CHAPTER 2 - SOLIDS QUANTITIES AND MASS MODELING

2.1 General

The purpose of this chapter is to present the flow and solids loading criteria used in the design of the FIRP and the NSPF, and to compare the criteria with recorded solids production rates since the start-up of the Metro Biosolids Center. Figures 2-1, 2-2 and 2-3 present the overall plant, NSPF and FIRP Process Flow Diagrams respectively. The latter two diagrams indicate the flows and solids load quantities used as the design basis for the Consumer Alternative Plan Phase I facilities. Lastly, Figure 2-4 presents the hydraulic profile of MBC.

The latter part of this chapter summarizes the solids mass modeling done for MBC to evaluate three projects identified from the Phase I Condition/Operation Assessment of this master planning effort.

2.2 MBC Influent Solids Loading

Table 2-1 presents the projected average and peak solids production from the NCWRP and PLWTP based on the key process parameters shown in Table 2-2.

TABLE 2-1
NCWRP and PLWTP Projected Average and Peak Solids Flow Rates[1]
(CONSUMER'S ALTERNATIVE PLAN)

Source	Phase I (2010)		Phase II (2050)	
	Avg	Peak	Avg	Peak
NCWRP (Raw Solids @ 0.5%)				
-Flow, mgd	1.69	2.71	2.40	3.85
-Solids, ppd	75,940	121,774	107,648	172,685
Other Northern WRPs[2]				
-Flow, mgd	0	0	0.65	1.04
-Solids, ppd	0	0	29,358	46,647
Total to NSPF				
-Flow, mgd	1.69	2.71	3.05	4.89
-Solids, ppd	75,940	121,774	137,006	219,332
PLWTP (Digested Biosolids @ 3%)[3]				
-Flow, mgd	1.04	1.43	1.36	1.90
-Solids, ppd	259, 961	357,446	344,033	480,634

[1] Loadings taken from M&E's "FIRP/NSPF Design Concept Report" dated August 1993. 3.3 Design Criteria, Tables 3-2, 3-3 and 3-8.
[2] Other Northern and Central WRPs include Mission Valley, Mission Gorge and Santee.
[3] PLWTP receives raw solids from South Bay Plant through the sewers. The digested solids figures above include the South Bay Plant solids.

TABLE 2-2
Key Assumptions in Solids Production Projections

Parameter	Unit	NCWRP	PLWTP
Influent TSS Levels	mg/l	220	306
Influent BOD Levels	mg/l	220	306
Primary TSS Removal Efficiency	%	60	75-85[a]
Primary BOD Removal Efficiency	%	35	45-55[a]
Final Effluent TSS	mg/l	5	10
VSS/TSS Primary Solids Ratio	%	74	71
VSS/TSS Secondary Solids Ratio	%	80	80
BVSS/VSS Primary Solids Ratio	%	60	60
BVSS per pound of BOD Removed. Y_{net}	lb/lb	0.6	0.6
Ferric Chloride Added to Primary Tanks	mg/l	0	50
VSS Destruction in Anaerobic Digesters	%	50	50
Thickening Capture Rate[b]	%	95	95
Dewatering Capture Rate[b]	%	95	95
Centrate from Biosolids Thickening and Dewatering sent to PLWTP	%	100	100
Amount of Digested Biosolids going to FIRP to Dewatering	%	100	100
Dewatered Biosolids Concentration	%	30	30

Reference: Table 3-4 of M&E's "FIRP/ NSPF Design Concept Report: August 1993"
a. First number for secondary treatment, second number for advanced primary treatment only.
b. 95% capture rate for solids related equipment design and 90% capture rate for side stream related equipment design.

2.3 Historic Solids Loadings from NCWRP AND PLWTP

Tables 2-3 and 2-4 display the amount of biosolids produced at PLWTP and NCWRP from 1999 to 2003. Comparing these historic quantities to the design loadings of the Consumer's Alternative in Table 2-1 demonstrates that NCWRP's historic average and peak solids are less than those projected for Phase I.

The average loads from PLWTP for 4 years were equal to or greater than the Phase I projections. However, in terms of the lbs/day sent to MBC from 1999 to 2003, the digested biosolids quantities are lower than the projections. The higher sludge flows are due to the lower concentration of solids being sent versus percent solids used during design (2.5% actual vs. 3 % design).

TABLE 2-3 **NCWRP Raw Biosolids Sent to MBC [2, 3]**					
	1999	2000	2001	2002	2003
Average - mgd - ppd	 1.44 60,050	 Complete Data not available [1]	 1.04 43,370	 1.05 43,790	 1.13 47,120
Peak -mgd -ppd	 1.97 82,150	 1.08 45,040	 1.17 48,790	 1.21 50,460	 1.29 53,790

[1] Complete readings not available.
[2] Based on NCWRP Annual Monitoring Reports for indicated years.
[3] Raw solids @ 0.5% solids.
mgd- million gallons per day
ppd - pounds per day

TABLE 2-4 **PLWTP Digested Biosolids [1, 2, 3]**					
	1999	2000	2001	2002	2003
Average - mgd - ppd	 1.18 232,000	 1.03 214,000	 1.04 210,000	 1.09 208,000	 1.13 216,000
Peak -mgd -ppd	 1.24 248,000	 1.12 226,000	 1.14 222,000	 1.18 220,000	 1.25 238,000

[1] Based on Point Loma Ocean Outfall Annual Monitoring Reports for indicated years.
[2] Includes raw solids received from South Bay WRP.
[3] Digested biosolids @ 2.5% solids
mgd- million gallons per day
ppd - pounds per day

2.4 Dewatered Biosolids Production

The table below shows the projected dewatered biosolids production for the MBC facility for years 2010 and 2050. These quantities were the basis for the design of MBC's FIRP Facility including the storage silos, truck loadout silos and biosolids transfer pumps.

TABLE 2-5 **MBC Dewatered Biosolids Projections [1]**		
	2010	2050
Annual Average		
-ppd	288,337	401,449
-dtpd	144	201
-wtpd (@ 32 % solids)	450	628
Annual Peak		
-ppd	385,340	536,572
-dtpd	193	268
-wtpd (@ 30% solids)	643	893
Solids flow, mgd		
-avg	0.11	0.15
-peak	0.15	0.21

1-From the M&E "FIRP/ NSPF Design Concept Report," Appendix B.
ppd – pounds per day
dtpd – dry tons per day
wtpd – wet tons per day

Table 2-6 below shows the actual average biosolids production at MBC from year 2001 to 2004. Compared with the Consumer's Alternative projections in Table 2-1 and M&E's design quantities in Figure 2-2 and Figure 2-3, these actual quantities are shown to be smaller than the planning and design biosolids projections.

TABLE 2-6
MBC Biosolids Cake Production (Average)

	2001[1]	2002	2003	2004[2]
Wtpd	265	343	357	367
% solids	29.6	29.4	28.8	28.5
Dtpd	79	101	103	105

[1] Only for months of July to December.
[2] Only for months of January to September.
dtpd – dry tons per day
wtpd – wet tons per day

The above comparisons appear to show that the MBC dewatering facilities have plenty of capacity to process current solids loads up to year 2010. However, these actual production rates are deemed to be a truer indication of MBC's real capacity as affected by various design and operational constraints described in this report.

2.5 Phase II Mass Modeling

In the Phase II effort of this master plan for MBC, a computerized mass balance modeling based on more accurate assumptions learned and honed from five years of operation of the upgraded PLWTP (with advanced primary treatment) and the new NCWRP including MBC's operations was performed with the assistance of MWWD 's as-needed engineer Brown and Caldwell (B&C). The Phase II mass balance model runs (also called MBC CAMP runs) also estimated the construction timing for certain MBC facilities identified for upgrade or expansion in the Phase I condition and operation assessment. A copy of the Technical Memorandum submitted by Brown & Caldwell as requested by the City is presented in Appendix C. A summary of this technical memorandum is presented herein.

The three MBC facility improvements of interest due to their criticality to MBC operation, as listed in the *MBC UPGRADES PROJECTS* resulting from the Phase I Condition and Operation Assessment (see Chapter 1, Table 1-2), are the following:

- Project P-10.6 – Replace 4 Dewatering Centrifuges with Larger Capacity Units
- Project P-11.1 - Additional Biosolids Storage Silos
- Project P-11.6 – New Biosolids Truck Loadout Facility

2.5.1 MODELING METHODOLOGY

The step-by step process performed to arrive at the projected estimates were as follows:

1. ***Collected influent and effluent flow, TBOD, and TSS information for PLWTP, NCWRP, SBWRP, and MBC.*** Data collected for years 2001, 2002 and 2003 were used for model calibration purposes.
2. ***Determined average, minimum, maximum, and 90th and 95th percentile values of the collected data.*** The 95th percentile values of 7-day rolling averages were used to calibrate the models for capacity assessment of MBC centrifuge and cake storage facilities.
3. ***Calibrated Model.*** Model parameters such as removal efficiencies for primary sedimentation process, capture efficiencies for thickening and dewatering processes were adjusted to match 95th percentile effluent concentrations for daily and 7-day rolling averages.
4. ***Determined Calendar Year When Capacities are Reached.*** After establishing the model parameters, the model was run using projected flows for the service area at a given year. Using an iteration procedure, the year when available capacities match projected biosolids production was determined.

2.5.2 GENERAL KEY ASSUMPTIONS

For all MBC CAMP model runs, it was assumed that PLWTP, NCWRP and SBWRP were the only wastewater treatment plants in service and that the WRPs produce secondary effluent. The NCWRP effluent was assumed to be returned to the sewer for re-treatment at PLWTP and the

SBWRP effluent was disposed through the South Bay Ocean Outfall. SBWRP solids are returned to the South Metro Interceptor for treatment at PLWTP and eventual conveyance to MBC. PLWTP is assumed to continue operating as an advanced primary treatment plant. Model runs were performed only until 2025 when the draft 2005 MWWD Framework Plan indicates that the Southern Sludge Processing Facility and a South Bay Secondary Treatment Plant would be in service. Solids from the SBWRP will then be processed at this new south facility relieving load on MBC.

The process parameters provided in Table 2-7 below were used in all model runs for this project. These parameters were based on data collected from the three treatment plants including MBC for 2001, 2002, and 2003. These parameters were confirmed by the operational staff of the plants. A detailed discussion of the changes made on the operational parameters originally used for PLWTP, NCWRP and MBC based on MWWD staff comments and suggestions is presented in the B&C CAMP Technical Memorandum (See Appendix C).

TABLE 2-7
MBC CAMP Mass Balance Model Parameters[1]

Parameter	Old	New
Chemical Sludge Production, lb TSS/lb $FeCl_3$ Added (see Attachment C for backup calculation)	0.7	1.1
Capture of Chemical Sludge, %	95%	100%
Chemical Addition – ferric chloride, mg/L	40	30
Combined Sludge Specific Gravity	1.0	1.01
Thickened Sludge Specific Gravity	1.01	1.03
Combined Sludge VSS Destruction, %	45%	52%
Gas Production Rate, scf/lb VSS destroyed	15	14.5
Digester Influent to Effluent Ratio	1.0	0.99
Digested Sludge Specific Gravity	1.02	1.03
Solids Concentration of Dewatered Sludge, % (w/w)	30%	28%
Solids Recovery in Thickener, %	90%	97%
Thickened Sludge Solids Concentration, % (w/w)	3.0%	3.5%
NCWRP TSS Removal in Primaries	60%	65%
NCWRP TBOD Removal in Primaries	35%	38%
NCWRP Secondary MLTSS Concentration, mg/L	2800	2155
NCWRP MCRT, days	5	5.86
NCWRP $FeCl_3$ Addition, mg/L	15	10
$FeCl_3$ Solution Strength, %	40%	44%
$FeCl_3$ Solution Specific Gravity	1.31	1.467

[1] See "List of Acronyms and Abbreviations" at front of this report.

Copies of the CAMP model runs performed are provided in the Technical Memorandum Appendix C.

2.5.3 MODEL RESULTS

Additional adjustments to the original mass balance model resulting from the calibration runs for each of the three projects in consideration are reported in the Technical Memorandum in Appendix C.

A. Project P-10.6 – Replace 4 Dewatering Centrifuges with Larger Capacity Units

Additional assumptions made regarding the dewatering centrifuges include the following:

- 6 of 8 dewatering centrifuges are in operation (i.e., two are in standby mode at all times)
- Each existing centrifuge can process up to 225 gpm average or 300 gpm peak of digested biosolids, using average capacity for determining expansion needs
- 3.0% solids content in digested biosolids

Results

The existing dewatering centrifuges at MBC are adequate until the year 2025. Therefore, designing for upgrade or expansion of the units will have to be started in about 2020. Any earlier modifications will be driven by the useful life of the equipment.

B. Project P-11.1 - Additional Biosolids Storage Silos

Additional assumptions made specific to the operation of the existing silos include the following:

- Dewatering centrifuges produce a dewatered cake with 28% solids
- Maximum storage capacity required is equivalent to the amount of dewatered cake produced in 3.63 days (during a 3-day weekend starting 3 p.m. on Friday when truck loadout stops until 6 a.m. on the following Tuesday when loadout resumes) or in 2.63 days (during a 3-day weekend except with MBC staff working 9 hours on Saturday).
- One or two silos are out of service for each storage scenario
- Each silo has a maximum storage capacity of 6,950 cubic feet, only 90% of this volume can be used on a daily basis based on actual operation.

Results

1. With 3.63-day weekend storage and 6 of 8 silos in operation (2 on standby), existing silo capacity is currently exceeded.
2. With 3.63-day weekend storage and 8 of 8 silos in operation, capacity is currently exceeded.
3. With 2.63-day weekend storage and 7 of 8 silos in operation, capacity will be adequate until 2014.

4. With 2.63-day storage and 8 of 10 silos (2 new silos added now), capacity will be adequate until 2025.
5. With 3.63-day storage and 10 of 12 silos in operation (4 new silos added now), capacity will be adequate until 2017.
6. With 3.63-day storage and 11of 13 silos in operation (5 new silos added now), capacity will be adequate until 2025.

C. <u>Project P-11.6 – New Biosolids Truck Loadout Facility</u>

Additional assumptions specifically related to the Truck Loadout Facility include the following:

- Each truck loadout bay has the capacity to hold 648 cubic feet of dewatered biosolids per load
- Two loadout bays are available at all times
- Each truck requires a total of 25 minutes to drive in, accept load, and drive out
- Cake pumps are capable of transferring biosolids from the silos to the truck loadout within the loading duration noted above
- Bays are only open 5 or 6 days per week and 8 or more hours per day (Various operating scenarios are indicated in Table 2-8)
- Truck loadout opens one hour extra than the hours indicated on Table 7 to account for startup and cleanup time at the beginning and end of each work day

<u>Results</u>

1. At normal operation of 5 days per week and 8 hours per day, the existing two truck loadout bays are adequate until 2014.
2. If the City chooses to operate on Saturdays, the existing bays are adequate until 2025.
3. At normal operation of 5 days per week and but at a little over 9 hours per day, the existing bays are adequate until 2025.

2.5.4 CONCLUSIONS / RECOMMENDATIONS

Recommended startup years for the selected MBC expansion projects are provided in Table 2-8 under the various operating scenarios for each project. Based on project needs and funding allocation, the final MWWD recommendations/decisions made are also indicated.

TABLE 2-8
Final Recommendations on MBC CAMP Projects

Project / Operating Scenarios	**Recommended Start-Up Year by Model**	**Final MWWD Decision**
P-10.6 – Replace 4 Dewatering Centrifuges with Larger Capacity Units	• Beyond 2025	**Due to current wear and tear conditions, replace 8 existing units with new same-size units. Implement in 2007-2014.**
P-11.1 – Additional Biosolids Storage Silos • 3.63 days storage; 6 of 8 in Operation • 3.63 days storage; 8 of 8 in Operation • 2.63 days storage; 7 of 8 in Operation • 3.63 days storage; 10 of 12 in Operation – 4-unit Expansion has Occurred • 2.63 days storage; 8 of 10 in Operation – 2-unit Expansion has Occurred • 3.63 days storage; 11 of 13 in Operation – 5-unit Expansion has Occurred	 • Currently Exceeds Capacity • Currently Exceeds Capacity • 2014 • 2017 • Beyond 2025 • Beyond 2025	**Implement 2- unit expansion in 2007-2014. In the interim until 2014, during 3-day weekends MBC to load silos on Saturdays for 8 hours.**
P-11.6 – New Biosolids Truck Loadout Facility • 2 Bays in Operation; 5 days/week; 8 hours/day • 2 Bays in Operation; 6 days/week; 8 hours/day • 2 Bays in Operation; 5 days/week; 9 hours/day	 • 2014 • Beyond 2025 • Beyond 2025	**Construct new Loadout Facility in 2024-2030. In the interim, MBC to operate bays at 9 hrs/day, 5 days per week.**