section 3.0.

A high influent raw COD value of 904 mg/L was recorded on 5/25. The number was replaced with the recorded plant sample for this day of 506 mg/L.

2.3 Other Analyses (May 12 – June 2, 2005)

Other analyses were also undertaken during the special sampling period. Table 6 details results that were further utilized in the *BioWin*TM specifier spreadsheet as detailed in Section 3.0.

Table 6: Data Used in the BioWin Input Specifier Spreadsheet

Date	Alkalinity mgCaCO ₃ /L	BOD ₅ (mg/L)	COD (mg/L)	TKN (mgN/L)	NH ₃ (mgN/L)	NO ₂ , NO ₃ (mgN/L)	TP (mgN/L)	TSS (mgN/L)	VSS (mgN/L)	pH
5/12/05	218	254	555	43.2	32.8	4.1	5.3	243	218	7.1
5/17/05	214	243	550	41.0	32.0	4.2	5.4	202	177	7.0
5/25/05	224	304	904	44.7	33.3	5.8	5.2	402	351	6.9
6/2/05	209	232	578	40.4	34.2	4.8	5.4	197	173	6.7

3.0 BIOWIN INPUT SPECIFIER SPREADSHEET

The *BioWin*TM input specifier spreadsheet is used as a check on the various wastewater fractions input to the *BioWin*TM model. As detailed in Appendix G data is first input (*Step 1*) and a check using the various fractions and known equations linking COD, BOD and VSS is calculated and presented in *Step 2*. At this point iterative changes to the initial assumptions can be made to obtain a match between the measured and calculated values.

The Fxsp fraction was adjusted to obtain the best data fit. Finally *Step 3* details the *BioWin™* input values to be used in the modeling.

The following assumptions were made to allow the analysis to proceed:

- An assumed BOD_{sol}/BOD₅ ratio of 50% was used in the spreadsheet. This is below the measured values of around 30%, however the 50% value gave good correlation between the various fractions for the four sample days. This ratio should be further investigated, but for the purpose of master planning *BioWin™* modeling it is not a significant issue.
- Influent Acetate = 15 mgCOD/L
- Influent Ortho-phosphate = 4.0 mgP/L (measured data, indicated ortho-phosphate to be above total phosphorus measured values)

Default numbers for the remaining input raw wastewater parameters were used as follows:

- Calcium = 160 mg/L
- Magnesium = 25 mg/L
- Dissolved Oxygen = 0.0 mg O₂/L

Appendix G contains details on *Steps 1, 2* and *3* from the *BioWin* “specifier”. The average values from *Step 3* for the four runs are the recommended input variables as detailed in Table 7.

Table 7: Recommended *BioWin™* Input Parameters

COD Influent Fraction	Default	Value
Fbs – Readily biodegradable (including Acetate) (g COD/g of total COD)	0.2	0.17
Fac – Acetate (g COD/g of readily biodegradable COD)	0.15	0.15
Fxsp – Non colloidal slowly biodegradable (g COD/g of total COD)	0.75	0.69
Fus Unbiodegradable soluble (g COD/g of total COD)	0.05	0.05
Fup Unbiodegradable particulate (g COD/g of total COD)	0.13	0.13
Other Influent Fractions		
Fna Ammonia (gNH ₃ -N/gTKN)	0.66	0.78
Fnox Particulate organic nitrogen (gN/g organic N)	0.5	0.5
Fnus soluble unbiodegradable TKN (gN/gTKN)	0.0	0.0
F _{PO4} phosphate (gPO ₄ /gTP)	0.5	0.74

Table 8 details the other measured constituents to be input into the *BioWin™* model, all other values will be the *BioWin™* default values.

Table 8: Average Measured *BioWin*TM Input Variables

Input Variable	Value
TKN (mgN/L)	42.3
Nitrate (mgN/L)	4.7
TP (mgP/L)	5.3
pH	6.9
Alkalinity (mgCaCO ₃ /L)	216
ISS (mg/L)	28

APPENDIX F - OSP BIOWIN ANALYSIS FEBRUARY 2007

APPENDIX F - OSP BIOWIN ANALYSIS FEBRUARY 2007

1.0 BACKGROUND

As a starting point, the *BioWin* file labeled *Oceanside Steady State Ideal*, dated 12/9/2005 was used as the initial base model. Note all model runs were undertaken with only two out of three available aeration basins on-line, unless specified. All work was undertaken with *BioWin*, Version 2.2. Maximum month and maximum week CBOD₅ and TSS loads are conservatively assumed to occur together. As a comparison for this work, Addendum 1 contains the results from the *BioWin Oceanside Steady State Ideal*, dated 12/9/2005 modeling, and the plant performance at the OWPCP plant for 2004 dry weather averages.

2.0 SCENARIO 1, OCEANSIDE STEADY STATE IDEAL

Influent conditions for *Scenario 1* are detailed in Table 1.

Table 1: Scenario 1, Influent Conditions

Q = 16.5 mgd	pH = 6.9
COD = 484 mg/L ⁽¹⁾	Alkalinity = 215 mg CaCO ₃ /L
TKN = 42.3 mgN/L	DO = 0 mg/L
TP = 8.0 mg P/L	Ca = 160 mg/L
NO ₃ -N = 4.7 mgN/L	Mg = 25 mg/L
Notes: ISS = 23 mg/L (TSS- VSS) ~ 12% of TSS (1) COD = 2.0 * CBOD ₅	

Significant results from the model run are detailed in Tables 2 and 3.

Table 2: Scenario 1, Aeration System Results

MLSS ~ 1320 mg/L	SRT (Total) ~ 2.1 days
MLVSS ~ 1189 mg/L	SRT (Aeration) ~ 0.8 days
WAS * Q ~ 0.43 mgd	SRT (Reactors) ~ 0.9 days
WAS concentration ~ 5,409 mg/L TSS ~ 4,871 mg/L VSS	

Table 3: Scenario 1, Predicted Secondary Effluent

BOD ~ 11 mg/L	NH ₃ -N ~ 33 mg/L
COD ~ 47 mg/L	NO ₃ -N ~ 4.7 mg/L
TSS ~ 11 mg/L	Total N ~ 40 mg/L
pH ~ 6.4	TP ~ 5.8 mg/L

2.1 Scenario 2, Oceanside Steady State, Improved SRT Calculation

There was an error in the original file for the SRT total calculation. The gravity belt thickener (GBT) was included in the total SRT calculation. The GBT element was replaced with the secondary clarifier element. The secondary clarifiers are operated as ideal secondary clarifiers in the model with a sludge blanket depth of 0.13 of the clarifier depth (16 ft), giving a sludge blanket depth of 2.1 ft and a given TSS removal of 99.4%.

No significant changes were obtained with the new runs except for the total system mass as follows:

- SRT (total) ~ 2.3 days
- SRT Aeration ~ 0.8 days
- SRT Reactors ~ 0.9 days

This modification was kept in for all subsequent runs.

2.2 Scenario 3, Oceanside Steady State, Anaerobic Selector

To better model the OWPCP, the first three zones were switched from aerobic to anaerobic operation. The results are presented in Table 4 and Table 5.

Table 4: Scenario 3, Aeration Systems Results, Anaerobic Selector Results

MLSS ~ 1333 mg/L	SRT (total) ~ 2.3 days
MLVSS ~ 1221 mg/L	SRT (Aeration) ~ 0.8 days
WAS(Q) ~ 0.43 mgd	SRT (Reactors) ~ 0.9 days
WAS concentration ~ 5,461 mg/L TSS ~ 5,002 mg/L VSS	

Table 5: Scenario 3, Predicted Secondary Effluent

BOD ~ 12.4 mg/L	NH ₃ -N ~ 33 mg/L
COD ~ 55.4 mg/L	NO ₃ -N ~ 0 mg/L
TSS ~ 13.6 mg/L	Total N ~ 35 mg/L
pH ~ 6.4	TP ~ 5.3 mg/L

3.0 SCENARIO 4, OCEANSIDE BASE CASE, ANNUAL AVERAGE CONDITIONS

As per the updated spreadsheet entitled *Master Plan Alternatives Flow and Loads 1/8/07*, influent conditions were modeled in Table 6.

Table 6: Scenario 4, Influent Conditions

Q = 15.3 mgd	pH = 6.9
COD = 626 mg/L ⁽¹⁾	Alkalinity = 215 mg CaCO ₃ /L
TKN = 42.3 mgN/L	DO = 0 mg/L
TP = 8.0 mgP/L	Ca = 160 mg/L
NO ₃ -N = 4.7 mgN/L	Mg = 25 mg/L
Notes: CBOD ₅ = 39,900 lbs/d = 313 mg/L @ ADWF of 15.3 mgd ISS = 40 mg/L (12% of 332 mg/L) (1) COD = 2.0 * CBOD ₅	

Table 7: Scenario 4, Aeration System Results

MLSS ~ 1637 mg/L	SRT (Total) ~ 2.3 days
MLVSS ~ 1470 mg/L	SRT (Aeration) ~ 0.8 days
WAS Q ~ 0.43 mgd	SRT (Reactors) ~ 0.9 days
WAS concentration ~ 6708 mg/L TSS 6022 mg/L VSS	

Table 8: Scenario 4, Predicted Secondary Effluent

BOD ~ 12 mg/L	NH ₃ -N ~ 33 mg/L
COD ~ 55 mg/L	NO ₃ -N ~ 0 mg/L
TSS ~ 14 mg/L	Total N ~ 35 mg/L
pH ~ 6.4	TP ~ 5.3 mg/L

3.1 Scenario 4a, Oceanside Base Case, Maximum Month Conditions

All other parameters kept constant except for:

$$\begin{aligned} \text{Max month CBOD}_5 &= 46,700 \text{ lbs/d} \\ &= 366 \text{ mg/L @ ADWF of 15.3 mgd} \end{aligned}$$

$$\text{COD} = 2.0 * \text{CBOD}_5 = 732 \text{ mg/L COD}$$

$$\text{ISS} = 48 \text{ mg/L (12\% of 401 mg/L)}$$

Table 9: Scenario 4a, Aeration System Results

MLSS ~ 1918 mg/L	SRT (total) ~ 2.3 days
MLVSS ~ 1718 mg/L	SRT (Aeration) ~ 0.8 days
WAS Q ~ 0.43 mgd	SRT (Reactors) ~ 0.9 days
WAS concentration ~ 7861 mg/L TSS 7042 mg/L VSS	

Table 10: Scenario 4a, Predicted Secondary Effluent

BOD ~ 13.8 mg/L	NH ₃ -N ~ 32mg/L
COD ~ 64 mg/L	NO ₃ -N ~ 0mg/L
TSS ~ 16.5 mg/L	Total N ~ 34 mg/L
pH ~ 6.4	TP ~ 5.0mg/L

3.2 Scenario 4b, Oceanside Base Case, Maximum Week Conditions

All other parameters kept constant except for:

Max week CBOD₅ = 59,100 lbs/d

= 463 mg/L @ ADWF of 15.3 mgd

COD = 2.0 * CBOD₅ = 926 mg/L COD

ISS = 63 mg/L (12% of 524 mg/L)

Table 11: Scenario 4b, Aeration System Results

MLSS ~ 2436 mg/L	SRT (Total) ~ 2.3 days
MLVSS ~ 2175 mg/L	SRT (Aeration) ~ 0.8 days
WAS Q ~ 0.43 mgd	SRT (Reactors) ~ 0.9 days
WAS concentration ~ 9981 mg/L TSS ~ 8913 mg/L VSS	

Table 12: Scenario 4b, Predicted Secondary Effluent

BOD ~ 16.5 mg/L	NH ₃ -N ~ 30 mg/L
COD ~ 79 mg/L	NO ₃ -N ~ 0 mg/L
TSS ~ 20.9 mg/L	Total N ~ 32 mg/L
pH ~ 6.4	TP ~ 4.3 mg/L

3.3 Discussion

Results indicate that even with only two aeration basins on-line and coinciding maximum month and week loads of TSS and CBOD₅ and using an aggressive SRT of around 0.8 – 0.9 days, the plant MLSS values (1600 ~ 2300 mg/L) and other operational parameters stay within reasonable values.

4.0 SCENARIO 5, OCEANSIDE WITH CAYUGA DIVERSION ANNUAL AVERAGE CONDITIONS

Influent conditions for Scenario 5 are detailed in Table 13.

Max month CBOD₅ = 67,100 lbs /d

= 318 mg/L @ ADWF of 25.3 mgd

COD = 2.0 * CBOD₅ = 636 mg/L COD

ISS = 41 mg/L (12% of 338 mg/L)

The Reactor SRT was controlled at around one day for all *BioWin* runs. For these scenarios the ideal clarifier removal was increased from 99.35% to 99.5%

Table 13: Scenario 5, Influent Conditions

Q = 25.3 mgd	pH = 6.9
COD = 636 mg/L	Alkalinity = 215 mg CaCO ₃ /L
TKN = 42.3 mgN/L	DO = 0 mg/L
TP = 8.0 mg P/L	Ca = 160 mg/L
NO ₃ -N = 4.7 mgN/L	Mg = 25 mg/L

Table 14: Scenario 5, Aeration System Results

MLSS ~ 3057 mg/L	SRT (Total) ~ 2.7 days
MLVSS ~ 2727 mg/L	SRT (Aeration) ~ 0.9 days
WAS Q ~ 0.36 mgd	SRT (Reactors) ~ 1.0 days
WAS concentration ~ 12544 mg/L TSS ~ 11193 mg/L VSS	

Table 15: Scenario 5, Predicted Secondary Effluent

BOD ~ 15.7 mg/L	NH ₃ -N ~ 32.3 mg/L
COD ~ 63.4 mg/L	NO ₃ -N ~ 0 mg/L
TSS ~ 20.2 mg/L	Total N ~ 35 mg/L
pH ~ 6.4	TP ~ 5.4 mg/L

4.1 Scenario 5a, Oceanside with Cayuga Diversion Maximum Month Conditions

All other parameters constant except for:

Max month CBOD₅ = 80,600 lbs

= 382 mg/L @ ADWF of 25.3 mgd

COD = 2.0 * CBOD₅ = 764 mg/L COD

ISS = 54 mg/L (12% of 446 mg/L)

Table 16: Scenario 5a, Aeration System Results

MLSS ~ 3700 mg/L	SRT (Total) ~ 2.7 days
MLVSS ~ 3276 mg/L	SRT (Aeration) ~ 0.9 days
WAS Q ~ 0.36 mgd	SRT (Reactors) ~ 1.0 days
WAS concentration ~ 13445 mg/L TSS ~ 13187 mg/L VSS	

Table 17: Scenario 5a, Predicted Secondary Effluent

BOD ~ 18.3 mg/L	NH ₃ -N ~ 31 mg/L
COD ~ 75 mg/L	NO ₃ -N ~ 0 mg/L
TSS ~ 24.4 mg/L	Total N ~ 34 mg/L
pH ~ 6.4	TP ~ 5.0 mg/L

4.2 Scenario 5b, Oceanside with Cayuga Diversion Maximum Month Conditions, 3 Aeration Basins

The predicted MLSS and MLVSS were too high for Scenario 5a, and therefore the model run was repeated with all three aeration basins on line as follows.

Table 18: Scenario 5b, Aeration System Results

MLSS ~ 2830 mg/L	SRT (Total) ~ 2.5 days
MLVSS ~ 2480 mg/L	SRT (Aeration) ~ 1.1 days
WAS Q ~ 0.46 mgd	SRT (Reactors) ~ 1.2 days
WAS concentration ~ 10179 mg/L TSS ~ 11617 mg/L VSS	

Table 19: Scenario 5b, Predicted Secondary Effluent

BOD ~ 14.1 mg/L	NH ₃ -N ~ 31 mg/L
COD ~ 67 mg/L	NO ₃ -N ~ 0 mg/L
TSS ~ 18.7 mg/L	Total N ~ 33 mg/L
pH ~ 6.4	TP ~ 4.9 mg/L

4.3 Scenario 5c, Oceanside with Cayuga Diversion, Maximum Week Conditions, 3 Aeration Basins

All other parameters kept constant except for:

Max month CBOD₅ = 96,100 lbs

= 455 mg/L @ ADWF of 25.3 mgd

COD = 2.0 * CBOD₅ = 910 mg/L COD

ISS = 68 mg/L (12% of 565 mg/L)

Table 20: Scenario 5c, Aeration System Results

MLSS ~ 3343 mg/L	SRT (Total) ~ 2.5 days
MLVSS ~ 2918 mg/L	SRT (Aeration) ~ 1.1 days
WAS Q ~ 0.47 mgd	SRT (Reactors) ~ 1.2 days
WAS concentration ~ 13720 mg/L TSS ~ 11974 mg/L VSS	

Table 21: Scenario 5c, Predicted Secondary Effluent

BOD ~ 16.2. mg/L	NH ₃ -N ~ 28.7 mg/L
COD ~ 78 mg/L	NO ₃ -N ~ 0 mg/L
TSS ~ 22.1 mg/L	Total N ~ 31.4 mg/L
pH ~ 6.4	TP ~ 4.4 mg/L

5.0 DISCUSSION

Under maximum month and week conditions it is necessary to have all three aeration basins on-line to keep the MLSS concentrations within reasonable values. The maximum week values are still relatively high, although during this period a more aggressive SRT could be utilized to lower the MLSS values. A more detailed process analysis is needed from the total plant perspective to evaluate the Cayuga diversion.

References for Appendix F

Sierra, N., Huang, G., Jones, B., Velasco, A. Haddad, D., Chan, R. Chu, I., Feng, Y. Jolis, D. *Whole-Plant Simulations for Two Pure-Oxygen Activated Sludge Plants in San Francisco*, WEFTEC Proceedings, 2006.

ADDENDUM 1 - OSP MODELING AND PLANT DATA 2004

Oceanside Steadystate Ideal

Process	Parameter	Unit	OSP 2004 DW	BioWin Model
Raw Influent				
	Flow	MGD	16.5	16.5
	ISS/TSS	mg/L	192	30/205
	Total COD	mg/L	308	484
	Total BOD		242	241cBOD
	TKN	mg/L	-	42.3
	Total P	mg/L	-	8
	pH	-	-	6.9
Primary Treatment				
Primary Clarifiers	Surface Overflow Rate	gpd/ft ²	837	781
	Primary Influent COD	mg/L	546	475
	1 Effluent TSS	mg/L	109	76
	1 Effluent pH	-	-	6.87
	1 Effluent COD	mg/L	369	303
	COD removal %	%	35	36
	TSS removal %	%	62.8	62.8
	1 Sludge	mgd	0.14	0.14
	1 Sludge Production	1000 lb TS/day	17.5	18.2
	1 Sludge Concentration	mgTSS/L	-	15,158
Secondary Treatment				
Pure-O2 Aeration Trains	MLSS	mg/L	1,512	1,372
	MLVSS	mg/L	1,328	1,211
	Aeration MCRT	days	1.07	0.83
	pH	-	-	6.39
Secondary Clarifiers	RAS Flow	%	32	32
	RAS TSS	mg/L	4,954	5,626

Process	Parameter	Unit	OSP 2004 DW	BioWin Model
	RAS Mass TSS	1000lb/day		248
Effluent	2 Effluent TSS	mg/L	11.9	9.1
	2 Effluent COD	mg/L	54.0	39.6
	2 Effluent BOD	mg/L	16.28 - BOD5	8.1 - CBOD
	Final effluent pH	-	6.4	6.4
	WAS Flow	MGD	0.43	0.42
	WAS Production	1000lb TS/day	18	20
	WAS TSS	mg/L	4,954	5,626
Solid handling				
Gravity Belt Thickeners	Hydraulic Loading	MGD	0.58	0.56
	Solid Concentration	mg/L	-	8,060
	Solid Loading	1000 lbs/day	35	38
	Filtrate TSS	mg/L	119	98
	Total COD	mg/L	354	203
	Solids Capture	%	99.1	99.0
	pH	-	-	6.5
Sludge Feed	Flow	1000 gpd	102	102
	TSS loading	1000 lb TSS/day	35	38
	TSS concentration	mg/L	-	44,121
	TS	%	5.6	-
	VS	%	85	85
Anaerobic Digesters	Detention Time	days	23.3	22.1
	Temperature	Degrees F	96	96
	Digested Sludge TS	%	2.4	-
	Digested Sludge VS	%	63.1	-
	VSS Reduction	%	64.0	61.5
	pH	-	7.3	6.8
	Biogas Production	1000 cf/day	297	274

Process	Parameter	Unit	OSP 2004 DW	BioWin Model
	lbs VS Removed	1000 lb VS/day	19	20
	Biogas Production	Ft3/Lb VS destroyed	15.5	13.9
Belt Presses	Belt press feed	MGD	0.1	0.102
	TS	mg/L	-	20,151
	TS loading	1000lb/day	15.9	17.8
	Filtrate Total COD	mg/L	1,047.0	255
	Cake TS	%	15.1	15.2
	Filtrate TSS	mg/L	135	100
	Solids Capture	%	99.57	99.57
	Cake Production (wet)	tons/day	69	55
	Cake Production (dry)	1000lbs/day	23	17
	Cake Production (dry)	tons/day	11.4	8.5