Supplemental Documentation Volume 8

Stress Testing of the Southwest WPCP

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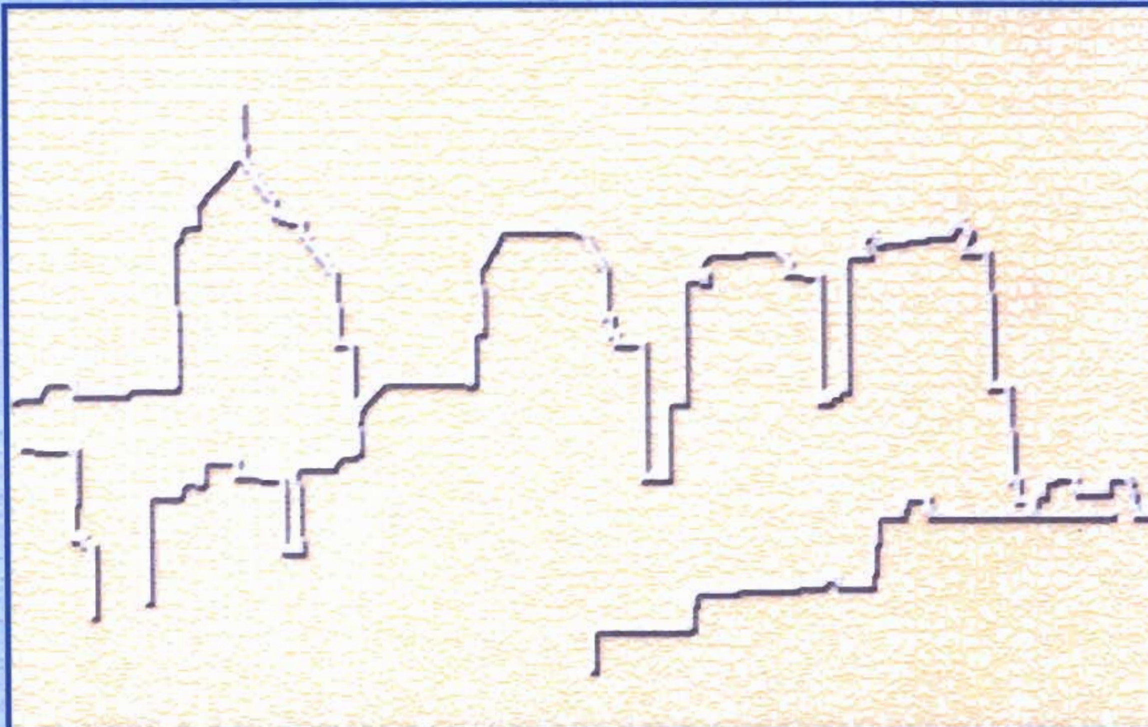
FINAL REPORT



Stress Testing of the Southwest WPCP

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Prepared for

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SECTION 1

INTRODUCTION

1. Introduction

1.1 Project Objectives and Methodology

As part of its obligations under the Federal Clean Water Act and the Pennsylvania Clean Streams Law, the City of Philadelphia Water Department (PWD) has initiated a program with an objective to minimize the impact of Combined Sewer Overflows (CSO) on local receiving waters. One of the proposed strategies for reducing the CSO volume is to maximize flow to be treated by the water pollution control plants (WPCP) during periods of wet weather. To implement this strategy effectively, the PWD needs to have a clear understanding of the factors that affect how much flow each of the three WPCPs can effectively treat. With this knowledge, the PWD will be able to identify and prioritize plant upgrades and other system modifications that will allow it to meet the CSO minimization objectives in the most environmentally-sound and cost-effective manner.

PWD contracted CH2M HILL to conduct stress testing at the three wastewater treatment plants that are owned and operated by the City. The objective of the stress testing was to determine the reliable maximum capacity of these facilities and identify cost-effective methods of increasing the ability of the existing facilities to treat peak hydraulic flows associated with wet weather conditions. The major tasks performed during the project are briefly described below.

Historical Data and Operations Review. The objective of the historical data and operations review was to evaluate the physical condition, current loading, and treatment efficiency provided by the existing unit processes. A tour of the plant was conducted, and the process equipment and facilities were examined. Operating records, design information, and engineering drawings were studied to develop a strong understanding of the operations and constraints. Technical Memorandum 1 – Historical Data Review was produced to summarize the results of the site visit and historical data analysis.

Short-Term Stress Testing. CH2M HILL performed a series of capacity and diagnostic tests to determine the loading versus performance characteristics of specific unit processes at each facility. The short-term stress testing focused on determining the response of the primary and secondary clarifiers to increased hydraulic loading under different operating conditions. The short-term stress testing at the Southwest WPCP (SWWPCP) included primary clarifier stress tests, secondary clarifier stress tests, secondary clarifier dye tests, and flow meter calibration. The results of each test are summarized in a test description report in Technical Memorandum 2 – Short-Term Test Results.

Long-Term Stress Test (Online Monitoring). Online monitoring equipment was installed to quantify the dynamic load/response characteristics of the secondary treatment system to naturally-occurring storm events. The equipment was also used to monitor the effect increased flows had on the solids inventory in the system and secondary effluent quality. Online monitoring included total plant flow, return activated sludge (RAS) flow, mixed liquor suspended solids (MLSS) concentration, sludge blanket levels, and secondary effluent total suspended solids (TSS) concentration. The equipment was in place from March 1 to June 30, 1999 and recorded data on a 10-minute interval. The long-term monitoring period was extended to include the fall and winter period from October 1, 1999 to January 31, 2000. The results of the long-term stress test are summarized in Technical Memorandum 3 – Long-Term Online Monitoring Results. The detailed online monitoring data and instrument calibration records are provided under separate cover.

Hydraulic Throughput Capacity Assessment. WinHYDRO, a computer model that facilitates complex analysis of plant hydraulics, was used to evaluate the hydraulic throughput capacity of the SWWPCP. Hydraulic and energy grade lines from the headworks to the plant outfall were developed for the average and peak flow conditions. Hydraulic bottlenecks, which limit the hydraulic throughput capacity of the existing facilities, and flow distribution problems were identified and evaluated. The hydraulic throughput capacity of each unit process was determined. The results of the hydraulic modelling performed are summarized in Technical Memorandum 4 – Hydraulic Throughput Capacity of Existing Facilities.

Evaluation if Potential Improvements. Based upon stress testing and hydraulic modeling results, major bottlenecks that limit plant capacity were identified and potential solutions were developed to increase peak instantaneous capacity. Budgetary cost estimates were developed for each potential solution. The results of this analysis are summarized in Technical Memorandum 5 – Budgetary Cost Estimates for Potential Plant Improvements.

1.2 Report Organization

The project notebook consists of a final report and a series of attachments. The main body of the report contains a summary of the results from the stress testing, plant data analysis, and the evaluation of process improvements and upgrade options. The detailed results from the historical data review, short-term testing (stress tests, dye tests and flow meter calibration), online monitoring, and hydraulic throughput capacity assessment are included in the project notebook as attachments. Tables describing the design criteria, scope of work, and estimated capital costs for the potential process modifications and capital upgrades, and the current National Pollution Discharge Elimination System (NPDES) discharge permit for the site are also included as attachments.

SECTION 2

CURRENT PERFORMANCE

2. Current Performance

2.1 Description of Facilities

Figure 2.1 presents a site plan and Table 2.1 summarizes the existing unit processes at the SWWPCP.

TABLE 2.1
SOUTHWEST WPCP – SUMMARY OF UNIT PROCESSES

Unit Process	Number	Description
Influent Flow Meter	1	Parshall flume – low-level gravity sewer
	3	Venturi –high-level gravity sewer
	1	Venturi –DELCORA forcemain
Low-Level Pumps	6	Archimedes screw (operating 2 in series) Q = 32 mgd, diameter = 8.5 ft, head = 22 ft (each), 42 ft total
Bar Screens	5	Width = 6 ft, 84° incline, front cleaned, 1-in. opening
	1	Width = 6 ft, 84° incline, front cleaned, 5/8-in. opening
Grit Removal	4	Rectangular Detritor Length = 60 ft, width = 60 ft, SWD = 8 ft
Flocculation (Pre-aeration)	1 (west)	Length = 127.25 ft, width = 28.75 ft, SWD = 12 ft, Volume = 43,900 ft^3
	1 (east)	Length = 127.25 ft, width = 28.75 ft, SWD = 12 ft, Volume = 43,900 ft^3
Primary Clarifiers	5	Length = 250 ft, width = 125 ft, SWD = 12 ft Area = 31,250 ft^2, weir length = 1,008 ft (each) C and F sludge mechanism, influent end hopper
Flow Split Chamber	36	Gates at 86-in. weir length 6 gates for 2 aeration basins
Aeration Basin	10	Four-pass – through flow only Length = 160 ft, width = 40 ft, SWD = 17 ft Operate with first pass as selector – seasonally
Aeration System	2	Cryogenic, 90 lbs O_2 per day
	40	125 hp, 100 hp, 75 hp, 60 hp (per basin)
Secondary Settling Tanks	20	Length = 260 ft, width = 76 ft, SWD = 11 ft Weir length = 816 ft (each) Chain and flight sludge mechanism
RAS Pumps	30	Q = 6.2 mgd, 3 pumps for 2 clarifiers
Effluent Pumps	5	Q = 115 mgd, hp = 500, VSD 3 units
DAF	8	Length = 70 ft, width = 18 ft, SWD = 12 ft
Anaerobic Digesters	12	Diameter = 110 ft, SWD=30 ft, volume = 2.1 mg (each)
	1	Sludge storage tanks

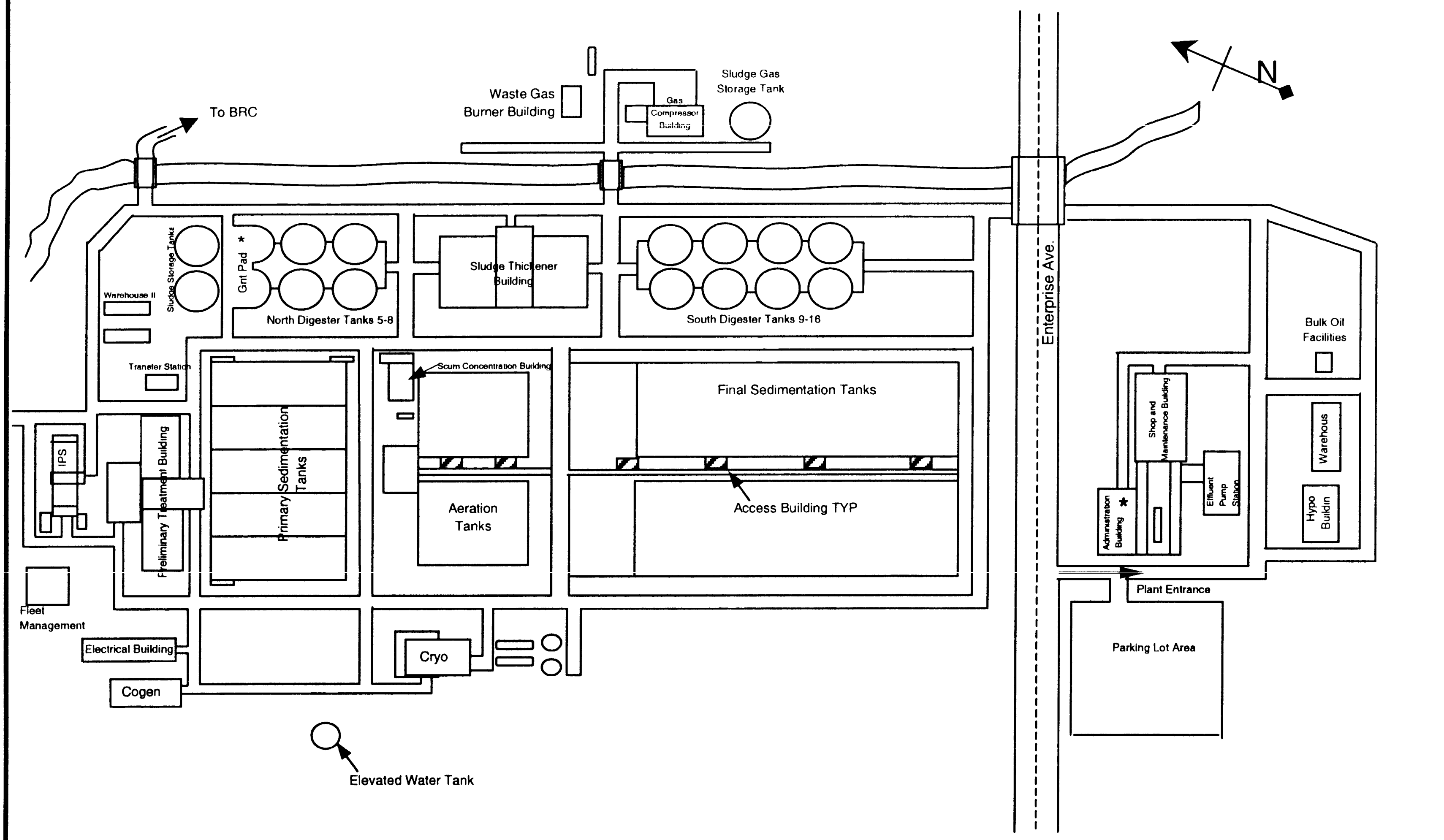


FIGURE 2-1
SITE PLAN
SOUTHWEST WATER POLLUTION CONTROL PLANT
CITY OF PHILADELPHIA WATER DEPARTMENT

2.1.1 Preliminary Treatment

The SWWPCP receives wastewater from a triple-barrel, high-level gravity sewer; a low-level gravity sewer; and the DELCORA forcemain. The triple-barrel, high-level sewer provides approximately 68 percent of the flow to the facility. Three venturi flumes, one for each line in service, measure the flow. The DELCORA forcemain provides approximately 23 percent of the flow to the facility and is measured by a separate venturi flume. Flow from the Biosolids Recycling Center (BRC) is combined with the low-level gravity sewer discharges upstream of the low-level pump wet well. The plant drain system, which includes the recycle flow from the sludge thickening processes onsite, also flows to the low-level pump wet well. The BRC and plant drain flows are measured separately and provide a significant solid and organic loading to the facility. The flow from the low-level pump is measured by a Parshall flume and represents less than 10 percent of the flow to the facility.

The low-level flow discharges on the east side of the common raw sewage channel. Inadequate mixing of the combined raw sewage flow is a concern because the low-level sewer flow travels preferentially to the east side of the SWWPCP facility. The inadequate mixing results in higher organic loadings to the east primary clarifiers (Clarifiers 1 and 5) and the east secondary treatment system.

The SWWPCP has six mechanically-cleaned bar screens. Five of the six screens have 1-inch bar openings, while the sixth screen has 5/8-inch openings. In general, the bar screens operate satisfactorily. However, the 5/8-inch screen experiences grit accumulation upstream of the screen. The screenings are collected and are hauled offsite for disposal. The SWWPCP is able to pass the current peak flow with five of the six screens in service.

The SWWPCP has four rectangular detritor grit removal tanks. Under dry weather flow conditions, two of the four grit tanks are in service. The standby grit tanks are brought into service under high flow conditions. The grit is removed from the detritors and is pumped to the hydrogritters. The washed grit is then removed from the site for disposal. The recycle stream from the hydrogritters discharges into the flocculation basin. A significant volume of grit passes through the existing grit removal system and is deposited in the flocculation tanks downstream. The flocculation tanks must be drained so that the accumulated grit can be removed on a periodic basis. The grit removal process requires one tank to be out of service for approximately two weeks. The hydraulic throughput capacity of the flocculation basins is very limited during this cleaning process.

There are two flocculation tanks at the SWWPCP. Under high flow conditions, the water surface level (WSL) in the flocculation tanks is very close to the top of the wall. Splashing and periodic, short-term overtopping of the walls can occur under high flow conditions when either one primary clarifier and/or one flocculation tank is out of service. The hydraulic restriction is associated with the primary clarifier collection channel and the piping between the primary tanks and aeration basins. This issue is discussed in greater detail in Section 3.2.

2.1.2 Primary Treatment

The SWWPCP has five 250 by 125 feet rectangular primary clarifiers with a side wall depth of 12 feet. Each tank has seven chain and flight mechanisms that move the sludge to the influent end of the basin. The flow from the flocculation tanks enters the common influent channel between Primary Clarifiers 2 and 3. The flow is unequally distributed between tanks, with the east clarifiers receiving approximately 20 percent more flow. The sludge blanket level in Primary Tank 5 is higher than the sludge blanket levels in the other clarifiers because of the higher solids loading associated with the BRC flows. The primary sludge is pumped sequentially from each tank once per day. The primary sludge is pumped to the mixing chamber where it is combined with the thickened waste activated sludge (WAS) and the sludge pumped from the Southeast WPCP (SEWPCP).

Primary effluent discharges into a common effluent channel. Two flow splitter boxes control the flow distribution to the aeration basins. The 20 percent flow imbalance between the east and west primary clarifiers is also seen in the flow distribution to secondary treatment.

The SWWPCP collects a 24-hour composite primary effluent sample from the east and west flow splitter boxes. The primary effluent TSS and five-day biochemical oxygen demand (BOD_5) concentrations are approximately 10 percent higher in the east flow splitter box. Therefore, the loading to the east secondary system is higher due to both a hydraulic imbalance as well as an organic loading imbalance.

2.1.3 Secondary Treatment

The SWWPCP has ten 4-pass UNOX pure oxygen aeration basins. Under current loading conditions, eight of the ten aeration basins are in service. Each basin is 160 by 40 feet with a side wall depth of 17 feet. The aeration basins consist of four cells operating in series. The primary effluent follows a serpentine flow pattern through the basin, and the return activated sludge (RAS) is pumped to the upstream end of Cell A. There are no structures to allow step-feed in the basin.

Each cell has a single, two-paddle submerged aerator/mixer located in the center of the tank. The SWWPCP operates the first cell as an anoxic selector by turning off the first aerator/mixer in the summer months to combat Nocardia and thereby improve the settling characteristics of the mixed liquor. During the winter months, the SWWPCP turns off the aerator mixer in the second cell as part of its ongoing energy management efforts. The first mixer is placed back in service when the second mixer is turned off.

The east and west secondary treatment processes are operated as separate systems. The mixed liquor from the east aeration basins flows to the east secondary clarifiers, and the RAS from the east secondary clarifiers is pumped to the east aeration basins. The mixed liquor suspended solids concentration is approximately 2,270 mg/L and 1,940 mg/L for the east and west secondary systems, respectively. The difference in mixed liquor concentration is due to the difference in loading. The RAS is flow-paced at approximately 32 percent of the flow through the plant.

The mixed liquor from each set of four aeration basins flows through a common mixed liquor channel to a set of ten secondary clarifiers. The caulking on some of the clarifier launders is missing, resulting in a large volume of flow in the launders that is not controlled by the clarifier weir elevation. This results in a flow imbalance between clarifiers that is difficult to predict or control.

Each set of secondary clarifiers consists of ten 76 by 260 foot rectangular clarifiers with a sidewall depth of 11 feet. Each clarifier has eight chain and flight mechanisms that transport the sludge to a central hopper located at approximately the mid-length of the clarifier. The RAS flow rate is measured separately for each clarifier. The maximum RAS per clarifier is limited to 6.2 mgd.

2.1.4 Disinfection

Secondary effluent from the east and west secondary treatment processes flows through the secondary effluent channel to the effluent pump station wet well. The conduit is separated for approximately 200 feet before it is combined upstream of the common wet well. Under dry weather flow conditions, the secondary effluent flows by gravity through a triple-barrel outfall to the Delaware River. The outfall conduit provides contact time for disinfection.

The SWWPCP has five effluent pumps, four of which are in service. Three of the effluent pumps are equipped with variable speed drives, two pumps are single speed only. The effluent pumps are operated based on the WSL in the effluent pump station wet well. Under wet weather flow and/or high tide conditions, the pumps are controlled automatically based on wet well level, but they must be placed into service manually.

2.1.5 Solids Handling

The waste activated and primary sludge generated at the SEWPCP is treated at the SWWPCP. The WAS from the SEWPCP and SWWPCP is pumped to the sludge thickeners. The SWWPCP has eight 18 by 70 feet dissolved air floatation (DAF) sludge thickeners. All attempts are made to keep the eight tanks in service, because additional sludge thickening capacity is often required. The thickened WAS sludge is pumped to the sludge-mixing chamber where it is combined with the primary sludge. The underflow from the DAF sludge thickeners flows to the plant drain and therefore to the wet well of the low-level sewage pump station. However, when the sludge volume index (SVI) of the WAS is high, the DAF units are not able to separate the WAS, and the underflow from the DAF units has a very high solids concentration. The sludge thickening process can become limiting, depending on the quality and quantity of sludge pumped from the SEWPCP, BRC centrate loadings, and/or if one or more units is out of service.

The SWWPCP has 12 anaerobic digesters with an average hydraulic residence time (HRT) of 18 days. The combined primary and waste activated sludge is pumped to the anaerobic digesters sequentially, with each digester receiving solids for nine minutes on each sequence. The digested solids are transported to the BRC for composting and beneficial reuse. The recycle streams from the BRC facility are returned to the SWWPCP headworks for treatment.

2.2 Regulatory Requirements

The SWWPCP NPDES permit limits include effluent BOD_5 and TSS concentrations; mass loading discharges; and percent removal for daily, weekly averages and monthly averages. Table 2.2 summarizes the NPDES permit criteria for the facility in effect during testing. Compliance is based on the flow measured by the four venturi meters and one Parshall flume located upstream of the preliminary treatment and 24-hour composite samples collected daily at the influent and outfall station.

TABLE 2.2
SOUTHWEST WPCP – NPDES PERMIT REQUIREMENTS

Parameter	Units	Monthly Average	Weekly Average	Maximum Day	Peak Instantaneous
BOD_5					
Concentration	mg/L	30	45		60
Mass loading	lbs./day	21,650	32,475	--	
Percent removal	%	89.25			
TSS					
Concentration	mg/L	30	45		60
Mass loading	lbs./day	50,040	75,060	--	
Percent removal	%	85			
Flow	mgd	200		300	400

PWD has negotiated a new NPDES permit for the facility effective July 2000. The modifications to the NPDES permit are summarized below.

As part of PWD's long-term combined sewer overflow (CSO) program, PWD will be reducing the frequency and volume of untreated sewage discharges through the CSOs. In order to account for the increased loading due to the combined sewage flows that exceed the treatment plant's rated hydraulic capacity, the following methods may be used for calculating and reporting mass loadings and effluent concentrations on the monthly discharge monitoring report.

- If a calendar month includes one or more days where flows exceed 300 mgd, a value of 85 percent may be used for those days for the purpose of calculating average monthly TSS percent removal. The actual TSS percent removal associated with those days shall be reported on the appropriate space provided on the DMR.
- If a calendar month includes one or more days where flows exceed 300 mgd, a value of 89.25 percent may be used for those days for the purpose of calculating average monthly BOD_5 percent removal. The actual BOD_5 percent removal associated with those days shall be reported on the appropriate space provided on the DMR.
- When daily flows exceed 300 mgd, the TSS and BOD_5 mass loadings for those days may be omitted from the average monthly and average weekly mass loading calculations. The actual TSS and BOD_5 loadings associated with those days shall be reported on the appropriate space provided on the DMR.

PWD has requested that $cBOD_5$ data be used to establish compliance with permit requirements. Analysis of the data collected over the previous permit cycle indicated that there is relatively little variation in the influent ratios of $cBOD_5/BOD_5$. Therefore, calculating the theoretical influent $cBOD_5$ loadings based on historic BOD_5 data can be used to develop recommended $cBOD_5$ limits for this facility.

The new NPDES $cBOD_5$ permit requirements for SW WPCP are:

	Concentration (mg/L)	Mass Loading (lbs/day)	Percent Removal (%)
Average monthly	25	19,800	89.25
Average weekly	40	29,700	
Instantaneous maximum	50		

The $cBOD_5$ in the raw wastewater shall be reduced by at least 89.25 percent as a monthly average. The percent removal shall be calculated from daily 24-hour composite samples of the influent and effluent. The $cBOD_5$ percent removal requirement will be relaxed to 86 percent when the influent $cBOD_5$ concentration is less than 103 mg/L on a monthly average basis as long as the $cBOD_{20}$ allocation, equivalent mass BOD_5 limitation, and an effluent $cBOD_5$ concentration of 14 mg/L are not exceeded on a monthly basis.

A copy of the new NPDES permit is located in the Project Notebook.

2.3 Current Loading and Performance Achieved

2.3.1 Unit Process Loading

Table 2.3 presents a summary of the current unit process loading over a three-year period from July 1995 to July 1998. The average and maximum daily flows were 176 mgd and 384 mgd, respectively. The maximum instantaneous flow was 439 mgd. On September 16, 1999, during Hurricane Floyd, the maximum instantaneous flow at the plant reached 486 mgd.

The average raw sewage TSS and BOD_5 concentrations were 154 mg/L and 108 mg/L, respectively. The average organic loadings to the treatment plant, calculated based on the raw sewage TSS and BOD_5 concentration and the average flow for each day, were 224,434 lbs/day and 156,642 lbs/day, respectively. Approximately 30 percent of the TSS loading to the SWWPCP is from the BRC recycle streams.

2.3.2 Primary Treatment Performance

The average and peak SORs for the primary clarifiers were approximately 1,126 gpd/ft^2 and 2,810 gpd/ft^2, respectively. Typical overflow rates for rectangular clarifiers are between 1,000 gpd/ft^2 and 3,000 gpd/ft^2. The primary clarifiers at the SWWPCP are operating at close to the expected maximum capacity based on typical SORs.

The removal efficiencies are lower than expected based on current hydraulic loading. The expected TSS and BOD_5 removal efficiencies are 60 and 35 percent, respectively. The average TSS removal efficiencies in the primary clarifiers were 47 and 43 percent for the east and west sides of the plant, respectively.

Based on solids removal efficiency, the east clarifiers performed slightly better than the west clarifiers. This is due to the higher solids concentration in the primary influent on the east side of the plant. Based on primary effluent solids concentration, the west primaries performed significantly better than the east primaries. The average TSS concentrations in the primary effluent were 125 mg/L and 95 mg/L for the east and west, respectively. The BOD_5

removal efficiencies in the primary clarifiers were 28 and 38 percent for east and west primary clarifiers, respectively. The BOD_5 removal efficiencies were closer to the expected values.

2.3.3 Secondary Treatment Performance

The average primary effluent TSS and BOD_5 concentrations were 110 mg/L and 75 mg/L, respectively. The average and 95^{th} percentile total BOD_5 loading to the secondary treatment system, calculated based on the primary effluent BOD_5 concentration, and the average flow for each day were 104,720 lbs/day and 153,0455 lbs/day, respectively.

TABLE 2.3
SOUTHWEST WPCP – SUMMARY OF CURRENT UNIT PROCESS LOADINGS (JULY 1995 – JULY 1998)

Unit Process	Units	Current Loadings		Typical Values	Notes
		Average	Maximum		
Loading					
Hydraulic	mgd	176	439		1
Organic					
BOD	lb/d	156,642	196,449		2
TSS	lb/d	224,434	337,762		2
Grit Tanks					
Volume (total)	ft^3	133,200			
Area (total)	ft^2	14,400			
HRT	minutes	4.1	3.3	3 – 5	3
Primary Clarifiers					
Area (total)	ft^2	156,250			
Weir Length (total)	ft	5,040			
Surface Overflow Rate	gpd/ft^2	1,126	2,810	1,000 – 3,000	4
Removal Efficiency					
BOD	%	33		35	
TSS	%	45		60	
Aeration Basins					
Volume (total)	mg	13.6			5
BOD loading	lb/d/1000 ft^3	52	79		2
HRT	hours	2.0	0.80		5
MLSS	mg/L	2,265 (east) 1,947 (west)			
SVI	mL/g	103		100 – 150	
ISV	ft/hr	9.4			
SRT	day	2.0			5
F/M	1/day	0.41 (east) 0.45 (west)			5
Secondary Clarifiers					
Area (total)	ft^2	395,200			4
Weir length (total)	ft	16,320			4,1
Surface overflow rate	gpd/ft^2	445	1,111	600 – 1,500	4,2
Solids loading rate	lb/ft^2	12.1 (east) 9.6 (west)	19.5 (east) 14.7 (west)		
Chlorination					
Volume	mg	8.68			
HRT	minutes	71	28	15	4

Notes:
1. Maximum hydraulic loading based on instantaneous flow
2. Maximum loading based on 95th percentile
3. Based on two units in service for average day flow and four units in service for maximum flow
4. Based on all units in service
5. Based on eight aeration basins in service

The Southwest WPCP has three sources that provide flow to the plant. The high level interceptor can deliver up to 540 mgd to the plant. The DELCORA interceptor can deliver up to 110 mgd. The low level gravity sewer delivered capacity is limited to the pumping capacity at the headworks, which is 96 mgd with all three pumps running.

The estimated treatment capacity of the preliminary treatment system is 475 mgd. This is based on two of the three low level pumps in service (64 mgd) and the remainder of flow provided by the interceptors. Treatment capacity is based upon acceptable bar screen face velocities and one bar screen out of service. Under peak flow conditions, the face velocity on the bar screens will vary between 0.2 to 0.4 ft/sec.

The design of the SWWPCP allows the east and west secondary treatment processes to be operated as different systems. The organic loading to the east secondary treatment system is approximately 20 percent higher. The average mixed liquor concentrations in the east and west secondary treatment systems were 2,265 mg/L and 1,947 mg/L, respectively. The east and west aeration basins are currently operating with a solids residence time (SRT) of 2.0 days. The food to microorganisms (F:M) ratio in the aeration basins averaged 0.4 day^{-1}.

The average SVIs were 111 mL/g and 94 mL/g for the east and west systems, respectively, indicating a well-settled sludge. Typically, SVI values for a well-settled activated sludge are between 100 mL/g and 150 mL/g. During the summer months, the SWWPCP experiences occasional episodes of Norcardia infestations. Plant operations is able to control the filamentous growth by creating an anoxic selector in the first cell of the aeration basin by turning off the first aerator/mixer.

The average and peak SORs for the secondary clarifiers were approximately 445 gpd/ft^2 and 1,110 gpd/ft^2, respectively. Typical SORs for rectangular Gould-type clarifiers are between 800 gpd/ft^2 to 1,500 gpd/ft^2. The secondary clarifiers at the SWWPCP are operating well below their expected maximum hydraulic capacity based on typical SORs.

The average and peak solids loading rates (SLRs) for the secondary clarifiers were approximately 12 and 19 lbs/day/ft^2 on the east clarifiers and 10 and 15 lbs/day/ft^2 on the west clarifiers. Typical peak SLRs for rectangular Gould-type clarifiers are between 20 and 40 lbs/day/ft^2. The secondary clarifiers at the SWWPCP are operating at lower than typical SLRs.

The secondary clarifiers at the SWWPCP achieve a very good quality final effluent. The daily TSS and BOD_5 concentrations were consistently below the NPDES criteria of 60 mg/L. The average effluent TSS and BOD_5 concentrations were 6.4 and 9.1 mg/L, respectively.

SECTION 3
CURRENT CAPACITY

3. Maximum Instantaneous Capacity

3.1 Maximum Treatment Capacity

The current maximum instantaneous treatment capacity of the unit processes at the SWWPCP was estimated using a combination of manufacturers information, standard engineering design loading and performance criteria, operations staff observations of previous performance, and field testing of specific unit processes.

The field testing conducted at the SWWPCP included the following:

Online Monitoring Data

- Secondary Clarifier 2
- Plant flow, RAS flow, mixed liquor TSS, sludge blanket level, and effluent TSS from March 1 to June 30 1999, and from October 1, 1999, to January 31, 2000

Primary Clarifier Stress Tests

- Primary Clarifier 5 with BRC solids
- Primary Clarifier 4 without BRC solids

Secondary Clarifier Stress Tests

- Secondary Clarifier 20

Flow Distribution Dye Tests

- East and west mixed liquor channel
- Primary clarifiers

Table 3.1 summarizes the estimated treatment capacity for each unit. The basis of the estimated capacity is discussed below. The detailed field test results are presented in Technical Memorandum 2 – Short-Term Test Results and Technical Memorandum 3 – Long-Term Online Monitoring Results

3.1.2 Preliminary Treatment

The estimated treatment capacity of the preliminary treatment system is 475 mgd. This is based on the rated capacity of 32 mgd of the existing pumps with two of the three pumps in service, plus an estimated capacity of 475 mgd for the high-level interceptor.

For peak flow conditions, the face velocity for the bar screens will vary from 0.2 to 0.4 ft/s. The face velocity is determined by the water surface level through the bar screen channel.

The theoretical treatment capacity of the grit removal tanks is 625 mgd. This is based on three of the four grit detritors in service, with an allowable SOR of 58,000 gpd/ft^2. The theoretical removal efficiency of the grit removal system is 90 percent of particles greater than 60 mesh (25 mm) under peak flow conditions.

TABLE 3.1
SOUTHWEST WPCP TREATMENT CAPACITY ASSESSMENT

Unit Process	Estimated Capacity (mgd)	Criteria
Preliminary Treatment	540 mgd – screening and raw sewage pumping capacity	
	Low level interceptor[1] – 64 mgd	Rated capacity of pumps
	High level interceptor – 475 mgd	Observed maximum flow
Grit Removal	625 mgd – grit removal [2]	SOR – 58,000 gpd/ft^2
Primary Treatment	250 mgd[3] – with BRC solids	Based on allowable SOR – 2,000 gpd/ft^2
	350 mgd[3] – with BRC solids	Based on allowable SOR – 2,800 gpd/ft^2
	440 mgd[3] – without BRC solids	Based on allowable SOR – 3,500 gpd/ft^2
Aeration Basins	N/A no change to organic loading patterns.	
Secondary Clarifiers	675 mgd [3] – existing	Based on allowable SOR – 1,800 gpd/ft^2
	550 mgd [3] – mixed liquor concentration 2,000 mg/L	Based on allowable SLR – 30 lbs/day/ft^2
	350 mgd [3] – mixed liquor concentration 3,000 mg/L	Based on allowable SLR – 30 lbs/day/ft^2
ES station	460 mgd [4] (1 pump out of service)	115 mgd rated capacity
Chlorination	830 mgd – volume of plant outfall	HRT – 15 minutes

[1]Based on design capacity of 32 mgd for each pump, with one pump out of service
[2]Based on unit out of service
[3]Based on one clarifier out of service
[4]Based on one pump out of service

3.1.3 Primary Treatment

Six primary stress tests were conducted at the three wastewater treatment plants owned and operated by the PWD. Table 3.2 summarizes the physical characteristics of the clarifiers at each site and the stress tests performed. The primary clarifiers at all three plants are hydraulically similar. Differences in behaviour are the result of differences in influent characteristics and minor differences in influent and effluent structures.

TABLE 3.2
PRIMARY CLARIFIERS STRESS TEST PERFORMED

Site	SEWPCP	SWWPCP	NEWPCP	
Clarifier dimension			**Set 1**	**Set 2**
# of clarifiers	4	5	8	4
Type	Rectangular	Rectangular	Rectangular	Rectangular
Length (ft)	250	250	240	250
Width (ft)	125	125	65	125
SWD (ft)	12	12	10	10
Sludge Removal				
Hopper location	Influent end	Influent end	Influent end	
Sludge collection	Chain & flight	Chain & flight	Chain & flight	

TABLE 3.2
PRIMARY CLARIFIERS STRESS TEST PERFORMED

Site	SEWPCP	SWWPCP	NEWPCP	
Pumping freq.	Once every two days	Once per day	Three times per day	
Influent structure				
Channel	Common	Common	Common	Common
Clarifier openings	Orifice and weirs	Orifice	Orifice	Orifice
Openings/clarifier	8 Orifices and 14 weirs	8	4	12
Location	Surface and mid-level	mid SWD	Bottom SWD	Surface and Bottom SWD
Baffling	Yes	Yes	yes	Yes
Effluent structure				
Type	Lateral launders	Finger launders	Finger launders	Finger launders
Orientation	Cross flow	Longitudinal	Longitudinal	Longitudinal
Weir length (ft)	193	307	137	274
Launders	3	21	12	24
Test performed	1	2	2	1
Target SOR (range) gpd/ft^2	1,000-2,400	1,000-3,500	1,000-3,000	750-2,800

Two stress tests were performed on the primary clarifiers at the SW WPCP. Figure 3-1 presents the measured TSS removal efficiency as a function of SOR and Figure 3-2 presents the measured effluent TSS concentration as a function of SOR. The test procedures and detailed results are described in Technical Memorandum 2; the main findings are summarized below.

Primary Clarifier 5 – With BRC Recycle. The stress test on the SWWPCP Primary Clarifier 5 indicated that the clarifier performance deteriorated at a SOR of 2,800 gpd/ft^2 with a removal efficiency less than 60 percent. However, the primary effluent TSS concentration was consistently greater than 80 mg/L at SOR greater than 2,300 gpd/ft^2. The apparently high solids removal efficiency was associated with the high solids concentration in the primary influent. The sludge blanket in the clarifier was greater than four feet and rose steadily through the test. The solids in the primary effluent were black.

Primary Clarifier 4 – Without BRC Recycle Stream. The stress test on the SWWPCP Primary Clarifier 4 indicated that the clarifier performance deteriorated at a SOR of 3,100 gpd/ft^2 with a TSS removal efficiency of less than 60 percent. The sludge blanket in the clarifier remained relatively constant through the test, rising slightly at the effluent end of the clarifier at the end of the test period. The primary effluent TSS concentration remained below 80 mg/L throughout the test.

Figure 3-1
SWWPCP Primary Clarifier Stress Test
TSS Removal Efficiency as a Function of Hydraulic Loading

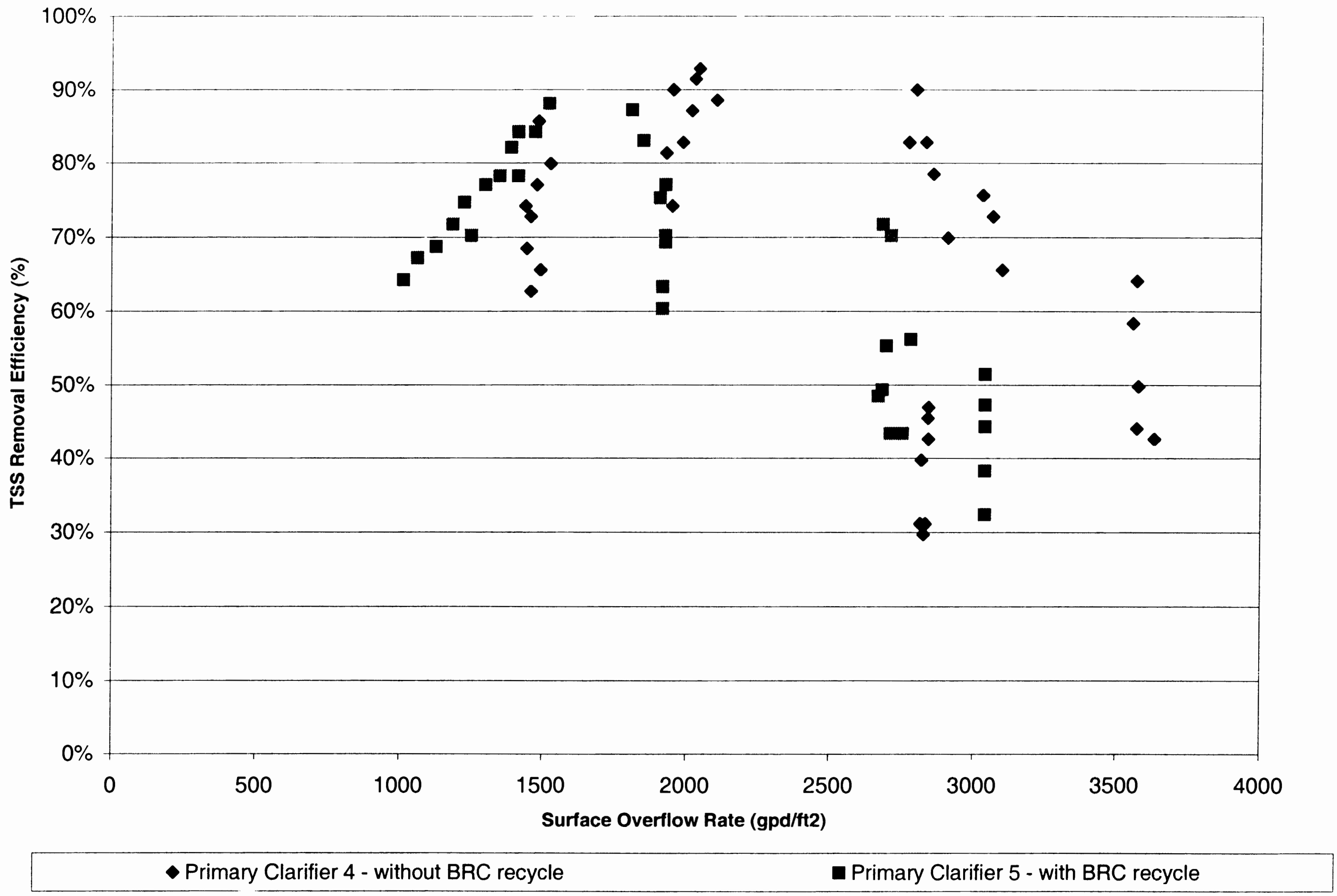
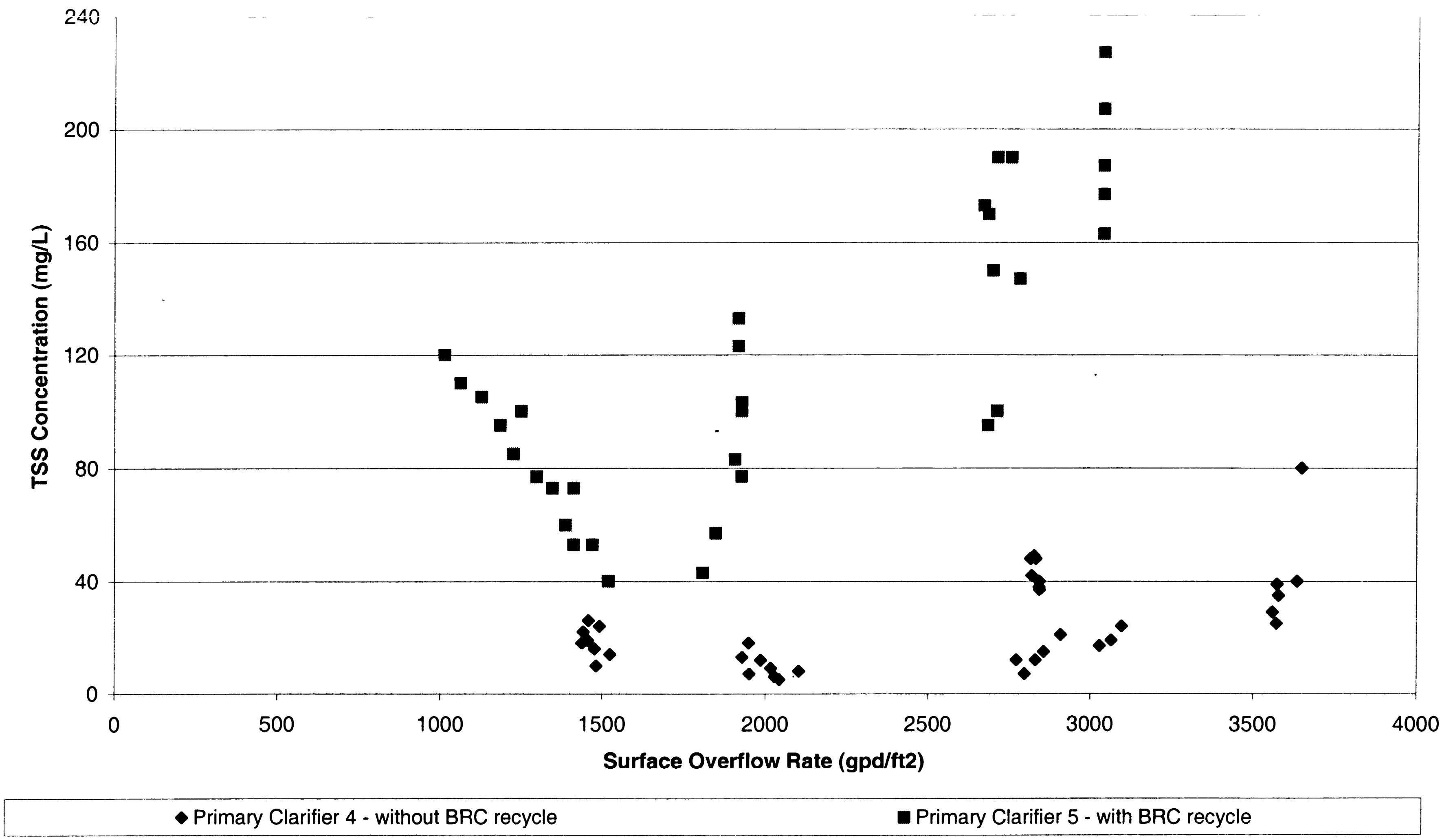


Figure 3-2
SWWPCP Primary Clarifier Stress Test
TSS Concentration as a Function of Hydraulic Loading



The estimated treatment capacity of the SWWPCP primary clarifiers is between 250 and 350 mgd with four clarifiers in service. This is based on the results of the Primary Clarifier 5 stress test. The clarifier performance deteriorated at an SOR of 2,000 and 2,800 gpd/ft^2, respectively. The BRC recycle stream has a negative impact on the primary clarifier performance. The BRC solids impact the east primary clarifiers, but have a less significant impact on the west primary clarifiers. Under high flow conditions, the TSS removal efficiency of Primary Clarifier 5 is poor at overflow rates greater than 2,000 gpd/ft^2. More significantly, the primary effluent TSS concentration is more than four times higher for Primary Clarifier 5. This results in a significant increase in organic loading to the east secondary treatment system.

The estimated treatment capacity of the primary clarifiers without BRC loading is 440 mgd with four clarifiers in service. This is based on the results of the Primary Clarifier 4 stress test performed at the SWWPCP. The clarifier performance deteriorated at an SOR of 3,500 gpd/ft^2, and the primary effluent TSS concentration remained below 80 mg/L throughout the test.

3.1.4 Secondary Treatment

Six secondary clarifier stress tests were conducted at the three wastewater treatment plants owned and operated by the PWD. Table 3.3 summarizes the physical characteristics of the clarifiers at each site and the secondary clarifier stress tests performed. The secondary clarifiers at all three plants are very similar and performed similarly. Differences in performance were largely the result of differences in mixed liquor settling characteristics and solids loading during the tests.

TABLE 3.3
PHYSICAL CHARACTERISTICS OF THE SECONDARY CLARIFIERS TESTED

Site	SEWPCP	SWWPCP	NEWPCP	
Clarifier dimension			**Set 1**	**Set 2**
# of clarifiers	12	20	8	8
Type	Gould	Gould	Gould	Gould
Length (ft)	214	260	214	231
Width (ft)	68	75	75	70
SWD (ft)	11	11	11	13
Sludge Removal				
Hopper location	mid length	mid length	mid length	
Sludge collection	Chain & flight	Chain & flight	Chain & flight	
RAS removal	Gravity to sump	Pump per clarifier	Common pump	
RAS rate	30%	35%	15-30%	
MLSS	1,300	2,100	1,100	

TABLE 3.3
PHYSICAL CHARACTERISTICS OF THE SECONDARY CLARIFIERS TESTED

Site	SEWPCP	SWWPCP	NEWPCP	
Influent structure				
Channel	Common to 6	Common to 10	Common to 8	Common to 4
Clarifier openings	Adjustable weir	Orifice	Overflow Weir	Overflow Weir
Number per clarifier	4	4	4	4
Location	Top	Surface	Surface	Surface
Baffling	Yes	Yes	No	Yes
Effluent structure				
Type	Finger launders	Finger launders	Finger launders	Finger launders
Orientation	Longitudinal	Longitudinal	Longitudinal	Longitudinal
Weir length (m)	784	816	850	850
Number of Launders/	24	12	24	24
Test performed				
Stress test	2	1	0	3
Target SOR (range) gpd/ft^2	860-2,000	600-2,100		1,000-2,100
Dye tests	1	0	3	1

One stress test was performed on the SWWPCP secondary clarifiers. The test procedures and results are described in Technical Memorandum 2; the main findings are summarized below.

The stress test was conducted on Secondary Clarifier 20. Figure 3-3 presents the flow and effluent TSS concentration as a function of time for the test. Figure 3-4 presents the effluent TSS concentration as a function of SOR. The test was conducted by increasing the hydraulic loading on the clarifier in incremental steps. The effluent TSS concentration remained below 60 mg/L. The maximum SOR achieved during the tests was 2,100 gpd/ft^2. The blanket in the clarifier began to rise at an SOR of 2,100 gpd/ft^2.

Dye dilution was used to measure the flow in the mixed liquor channel for the east and west secondary treatment system. The testing indicated that the east side received approximately 20 percent more primary effluent flow.

The operators' experience indicates that the secondary clarifiers will fail at a total plant flow rate of less than indicated by the stress test results and that the east clarifiers are more susceptible to failure. The mixed liquor concentration is approximately 17 percent higher in the east secondary treatment system and the hydraulic loading is approximately 20 percent greater. The combination of increased flow and increased mixed liquor concentration results in an increase of 35 to 40 percent in the solids loading to the east clarifiers. The operators use the two empty aeration tanks to store RAS, thereby reducing the solids loading on the clarifiers during high flow conditions.

The caulking on the secondary clarifier effluent launders is in poor condition. A large volume of flow was observed coming up through the launder joints and connections after rather than over the clarifier effluent weirs. This results in an uneven flow distribution between clarifiers that is difficult to control or predict. Replacing the caulking in the clarifiers affected will improve the flow distribution between clarifiers and prevent premature failure.

The performance of the secondary clarifier was monitored over two 4-month periods using online instrumentation to quantify the dynamic performance of the clarifiers to naturally-occurring storm events. The online instrumentation recorded total plant flow, RAS flow, mixed liquor TSS concentration, sludge blanket levels, and effluent TSS concentration. The online monitoring recorded the response of the secondary clarifier to 15 storm events. Table 3.4 summarizes results of the online monitoring program; more detailed results are presented in Technical Memorandum 3.

TABLE 3.4
RESULTS OF THE ONLINE MONITORING PROGRAM

Date	SVI ml/g	MLSS mg/L	Online TSS Concentration		24 h Average Effluent TSS	Peak Achieved	
			Average mg/L	Peak mg/L	(mg/L)	Q mgd	SOR gpd/ft^2
March 6	NA	1,240	NA	NA	2.5	334	845
March 14	131	1,750	NA	NA	3.6	382	967
March 21	98.5	1,340	NA	NA	16.8	425	1,075
April 9	106	1,420	NA	NA	19	381	964
April 11	100	1,400	NA	NA	9.2	392	992
April 23	136	1,580	NA	NA	4	339	858
May 19	111	2,250	NA	NA		349	883
May 24	136	1,890	NA	NA		408	1,032
November 1	110	1,270	6.8	28	3.6	450	1,139
November 25	116	1,720	11.5	16	7.6	370	936
December 6	92	1,410	15.6	40	21	345	873
December 10	105	1,240	34.9	59	22	344	870
December 13	100	1,300	17.2	34	23	414	1,048
December 20	78	1,540	14.2	22	11.2	337	853
Jan 10, 2000	138	1,380	14.1	19	11.3	354	896

The secondary clarifier TSS concentration did not exceed 60 mg/L during the online monitoring period. During the storm events of December 6, December 10, and December 13, 1999, the online effluent TSS monitor indicated that the effluent TSS concentration reached peaks of 40, 59 and 34 mg/L, respectively. During the storm event of December 10, 1999, the effluent TSS concentration increased dramatically under relatively low hydraulic loading conditions. The plant flow data indicates that, during the storm, the return activated sludge pump was operating erratically. The inconsistent pumping during the storm likely resulted in elevated effluent TSS concentration in the final effluent.

Figure 3-3
SWWPCP Secondary Clarifier Stress Test
Effluent TSS Concentration Versus Time

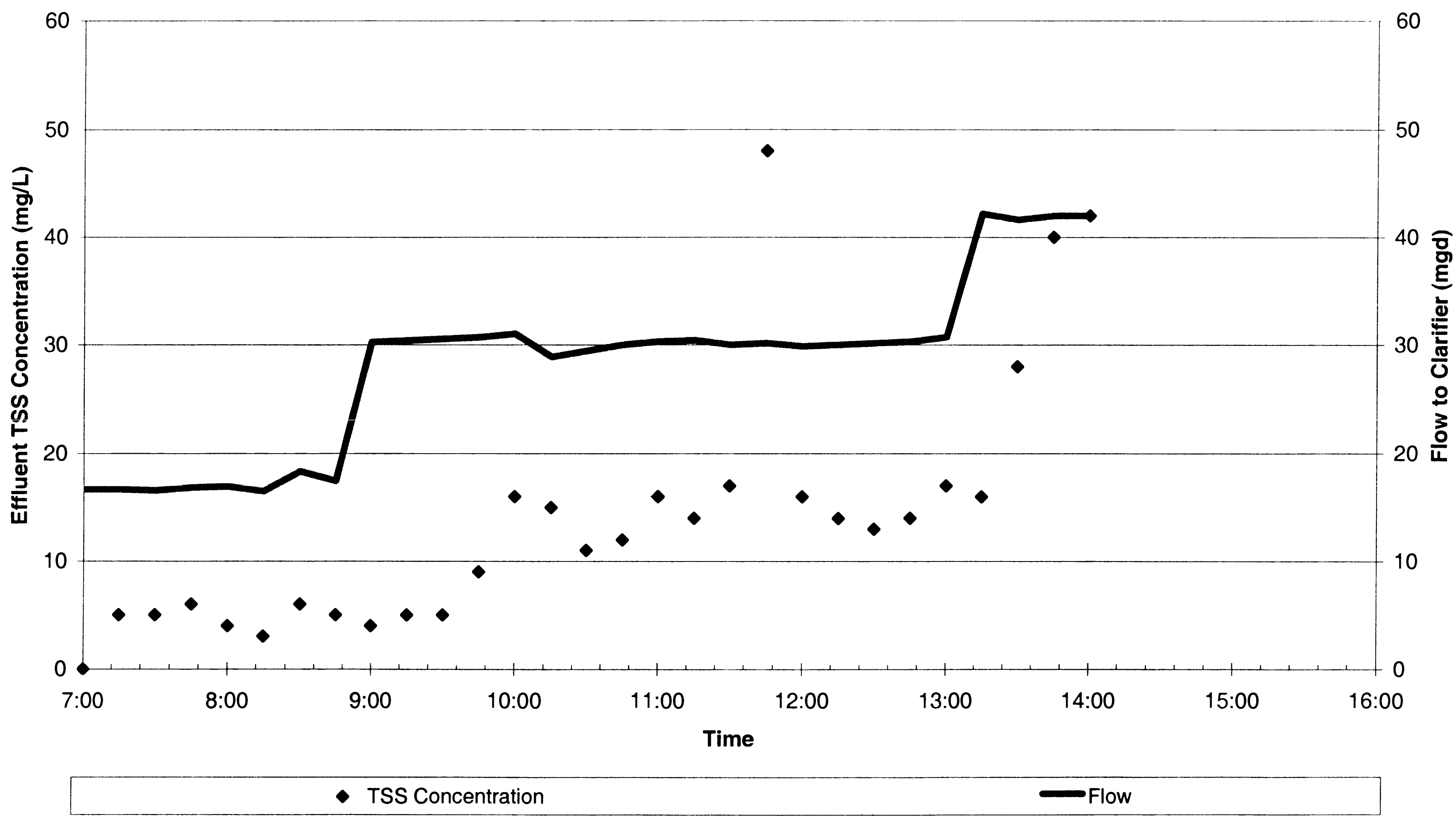
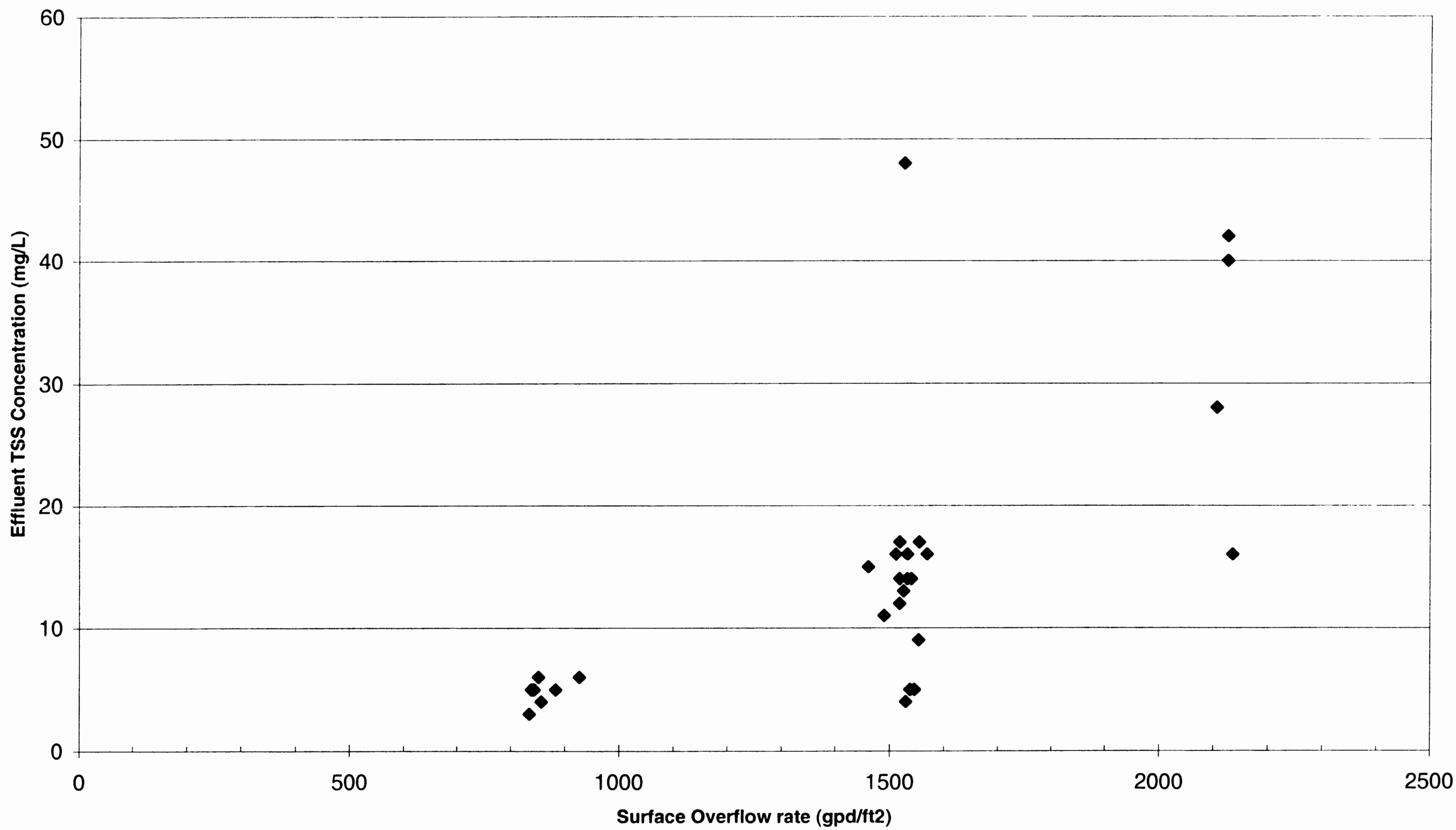


Figure 3-4
SWWPCP - Secondary Clarifier Stress Test
Effluent TSS Concentration as a Function of Hydraulic Loading



3.1.5 Disinfection and Effluent Pump Station

The estimated capacity of the SWWPCP effluent pump station is 460 mgd. This is based on the rated capacity of the existing pumps with one pump out of service. The rated capacity of the disinfection is 830 mgd. This is based on 15-minute HRT in the existing outfall under peak flow conditions.

3.2 Hydraulic Throughput Capacity

The hydraulic throughput capacity of the unit processes at the SWWPCP were estimated using WinHYDRO, a computer model that facilitates complex analysis of plant hydraulics. Hydraulic and energy gradelines from the headworks to the plant outfall were developed for a number of flow rates. The hydraulic throughput capacity of each unit process was developed based on the assumption that the downstream hydraulic bottlenecks had been resolved. Table 3.2 summarizes the estimated hydraulic throughput capacity for each unit process. The detailed hydraulic modelling results are presented in Technical Memorandum 4 – Hydraulic Throughput Capacity of Existing Facilities.

TABLE 3.2
SOUTHWEST WWTP CURRENT HYDRAULIC THROUGHPUT CAPACITY

Unit Process	Estimated Capacity (mgd)	Basis of capacity estimate
Outfall	>800 mgd	• Flow path – from the Delaware River to the effluent pump station • Hydraulic control section – mean high tide of 97.75 feet • Two outfall channels in service • Hydraulic exceedance – pump station discharge weir elevation
Secondary effluent channel	Version A – 410 Version B – >800	• Flow path – effluent PS wet well to the secondary clarifier weir • Hydraulic control section – PS wet well water surface level Version A – wet well level at maximum WSL - 99 ft feet Version B – wet well level at WSL – 96 feet • Twenty secondary clarifiers in service • Hydraulic exceedance – secondary clarifier overflow weir elevation
Mixed liquor channel	790	• Flow path – secondary clarifier effluent weir to the aeration basin overflow weir • Hydraulic control section – secondary clarifier weir • The secondary clarifier weir has a free discharge Hydraulic exceedance – aeration basin overflow weir elevation
Aeration basin and primary flow split box	Capacity 1 - 340 Capacity 2 - 410 Capacity 3 > 500	• Flow path – aeration basin overflow weir to the primary clarifier overflow weir • Hydraulic control section – aeration basin overflow weir • 50/50 flow split between east and west side, eight aeration basins in service • Hydraulic exceedance [1] – primary effluent flow split weir elevation Hydraulic exceedance [2] – primary clarifier overflow weir elevation Hydraulic exceedance [3] – top of concrete

TABLE 3.2
SOUTHWEST WWTP CURRENT HYDRAULIC THROUGHPUT CAPACITY

Unit Process	Estimated Capacity (mgd)	Basis of capacity estimate
Preliminary treatment	520 – Parshall flume 680 – top of concrete	• Flow path – primary clarifier overflow weir to influent channel downstream of the Parshall flume • Hydraulic control section – primary clarifier overflow weir • Five primary clarifiers, two flocculation tanks, four detritors, and five bar screens in service • Hydraulic exceedance – Parshall flume flooded Hydraulic exceedance – top of concrete at bar screens

The hydraulic throughput capacity of the SWWPCP is greater than 600 mgd, except for the following locations:

- **Aeration Basin Overflow Weir** - Under high flow conditions, the water surface level in the aeration basin increases and submerges the primary effluent flow split weirs. The primary effluent flow split weirs become submerged at approximately 340 mgd with eight aeration basins in service. The primary clarifier effluent weirs become submerged at approximately 410 mgd. The water surface level in the flocculation tanks and grit chambers are impacted by the increase in water surface level in the primary clarifiers. The hydraulic limitation is the aeration basin outfall weirs. The weir discharge is restricted to keep oxygen in the enclosed aeration tanks.

- **Parshall Flume** - At flow rates greater than 520 mgd, the water surface level downstream of the parshall flume will impact the flow measurement.

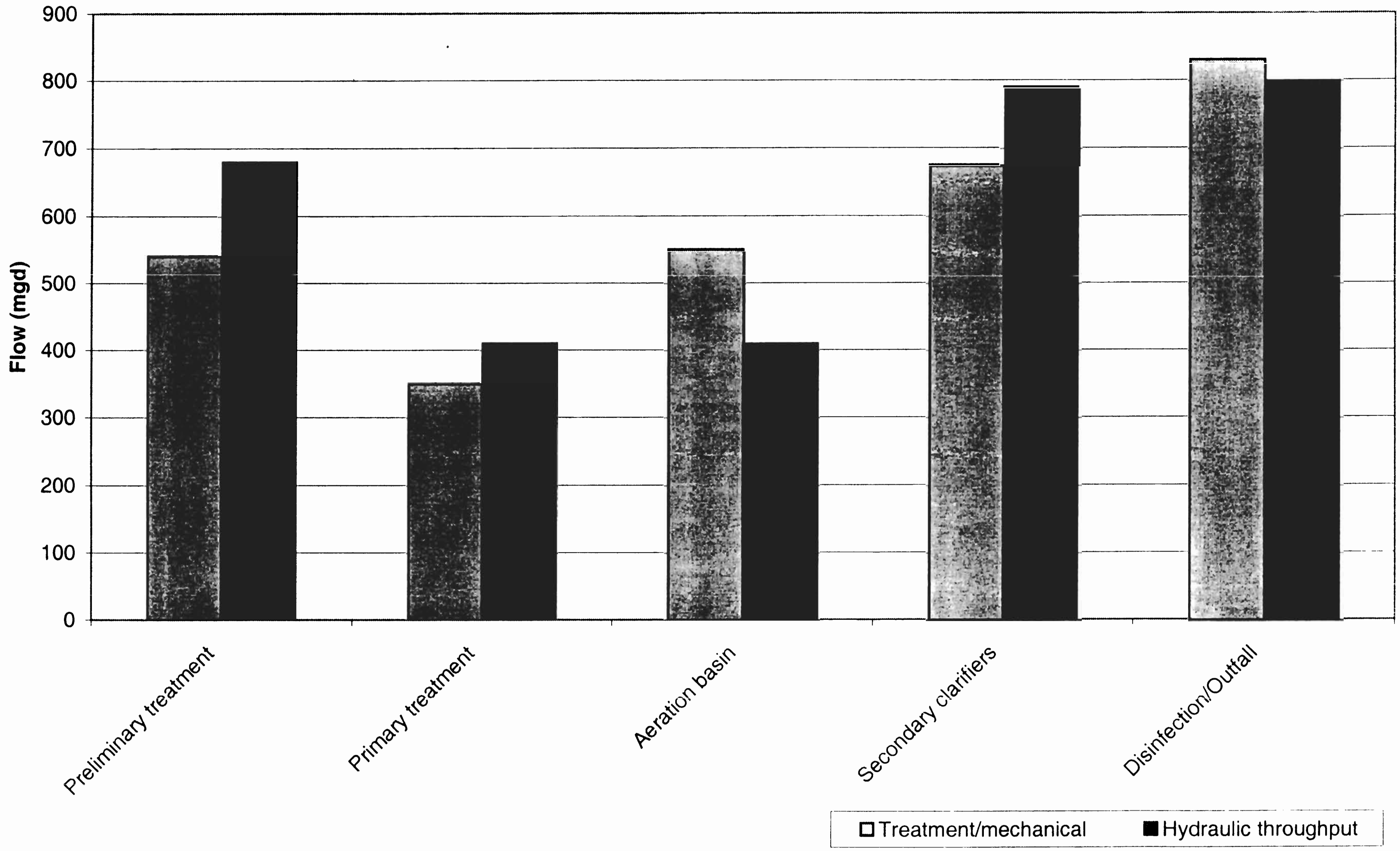
3.3 Capacity Limiting Factors

Figure 3-5 presents a summary of the estimated current capacity on a unit process basis for the SWWPCP. The major capacity bottlenecks for the facility follow:

- **Aeration Basin** - The hydraulic throughput capacity of the aeration basins is limited to 340 mgd with eight basins in service. At flow rates greater than 340 mgd, the weirs in the flow distribution box become flooded, resulting in loss of control over the flow distribution between aeration basins. The facility will continue to operate, but there will be a deterioration in process control under these circumstances. At flow rates greater than 410 mgd, the primary clarifier weirs are impacted. Loss of control of the flow distribution will not result in an immediate failure of the treatment system. However, there will be a negative impact on treatment efficiency if the flows remain greater than 340 mgd over an extended period of time. Secondary effluent pumping or aeration basin bypass (extreme step feed) is required to resolve this bottleneck.

- **Primary Treatment** - The estimated treatment capacity of the primary clarifiers is 350 mgd based on an allowable SOR of 2,800 gpd/ft^2 and four clarifiers in service. The capacity of the primary clarifiers could be increased to 440 mgd if the recycle stream from the BRC facilities is not treated at the SWWPCP.

Figure 3-5
Southwest WPCP - Estimated Current Capacity



SECTION 4

CURRENT SUSTAINABLE TREATMENT CAPACITY

4. Current Sustainable Treatment Capacity

4.1 Sustainable Treatment

The estimated treatment capacities summarized in Section 3 of this report utilize maximum instantaneous limits currently in PWD's NPDES permits as the goal for the effluent quality. Since the maximum instantaneous and maximum daily limits are the same values, a process operation whose final effluent quality will meet the instantaneous maximum limits will also meet the daily maximum limits. However, the current NPDES permits, based on expected performance for plants that intake substantial quantities of stormwater, include maximum weekly and monthly limits that are significantly more stringent than the daily/ instantaneous limits. Furthermore, strict compliance with maximum monthly concentration limits will not guarantee monthly compliance with other quality limits in the permit, such as average monthly and weekly loading limits and percent removal requirements.

An important but difficult question remains regarding how long a facility (or process) can sustain high flows that allow effluent quality to meet all the permit effluent quality requirements.

The performance of the secondary clarifiers determines the final effluent quality from the SWWPCP. The data collected during the field-testing was used to predict final effluent quality as a function of flow rate. The predicted final effluent TSS and BOD_5 concentration for a given flow rate was used to determine the maximum flow that could be maintained for an infinite period of time with effluent quality meeting the monthly and weekly loading and percent removal requirements in the NPDES permit.

Secondary clarifier capacity is defined by either the clarification capacity, which is a function of SOR or the solids flux capacity which is a function of solids loading rate (SLR). Clarifier performance as a function of both SOR and SLR was collected during the testing for a range of operating conditions. Data from the six secondary clarifier stress tests was used to quantify the secondary clarifier performance as a function of hydraulic loading and to identify the maximum allowable solids loading rate for the clarifiers.

The historical data was used to determine the yield and mixed liquor concentrations required as a function of primary effluent quality. The data from the primary clarifier stress tests was used to determine the expected primary effluent quality as a function of flow rate. The mixer liquor required for the expected primary effluent quality determines the solids loading rate for the secondary clarifier.

4.2 Analysis Methodology

4.2.1 Predicting Secondary Effluent Quality as a Function of the SOR

In the stress tests of the secondary clarifiers, the TSS and BOD_5 concentrations in the secondary effluent were measured as a function of the surface overflow rate applied to the clarifiers. A linear regression was performed on the field testing data to establish the relationship between SOR and TSS and BOD_5 concentrations in the effluent. The intercept and slope values obtained for the regression were statistically analyzed to find the 95% confidence level associated with these two coefficients. Using the upper 95% confidence level interval provides a conservative description of the relationship between the SOR and effluent quality. The model is used to predict TSS or BOD_5 for a given SOR; the value generated using the linear regression will be lower than the actual value observed 95 out of 100 times.

The estimated effluent concentrations and discharge loads (which are equal to the effluent flow rate multiplied by the effluent concentration) can then be compared to permit levels to determine the sustainable treatment capacity of the facility on a SOR basis.

4.2.2 Effect of the SLR on Secondary Clarifier Performance

Failure of the secondary clarifiers may occur either due to clarification or thickening. An increase in the hydraulic loading to the primary clarifiers will result in an increase in organic loading to the aeration basin due to an increase in the amount of organic material entering the plant and deterioration in the primary clarifier performance. An increase in the organic loading to the aeration tanks results in an increase in the mixed liquor concentrations and therefore an increase in he solids loading for a given flow. Therefore, the analysis done in terms of the SOR must be complemented with an analysis of the effect of influent flow rate versus SLR.

Stress tests were performed on the primary clarifiers, and removal efficiencies as a function of the surface overflow rate in the primary clarifiers were documented. The data was used to predict the quality of the primary effluent as a function of the influent flow rate. This analysis, combined with analysis of historical data on solids production, was used to estimate the SLR as a function of flow, taking into account both the performance of the primary clarifiers and the increase in the organic loading associated with augmented flows.

The stress tests on the secondary clarifiers indicated that the maximum SLR that could be maintained before thickening failure occurs is 35 lb/(ft^2.day). The flow at which these solids loading rates are achieved is the maximum sustained flow that can be maintained in the plant before thickening failure occurs.

4.3 Analysis Results

4.3.1 Predicting Maximum Flows as a Function of the SOR

Figure 4.1 is a plot of the TSS in the secondary effluent and the SOR applied in the secondary clarifier from the six secondary clarifier stress tests conducted at the facilities owned and operated by PWD. The data from all six secondary clarifier stress tests was used in the preparation of this plot. Figure 4.2 presents the same analysis was done for the BOD_5 concentration in the secondary effluent.

The amount of TSS and BOD_5 discharged results from the product of the flow rate and the concentrations predicted by the 95% confidence level regressions. The discharge values were compared to the NPDES Permit values for the SWWPCP. The results of this analysis are presented in Table 4.1.

TABLE 4.1 SOUTHWEST WPCP – NPDES PERMIT REQUIREMENTS AND RESULTS OF THE SUSTAINABLE FLOW ANALYSIS[1]

Parameter	Units	NPDES Limit	Maximum Sustainable Flow based on SOR		Maximum Sustainable Flow based on SLR
			TSS Limit	BOD_5 Limit	
Maximum Day Limits	Mgd	400			320
Maximum Week Limits	Mgd		380	225	
BOD_5 Concentration	mg/L	45			
BOD_5 Mass Loading	lbs/day	32,475			
TSS Concentration	mg/L	45			
TSS Mass Loading	lbs/day	75,060			
Maximum Monthly Limits	Mgd	200	288	175	
BOD_5 Concentration	mg/L	30			
BOD_5 Mass Loading	lbs/day	21,650			
BOD_5 Percent Removal	%	89.25			
TSS Concentration	mg/L	30			
TSS Mass Loading	lbs/day	50,040			
TSS Percent Removal	%	85			

1 – BOD_5 limits based on old permit, plant now monitors $cBOD_5$ for compliance.

The maximum sustainable flows at which the model predicts the SWWPCP can meet the weekly NPDES TSS and BOD_5 effluent mass loading requirements are 380 and 225 mgd, respectively. The BOD_5 weekly mass loading is the limiting criteria because the allowable effluent BOD_5 mass loading is significantly lower than the weekly concentration limit. The maximum weekly flow in the NPDES permit is 300 mgd. The model predicts that the facility will not be able to meet the BOD_5 weekly mass loading at a sustained flow of 300 mgd.

The maximum sustainable flows at which the model predicts the SWWPCP can meet the monthly NPDES TSS and BOD_5 effluent mass loading requirements are 288 and 175 mgd, respectively. The maximum month sustainable capacity for BOD_5 is lower than the average design capacity of the facility. This corresponds reasonably well to the historical performance of the facility. The SWWPCP is currently operating at 88 percent of its rated capacity. A 30-day running average of the effluent BOD_5 data was within 95 percent of its monthly average BOD_5 mass loading requirements on two occasions over the three-year period from July 1995 to July 1998.

The sustainable capacity values for weekly and monthly flows based on BOD_5 limits as estimated by the model are low due to several factors that influence the model in relation to the SW WPCP. First, an analysis for the SWWPCP plant operations versus the other two plants indicates that the SW plant normally runs its secondary clarifiers at lower surface overflow rates (SORs). Observing the trend in data in Figure 4.2 for lower SOR values, it is apparent that the model is conservative in SORs below 1000 gpd/sf, which is where under high flow conditions the SW WPCP will operate. Additionally, the model predicted sustainable flow at the plant is developed assuming two secondary clarifiers out of service.

The most significant influence on the SWWPCP ability to sustain high flows is the difference in the operation of the plant during these events as compared to what is done at the other PWD treatment plants. Operational changes that cannot be reflected in the model results, such as the ability to store solids in tanks that are off-line, significantly increases the ability of the plant to sustain adequate treatment during high flow events. SWWPCP has been able to treat over 300 mgd of flow for a sustained period of time (almost a week) during unusual storm events without any significant deterioration of the effluent quality.

Figure 4-1
Secondary Clarifier Stress Test - Effluent TSS Concentration as a Function of SOR

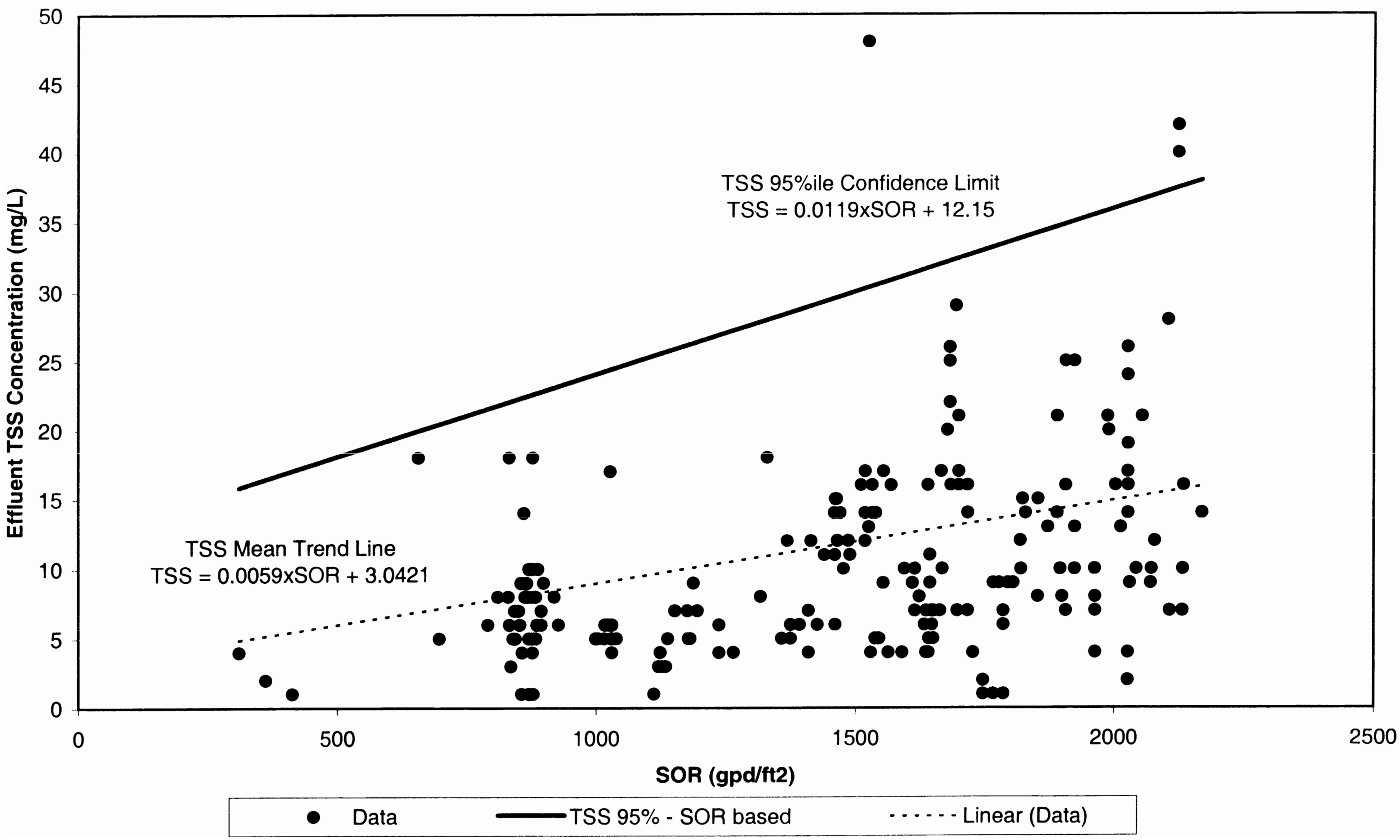
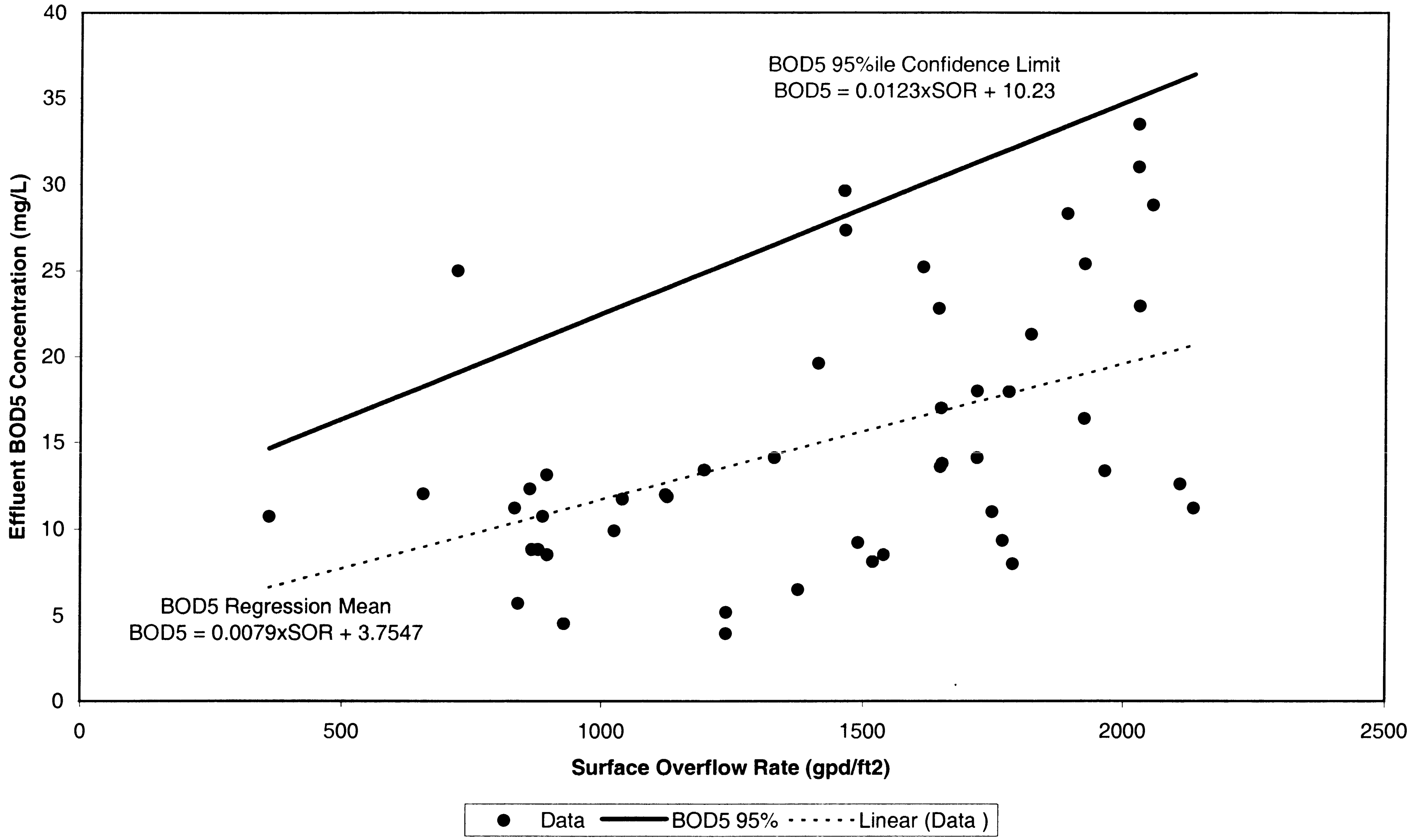


Figure 4-2
Secondary Clarifier Stress Test - Effluent BOD5 Concentration as a Function of SOR



4.3.2 Predicting Maximum Flows as a Function of SLR

The stress tests of the secondary clarifiers indicated that the maximum solids loading rate that could be sustained by the secondary clarifiers was 35 lb/(ft^2.day). The solids loading rate is a function of the MLSS concentration in the aeration basin and the influent and RAS flow rates. The MLSS concentration is dependent on the loading to the aeration basins, which in turn is dependent on the performance of the primary clarifiers as a function of the flow. The objective is to develop an overall correlation between the flow coming into the plant and the resulting solids loading rate into the secondary clarifiers.

The primary clarifier stress test results were used to determine the TSS percent removal in the primary clarifiers as a function of influent flow rate. A regression analysis of all stress test results performed in the primary clarifiers (except the test performed at the Southeast Plant where the clarifier failed prematurely due to the hydraulic limitations of the launders) was performed, and the lower 95% confidence levels associated with the regression parameters were calculated. Figure 4.3 presents the results of this analysis.

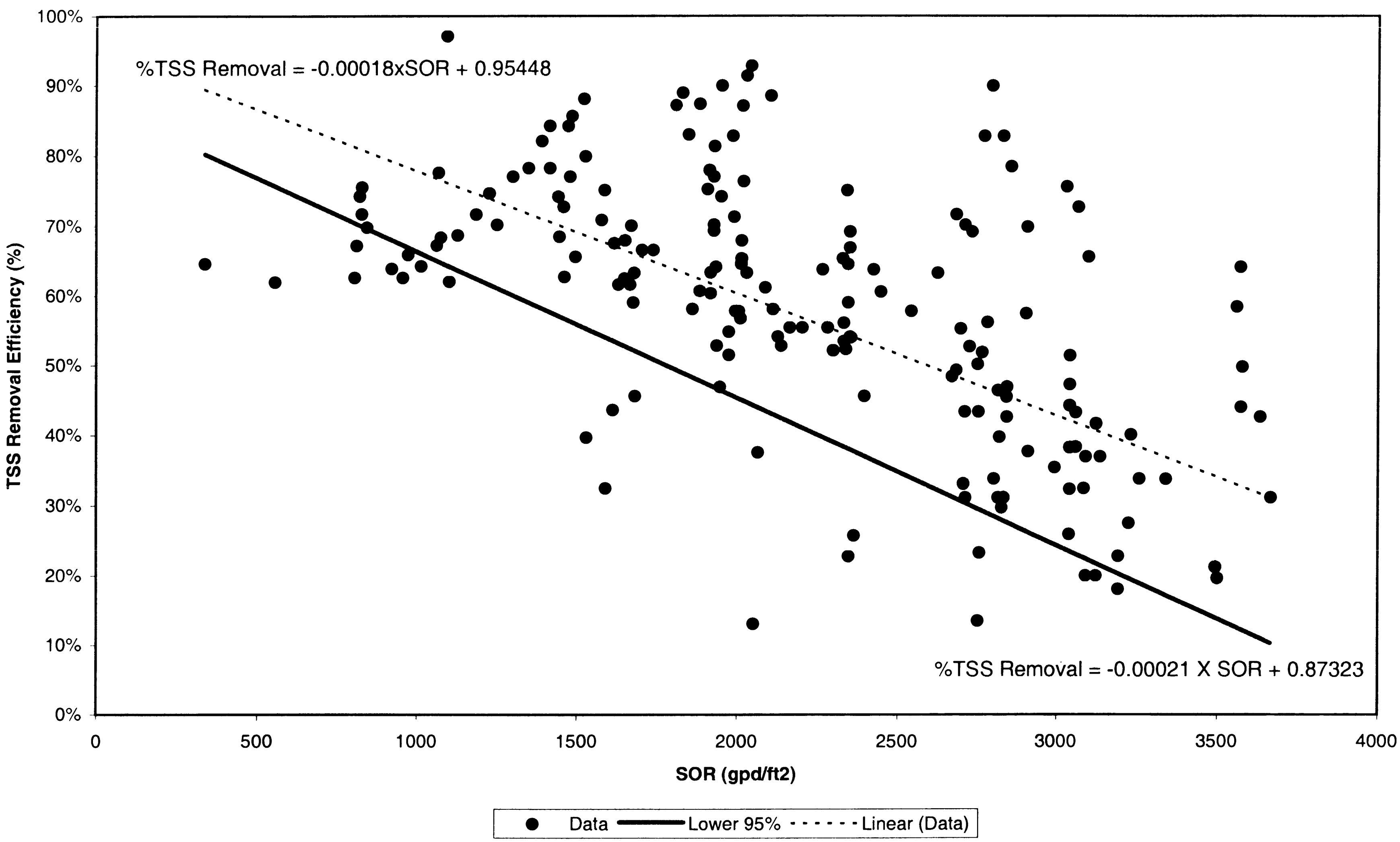
The yield for the SWWPCP was estimated based on the historical data of waste activated produced and the TSS and BOD_5 concentrations in the primary effluent. The SWWPCP is operated at an SRT of 1.9 days, the RAS flow rate is about 35 percent of the influent flow rate, and the raw wastewater has an average TSS concentration of 154 mg/L. For the determination of the SLR limiting flow, it was assumed that all of the primary and secondary clarifiers are in service, but that only eight of the ten aeration basins are in use. This corresponds to current operating practice at the site.

The SLR becomes 35 lb (ft^2.day) at the SWWPCP when the sustained flow is equal to 320 mgd. At flow rates greater than 320 mgd, thickening failure will occur unless measures are taken to reduce the solids loading rate to the secondary clarifiers. Preventative measures that are currently implemented at the SWWPCP include reducing the mixing in the aeration basin to allow solids to settle in Cells 3 and 4 and using the two aeration basins that are out of service as RAS storage for the duration of the storm.

Alternatively, step feed could be implemented at the SWWPCP by constructing an "in basin" primary effluent conduit along the length of the basin. The conduit would operate as a submerged diffusor and would require structural modifications to existing tanks. Improving the primary clarifier performance by providing pretreatment of the BRC centrate would significnatly improve the primary clarifier performance. Providing "out of clarifier" primary sludge thickening or enhanced primary clarifier performance through chemical addition would also reduce the solids loading to the secondary clarifiers. These alternatives would require capital expenditure for additional facilities.

Improving the solids removal efficiency of the secondary clarifiers would effectively increase the allowable solids loading rate to the clarifier. This would require modifications to the existing RAS system.

Figure 4-3
Primary Clarifier Stress Test – Percent TSS Removal Efficiency as a Function of SOR



4.4 Control of High Flow Duration

Discussions with PWD managers directing PWD's CSO program indicated that current CSO inline storage and draw-down plans expect that stored combined sewerage would be released to the plant over a 12-hour period following a storm event. This is a volume of combined sewerage that PWD's plants have not received in the past. Furthermore, there is flexibility in the draw-down strategy since the primary objective of the effort would be to return the storing sewer back to its original condition prior to the next storm event. It was clear that this is only a current plan and it would change should PWD be required in the future to provide additional combined sewerage storage to meet receiving water quality objectives.

From the wastewater treatment plants' perspective, a number of factors can influence the ability of a plant to achieve weekly or monthly limits when the plant is being stressed by storm-induced, high influent flows. The number and distribution of rain events during the week/month, together with plant effluent quality during non-rain event periods, rank high on the list of influences. PWD's revised permit language provides effluent quality relief, but only when the daily plant flow exceeds the permitted maximum daily flows currently stated in the permits. No such relief occurs for flows below the maximum daily flow limits.

Since the impact of stored combined sewerage on the SWWPCP performance is an unchartered experience, it is recommended that the duration of storage be no greater than a 24-hour period for each storm event. Should the CSO program's strategy for stored combined sewerage change beyond this 24-hour period, the issue of plant compliance for all monthly and weekly effluent quality requirements should be reviewed.

SECTION 5
POTENTIAL UPGRADES

5. Potential Upgrades

A list of potential upgrades was developed to increase the capacity or improve the performance of the SWWPCP. The potential improvements are based on the results of stress tests on unit process, long-term monitoring of the plant, and hydraulic modelling.

Each upgrade option has been prioritized based upon the following criteria:

- **Priority A – Existing Facilities Optimization.** Improvements that are easily implemented, low cost, high benefit, and will have an immediate positive impact upon normal operations. These are options that can be included in short-term capital budgets.

- **Priority B – Proactive Improvements.** Improvements that are moderate in cost and will have a positive impact on plant capacity. These are options that should be included in a long-term improvement plan.

- **Priority C – Improvements to Increase the Solids Handling Capacity of the Secondary Clarifier.** The stress tests identified that the solids handling capacity of the secondary clarifiers is very limited. This category includes improvements that are necessary to increase the secondary clarifier capacity with current mixed liquor concentration and/or to maintain existing capacity if increased mixed liquor suspended solids are required in the future.

- **Priority D - Capacity De-bottlenecking.** Improvements that have large costs associated with them and will greatly increase capacity above the current permitted peak flow. These options should be considered in an overall long-term, wet-weather, flow-control program and in the long-term improvement plan if significantly more treatment capacity is required at the facility.

The list of potential upgrades, budgetary cost estimate, and their associated prioritization is summarized below. Detailed descriptions of each upgrade are presented in Technical Memorandum 5 – Budgetary Cost Estimates for Potential Plant Improvements.

The cost estimates shown here are based on preliminary costs and are for use as "budgetary" values only. The cost estimates are Class "C" cost estimates (order-of-magnitude costs) as defined by the American Association of Cost Engineers. The level of accuracy of the Class "C" cost estimates is +50 percent to –30 percent of the actual cost of construction. These costs can be used for decisionmaking to select those options for more detailed analysis that are most feasible from both a design and cost perspective.

Table 5.1 includes the final estimated cost for each improvement. Table 5.2 presents a summary of the overall cost for improvements at the SWWPCP, which are broken down into alternatives that are dependant upon one another for an increase in capacity at the plant.

TABLE 5.1
POTENTIAL UPGRADE OPTIONS AT SOUTHWEST WPCP

Option No.	Description	Priority Classification	Estimated Conceptual Cost
1	Replace caulking on secondary clarifier launders to improve flow distribution [1]	A	$1,640,000
2	Provide preliminary treatment for the BRC centrate that is recycled to the plant	B/C	$8,585,000
3	Modify existing RAS system in the secondary clarifiers	C	$4,256,000
4	Provide primary effluent bypass to secondary clarifiers	D	$902,000
5	Provide separate facilities for primary sludge thickening	D	$9,892,000
6	Resolve hydraulic limitations between primary clarifiers and aeration basin	D	$5,429,000
7	Provide an additional effluent pump at the effluent pumping station	D	$806,000

[1] Complete or in progress.

TABLE 5.2
SUMMARY OF BUDGETARY COSTS FOR POTENTIAL IMPROVEMENTS AT SOUTHWEST WPCP

Plan	Total Costs for Improvements (Million $)	Cumulative Costs for Improvements (Million $)	Peak Treatment Capacity (mgd)			
			Facility	Preliminary	Primary	Secondary
Process improvements (Option 1)	1.64	1.64	340[1]	540	350	340
Increase primary treatment capacity w/ aeration bypassing (Options 2, 4, 5)	19.4	21.0	440	540	440	340[2]
Increase secondary treatment capacity (Options 2, 3, 6, 7)	19.1	31.5	540	540	540[3]	540

1. Existing facility is able to treat peak instantaneous flows of 440 mgd for a short period of time
2. Capacity of secondary is limited by hydraulic restriction into the aeration basin, however bypass will allow plant to increase overall capacity.
3. Deterioration of primary clarifier performance is offset by maintaining aeration basins in service

Process Improvements. The performance of the secondary clarifiers at the SWWPCP is negatively affected by an uneven flow distribution between individual clarifiers due to deterioration of the grouting in the effluent launders. The objective of this plan is to improve the performance of the SWWPCP under high flow conditions by improving the flow distribution. These improvements will not increase the peak hydraulic capacity of the facility beyond its current capabilities.

Increase Primary Treatment Capacity with Aeration Bypassing. The primary treatment capacity is limited at the SWWPCP. A significant portion of capacity is being used to treat the BRC recycle stream. Poor primary clarifier performance under current loading conditions requires a higher mixed liquor concentration, which has a negative impact on the secondary clarifier capacity. The objective of Options 2, 4, and 5 is to increase the peak capacity of the primary treatment to 440 mgd and to improve primary clarifier performance under all flow conditions.

The work would include providing pretreatment of the BRC recycle stream at the BRC facility, increased sludge removal from the primary tanks, and a bypass conduit from the primary effluent channel to the mixed liquor channel.

The estimated cost of providing pretreatment of the BRC recycle stream is $8,585,000. This includes chemical addition, coagulation, flocculation, and sedimentation facilities. However, based on recent jar testing work performed by PWD, the cost of chemical addition may be reduced if the recycle stream can be treated immediately.

A bypass between the primary clarifier effluent channel and the plant outfall will be required to circumvent the hydraulic bottleneck between the pimary clarifiers and the aeration basins. One approach would be to construct the primary effluent channel to the mixed liquor channel. The estimated cost for this potential upgrade is $902,000. The primary effluent would be added to the upstream end of the mixed liquor channel and pass through the secondary clarifiers before discharge. The estimated peak hydraulic capacity of the secondary clarifiers is 695 mgd at current mixed liquor concentrations. The primary effluent will increase the hydraulic loading on the secondary clarifiers without increasing the solids loading. Therefore, the secondary clarifiers have sufficient hydraulic capacity to treat the additional load.

The advantage of this approach is that the primary effluent will receive some additional treatment due to contact with the mixed liquor and the "sweeping" action of the activated sludge in the secondary clarifiers. The final effluent will be of higher quality than the blended effluent from the secondary clarifier and the bypass stream combined after the secondary clarifier. However, the contact time between the activated sludge and primary effluent bypass will be very small, and therefore BOD_5 removal from the primary effluent will be minimal. A relaxation in the permit requirements on days when aeration tank bypassing occurs is recommended. An alternative approach would be to bypass both the aeration basin and the secondary clarifiers. The primary effluent would flow directly to the secondary effluent channel. This approach would not provide the benefit of additional treatment as the primary effluent passes through the aerated mixed liquor channel and secondary clarifiers.

The potential primary treatment capacity of the SWWPCP is 540 mgd with five clarifiers in service. Increased primary sludge pumping may be required to achieve the additional primary treatment capacity. The estimated cost of providing a gravity sludge thickening facility at the SWWPCP is $9,892,000.

Increase Secondary Treatment Capacity. The objective of the remaining improvements is to increase the secondary treatment capacity to 540 mgd by eliminating the hydraulic bottlenecks at the influent end of the aeration basins. Offline sludge thickening would not be required because the primary effluent would receive full secondary treatment and no bypass arrangement of the aeration basins would be used. The estimated capital cost to provide intermittent pumping between the primary clarifiers and the aeration basin is $5,429,000. The capacity of the effluent pump station will also need to be increased. The estimated capital cost of providing an additional effluent pump is $806,000. In addition, to achieve this full plant capacity of 540 mgd, BRC pretreatment (Option 2) and modifications to the existing RAS system (Option 3) would have to be implemented.