City and County of San Francisco
2030 Sewer System Master Plan

TASK 500
TECHNICAL MEMORANDUM NO. 509
COMBINED SEWER DISCHARGES

FINAL DRAFT
December 2010

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CITY AND COUNTY OF SAN FRANCISCO
2030 SEWER SYSTEM MASTER PLAN

TASK 500

TECHNICAL MEMORANDUM
NO. 509
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COMBINED SEWER DISCHARGES

1.0 PURPOSE OF MEMORANDA

The purpose of these memos is to document the historical activation frequency, discharge volume, and impact of San Francisco's CSDs on the receiving waters of the Pacific Ocean and San Francisco Bay. In addition, the TM includes a memo that summarizes a planning exercise conducted in February of 2007 to examine the potential infrastructure solutions needed to meet a "one or less CSD in a typical year". This analysis was based on expanding the storage and pumping infrastructure identified for early configurations that have not been carried forward since the 2007 planning effort. It was determined by the SFPUC and the consultants that it was important to capture this concept at the time of development so the reviewers could see the progression of information and the analyses completed as part of the modeling and planning effort. Please also note that the word "alternatives" was used in this project memo instead of "configurations." This was the wording used at the time the PM was written. In the Summary Report, the term was updated to "configuration" so as to not confuse the CEQA review process. The configurations mentioned herein may have changed or been eliminated and are not considered full CEQA alternatives.

The information contained in this memo is helpful in understanding the historical activation frequency of CSDs derived from recorded data. This historical perspective was used by the SSMP team to define focus areas for evaluation under the planning effort, but this data was also used to validate the collection system model representation of the annual activation frequency. Readers of this TM should also review the memos that document the baseline annual activation frequency predicted by the calibrated collection system model. The combination of the actual performance data and the model predictions will provide a reviewer with an understanding of magnitude of historical wet weather overflows and the conditions from which analyses were based during development of the SSMP.

After completion of the SSMP, SFPUC through amendments and additional contracts, have continued to update the collection system model and further refine baseline annual activation frequency estimates. Reports from these studies and projects are also included (by reference) in this cover memo to provide the reviewer with additional resources to examine if a current understanding of the model and baseline CSD frequency is desired.

2.0 REFERENCED DOCUMENTS

The following is a list and brief summary of the project memos attached to this TM. The descriptions provide an overview of how these memo topics relate to the objective of the TM. To provide the reviewer with a complete perspective of the efforts to date, additional documents developed as part of additional studies and project are described in the list below but are not attached to the TM. The purpose of this is to direct a reviewer to additional information, if needed, while keeping maintaining the original structure of the TM.

PMA23 – Historical CSD Frequency and Location of Discharge: Document provides a description and map of CSD locations in both the Oceanside and Bayside systems. Historical activation frequency as reported in the annual wet weather reports are presented for FY1987 through FY2004.

PMA11 – Summary of CSD Water Quality Data: Documents the water quality sampling data collected at CSD points. References to appendices are not included with this PM but are available in monthly reports maintained at SFPUC.

PMA31 – CSD Mass Balance Analysis: References as mass balance report being prepared in support of the SSMP and references the findings of historical mass balance analyses that provide an understand of the level of treatment provided by the transport/storage boxes that ring the City and the impact of this treatment on CSD quality.

Model Development, Validation, and Baseline Report (October 2007): Included by reference only. This document is included under TM501 but the discussion of the baseline CSD activation frequency (Section 4.0) as predicted by the model establishes the starting point from which the impact of alternatives were assessed. As part of the calibration effort done in advance of this baseline simulation, the model predictions were compared against the

DDMP Draft Technical Memorandum #3, Modeling Approach (12/6/07): Included by reference only. This document developed as part of an amended scope of work to the SSMP summarizes updates made to the baseline model configuration to support detailed evaluation of drainage and flooding concerns in seven focus areas shown in Figure 1. As described in Section 1 of the memo, the general approach to modeling for this work focused on updates to the model configuration developed as part of the SSMP project:

> The seven focus areas for the study have been selected with input from Bureau of Engineering (BOE) staff based on the potential and susceptibility to flooding issues. The types, causes, and degree of potential for flooding vary across the seven areas. The study will address the potential flooding issues, recommend mitigation criteria and alternatives, and provide insight for further future analyses.
>
> The San Francisco Sewer System Master Plan (SSMP) model was developed using the InfoWorks software package to simulate dry-weather and wet weather flows in pipes 30-inches and larger. It was developed primarily to predict the frequency and volume of combined sewer discharges (CSD) to the Ocean and San Francisco Bay. Once calibrated, this tool was then used to analyze the impact of alternatives designed to reduce flooding and combined sewer overflows to San Francisco Bay and the Pacific Ocean. The current planning level model does not provide the level

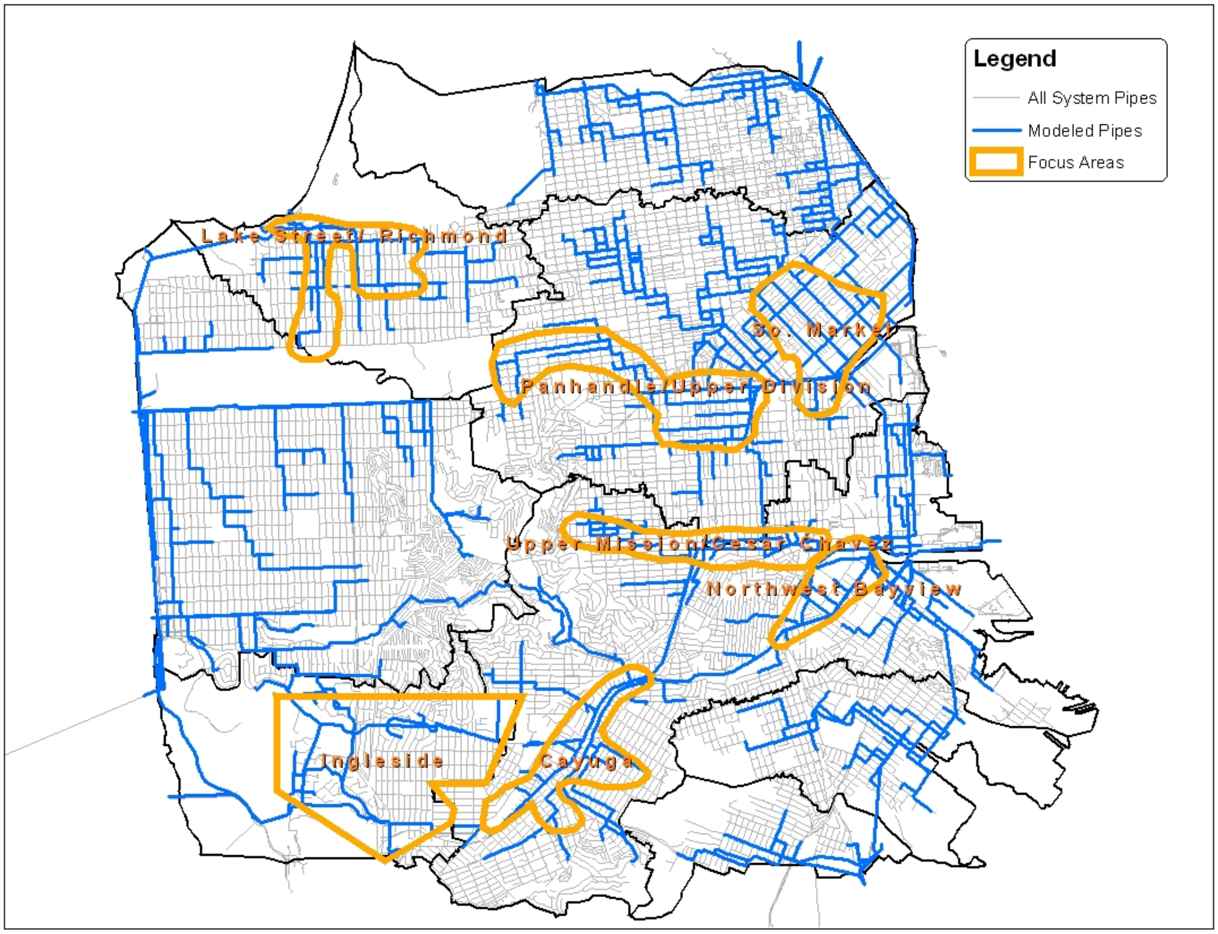


Figure 1 Focus Areas of DDMP Analysis (2007)

of detail necessary to conduct detailed drainage and flooding assessments. As such, it will need to be extended, refined and updated to improve drainage and flooding analysis capability. The modifications will server to better simulate existing conditions as well as the measures and alternatives that may be considered to improve the system. In general, three measures that could be taken to enhance the model include: (1) add additional network details (more pipes in upstream areas, less than 30-inches in diameter), (2) add more detail to the hydrologic runoff simulation component, and (3) add a surface routing hydraulic component. One or more of these measures may be used according to the conditions and needs in each area. The model may also be further enhanced by taking advantage of more extensive or refined data that have become available since the development of the original SSMP model. These data include flow and rainfall monitoring data as well as more refined physical data such as multi-spectral land use data.

Sewer System Improvement Program Report, DRAFT Report for SFPUC Commission Review Included by reference only. In support of the SSIP program, the DDMP model was used to complete a series of additional analyses to address flooding and conveyance concerns outlined in the memo. Significant updates to the model were not made from the DDMP configuration, however, minor updates were made to local sewer networks to better reflect the objective of the configurations explored as part of this program. The model network developed under this project represents the most up-to-date representation of San Francisco's sewer collection system.

Annotated Outline for One or Less CSD's Alternatives Analysis (2/9/07): Memo presents the results of an exercise conducted in 2007 to understand the magnitude of infrastructure needs to control all CSDs to less than one CSD in a typical year. This bookend exercise enabled SFPUC to understand the ramifications of going to a high level of control. The configurations explored were based on alternatives evaluated in 2007 that have since been significantly modified. As noted above, it was determined by the SFPUC and the consultants that it was important to capture this concept at the time of development so the reviewers could see the progression of information and the analyses completed as part of the modeling and planning effort. Note that in PMB12 which can be found in TM603 (Assumptions for Footprint and Cost Estimate of One Combined Sewer Discharge Per Year, 4/10/07) an assessment of the treatment impacts of less than one CSD in a typical year is presented. This document should be reviewed in conjunction with the collection system alternatives analysis memo (2/9/07) to understand the full impact of this level of control.

Assumptions for Footprint and Cost Estimate of One Combined Sewer Discharge Per Year (4/10/07). Included by reference only. This memo can be found in the back of TM 603 and summarizes the treatment components necessary to achieve one combined sewer discharge per year. This document is intended to be a component of the memo referenced directly above.

3.0 SUMMARY

The collection of memos that comprise TM 508 provide a reader with both a historical perspective of CSD activation based on field data collected by SFPUC staff and model representation of the annual CSD activation frequency that has been used for various planning efforts and exercises.

In general, the field data was used to calibrate the collection system model so there is an expectation that the two types of data will closely match. However, this may not always be possible due to annual rainfall variability year-to-year, quality of outfall telemetry data, and model refinement in the areas tributary to any of the CSD outfalls.

In general, the consultants and SFPUC staff were confident of the model representation of the annual activation frequency and believe the baselines used for the different studies were an appropriate starting point for considering control options. The additional documents, included by reference only, provide a reader with additional documents to review in order to understand the evolution and development of the collection system model and baseline annual CSD activation frequency and overflow volume used for master planning efforts.

APPENDIX A - PROJECT MEMORANDUM - PMA 23 - HISTORICAL CSD FREQUENCY AND LOCATION OF DISCHARGE

FINAL DRAFT PROJECT MEMORANDUM

Project Name:	SFPUC Sewer Master Plan	**Date:**	8/3/07
Client:	City and County of San Francisco	**Project Number:**	7240A.00
Prepared By:	Patricia McGovern, PME		
Reviewed By:	Jeff Berlin, Arleen Navarret		
Subject:	PMA 23 – Historical CSD Frequency and Location of Discharge		
Distribution:	Arleen Navarret, Jeff Berlin, Pricilla Bloomfield, Elisa Garvey, Lydia Holmes, Steve McDonald, Fred Krieger		

Purpose and Summary

The purpose of this Project Memorandum (PM) is to quantify historical Combined Sewer Discharge (CSD) events and compare the existing performance with design criteria. Over the historical record (1987 through 2004), the number of CSDs for each basin and collectively have been very near the design number of CSDs (either less than or + 1 CSD event), showing that the storage/transport system is performing as designed.

Overview

The City and County of San Francisco has a combined storm water and wastewater system. All dry weather flow, including street runoff, receives full secondary treatment at either the Oceanside or Southeast wastewater treatment plants. Wet weather flow receives either secondary or primary treatment at the Oceanside, Southeast, or North Point wet weather facilities or an equivalent of wet weather primary treatment within the transport storage structures that surround the perimeter of San Francisco. When the capacity of the transport storage system is exceeded, a combination of treated sanitary (~6%) and rainwater (~94%) flows discharge from the transport storage boxes to near shore receiving waters. These CSDs may be discharged from a number of different locations around the City (see Figure 1).

The transport storage system was built as part of San Francisco's Long Term Control Plan (LTCP) over several decades. The system was designed to capture, store, and treat all combined flows with a long-term rainfall average frequency protective of beneficial uses. The system design frequency for permitted CSDs within each drainage basin is provided below. Additionally, a recreation uses study was conducted in June, 2006 (*SFPUC Bayside Recreation Use Study, June 2006*). The study reported that, of the 29 CSD structures, CSD structures #9, #42, and #43 are within reasonable proximity to impact water quality conditions in areas of recreational use. The following briefly describes recreational uses within the basins. .

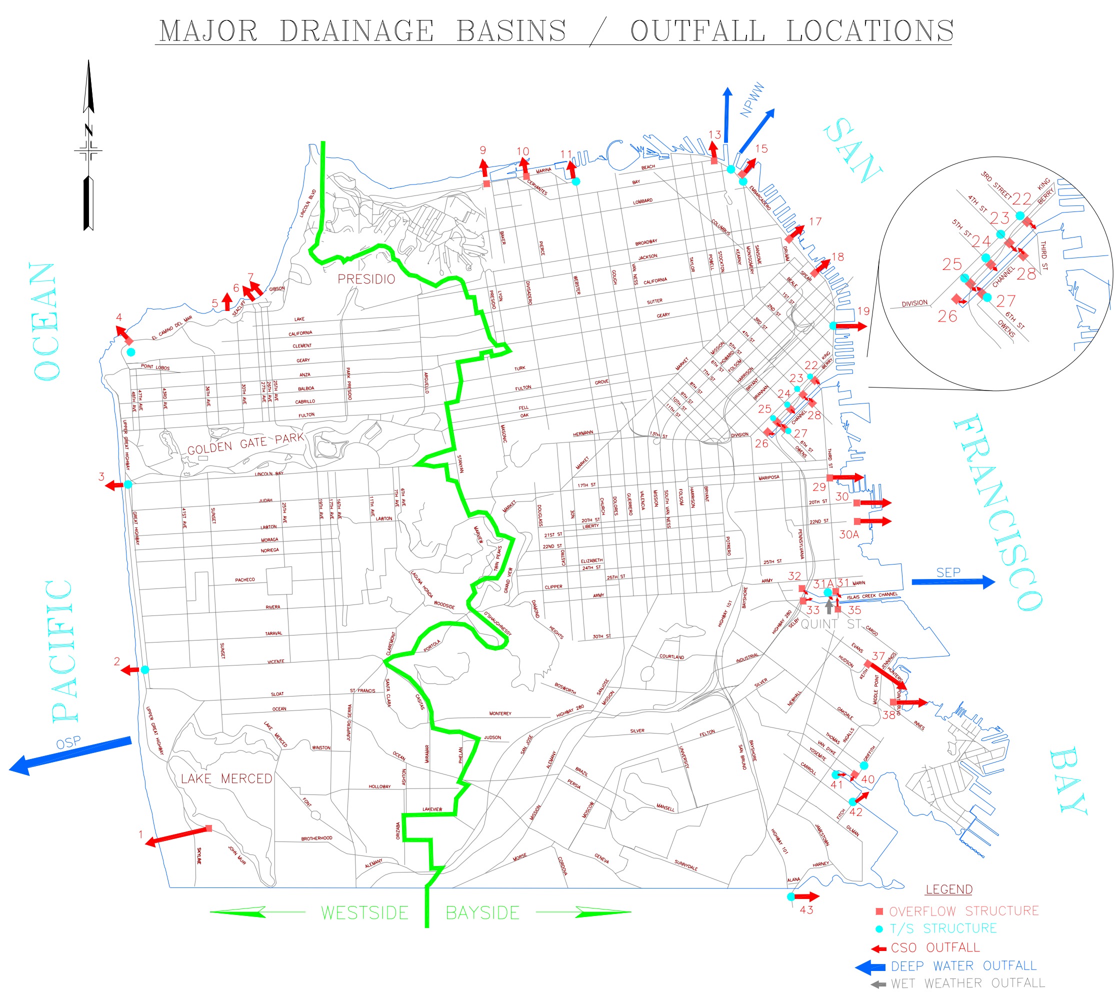
Westside - CSD #1 through CSD #8

The Westside transport/storage system has seven CSD structures (CSD #1, #2, #3, #4, #5, #6, #7) and was designed to allow a long-term average of up to eight (8) permitted discharges per year. Westside CSD structures are not located in the vicinity of any recreational use areas.

North Shore – CSD #9 through CSD#17

North Shore has six (6) CSD structures (#9, #10, #11, #13, #15, and #17) which were designed

Figure 1. Combined Sewer Discharge Locations around San Francisco



OUTFALL NO.	OUTFALL NAME	STRUCTURE OR T/S STRUCTURE	T/S OR DRAINAGE BASIN
1	LAKE MERCED	John Muir Drive	LMT
2	VICENTE	T/S Box at Great Hwy/Vicente St.	WST
3	LINCOLN WAY	T/S Box at Great Hwy/Lincoln Way	WST
4	MILE ROCK	Tunnel Junction Structure	RT
		Tunnel Overflow Chamber	RT
5	SEACLIFF #1	Pump Station	SEACLIFF
6	SEACLIFF	Outfall Structure Betw. 26th/27th Ave.	SEACLIFF
7	SEACLIFF #2	Pump Station	SEACLIFF
8			
9	BAKER STREET	Outfall Structure at DAF	NSOC
10	PIERCE STREET	Outfall Structure	NSOC
11	LAGUNA STREET	T/S Box at Marina/Laguna	NSOC
13	BEACH STREET	Outfall Structure	NSOC
15	SANSOME	T/S at Embarcadero & Sansome	NSOC
		T/S at Embarcadero & Bay	NSOC
		Outfall Structure	NSOC
17	JACKSON STREET	Outfall Structure	NSOC
18	HOWARD STREET	Overflow Structure	COC
19	BRANNAN STREET	T/S at Embarcadero & Brannan	COC
22	3RD STREET	T/S structure at 3rd/King	COC
		Overflow Structure	COC
23	N. 4TH STREET	T/S structure at 4th/King	COC
		Overflow Structure	COC
24	5TH STREET	T/S at 5th/Berry	COC
		Overflow Structure	COC

OUTFALL	LONG TERM AVERAGE OVERFLOWS	AREA NAME
1 – 8	8	WESTSIDE
9 – 17	4	NORTHSHORE
18 – 35	10	CENTRAL BASIN
37 – 43	1	SOUTH BASIN

SAMPLING LOCATIONS

STATION NO.	OUTFALL NO.
0-1	29
0-2	33
0-3	43
0-4	10
0-5	42
0-6	25
LAKE MERCED	1
VICENTE	2
LINCOLN	3
MILE ROCK	4

OUTFALL NO.	OUTFALL NAME	STRUCTURE OR T/S STRUCTURE	T/S OR DRAINAGE BASIN
25	N. 6TH STREET	T/S at 6th/Berry	COC
		Overflow Structure	COC
26	DIVISION STREET	Overflow Structure	COC
27	S. 6TH STREET	T/S at 6th/Owens Street	COC
		Overflow Structure	COC
28	S. 4TH STREET	Overflow Structure	COC
29	MARIPOSA STREET	Overflow Structure	MTS
30	20TH STREET	Overflow Structure	MTS
30A	22ND STREET	Overflow Structure	MTS
31	N. 3RD STREET	Overflow Structure at 3rd/Marin	N 3RD ST
31A	ISLAIS NORTH	Overflow Structure	ISLAIS CREEK
32	MARIN STREET	Overflow Structure	ISLAIS CREEK
33	SELBY STREET	Overflow Structure	ISLAIS CREEK
35	S. 3RD STREET	Overflow Structure at 3rd/Cargo	SOUTHEAST
37	EVANS STREET	Overflow Structure at Evans/Keith	HP
38	HUDSON STREET	Overflow Structure at Hudson/Hunters Point	HP
40	S. GRIFFITH	T/S Structure at Griffith/Thomas	Y/F
		Overflow Structure at Wallace	Y/F
41	YOSEMITE STREET	T/S Structure at Yosemite Channel	Y/F
42	FITCH STREET	T/S & Overflow Structure	Y/F
43	SUNNYDALE	T/S Structure at Harney Way	SUNNYDALE

LMT	Lake Merced Transport
WST	Westside Transport
NSOC	Northshore Outfalls Consolidations
COC	Channel Outfalls Consolidations
RT	Richmond Transport
MTS	Mariposa Transport / Storage
HP	Hunters Point
Y/F	Yosemite Fitch Transport / Storage
SUNNYDALE	Sunnydale Transport / Storage

SJ@EE/PUC/CCSF 8/99

BASED ON A DRAWING FROM HYDRAULICS SECTION/BUREAU OF ENGINEERING/CCSF

for a long-term average of four (4) discharges per year. Aquatic Park Beach is located within the North Shore and is the most frequently used area within the San Francisco shoreline for full body immersion, year-round water contact recreation. Aquatic Park Beach is isolated from any active CSD structures by a man-made breakwater and land outcropping to the west and numerous piers to the east. The land area to the south of Aquatic Park Beach is part of the Port

of San Francisco property.
Crissy Field, located in the Presidio National Park and under the jurisdiction of the U.S. Federal Government, is also located within the North Shore Basin. Street runoff and stormwater flow from the Presidio is collected in separate storm drains and flows directly to San Francisco Bay (sanitary flows are directed to the City's combined system). CSD structure #9 is located and discharges to the east of Crissy Field. The majority of activity at Crissy Field Beach is boardsailing which typically occurs from March/April and runs into September, and therefore does not coincide with the wet weather season. Crissy Field is a dangerous place to boardsail and is used mainly by advanced boardsailers. During storm events the San Francisco Boardsailing Association discourages going to Crissy Field Beach and directs all boardsailers to other locations.

Central Bayside – CSD #18 though CSD #35
Central Bayside has 19 CSD structures which were designed for a long-term average of ten (10) discharges per year. The original design of the system routed the discharges towards these areas since they were highly industrial area. Since the original design, new development has increased recreational use in the area. The Central basin is differentiated into the Mission Creek (#19, #22, #23, #24, #25, #26, #27, #28) system, Mariposa (#29), the 20th Street Pump Station (#30, #30A), and the Islais Creek system (#31, #31A, #32, #33, #35), as well as structures #18, #37, and #38.

Mission Creek previously was limited to non-existent water contact recreation, as there were no organized entry locations or activities. In 2000, the San Francisco Giants baseball stadium opened up on the northeast shore of Mission Creek, attracting boat traffic for fans that want to catch a homerun baseball. Games have not yet coincided with wet weather CSDs in the Mission Creek area and are unlikely to in the future due to the timing of the baseball season.

Access to Islais Creek did not lend itself to water recreation. In recent years however, with the development of Islais Landing on the south shore of Islais Creek, recreational use has increased with organized and individual kayak and canoeing activities. It is unlikely that this type of recreation will occur during wet weather events (when CSDs occur).

South Basin – CSD #37 though CSD #43
South basin has 4 CSDs located in the southeastern, bayside of San Francisco which were designed for a long-term average of one (1) discharge per year to protect the sensitive shellfish beds in the Yosemite Valley area. Three of the CSDs comprise the Griffith system (#40, #41, #42) and one is located in Sunnydale (#43).

Candlestick Point Recreation Area (CSD #42 – CSD #43) is most frequently used by walkers, joggers, people engaged in fishing, and board sailors. In the survey conducted from 2003 through 2006, beaches in the area were posted five times and remained posted for as many as 27 days following the discharge event. It is likely that stormwater contamination from separate drain sewers in the area added to the water quality impacts within the area during these events.

Performance
The City's combined sewer and storm water system was designed and constructed to protect beneficial uses. Based on 70 years of historical rainfall data, a long term average number of overflows per year, per basin (as previously described) were found to provide adequate protection of beneficial uses. Although the system was designed and constructed based on meeting these long-term averages, it is understood that some years are more wet than others. Therefore, the permit does not require that the averages be met.

To identify a discrete “event”, an event has been defined as an overflow from one or more of the diversion structures within one of the four basins within a six-hour period. For example, if a discharge at one diversion structure occurs and then 5 hours later another discharge occurs from a different diversion structure, yet within the same basin, then this is considered one event. If a similar discharge were to occur more than 6 hours later, it would be considered a separate event. This definition was incorporated into the latest Westside NPDES permit (NPDES Permit No. CA 0037681, August 2003) with the following text: “[t]o be considered a discrete overflow event, the overflow must be separated by six hours in time from any other overflow.” The latest Bayside NPDES permit (NPDES Permit No. CA 0037664, June 2002) does not identify how a CSD is to be defined.

The historical CSD performance for the four basins from 1987 through 2004 is presented in Table 1. This data was taken by PUC staff from the annual wet weather reports for both the Westside (*Westside Wet Weather Summary – Annual Summary*) and the Bayside (*Annual Wet Weather Summary – Northshore, Central, and South Basins*). Over the historical record, the total average number of CSDs (1987 through 2002) and the average number of CSDs for each individual basin is very near to the design values, showing that the system is operating as designed. Graphical presentations showing the yearly number of CSDs and compared to the design levels is presented in Figure 1 (Total Number of CSDs), Figure 2 (Westside), Figure 3 (Northshore), Figure 4 (Central Basin), and Figure 5 (South Basin).

Table 1. Historical CSD Performance

	Number of CSDs				
Fiscal Year	**Westside**	**Northshore**	**Central**	**South**	**Total**
1987	1	0	13	0	14
1988	4	1	5	0	10
1989	1	2	5	0	8
1990	2	1	7	1	11
1991	5	1	7	0	13
1992	4	3	14	2	23
1993	2	2	7	0	11
1994	4	3	15	2	24
1995	9	4	15	6	34
1996	8	6	15	5	34
1997	14	7	21	10	52
1998	7	1	13	0	21
1999	7	3	12	1	23
2000	3	0	8	0	11
2001	7	2	9	3	21
2002	25	3	14	8	50
2003	NA	4	8	3	NA
2004	NA	4	15	1	NA
Average*	**6**	**3**	**11**	**2**	**22**
Design	**8**	**4**	**10**	**1**	**23**

NA = Not available

* Westside and Total averages based on 1987 through 2002

because Westside data was not available for 2003 through 2004

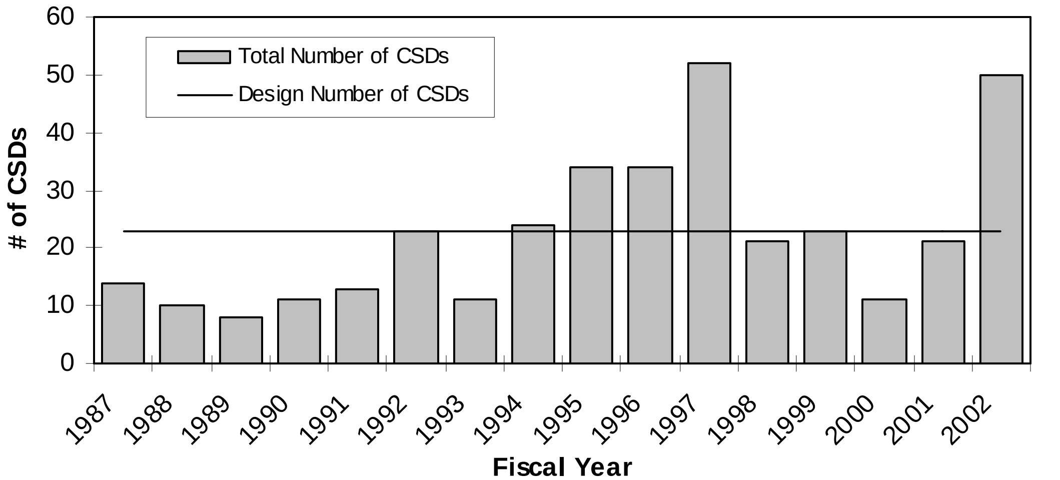


Figure 1. Total Number of CSDs 1987-2002

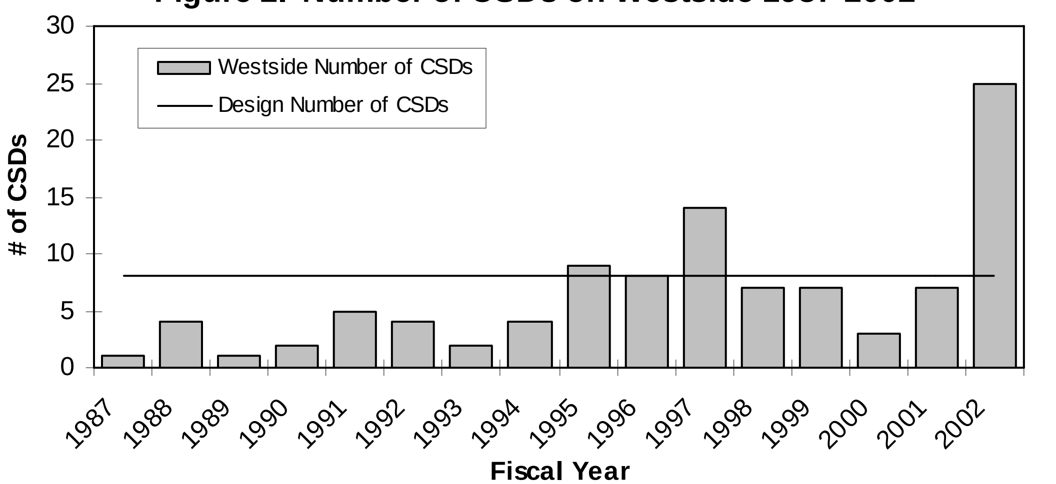


Figure 2. Number of CSDs on Westside 1987-2002

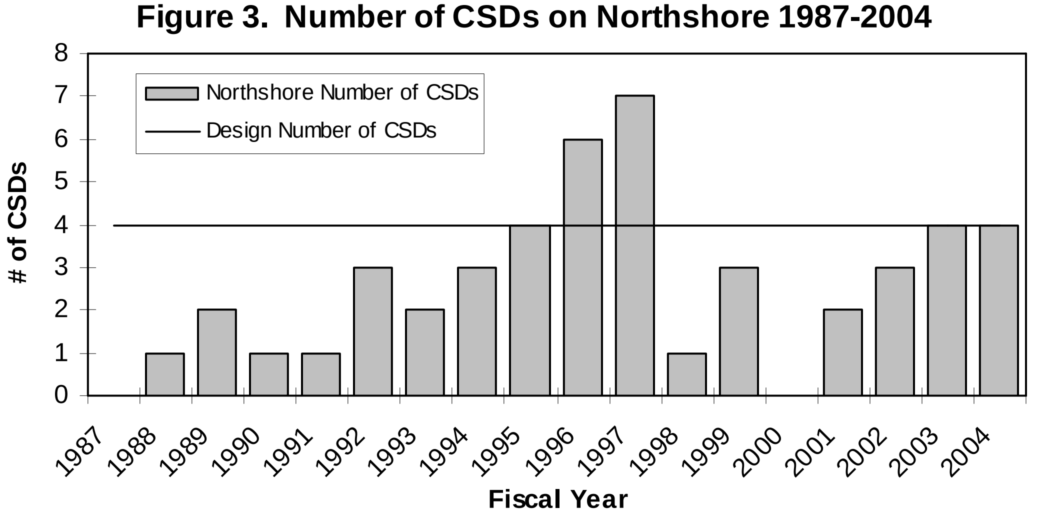


Figure 3. Number of CSDs on Northshore 1987-2004

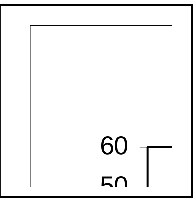


Figure 4. Number of CSDs on Central Basin 1987-2004

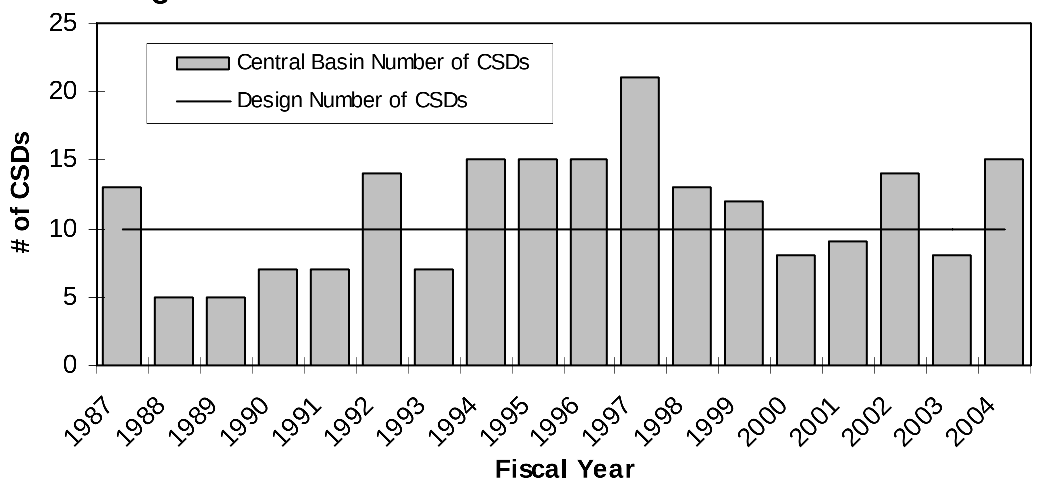
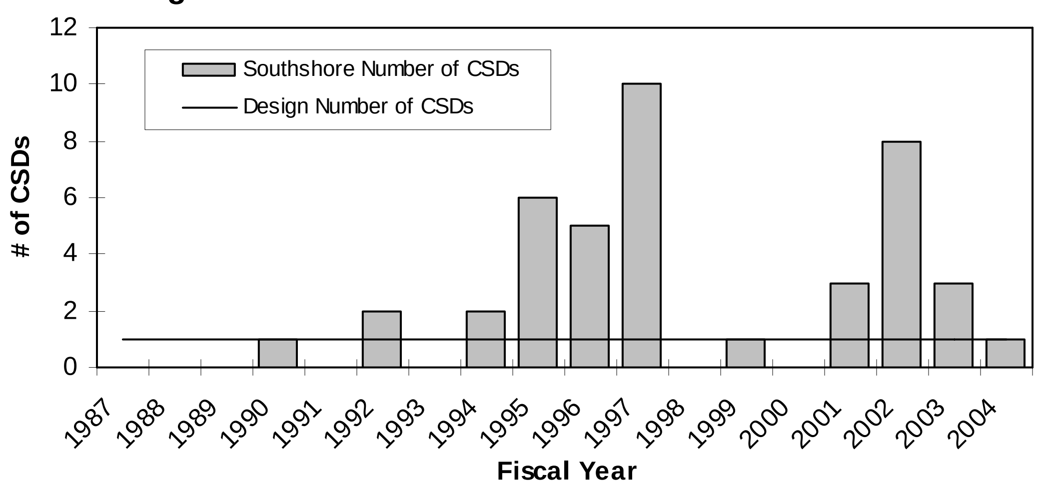


Figure 5. Number of CSDs on Southshore 1987-2004



APPENDIX B - PROJECT MEMORANDUM - PMA 11 - SUMMARY OF CSD WATER QUALITY DATA

DRAFT PROJECT MEMORANDUM

Project Name:	SFPUC Sewer System Master Plan	**Date:**	7/19/06
Client:	City and County of San Francisco	**Project Number:**	7240A.00
Prepared By:	Priscilla Bloomfield		
Reviewed By:	Lydia Holmes		
Subject:	PMA 11 - Summary of CSD Water Quality Data		
Distribution:	Steve McDonald, Fred Krieger, Patricia McGovern, Arleen Navaret, Jeff Berlin		

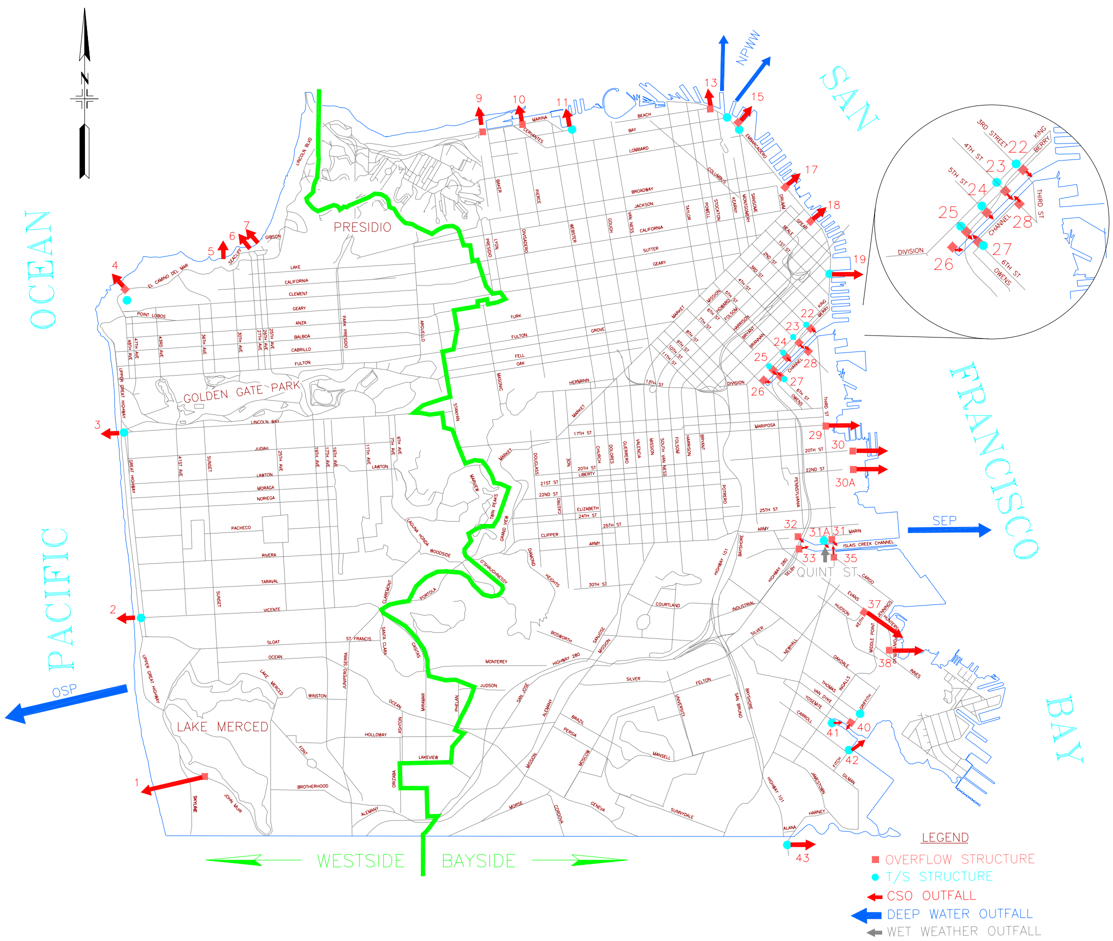
Introduction

The purpose of this PM is to summarize the Combined Sewer Discharge (CSD) data that SFPUC has provided for the Bayside, Westside, and Westside Decant discharges. SFPUC has two objectives with the CSD data that they collect. The first is to comply with the 9th minimum control measure of the CSO policy and provide good stewardship. The second objective is to focus on a more quantifiable approach for developing pollutant reductions that occur within the storage/transport system.

All SFPUC combined sewer discharge locations can be seen in Figure 1. The data is collected in the form of grab samples, in sizes that range from 1 liter to 10 liter bottles, and after a storm event.

Figure 1(NPDES PERMIT NO. CA0037664)

MAJOR DRAINAGE BASINS / OUTFALL LOCATIONS



OUTFALL NO.	OUTFALL NAME	STRUCTURE OR T/S STRUCTURE	T/S OR DRAINAGE BASIN
1	LAKE MERCED	John Muir Drive	LMT
2	VICENTE	T/S Box at Great Hwy/Vicente St.	WST
3	LINCOLN WAY	T/S Box at Great Hwy/Lincoln Way	WST
4	MILE ROCK	Tunnel Junction Structure	RT
		Tunnel Overflow Chamber	RT
5	SEACLIFF #1	Pump Station	SEACLIFF
6	SEACLIFF	Outfall Structure Betw. 26th/27th Ave.	SEACLIFF
7	SEACLIFF #2	Pump Station	SEACLIFF
8			
9	BAKER STREET	Outfall Structure at DAF	NSOC
10	PIERCE STREET	Outfall Structure	NSOC
11	LAGUNA STREET	T/S Box at Marina/Laguna	NSOC
13	BEACH STREET	Outfall Structure	NSOC
15	SANSOME	T/S at Embarcadero & Sansome	NSOC
		T/S at Embarcadero & Bay	NSOC
		Outfall Structure	NSOC
17	JACKSON STREET	Outfall Structure	NSOC
18	HOWARD STREET	Overflow Structure	COC
19	BRANNAN STREET	T/S at Embarcadero & Brannan	COC
22	3RD STREET	T/S structure at 3rd/King	COC
		Overflow Structure	COC
23	N. 4TH STREET	T/S structure at 4th/King	COC
		Overflow Structure	COC
24	5TH STREET	T/S at 5th/Berry	COC
		Overflow Structure	COC

OUTFALL	LONG TERM AVERAGE OVERFLOWS	AREA NAME
1 – 8	8	WESTSIDE
9 – 17	4	NORTHSHORE
18 – 35	10	CENTRAL BASIN
37 – 43	1	SOUTH BASIN

SAMPLING LOCATIONS

STATION NO.	OUTFALL NO.
0–1	29
0–2	33
0–3	43
0–4	10
0–5	42
0–6	25
LAKE MERCED	1
VICENTE	2
LINCOLN	3
MILE ROCK	4

OUTFALL NO.	OUTFALL NAME	STRUCTURE OR T/S STRUCTURE	T/S OR DRAINAGE BASIN
25	N. 6TH STREET	T/S at 6th/Berry	COC
		Overflow Structure	COC
26	DIVISION STREET	Overflow Structure	COC
27	S. 6TH STREET	T/S at 6th/Owens Street	COC
		Overflow Structure	COC
28	S. 4TH STREET	Overflow Structure	COC
29	MARIPOSA STREET	Overflow Structure	MTS
30	20TH STREET	Overflow Structure	MTS
30A	22ND STREET	Overflow Structure	MTS
31	N. 3RD STREET	Overflow Structure at 3rd/Marin	N 3RD ST
31A	ISLAIS NORTH	Overflow Structure	ISLAIS CREEK
32	MARIN STREET	Overflow Structure	ISLAIS CREEK
33	SELBY STREET	Overflow Structure	ISLAIS CREEK
35	S. 3RD STREET	Overflow Structure at 3rd/Cargo	SOUTHEAST
37	EVANS STREET	Overflow Structure at Evans/Keith	HP
38	HUDSON STREET	Overflow Structure at Hudson/Hunters Point	HP
40	S. GRIFFITH	T/S Structure at Griffith/Thomas	Y/F
		Overflow Structure at Wallace	Y/F
41	YOSEMITE STREET	T/S Structure at Yosemite Channel	Y/F
42	FITCH STREET	T/S & Overflow Structure	Y/F
43	SUNNYDALE	T/S Structure at Harney Way	SUNNYDALE

LMT — Lake Merced Transport
WST — Westside Transport
NSOC — Northshore Outfalls Consolidations
COC — Channel Outfalls Consolidations
RT — Richmond Transport
MTS — Mariposa Transport / Storage
HP — Hunters Point
Y/F — Yosemite Fitch Transport / Storage
SUNNYDALE — Sunnydale Transport / Storage

SJ@EE/PUC/CCSF 8/99 BASED ON A DRAWING FROM HYDRAULICS SECTION/BUREAU OF ENGINEERING/CCSF

Bayside

There are six combined sewer discharge locations on the Bayside for which the available CSD data was collected. The discharges are directly from the storage/transport boxes to the shoreline. The data provided by SPFUC was collected from November 1997 through December of 2001. Data was collected for the constituents as shown in Appendix A, Bayside Overflow Master.

A summary denoting averages, maximums, and minimums for this data is shown in Appendix B. Averages do not include data points that were marked as NS (not sampled), ND, or by a - mark. Data points that were denoted as at the limit of detection were assumed to be equal to the detection limit. For example, in the data collected, many data points have mercury shown as <0.3 µg/L. For the purposes of this data summary, mercury was assumed to be equal to 0.3 µg/L for that data point.

Westside

There are two combined sewer discharge locations on the Westside for which the CSD data provided by SFPUC was collected. The discharges are directly from the storage/transport boxes to the shoreline. The data provided by SFPUC was collected from January 1997 through March 2006. No data was collected in 2003. Data was collected for the constituents, as shown in Appendix C, Westside Overflow Master.

A summary denoting averages, maximums, and minimums for this data is shown in Appendix B. Averages do not include data points that were marked as NS (not sampled), ND, or by a - mark. Data points that were denoted as at the limit of detection were assumed to be equal to the detection limit. For example, in the data collected, many data points have mercury shown as <0.3 µg/L. For the purposes of this data summary, mercury was assumed to be equal to 0.3 µg/L for that data point. Although data was collected from 2001 through 2006, errors in the sampling method were detected prior to October 2004 per the CSO Control Annual Status Report, August 2005, such that the samples became sediment traps, therefore skewing the constituent concentrations in the samples. Therefore, summary data only includes data from October 2004 on.

Westside Decant

There is one combined sewer discharge location on the Westside for which decant data was collected. The discharge is directly from the Westside Transport to the Southwest Ocean Outfall (SWOO). The data provided by SFPUC was collected from January 1997 through March 2006. No data was collected in 2003. Data was collected for the constituents, as shown in Appendix D, Westside Decant Overflow Master.

A summary denoting averages, maximums, and minimums for this data is shown in Appendix B. Averages do not include data points that were marked as NS (not sampled), ND, or by a - mark. Data points that were denoted as at the limit of detection were assumed to be equal to the detection limit. For example, in the data collected, many data points have mercury shown as <0.3 µg/L. For the purposes of this data summary, mercury was assumed to be equal to 0.3 µg/L for that data point. Although data was collected from 2001 through 2006, errors in the sampling method were detected prior to October 2004 per the CSO Control Annual Status Report, August 2005, such that the samples became sediment traps, therefore skewing the constituent concentrations in the samples. Therefore, summary data only includes data from October 2004 on.

Summary

The data that has been collected to date by SFPUC has been suitable for their needs. However, in the future, it is recommended that additional data be collected, the sampling frequency be increased, and further analyses be completed on the new data. These recommendations are particularly necessary in order for SFPUC to meet their second CSD data objective, quantifying pollutant removal in the storage/transport system.

APPENDIX C - PROJECT MEMORANDUM - PMA 31 - CSD MASS BALANCE ANALYSIS

DRAFT PROJECT MEMORANDUM

Project Name:	SFPUC Sewer Master Plan	**Date:**	9/5/07
Client:	City and County of San Francisco	**Project Number:**	7240A.00
Prepared By:	Patricia McGovern, PME		
Reviewed By:	Jeff Berlin, Cari Ishida		
Subject:	PMA 31 – CSD Mass Balance Analysis		
Distribution:	Arleen, Navarret, Pricilla Bloomfield, Elisa Garvey, Lydia Holmes, Steve McDonald, Fred Krieger, Tracy Clinton		

Purpose

San Francisco has a combined wastewater and storm water collection system. During extreme wet weather events, the capacity of the system is exceeded and overflows occur at various near-shore locations around the City. San Francisco's collection system is unique in that overflows receive treatment within a storage/transport system before discharge. The storage/transport system primarily removes floatables and settleables from Combined Sewer Discharges (CSDs). The efficiency of the storage/transport system at removing suspended solids and other pollutants is unknown. Performing a mass balance of the system would help to determine the removal efficiency of solids and select pollutants.

The purpose of this PM is to achieve the following:
1) Present the purpose, need, and use of a mass balance analysis,
2) Summarize past mass balance efforts,
3) Describe the objectives, approach, and status of the current mass balance effort, and
4) Identify data gaps and future sampling needs.

Purpose, Need, and Use of a Mass Balance Analysis

A mass balance analysis identifies the sources and sinks of pollutant loadings throughout the system being analyzed. In this case, a mass balance analysis is to be conducted on the storage/transport system during wet weather when discharges from CSDs occur. Results of the mass balance analysis will answer the fundamental questions of what level of treatment the effluent discharged from the storage transport boxes receives and what are the pollutant loadings from the CSDs. Not only is this information necessary to meet regulatory requirements, this information is also useful when making future planning decisions (e.g. when/where additional treatment is necessary, cost benefit ratios, etc.).

The Clean Water Act requires that discharges, including those from combined systems, do not impair receiving water beneficial uses. More specifically, the 9th minimum control outlined in the CSO Control Policy requires that a CSO system be monitored in order to effectively characterize CSO impacts and the efficacy of CSO controls. This requirement is reiterated in both the

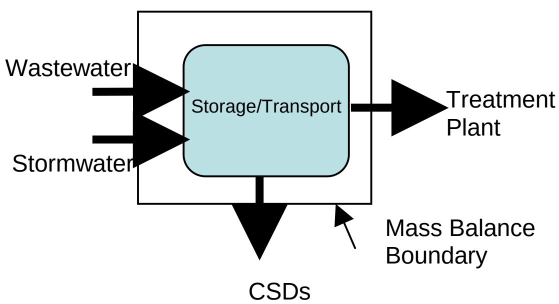
Oceanside Plant and Southeast Plant NPDES permits (NPDES Permit No. CA 0037681, page 33 and NPDES Permit No. CA 0037664, page 48, respectively), which require studies to assess the efficacy of the storage/transport systems. The results of the mass balance analysis will help satisfy the requirement of the CSO Control Policy's 9th minimum control.

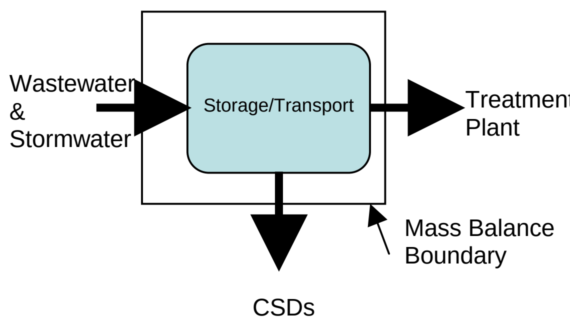
San Francisco Bay is 303(d) listed for a number of pollutants and Total Maximum Daily Loads (TMDLs) have been developed for PCBs and mercury (see PM 32). Waste load allocations based on TMDLs will be or have been defined for sources including stormwater and wastewater. By understanding the mass discharged from and/or captured within the storage/transport system, San Francisco may be able to receive "credit" for this storm water treatment. If a trading program were to be established, this stormwater credit may provide regulatory relief to San Francisco's wastewater allocation or San Francisco may be able to trade this credit to another agency.

The data gathered to conduct the mass balance study will be useful for supporting decisions related to method of treatment or Best Management Practices (BMPs), location of facilities, and whether or not additional treatment is necessary. Mass balance information may also assist with cost benefit analyses, support system modeling efforts, and help to identify problems in the system as they arise. Water quality data collected through this effort are invaluable to understanding the fate and transport of pollutants so that future systems can be built to incorporate these findings.

How a mass balance analysis might work – simplified

A mass balance on the storage/transport system requires identifying both water quality and flow for the influent and effluent streams. The graphics below show a simplified depiction of a mass balance flow diagram of San Francisco's storage/transport systems.





In the first simplified depiction of the system, the following parameters would be required to quantify the level of removals through the storage/transport system:

- Influent/raw wastewater water quality
- Influent wastewater flow
- Influent storm water quality
- Influent storm water flow
- Treatment plant influent water quality (or storage/transport effluent water quality)
- Influent treatment plant flow (or storage/transport effluent flow)
- CSD water quality
- CSD flows.

The second simplified depiction of the system may be more appropriate if combined stormwater and wastewater influent flows are available.

Prior to starting the mass balance analysis, the overall goals of the evaluation should be identified. If the mass balance analysis was for general, long-term average results the model would be significantly different than for individual storm, first flush, or annual average results. Once the overall goals are defined, a sampling and analysis plan and a model of the system can be developed. In general, sampling would occur during wet weather events when the storage/transport system is in use.

Careful documentation of the conditions during each sampling event is important. One significant condition is timing, because the concentration of the influent flow needs to correspond to the effluent flow. Therefore, understanding the time of travel and detention time through the system is necessary.

Pollutants to be measured are those with existing and future regulatory implications (i.e.TMDLs, permit limits, etc.) such as mercury, PCBs, and dioxin. Indicator parameters such as total suspended solids (TSS) and total organic carbon (TOC) should also be measured.

A model application, whether a simple spreadsheet model or a more complex mass balance model, would be developed and used. Each segment of the storage/transport system (e.g. Southeast, Northpoint, and Westside) will have different configurations that will make modeling them unique. Assumptions for each system should be documented.

Overall, having a detailed understanding of the storage/transport system is imperative in order to select the correct sample and flow metering locations, sample at the correct time, accurately model the system (i.e. identify the type and level of treatment received), and correctly interpret results.

Past Mass Balance Efforts

A number of studies have already been conducted to determine the efficiency of the storage/transport facilities in removing suspended solids and other constituents.

***Westside Transport Performance Evaluation Study*, March 1991**

In March 1991, a study was submitted to the RWQCB titled *Westside Transport Performance Evaluation Study* by David Jones and Trinh Nguyen (Clean Water Program) on behalf of the San Francisco PUC. This evaluation was conducted in response to Provision IV of the Westside Wet-Weather Facilities NPDES permit (Permit No. CA 0038415), which required a special study to assess the efficacy of the system in pollutant reductions. This study was conducted prior to the completion of construction of all storage/transport facilities. Consequently, this study evaluated removal efficiencies through the Westside Transport boxes only, without the contributions from the Lake Merced and Richmond watersheds. The Westside Transport boxes include the storage/transport boxes from Fulton Street to Sloat Street with two overflow locations at the Lincoln Street outflow and the Vicente Street outflow.

The following results and conclusions were reported in the study:

> Data from portions of ten storms were used to calculate flow-weighted average inflow and out-flow concentrations of TSS and BOD_5 for the transport and percentage removals for TSS and BOD_5. These data indicates that the Transport is removing between 25 and 40 percent of the TSS and BOD. However, an analysis of the quantities of sediments measured in the bottom of the Transport suggest that the Transport may be removing as much as 50 percent of the TSS entering the Transport. This disparity may be due to the auto-samplers under-reporting the TSS concentrations in raw wet-weather flow due to problems in picking-up solids with

higher settling velocities.

The performance of the Transport is not markedly different from that of a primary treatment plant when it is operating in its wet-weather capacity.

***Westside System Re-Evaluation*, August 2002**

In response to the requirement in the Oceanside NPDES Permit (Permit No. CA0037681, Item 9) to assess the range of engineering options to reduce CSOs, the *Westside System Re-Evaluation* study was completed by Hydroconsult Engineers in August 2002. Since the focus of this study was to determine the reduced number of CSDs, load reductions through the storage/transport system were not evaluated. However, this study did identify flow rates from Westside discharges that, in combination with concentration data, may be helpful in mass balance analyses of the Westside system.

***Oceanside Efficacy of CSO Controls Report, Annual Status Report*, August 30, 2005**

In the current Oceanside NPDES permit, the RWQCB and EPA required San Francisco to conduct a to characterize overflow impacts and the treatment efficacy of the CSD system (Permit No. CA 0037681, page 33). In response, San Francisco submitted the *Efficacy of CSO Controls Repor*t, *Annual Status Report* on August 30, 2005. This report summarized the data collected from the CSDs and compared this data with primary effluent data.

Samples were taken in 1997 (at the time the CSO Control Plan was completed) for the following parameters: BOD, TSS, ammonia, oil and grease, pH, pesticides, PCBs, metals, and PAHs. However, a flaw with the sampling methodology was reported in the data taken prior to 2004. Consequently, only one sampling season, 2004-2005, which had six overflow events (i.e. six data points) was available for review and analyses. Although there were not enough data to identify trends, TSS concentrations in the CSD effluent (taken at Vicente Box) and the primary effluent were compared (Table 1).

Table 1. Comparison of CSD and Primary Effluent during the 2004/2005 Wet Weather Season

Date	**CSD**	**Primary Effluent**
	TSS in mg/L	TSS in mg/L
10/26/2004	118	63
12/7/2004	98	73
12/8/2004	30	51
12/27/2004	48	28
2/16/2005	38	84
2/27/2005	44	78
Average	**62**	**63**

Inorganic pollutant concentrations tended to track TSS trends during the 2004-2005 wet weather season. Additionally, the report included the following clarification regarding CSD effluent:

> Copper, mercury, lead, and zinc concentrations were the only metals measured above the California Ocean Plan water quality objectives. The nature of the sampling effort during a combined sewer discharge makes it difficult to incorporate ultra clean sample technique in the sample collection process. The concentrations of these elements may decrease with more representative and consistent CSD sampling techniques in the future.

***Bayside Efficacy of CSO Controls Report,* June, 2006**
In the current Bayside NPDES permit, the RWQCB required San Francisco to conduct a study to characterize overflow impacts and the efficacy of the CSD system (NPDES Permit No. CA 0037664, page 48). In response, San Francisco submitted the *Efficacy of CSO Controls Repor*t, *Annual Status Report* on June 2006. This report first summarized the data collected from the CSDs and compared these data with primary effluent data.

Samples were taken in 1997 (at the time the CSO Control Plan was completed) through the 2001-2002 wet weather season, and then again during the 2005-2006 wet weather season. Samples were analyzed for the following parameters: TSS, ammonia, arsenic, cadmium, chromium (total), copper, lead, mercury, nickel, silver, zinc, and cyanide. Over this sampling period, the average TSS concentration from the Southeast Plant primary effluent (104 mg/L) was equivalent to the average TSS concentration from all CSDs (103 mg/L). At each sampling location, a reasonably strong relationship between the concentrations of TSS and the concentrations of chromium, copper, and lead was found. A slightly lesser relationship between the concentrations of TSS and the concentrations of nickel and zinc was also found.

Current Mass Balance Effort

A mass balance analysis effort is currently underway by the SFPUC with support from Hydroconsult Engineers. The original objectives of the study were the following:

- Characterize dry weather pollutant mass loads,
- Characterize stormwater runoff mass loads, specifically looking at loadings from small, medium, and large storms. Assess influent water quality during CSD events to determine if there is a first flush effect during a storm. Additionally, assess the variation between influent storm water quality at the beginning of the rainy season versus the water quality of a storm at the end of the season.
- Determine CSD volume and water quality, and
- Develop a pollutant mass balance to track pollutant mass loads through the collection system, storage/transport system and treatment facility.

The original approach designed to meet these objectives included collecting and analyzing numerous water quality and flow samples including:

- CSD effluent locations to determine the mass effluent loadings of the CSDs;
- Dry weather samples within the collection system of some watersheds to relate wastewater quality with land use;
- Influent stormwater samples throughout the wet weather season and throughout a storm event to assess seasonal and first flush variations; and
- Influent, effluent, and solids samples at the treatment plants to conduct a pollutant mass balance through the plant.

In an effort to pare down the sampling and analysis efforts, the study objectives and approach were refined. A two-year program has been identified and is being implemented. This refined study will estimate the loadings of TSS and metals in the CSD effluent on the Westside and in the Islais Creek watershed on the Bayside. Additionally, this study will assess the reductions of TSS and metals through the Westside Storage/Transport system and the Islais Creek Storage/Transport system. The following provides a brief synopsis of the current mass balance study.

Westside

Year 1 (2006-2007 wet season) – The purpose of gathering the following information is to characterize the water quality and mass of pollutants discharged from the CSDs. The following describes the activities on the Westside for Year 1:

- Two CSD effluents (Lake Merced and Vicente Street) will be sampled for flow, TSS, and metals.
- The decant from the storage transport will be sampled for TSS and metals.
- Samples will be collected for every CSD event.

Year 2 (2007-2008 wet season) – The purpose of gathering this information is to characterize the pollutant reductions through the Westside Storage/Transport Box. The following describes the activities on the Westside for Year 2:

- Continuation of Year 1 activities.
- Collection system monitoring immediately upstream of the Westside Storage/Transport Box will be sampled for TSS, and metals.
- Samples will be collected for every CSD event.

Bayside

Year 1 & 2 (2006-2007 – 2007-2008 wet seasons) – The Bayside study will focus on characterizing the Islais Creek watershed. Information gathered will characterize the water quality and mass of pollutants discharged, and the pollutant reductions from the Islais Creek Watershed CSDs. The following describes the activities on the Westside for Year 1 and Year 2:

- Three CSD effluents (i.e. Selby, Marin, Islais Creek North) will be sampled for flow, TSS, and metals.
- Collection system monitoring will be conducted immediately upstream of the Islais Creek Storage/Transport Box (i.e. Industrial box sewer at Barneveld and Marin box sewer at DPW) and will be sampled for TSS and metals.
- The decant from the storage transport will be sampled.
- Samples will be collected for every CSD event.

<u>Future Data Needs / Recommended Future Sampling</u>

Future needs to support a mass balance study will require flow metering, sample collection and analysis, modeling of the system, and interpretation and documentation of results. These types of activities require personnel (i.e. staff or consultants) to develop a sampling and testing plan, take samples, analyze samples in the laboratory, enter and QA/QC data, model the system, run the model, and interpret and document results. A mass balance study will also require sampling and flow metering equipment, use of a laboratory, and coordination between departments to fully understand all components of the system. The mass balance analysis currently being conducted is looking at segments of the system at a time, thereby reducing the number of samplers, flow meters, and personnel needed at the same time. Most importantly, a thorough understanding of the system is necessary to correctly model the system and make the best assumptions where information is unavailable.

APPENDIX D - PROJECT MEMORANDUM - ANNOTATED OUTLINE FOR ONE OR LESS CSD'S ALTERNATIVE ANALYSIS

PROJECT MEMORANDUM

Project Name:	San Francisco Sewer System Master Plan	**Date:**	02/09/07
Client:	City and County of San Francisco	**Project Number:**	
Prepared By:	Mary-Cate Opila & Chung Linh		
Reviewed By:	Wallis Lee, Greg Braswell, Geoff Grant		
Subject:	Annotated Outline for One or Less CSD's Alternatives Analysis		
Distribution:	Jon Loiacono, Bonnie Jones, Norman Chan, Steve McDonald, Tracy Clinton, Dave Bingham, Kenneth Sin		

To perform a compressive analysis of masterplan alternatives, the cost of reducing CSDs to one or less per year city wide was evaluated for each alternative. The relative cost to reduce discharges for each alternative were compared to other alternatives. Multiple scenarios were evaluated to achieve the one or less average annual CSD goal in the model to develop cost/performance curves for optimizing increased treatment vs. increased storage as well as to develop strategies to overcome flow limitations and bottlenecks in the existing system.

This discussion only involves the Scenarios that incorporate the Cayuga Flood Relief Tunnel. This is to address the importance of routing flows to the West that normally go East. Other model simulations that did not incorporate the Cayuga Relief Tunnel were looked at but are not a part of this discussion. All the pumping rates are relative to the same initial outfall capacity: 270 MGD at North Point Outfall, 250 MGD at Southeast Bay Outfall, and 590 MGD at Southwest Ocean Outfall.

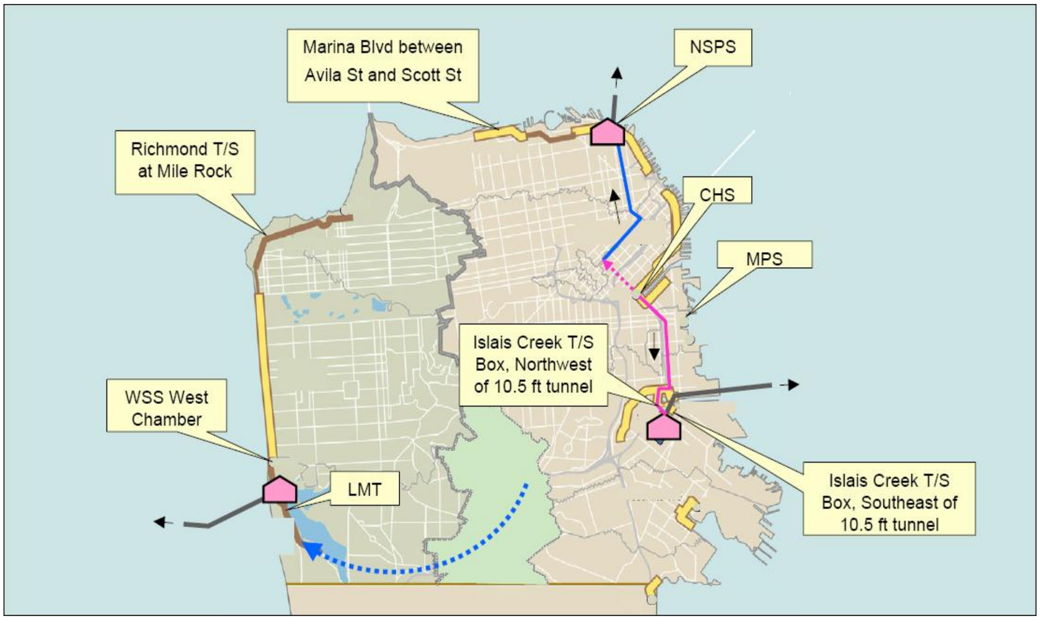
SCENARIO ONE

Scenario One served as a rough indicator of the level of effort required to achieve 0-CSD. This first series of model runs took a simplistic approach in alleviating the discharges by focusing on treatment only, simply by pumping the flow out of the system before it has a chance to discharge into the receiving waters. By focusing on treatment only, the modelers were able to gauge subsequent model runs against this baseline of treatment only.

This treatment only approach in the model runs led to the realization that flow constrictions exist in the system; increasing treatment rates to extremely high rates at existing treatment facilities did not produce proportional results at all locations. Therefore, to continue the treatment only approach, additional pump and outfall combinations were added to simulate the required additional treatment locations.

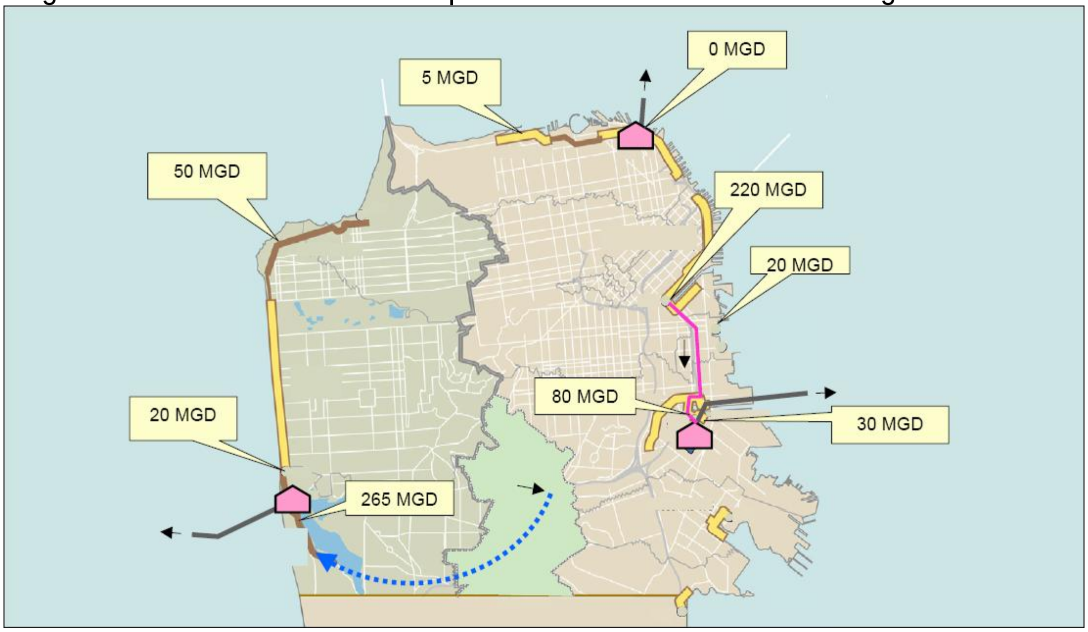
In addition to the existing treatment points at the North Point Treatment Plant, Southeast Treatment Plant and Oceanside Plant, additional pumping/treatment points were added to remove flows at the Channel Pump Station, Mile Rock Tunnel, Lake Merced Transport, Mariposa Facilities, the Northern Section of the Islais Creed Transport Storage Box, and Marina Boulevard.

FIGURE 1: LOCATIONS OF ADDITIONAL PUMPING FOR SCENARIOS 1 AND 2



Though the additional points served their purpose of decreasing annual discharges to one or less per year, the scenario required a tremendous amount of additional treatment capacity (Figure 2).

Figure 2: Additional Treatment Required to Obtain One or Less Average Annual CSD



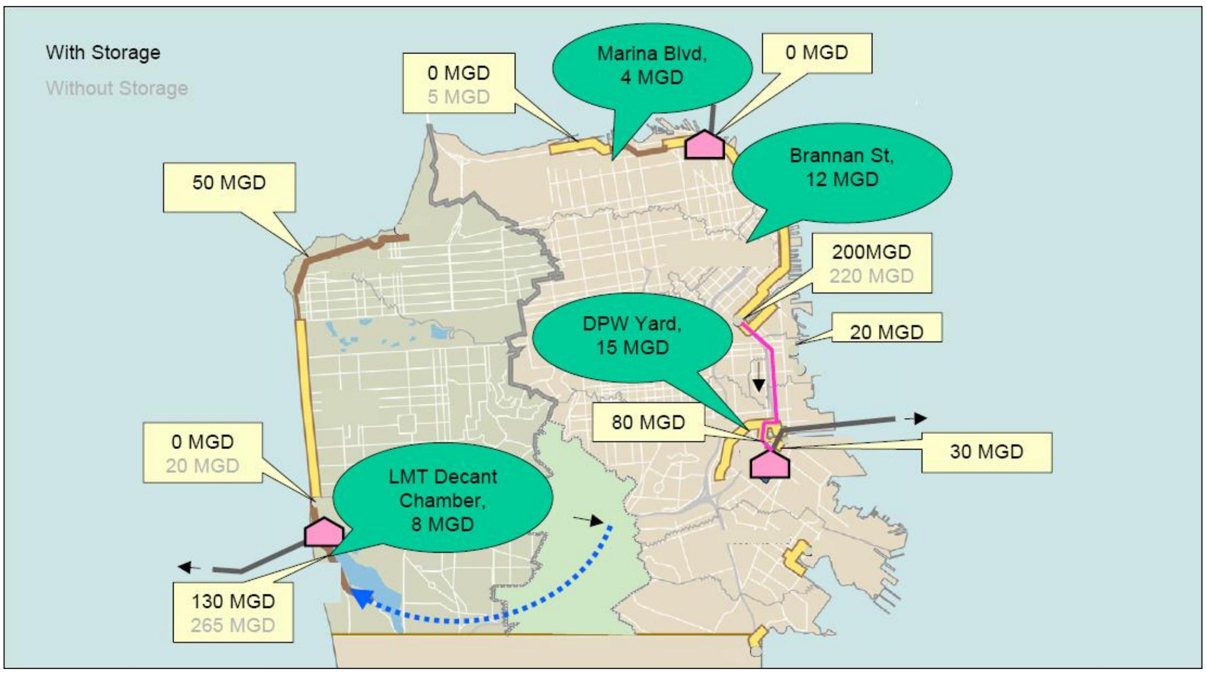
SCENARIO TWO

Scenario Two built upon the model runs in Scenario One by incorporating a limited amount of storage to see the effects of the storage on the pumping rates. As the cost of treatment is high compared with the less expensive cost of building additional storage, these model runs would also provide more reasonable solutions, financially speaking, towards the one or less average annual CSD.

By placing several storage units in the system, the capacity of the additional treatment units required could be reduced as these storage tanks capture the peak flows. For this evaluation, storage was placed at four locations throughout the city. The location and size of the storage included in the analysis was determined from actual available locations and volumes that could be placed in the system.

For these runs, additional storage was sited at four locations throughout the City, refer to Figure 3 for the locations and approximate capacities of additional storage added to the system for Scenario Two. The figure also presents the additional treatment required to obtain less than one average annual CSD. The treatment numbers in black represent treatment rates for Scenario Two, treatment rates shown in grey represent treatment rates for Scenario One without additional storage.

Figure 3: Additional Storage and Treatment to Obtain One or Less Annual Average CSD for Scenario 2



With the additional storage at the four specified locations, the total pumping rate required to achieve one or less CSD reduced by approximately 25%. The majority of this decrease in pumping rate pumping rate occurred in the Oceanside drainage basin as a direct result of the additional storage at the Lake Merced Transport.

SCENARIO THREE

Scenario Three of the analysis built upon the findings of Scenario One and Two by imposing real-world factors onto the model runs. Right from the start, it became apparent that no solution for one or less CSD alternative up to this point was viable. An all pumping/treatment solution, as in Scenario One, is prohibitively expensive; while a select number of storage locations, as in Scenario Two, even though it is more effective, did not reduce the pumping volumes drastically enough. Moreover, the difficulty in adding treatment at locations other than the three current treatment plants is prohibitive. Therefore, additional treatment was only considered as an option at the SEP, OSP and NSS.

Through the course of brainstorming and identifying possible courses of action to arrive at one or less CSD, four realizations became readily apparent:

1. The capacity of the Southwest Ocean Outfall (SWOO) must be utilized to its full potential, but to avoid the need to build a new Oceanside outfall, the Oceanside treatment capacity is limited to 590 mgd.
2. Additional storage will need to be added to the Oceanside to satisfy item number 1. Likewise, all storage in the system should be fully utilized. In particular, the storage capabilities of the Cayuga tunnel, all transport storage boxes and all storage facilities should be utilized completely.
3. A major flow constriction at Channel needs to be remedied before any additional plans could go on. This important connector will determine inter-operability between the North Point Treatment Facilities and the Southeast Plant.
4. The only treatment location on the Oceanside is located at the OSP. Therefore, the Sea Cliff and Mile Rock overflows need to be reduced by increasing storage in the area and relieving downstream constrictions.

The next series of model simulations attempted to address the above mentioned factors. To maximize the use of SWOO, and to avert the cost of delivering water to the East, it was decided to divert as much flow as possible to the West. This was accomplished via the Cayuga Flood Relief Tunnel. The orifice at the bottom of the tunnel was sized to allow sufficient flows so that OSP will operate at capacity without causing overflows or flooding in the Cayuga area. An additional pressure main was added to the Cayuga tunnel connecting the downstream end of the tunnel to the WST, decreasing the overflows at Lake Merced. Additional storage was added to the Oceanside adjacent the WST as well as in the Lake St. area. Flow constrictions between the Richmond and the WST were lessened to decease overflows at Seacliff and Mile Rock.

To reduce the flow constriction between Channel and Islais Creek, a 14 ft tunnel was constructed connecting the Channel Box and the Islais Creek Box. This tunnel not only provided additional conveyance between the regions, it also provided additional storage. Various smaller additional storage units were also added at several locations throughout the city.

The results from these simulations indicate that starting with Alternative 2, and making the above mentioned storage and conveyance changes to the system, additional treatment would only be necessary at SEP to a rate of 220 mgd.

Figure 4: Treatment to Obtain One or Less Annual Average CSD for Scenario 3 (Storage and Conveyance Additions not Included in Figure